INTERNATIONAL MARITIME ORGANIZATION

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Agenda item 17

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NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE

Outcome of DE 57

Note by the Secretariat

SUMMARY

Executive summary:	This document provides the outcome of DE 57 in relation to noise from commercial shipping and its adverse impacts on marine life, and, in particular, contains a draft MEPC circular on *Guidelines for the reduction of underwater noise from commercial shipping* to address the adverse effects on marine life, as set out in the annex, for consideration with a view to approval
Strategic direction:	7.1
High-level action:	7.1.2
Planned output:	7.1.2.3
Action to be taken:	Paragraph 7
Related documents:	DE 57/17, DE 57/25, annex 14 and MEPC 65/22

Introduction

1 MEPC 62, having noted that a new output on "Provisions for the reduction of noise from commercial shipping and its adverse impacts on marine life" had already been included in the biennial agenda of the DE Sub-Committee, instructed the DE Sub-Committee to address this issue.

2 MEPC 65 noted that DE 57, held from 18 to 22 March 2013, had finalized *Guidelines for the reduction of underwater noise from commercial shipping*, and its report had been circulated under document DE 57/25. However, due to the close proximity between DE 57 and MEPC 65, MEPC 65 agreed to consider the outcome of DE 57 concerning this agenda item at MEPC 66 (MEPC 65/22, paragraph 17.2).

Outcome of DE 57

3 DE 57 considered, inter alia, the report of the correspondence group (DE 57/17), submitted by the United States, containing draft Guidelines for minimizing underwater noise from commercial ships, to address the adverse impacts of underwater noise on marine life.

4 Following consideration, DE 57 agreed to a draft MEPC circular on *Guidelines for the reduction of underwater noise from commercial shipping* (DE 57/25, annex 14), as set out in the annex to this document for ease of reference, for consideration, with a view to approval by the MEPC. With regard to paragraph 1.3 of the Preamble, the DE Sub-Committee agreed to keep it in square brackets for a decision by the Committee.

5 When reviewing the draft Guidelines, the Committee may wish to add text to the title so that it is clear that the Guidelines aim to address the adverse impacts of underwater noise on marine life.

Proposals for further work

6 Having considered the proposals for further work on the matter, as listed in paragraph 9 of document DE 57/17, which the correspondence group had considered to be beyond its terms of reference, the DE Sub-Committee agreed to refer them to the Committee for consideration. For ease of reference, the proposals are set out below:

.1 including a specific noise reduction target from the 2008 Hamburg International Workshop on Shipping Noise and Marine Mammals: to reduce the contribution of shipping to ambient noise levels in the 10-300Hz range by 3dB in 10 years and 10dB in 30 years, relative to current levels;

.2 evaluating the contribution of underwater noise from vessels and other sources (land-based, drilling, ice breaking, etc.) so that mitigation can be directed at the largest contributor(s);

.3 quantification of the relationship between individual ship noise and regional ambient noise level reductions;

.4 continued progress in quantifying and understanding the adverse impact of noise on marine species;

.5 setting operating guidelines for sensitive marine areas that have significant noise issues where specific operational and/or design measures may be needed to fundamentally reduce underwater noise from ships that operate there regularly, because of their impact on marine life;

.6 identifying the types of areas and situations where waterborne noise is most disruptive for marine life (near-shore, during migration, ice breaking, etc.);

.7 using standardized measurement protocols to develop noise profiles for each ship type under different operating conditions;

.8 identifying the noisiest ships to gain a better understanding of the factors that elevate the noise levels of these ships;

.9 establishing baseline ambient noise levels in ocean areas of key concern such as those with high levels of marine biodiversity where shipping activities are forecasted to rapidly increase; and

.10 collect and provide information on sensitive areas, including well-known habitats or migratory pathways, to shipmasters and owners for the purpose of voyage planning.

Action requested of the Committee

7 The Committee is invited to:

.1 consider the proposals for further work on the reduction of underwater noise from commercial shipping, as listed in paragraph 5 above and decide as appropriate;

.2 consider and decide on the square brackets around paragraph 1.3 of the Preamble and on the final title of the Guidelines (paragraphs 4 and 5); and

.3 approve the draft MEPC circular on *Guidelines for the reduction of underwater noise from commercial shipping*, set out in the annex.

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ANNEX

DRAFT MEPC CIRCULAR

GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE FROM COMMERCIAL SHIPPING

1 The Marine Environment Protection Committee, at its [sixty-sixth session (31 March to 4 April 2014)], with a view to providing guidance on the reduction of underwater noise from commercial shipping, and following a recommendation made by the Sub-Committee on Ship Design and Equipment, at its fifty-seventh session, approved the annexed *Guidelines for the reduction of underwater noise from commercial shipping.*

2 Member Governments are invited to use the annexed Guidelines from [date] and to bring them to the attention of all parties concerned.

GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE FROM COMMERCIAL SHIPPING

1 Preamble

1.1 Concern has been raised that a significant portion of the underwater noise generated by human activity may be related to commercial shipping. The international community recognizes that underwater-radiated noise from commercial ships may have both short- and long-term negative consequences on marine life, especially marine mammals.

1.2 It is important to recognize that both the technical and cost-effectiveness of measures considered, either individually or in combination, will be strongly dependent on the design, operational parameters, and mandatory requirements relevant for a particular ship. A successful strategy to reduce radiated noise should consider interactions and contributions from measures provided to achieve other objectives such as reduction of onboard noise and improvements in energy efficiency.

[1.3 When efforts have been made to mitigate underwater noise, as far as reasonable and practical, evaluation should be undertaken to determine the success or otherwise of ship noise reduction efforts and to guide and enhance future activities at noise reduction. Such evaluation can include forms of radiated-noise measurements, simulations or other ways of data gathering.]

2 Application

2.1 These Guidelines can be applied to any commercial ship.

2.2 These Guidelines do not address the introduction of noise from naval and war ships and the deliberate introduction of noise for other purposes such as sonar or seismic activities.

3 Purpose

3.1 These non-mandatory Guidelines are intended to provide general advice about reduction of underwater noise to designers, shipbuilders and ship operators. They are not intended to form the basis of a mandatory document.

3.2 Given the complexities associated with ship design and construction, the Guidelines focus on primary sources of underwater noise. These are associated with propellers, hull form, onboard machinery, and operational aspects. Much, if not most, of the underwater noise is caused by propeller cavitation, but onboard machinery and operational modification issues are also relevant. The optimal underwater noise mitigation strategy for any ship should at least consider all relevant noise sources.

3.3 These Guidelines consider common technologies and measures that may be relevant for most sectors of the commercial shipping industry. Designers, shipbuilders, and ship operators are encouraged to also consider technologies and operational measures not included in these Guidelines, which may be more appropriate for specific applications.

4 Definitions

4.1 *Cavitation inception speed* is the lowest ship speed at which cavitation occurs.

4.2 *Propeller cavitation* is the formation and implosion of water vapour cavities caused by the decrease and increase in pressure as water moves across a propeller blade. Cavitation causes broadband noise and discrete peaks at harmonics of the blade passage frequency in the underwater noise spectrum. The broadband noise is caused by growth and collapse of a vast amount of individual cavitation bubbles in water. The discrete noise peaks are caused by the volume fluctuations of the sheet and tip vortex cavities.

4.3 *Underwater noise,* or the *underwater-radiated noise level,* for the purposes of these Guidelines refers to noise from commercial ships[*].

5 Predicting underwater noise levels

5.1 Underwater noise computational models may be useful for both new and existing ships in understanding what reductions might be achievable for certain changes in design or operational behaviour. Such models may be used to analyse the noise sources on the ship, the noise transmission paths through the ship and estimate the total predicted noise levels. This analysis can help shipowners, shipbuilders and designers, to identify noise control measures that could be considered for the specific application, taking into account expected operational conditions. Such measures may include amongst others: vibration isolation mounts (i.e. resilient mounts) for machinery and other equipment, dynamic balancing, structural damping, acoustical absorption and insulation, hull appendages and propeller design for noise reduction.

5.2 Types of computational models that may assist in reducing underwater noise include:

.1 Computational Fluid Dynamics (CFD) can be used to predict and visualize flow characteristics around the hull and appendages, generating the wake field in which the propeller operates;

.2 Propeller analysis methods such as lifting surface methods or CFD can be used for predicting cavitation;

.3 Statistical Energy Analysis (SEA) can be used to estimate high-frequency transmitted noise and vibration levels from machinery; and

.4 Finite Element Analysis (FEA) and Boundary Element Method (BEM) may contribute to estimate low-frequency noise and vibration levels from the structure of the ship excited by the fluctuating pressure of propeller and machinery excitation.

5.3 The value of a modelling exercise is enhanced if its predictive capabilities are assessed in case studies under various operational conditions.

6 Standards and references

6.1 Underwater noise should be measured to an objective standard for any meaningful improvements.

[*] Underwater-radiated noise level is reported in sound pressure levels in decibels and expressed as 10 times the logarithm of the square of the ratio of the rms sound pressure to a reference pressure of 1 micro Pascal. When it is a ship source level, the sound pressure level is adjusted to a level at 1 m from the source.

.1 The International Organization for Standardization (ISO) has developed the (ISO/PAS) 17208-1 – Acoustics – Quantities and procedures for description and measurement of underwater sound from ships – Part 1: General requirements for measurements in deep water. This measurement standard is for deep water which implies that the water depth should be larger than 150 m or 1.5 times overall ship length (engineering method), whichever is greater. This is a temporary publicly available standard. This standard is based on the American National Standards Institute and the Acoustical Society of America (ANSI/ASA) S12.64-2009 "Quantities and Procedures for Description and Measurement of Underwater Sound from Ships, Part 1: General Requirements".

.2 ISO is also developing ISO/DIS 16554 – Ship and marine technology – Measurement and reporting of underwater sound radiated from merchant ships – deep-water measurement, which is expected to be published in 2013. The standard would provide shipyards, shipowners and ship surveyors with a well-established measurement method for underwater sound radiated from merchant ships for use at the final delivery stage of ships.

6.2 Several research ships have been designed using the noise specification proposed by the International Council for the Exploration of the Sea (ICES) Cooperative Research Report No.209 (CRR 209). It should be noted that the ICES CRR 209 noise specification was designed for fishery research ships so that marine life would not be startled during biomass surveys; it was not intended to be used as a commercial ship design standard to prevent potential harm of marine life. However, certain design arrangements used to meet ICES CRR 209 may still be useful for new commercial ships to reduce underwater noise.

6.3 Other underwater noise rating criteria are available and may prove useful as guidance.

7 Design considerations

7.1 The largest opportunities for reduction of underwater noise will be during the initial design of the ship. For existing ships, it is unlikely to be practical to meet the underwater noise performance achievable by new designs. The following design issues are therefore primarily intended for consideration for new ships. However, consideration can also be given to existing ships if reasonable and practicable. While flow noise around the hull has a negligible influence on radiated noise, the hull form has influence on the inflow of water to the propeller. For effective reduction of underwater noise, hull and propeller design should be adapted to each other. These design issues should be considered holistically as part of the overall consideration of ship safety and energy efficiency.

7.2 *Propellers*

7.2.1 Propellers should be designed and selected in order to reduce cavitation. Cavitation will be the dominant radiated noise source and may increase underwater noise significantly. Cavitation can be reduced under normal operating conditions through good design, such as optimizing propeller load, ensuring as uniform water flow as possible into propellers (which can be influenced by hull design), and careful selection of the propeller characteristics such as: diameter, blade number, pitch, skew and sections.

7.2.2 Ships with a controllable pitch propeller could have some variability on shaft speed to reduce operation at pitch settings too far away from the optimum design pitch which may lead to unfavourable cavitation behaviour (some designs may be able to operate down to a shaft speed of two thirds of full).

7.2.3 The ship and its propeller could be model tested in a cavitation test facility such as a cavitation tunnel for optimizing the propeller design with respect to cavitation induced pressure pulses and radiated noise.

7.2.4 If predicted peak fluctuating pressure at the hull above the propeller in design draft is below 3 kPa (1st harmonic of blade rate) and 2 kPa (2nd harmonic) for ships with a block coefficient below 0.65 and 5 kPa (1st harmonic) and 3 kPa (2nd harmonic) for ships with a block coefficient above 0.65, this could indicate a potentially lower noise propeller. Comparable values are likely to be 1 kPa higher in ballast condition.

7.2.5 Noise-reducing propeller design options are available for many applications and should be considered. However, it is acknowledged that the optimal propeller with regard to underwater noise reduction cannot always be employed due to technical or geometrical constraints (e.g. ice-strengthening of the propeller). It is also acknowledged that design principles for cavitation reduction (i.e. reduce pitch at the blade tips) can cause decrease of efficiency.

7.3 *Hull design*

7.3.1 Uneven or non-homogeneous wake fields are known to increase cavitation. Therefore, the ship hull form with its appendages should be designed such that the wake field is as homogeneous as possible. This will reduce cavitation as the propeller operates in the wake field generated by the ship hull.

7.3.2 Consideration can be given to the investigation of structural optimization to reduce the excitation response and the transmission of structure-borne noise to the hull.

8 Onboard machinery

8.1 Consideration should be given to the selection of onboard machinery along with appropriate vibration control measures, proper location of equipment in the hull, and optimization of foundation structures that may contribute to reducing underwater radiated and onboard noise affecting passengers and crew.

8.2 Designers, shipowners and shipbuilders should request that manufacturers supply information on the airborne sound levels and vibration produced by their machinery to allow analysis by methods described in section 5.2 and recommend methods of installation that may help reduce underwater noise.

8.3 Diesel-electric propulsion has been identified as an effective propulsion-train configuration option for reducing underwater noise. In some cases, the adoption of a diesel-electric system should be considered as it may facilitate effective vibration isolation of the diesel generators which is not usually possible with large direct drive configurations. The use of high-quality electric motors may also help to reduce vibration being induced into the hull.

8.4 The most common means of propulsion on board ships is the diesel engine. The large two-stroke engines used for most ships' main propulsion are not suitable for consideration of resilient mounting. However, for suitable four-stroke engines, flexible couplings and resilient mountings should be considered, and where appropriate, may significantly reduce underwater noise levels. Four-stroke engines are often used in combination with a gear box and controllable pitch propeller. For effective noise reduction, consideration should be given to mounting engines on resilient mounts, possibly with some form of elastic coupling between the engine and the gear box. Vibration isolators are more readily used for mounting of diesel generators to foundations.

8.5 Consideration should be given for the appropriate use of vibration isolation mounts as well as improved dynamic balancing for reciprocating machinery such as refrigeration plants, air compressors, and pumps. Vibration isolation of other items and equipment such as hydraulics, electrical pumps, piping, large fans, vent and AC ducting may be beneficial for some applications, particularly as a mitigating measure where more direct techniques are not appropriate for the specific application under consideration.

9 Additional technologies for existing ships

In addition to their use for new ships, the following technologies are known to contribute to noise reduction for existing ships:

.1 design and installation of new state-of-the-art propellers;

.2 installation of wake conditioning devices; and

.3 installation of air injection to propeller (e.g. in ballast condition).

10 Operational and maintenance considerations

10.1 Although the main components of underwater noise are generated from the ship design (i.e. hull form, propeller, the interaction of the hull and propeller, and machinery configuration), operational modifications and maintenance measures should be considered as ways of reducing noise for both new and existing ships. These include among others:

10.2 *Propeller cleaning*

Propeller polishing done properly removes marine fouling and vastly reduces surface roughness, helping to reduce propeller cavitation.

10.3 *Underwater hull surface*

Maintaining a smooth underwater hull surface and smooth paintwork may also improve a ship's energy efficiency by reducing the ship's resistance and propeller load. Hence, it will help to reduce underwater noise emanating from the ship. Effective hull coatings that reduce drag on the hull, and reduce turbulence, can facilitate the reduction of underwater noise as well as improving fuel efficiency.

10.4 *Selection of ship speed*

10.4.1 In general, for ships equipped with fixed pitch propellers, reducing ship speed can be a very effective operational measure for reducing underwater noise, especially when it becomes lower than the cavitation inception speed.

10.4.2 For ships equipped with controllable pitch propellers, there may be no reduction in noise with reduced speed. Therefore, consideration should be given to optimum combinations of shaft speed and propeller pitch.

10.4.3 However, there may be other, overriding reasons for a particular speed to be maintained, such as safety, operation and energy efficiency. Consideration should be given in general to any critical speeds of an individual ship with respect to cavitation and resulting increases in radiated noise.

10.5 *Rerouteing and operational decisions to reduce adverse impacts on marine life*

Speed reductions or routing decisions to avoid sensitive marine areas including well-known habitats or migratory pathways when in transit will help to reduce adverse impacts on marine life.

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