Subject

Minimum Propulsion Power required by the Amendments to ANNEX VI of MARPOL 73/78 (EEDI related Requirements)

ClassNK
Technical Information

No. TEC-0954
Date 25 June 2013

To whom it may concern

Amendments to MARPOL ANNEX VI that make the "Energy Efficiency Design Index (EEDI)" and the "Ship Efficiency Management Plan (SEEMP)" mandatory were adopted at the 62nd session of the Marine Environment Protection Committee (MEPC 62) held in July 2011, and came into force from 1 January 2013.
Relevant information on the minimum propulsion power requirements applied for the ships to which compliance with an EEDI limit value (required EEDI) is required has already been provided in ClassNK Technical Information No. TEC-0938. Since the guidelines defining this requirement have been revised, the Technical Information is revised as described below. The said ClassNK Technical Information No. TEC-0938 is thus revoked, accordingly.

1. Background
   For ships to which the requirements regarding required EEDI specified in Reg. 21 of MARPOL ANNEX VI apply, the installed propulsion power is not to be less than the propulsion power needed to maintain the manoeuvrability of the ship under adverse conditions as defined in the guidelines developed by the IMO, in accordance with Reg. 21.5 of ANNEX VI.
   At MEPC 64 held in October 2012 and MSC 91 subsequently held in November 2012, "Interim Guidelines for Determining Minimum Propulsion Power to Maintain the Manoeuvrability of Ships in Adverse Conditions" were developed and issued as MSC-MEPC.2/Circ.11. At MEPC 64, it was agreed that the interim minimum power guidelines should be further examined and fine-tuned as required at MEPC 65 or later.
   After considerable deliberations at MEPC 65 held in May 2013, the revised version of the interim minimum power guidelines (hereinafter referred to as "2013 interim minimum power guidelines") were adopted as Resolution MEPC.232(65).

2. Application
   The 2013 interim minimum power guidelines are applicable only to bulk carriers, tankers, and combination carriers to which compliance with an EEDI limit value (required EEDI) is required by Reg. 21 of MARPOL ANNEX VI*.

   * Applies to bulk carriers, tankers, or combination carriers of 20,000DWT or above for which either the building contract is placed on or after 1 January 2013, or in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction on or after 1 July 2013, or the delivery of which is on or after 1 July 2015.

(To be continued)

3. Assessment procedures for minimum propulsion power

The ships mentioned in paragraph 2 above are required to fulfil either of the following two assessment levels in accordance with the 2013 interim minimum power guidelines. (If a ship does not satisfy the level-1 criteria, a level-2 assessment is to be considered.)

(1) Assessment level 1 - minimum power lines assessment

The minimum power lines for each ship type are calculated using the formula as the function of deadweight shown in the following table. The installed propulsion power (total main engine output) is not to be less than the power calculated using these formulas.

Ship Type	**Minimum Propulsion Power (kW)**
Bulk Carrier	0.0687 x DWT + 2924.4
Tanker/Combination Carrier	0.0689 x DWT + 3253.0

(2) Assessment level 2 - simplified assessment

A level-2 simplified assessment is an indirect assessment procedure based on the assumption that, under adverse condition, if the ship has sufficient installed power to move with a certain advance speed in head waves and wind, and it is lower than the torque limit (within the operating range) of the installed engine, the ship can also be expected to maintain course in waves and wind from any other direction. In the 2013 interim minimum power guidelines, the adverse conditions to be considered for the level-2 assessment are defined as shown in the following table.

Ship length, L_{PP} (m)	**Significant wave height, hs (m)**	**Peak wave period, T_P (s)**	**Mean wind speed, V_W (m/s)**
Less than 200	4.0	7.0 to 15.0	15.7
200 ≤ LPP < 250	*		*
More than L_{PP} = 250	5.5		19.0

(* Linearly interpolated value depending on ship's length)

The level-2 assessment procedure consists of three steps:

(i) Step 1: define the required advance speed (Vs) in head wind and waves, ensuring course-keeping in all wave and wind directions;

(ii) Step 2: calculate the propulsion power (Preq) necessary to ensure the required advance speed (Vs), and confirm that the total main engine output is more than the required propulsion power (Preq); and

(iii) Step 3: confirm that the torques at the required propulsion power (Preq) are lower than the torque limit (within the operating range) of the installed engine.

For the details regarding the assessment procedure, please refer to the Appendix in Attachment 1.

(To be continued)

4. Verification of compliance with the minimum propulsion power requirements
   The minimum propulsion power requirements are to be confirmed at the time of EEDI preliminary verification. In cases where the ship applies for a level-2 assessment, the following documents need to be submitted as additional information. On the other hand, if the ship complies with level-1 minimum power requirements, these documents do not need to be submitted.
   - calculation sheet for level-2 assessment
   - document in which the rudder area is identifiable
   - document in which the frontal/lateral windage areas are identifiable
   - basis for calculation of the aerodynamic resistance (if not use the simplified estimation formula given in the 2013 interim minimum power guidelines)
   - basis for calculation of the calm-water resistance and self-propulsion factor (if not use the simplified estimation formula given in the 2013 interim minimum power guidelines)
   - basis for calculation of the added resistance due to waves (model tank test results in waves or calculation results)
   - propeller open water characteristics of the design propeller
   - documents related to the installed main engine including the information for torque limit
   - other documents as deemed necessary

5. Future plans concerning minimum power guidelines
   The 2013 interim minimum power guidelines described above are applicable during phase 0 of EEDI implementation. In this context, final guidelines for determining minimum propulsion power for maintaining the manoeuvrability of ships in adverse conditions applicable to ships in phases 1, 2 and 3 are to be developed by IMO at a later stage.

For any questions about the above, please contact:

NIPPON KAIJI KYOKAI (ClassNK)
EEDI Division, Administration Center, Head Office
Address: 4-7 Kioi-cho, Chiyoda-ku, Tokyo 102-8567, Japan
Tel.: +81-3-5226-2058
Fax: +81-3-5226-2059
E-mail: eedi@classnk.or.jp

Attachment:

1. 2013 Interim Guidelines for Determining Minimum Propulsion Power to Maintain the Manoeuvrability of Ships in Adverse Conditions (Resolution MEPC.232(65))

ANNEX 16

RESOLUTION MEPC.232(65)

Adopted on 17 May 2013

2013 INTERIM GUIDELINES FOR DETERMING MINIMUM PROPULSION POWER TO MAINTAIN THE MANOEUVRABILITY OF SHIPS IN ADVERSE CONDITIONS

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING Article 38(a) of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee (the Committee) conferred upon it by international conventions for the prevention and control of marine pollution,

RECALLING ALSO that, at its sixty-second session, the Committee adopted, by resolution MEPC.203(62), amendments to the annex of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (inclusion of regulations on energy efficiency for ships in MARPOL Annex VI),

NOTING that the amendments to MARPOL Annex VI adopted at its sixty-second session by inclusion of a new chapter 4 for regulations on energy efficiency for ships, entered into force on 1 January 2013,

NOTING ALSO that regulation 21.5 of MARPOL Annex VI, as amended, requires that the installed propulsion power shall not be less than the propulsion power needed to maintain the manoeuvrability of the ship under adverse conditions as defined in the guidelines,

RECOGNIZING that the amendments to MARPOL Annex VI requires the adoption of relevant guidelines for smooth and uniform implementation of the regulations and to provide sufficient lead time for industry to prepare,

HAVING CONSIDERED, at its sixty-fifth session, the draft *2013 Interim Guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions*,

1. ADOPTS the *2013 Interim Guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions*, as set out at annex to the present resolution;

2. INVITES Administrations to take the annexed Guidelines into account when developing and enacting national laws which give force to and implement provisions set forth in regulation 20 of MARPOL Annex VI, as amended;

3. REQUESTS the Parties to MARPOL Annex VI and other Member Governments to bring the annexed Guidelines related to the Energy Efficiency Design Index (EEDI) to the attention of shipowners, ship operators, shipbuilders, ship designers and any other interested groups;

4. AGREES to keep these Guidelines under review in light of the experience gained; and

5. REVOKES the Interim Guidelines circulated by MSC-MEPC.2/Circ.11, as from this date.

ANNEX

2013 INTERIM GUIDELINES FOR DETERMINING MINIMUM PROPULSION POWER TO MAINTAIN THE MANOEUVRABILITY OF SHIP IN ADVERSE CONDITIONS

0 Purpose

The purpose of these interim guidelines is to assist Administrations and recognized organizations in verifying that ships, complying with EEDI requirements set out in regulations on Energy Efficiency for Ships, have sufficient installed propulsion power to maintain the manoeuvrability in adverse conditions, as specified in regulation 21.5 in chapter 4 of MARPOL Annex VI.

1 Definition

1.1 "Adverse conditions" mean sea conditions with the following parameters:

Significant wave height h_s, m	Peak wave period T_P, s	Mean wind speed V_w, m/s
5.5	7.0 to 15.0	19.0

JONSWAP sea spectrum with the peak parameter of 3.3 is to be considered for coastal waters.

1.2 The following adverse condition should be applied to ships defined as the following threshold value of ship size.

Ship length, m	Significant wave height h_s, m	Peak wave period T_P, s	Mean wind speed V_w, m/s
Less than 200	4.0	7.0 to 15.0	15.7
$200 \leq L_{pp} \leq 250$	Parameters linearly interpolated depending on ship's length		
More than L_{pp} = 250	Refer to paragraph 1.1		

2 Applicability*

2.1 These guidelines should be applied in the case of all new ships of types as listed in table 1 of appendix required to comply with regulations on Energy Efficiency for Ships according to regulation 21 of MARPOL Annex VI.

2.2 Notwithstanding the above, these guidelines should not be applied to the ships with un-conventional propulsion system such as pod propulsion.

2.3 These guidelines are intended for ships in unrestricted navigation; for other cases, the Administration should determine appropriate guidelines, taking the operational area and relevant restrictions into account.

* These Interim Guidelines are applied to ships required to comply with regulations on Energy Efficiency for Ships according to regulation 21 of MARPOL Annex VI during Phase 0 (i.e. for those ship types as in table 1 of appendix with the size of equal or more than 20,000 DWT).

3 Assessment procedure

3.1 The assessment can be carried out at two different levels as listed below:

.1 Minimum power lines assessment; and

.2 Simplified assessment.

3.2 The ship should be considered to have sufficient power to maintain the manoeuvrability in adverse conditions if it fulfils one of these assessment levels.

4 Assessment level 1 – minimum power lines assessment

4.1 If the ship under consideration has installed power not less than the power defined by the minimum power line for the specific ship type, the ship should be considered to have sufficient power to maintain the manoeuvrability in adverse conditions.

4.2 The minimum power lines for the different types of ships are provided in the appendix.

5 Assessment level 2 – simplified assessment

5.1 The methodology for the simplified assessment is provided in the appendix.

5.2 If the ship under consideration fulfils the requirements as defined in the simplified assessment, the ship should be considered to have sufficient power to maintain the manoeuvrability in adverse conditions.

6 Documentation

6.1 Test documentation should include at least, but not be limited to, a:

.1 description of the ship's main particulars;

.2 description of the ship's relevant manoeuvring and propulsion systems;

.3 description of the assessment level used and results; and

.4 description of the test method(s) used with references, if applicable.

* * *

Appendix

ASSESSMENT PROCEDURES TO MAINTAIN THE MANOEUVRABILITY UNDER ADVERSE CONDITIONS, APPLICABLE DURING PHASE 0 OF THE EEDI IMPLEMENTATION

1 Scope

1.1 The procedures as described below are applicable during Phase 0 of the EEDI implementation as defined in regulation 21 of MARPOL Annex VI (see also paragraph 0 – Purpose of these interim guidelines).

2 Minimum power lines

2.1 The minimum power line values of total installed MCR, in kW, for different types of ships should be calculated as follows:

$$\text{Minimum Power Line Value} = a \times (DWT) + b$$

Where:

DWT is the deadweight of the ship in metric tons; and
a and *b* are the parameters given in table 1 for tankers, bulk carriers and combination carriers.

Table 1: Parameters a and b for determination of the minimum power line values for the different ship types

Ship Type	a	b
Bulk Carriers	0.0687	2924.4
Tankers	0.0689	3253.0
Combination Carriers	see tankers above	

The total installed MCR of all main propulsion engines should not be less than the minimum power line value, where MCR is the value specified on the EIAPP Certificate.

3 Simplified assessment

3.1 The simplified assessment procedure is based on the principle that, if the ship has sufficient installed power to move with a certain advance speed in head waves and wind, the ship will also be able to keep course in waves and wind from any other direction. The minimum ship speed of advance in head waves and wind is thus selected depending on ship design, in such a way that the fulfilment of the ship speed of advance requirements means fulfilment of course-keeping requirements. For example, ships with larger rudder areas will be able to keep course even if the engine is less powerful; similarly, ships with a larger lateral windage area will require more power to keep course than ships with a smaller windage area.

3.2 The simplification in this procedure is that only the equation of steady motion in longitudinal direction is considered; the requirements of course-keeping in wind and waves are taken into account indirectly, by adjusting the required ship speed of advance in head wind and waves.

3.3 The assessment procedure consists of two steps:

.1 definition of the required advance speed in head wind and waves, ensuring course-keeping in all wave and wind directions; and

.2 assessment whether the installed power is sufficient to achieve the required advance speed in head wind and waves.

Definition of required ship speed of advance

3.4 The required ship advance speed through the water in head wind and waves, V_s, is set to the larger of:

.1 minimum navigational speed, V_{nav}; or

.2 minimum course-keeping speed, V_{ck}.

3.5 The minimum navigational speed, V_{nav}, facilitates leaving coastal area within a sufficient time before the storm escalates, to reduce navigational risk and risk of excessive motions in waves due to unfavourable heading with respect to wind and waves. The minimum navigational speed is set to 4.0 knots.

3.6 The minimum course-keeping speed in the simplified assessment, $V_{ck,}$ is selected to facilitate course-keeping of the ships in waves and wind from all directions. This speed is defined on the basis of the reference course-keeping speed $V_{ck,\ ref}$, related to ships with the rudder area A_R equal to 0.9 per cent of the submerged lateral area corrected for breadth effect, and an adjustment factor taking into account the actual rudder area:

$$V_{ck} = V_{ck,\ ref} - 10.0 \times (A_{R\%} - 0.9) \quad (1)$$

where V_{ck} in knots, is the minimum course-keeping speed, $V_{ck,\ ref}$ in knots, is the reference course-keeping speed, and $A_{R\%}$ is the actual rudder area, A_R, as percentage of the submerged lateral area of the ship corrected for breadth effect, $A_{LS,\ cor}$, calculated as $A_{R\%} = A_R/A_{LS,\ cor} \cdot 100\%$. The submerged lateral area corrected for breadth effect is calculated as $A_{LS,\ cor} = L_{pp}T_m(1.0+25.0(B_{wl}/L_{pp})^2)$, where L_{pp} is the length between perpendiculars in m, B_{wl} is the water line breadth in m and T_m is the draft a midship in m. In case of high-lift rudders or other alternative steering devices, the equivalent rudder area to the conventional rudder area is to be used.

3.7 The reference course-keeping speed $V_{ck,\ ref}$ for bulk carriers, tankers and combination carriers is defined, depending on the ratio A_{FW}/A_{LW} of the frontal windage area, A_{FW}, to the lateral windage area, A_{LW}, as follows:

.1 9.0 knots for A_{FW}/A_{LW} =0.1 and below and 4.0 knots for A_{FW}/A_{LW}=0.40 and above; and

.2 linearly interpolated between 0.1 and 0.4 for intermediate values of A_{FW}/A_{LW}.

Procedure of assessment of installed power

3.8 The assessment is to be performed in maximum draught conditions at the required ship speed of advance, V_s, defined above. The principle of the assessment is that the required propeller thrust, T in N, defined from the sum of bare hull resistance in calm water

R_{cw}, resistance due to appendages R_{app}, aerodynamic resistance R_{air}, and added resistance in waves R_{aw}, can be provided by the ship's propulsion system, taking into account the thrust deduction factor t:

$$T = (R_{cw} + R_{air} + R_{aw} + R_{app})/(1-t) \quad (2)$$

3.9 The calm-water resistance for bulk carriers, tankers and combination carriers can be calculated neglecting the wave-making resistance as $R_{cw} = (1+k)C_F \frac{1}{2}\rho S V_s^2$, where k is the form factor, $C_F = \frac{0.075}{(\log_{10}\mathrm{Re}-2)^2}$ is the frictional resistance coefficient, $\mathrm{Re} = V_s L_{pp}/\nu$ is the Reynolds number, ρ is water density in kg/m^3, S is the wetted area of the bare hull in m^2, V_s is the ship advance speed in m/s, and ν is the kinematic viscosity of water in m^2/s.

3.10 The form factor k should be obtained from model tests. Where model tests are not available the empirical formula below may be used:

$$k = -0.095 + 25.6\frac{C_B}{(L_{pp}/B_{wl})^2\sqrt{B_{wl}/T_m}} \quad (3)$$

where C_B is the block coefficient based on L_{pp}.

3.11 Aerodynamic resistance can be calculated as $R_{air} = C_{air}\frac{1}{2}\rho_a A_F V_{w,rel}^2$, where C_{air} is the aerodynamic resistance coefficient, ρ_a is the density of air in kg/m^3, A_F is the frontal windage area of the hull and superstructure in m^2, and $V_{w\,rel}$ is the relative wind speed in m/s, defined by the adverse conditions in paragraph 1.1 of the interim guidelines, V_w, added to the ship advance speed, V_s. The coefficient C_{air} can be obtained from model tests or empirical data. If none of the above is available, the value 1.0 is to be assumed.

3.12 The added resistance in waves, R_{aw}, defined by the adverse conditions and wave spectrum in paragraph 1 of the interim guidelines, is calculated as:

$$R_{aw} = 2\int_0^\infty \frac{R_{aw}(V_s,\omega)}{\zeta_a^2} S_{\zeta\zeta}(\omega)\,d\omega \quad (4)$$

where $R_{aw}(V_s,\omega)/\zeta_a^2$ is the quadratic transfer function of the added resistance, depending on the advance speed V_s in m/s, wave frequency ω in rad/s, the wave amplitude, ζ_a in m and the wave spectrum, $S_{\zeta\zeta}$ in m^{2}s. The quadratic transfer function of the added resistance can be obtained from the added resistance test in regular waves at the required ship advance speed V_s as per ITTC procedures 7.5-02 07-02.1 and 7.5-02 07-02.2, or from equivalent method verified by the Administration.

3.13 The thrust deduction factor t can be obtained either from model tests or empirical formula. Default conservative estimate is t=0.7w, where w is the wake fraction. Wake fraction w can be obtained from model tests or empirical formula; default conservative estimates are given in table 2.

Table 2: Recommended values for wake fraction *w*

Block coefficient	One propeller	Two propellers
0.5	0.14	0.15
0.6	0.23	0.17
0.7	0.29	0.19
0.8 and above	0.35	0.23

3.14 The required advance coefficient of the propeller is found from the equation:

$$T = \rho u_a^2 D_P^2 K_T(J)/J^2 \quad (5)$$

where D_P is the propeller diameter, $K_T(J)$ is the open water propeller thrust coefficient, $J = u_a/nD_P$, and $u_a = V_s(1-w)$. J can be found from the curve of K_T(J)/J^2.

3.15 The required rotation rate of the propeller, *n*, in revolutions per second, is found from the relation:

$$n = u_a/(JD_P) \quad (6)$$

3.16 The required delivered power to the propeller at this rotation rate *n*, P_D in watts, is then defined from the relation:

$$P_D = 2\pi\rho n^3 D_P^5 K_Q(J) \quad (7)$$

where $K_Q(J)$ is the open water propeller torque coefficient curve. Relative rotative efficiency is assumed to be close to 1.0.

3.17 For diesel engines, the available power is limited because of the torque-speed limitation of the engine, $Q \le Q_{max}(n)$, where $Q_{max}(n)$ is the maximum torque that the engine can deliver at the given propeller rotation rate *n*. Therefore, the required minimum installed MCR is calculated taking into account:

.1 torque-speed limitation curve of the engine which is specified by the engine manufacturer; and

.2 transmission efficiency η_s which is to be assumed 0.98 for aft engine and 0.97 for midship engine, unless exact measurements are available.

***