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TECHNICAL GUIDANCE ON CO-OPTIMIZING ENERGY EFFICIENCY AND UNDERWATER RADIATED NOISE AT THE DESIGN AND RETROFIT STAGE

1 The Marine Environment Protection Committee, at its eighty-fourth session (27 April to 1 May 2026), recognizing:

.1 potential synergies from the integration of underwater radiated noise reduction measures with energy efficiency considerations during ship design and retrofitting; and

.2 that section 7 of the *Revised guidelines for the reduction of underwater radiated noise from shipping to address adverse impacts on marine life* (MEPC.1/Circ.906/Rev.1) aims to explore the inter-relations between energy efficiency and reduction of underwater radiated noise,

approved the *Technical guidance on co-optimizing energy efficiency and underwater radiated noise at the design and retrofit stage*, as set out in the annex.

2 Member States and international organizations are invited to bring the annexed technical guidance to the attention of all parties concerned, in particular ship and equipment designers, shipbuilders and shipowners, operators, classification societies, equipment suppliers and manufacturers.

3 Member States and international organizations are also invited to submit information, observations, comments and recommendations based on the practical experience gained through the application of this technical guidance to the Marine Environment Protection Committee and the Sub-Committee on Ship Design and Construction, as appropriate.

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ANNEX

TECHNICAL GUIDANCE ON CO-OPTIMIZING ENERGY EFFICIENCY AND UNDERWATER RADIATED NOISE AT THE DESIGN AND RETROFIT STAGE

Introduction

1 The Marine Environment Protection Committee, at its eighty-second session (MEPC 82), approved the *Revised guidelines for the reduction of underwater radiated noise from shipping to address adverse impacts on marine life* (MEPC.1/Circ.906/Rev.1) (Revised URN Guidelines), aiming to support Member States and industry stakeholders in voluntarily reducing underwater radiated noise (URN) through technical and operational measures, and recognize potential synergies with energy efficiency (EE) initiatives. The Committee also agreed to continue with the three-year experience-building phase (EBP) for the Revised URN Guidelines, starting from MEPC 80.

2 The purpose of this circular is to provide supplementary technical guidance to support the integration of URN reduction measures with EE considerations during ship design and retrofitting. Specifically, it seeks to clarify potential trade-offs between URN mitigation and conventional propeller design, and to promote co-benefits between quiet ship technologies and clean energy performance objectives.

3 This technical guidance builds on experience gained through the URN experience-building phase and the outcomes of two workshops on URN and EE held in 2023[1] and 2025,[2] respectively. These workshops identified priority needs around intentional co-design, baseline measurement and monitoring, and de-risking adoption, and showcased practical case studies and modelling tools. The discussions underscored the importance of embedding both acoustic and EE objectives in ship design and retrofitting, and informed the development of this circular.

Background

4 Many EE measures, such as propeller design, hull form optimization, and biofouling management, directly influence URN by affecting cavitation and flow dynamics. These interventions often present a co-benefit opportunity: when efforts to improve EE and URN are combined at the design stage of a ship, improvements to both elements can be realized.[3]

5 Recent collaborative research highlights that current methodologies for EE and URN optimization should be closely aligned with clarified operating profiles to achieve the expected efficiency and noise reduction outcomes. Key insights include:

.1 Modern propeller design techniques allow for comprehensive optimization that simultaneously addresses both EE and URN reduction. The industry has progressed beyond simple trade-offs, developing holistic approaches that preserve the ship's core performance characteristics.[4]

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1 https://www.imo.org/en/about/events/pages/urn-workshop-2023.aspx

2 https://www.imo.org/en/about/events/pages/2025-workshop-on-the-relationship-between-ship-energy-efficiency-and-underwater-radiated-noise.aspx

3 https://wwwcdn.imo.org/localresources/en/About/Events/Documents/Technology%20Matrix.pdf, Energy Efficiency and Underwater Noise Technologies.pdf (section 5), Energy Efficiency and Underwater Noise Technologies.pdf (section 10)

4 https://www.noise-control.com/wp-content/uploads/2025/09/NCE-White-Paper-Current-Technologies-and-Management-Practices-for-Reducing-Underwater-Radiated-Noise-Produced.pdf (section 3.3)

.2 Effective design optimization requires precise definition of ship operating profiles and related speed ranges, rather than relying on a maximum-speed design point. Design optimization should move beyond generic approaches, focusing instead on tailoring strategies to specific ship operational conditions and speed ranges.[5]

6 Case studies presented at the 2025 Workshop[6] demonstrate that retrofits, such as propeller upgrades, appendage modifications and air lubrication systems, can yield URN reductions of 2 to 10 dB, often alongside EE improvements. However, outcomes vary by ship type, operating profile and retrofit package.

7 Notably, ships traditionally optimized for high-speed efficiency may benefit from quieter propeller designs when operating in sensitive areas where speed reductions are required. These findings highlight the importance of multi-objective design approaches, baseline acoustic measurement, and operational flexibility to maximize co-benefits across both URN and EE performance objectives.

Design considerations

8 Incorporating URN considerations at the earliest design stage, whether for newbuilds or retrofits, is essential to assess trade-offs between noise reduction and EE. Early integration opens opportunities for financial incentives linked to environmental performance over the ship's life cycle. A range of methodologies exists to support this process, enabling owners and designers to evaluate options and select strategies that align with both operational and environmental performance goals.[7] The involvement of suppliers of ship equipment, including energy-efficiency devices, engines and propellers, is highly recommended, as their information is necessary to support such methodologies.

9 Conventional hull form and propeller design approaches can be employed to create designs with positive impacts on EE and URN when consideration is given to both elements during ship design stages. URN requirements should be included in ship specifications, starting at concept-phase planning, to enable consideration of URN alongside EE and other design factors. URN requirements should include limits across relevant frequency bands. These limits can be based on baseline measurements and/or class society criteria for environmental notations.

10 Emerging propulsion technologies offer significant opportunities for simultaneous EE and URN reduction. Examples include:

.1 *Integration of Variable Frequency Drives (VFD) with Controllable Pitch Propellers (CPPs)*: Application to specific ships designed to operate in coastal areas, namely ferries, has demonstrated up to 16 dB reduction in URN and up to 40% gains in EE at reduced speeds (e.g. 14 knots). This retrofit option can be selectively activated in the presence of sensitive marine species, offering a cost-effective and adaptable solution for both acoustic and operational performance.[8]

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5 https://www.noise-control.com/wp-content/uploads/2025/09/NCE-White-Paper-Current-Technologies-and-Management-Practices-for-Reducing-Underwater-Radiated-Noise-Produced.pdf (section 3.4).

6 https://sway.cloud.microsoft/O9T8ZP3rYy4rzbxd?ref=Link (sessions 1 and 2).

7 https://sway.cloud.microsoft/O9T8ZP3rYy4rzbxd?ref=Link (session 3).

8 Energy Efficiency and Underwater Noise Technologies.pdf (section 5).

.2 *Electrification*: Application of hybrid/all-electric technologies for coastal workboats can significantly reduce URN and emissions, particularly in short-sea and harbour operations. However, uptake requires incentive programmes to offset higher capital costs, along with life-cycle analysis to ensure climate benefits depending on the source of electricity.[9]

11 Building technical expertise within ship designers and shipyards is essential to de-risk technology adoption and support the long-term integration of URN mitigation measures. Successful completion of multiple projects that meet specified URN requirements as well as retaining a shipyard's internal competences are essential to ensure cost-effective and scalable integration of URN mitigation measures.

Operational considerations

12 Design-based optimization of higher EE and reduced URN should be matched to planned and actual operational profiles. This alignment should account for power limitations and maintenance requirements, including effective biofouling control measures.

13 Evaluation of URN associated with fleet operations can leverage many of the same data inputs, for example, but not limited to, ship characteristics and operating conditions used for energy efficiency calculation, monitoring and reporting. This approach enables shipowners and operators to identify, track and quantify co-benefits in URN and energy efficiency.

14 Several empirical and semi-empirical methods exist for estimating both URN and one of its main sources, cavitation. These methods are increasingly being implemented in onboard systems that can provide real-time indications of the level of URN and cavitation contribution. This information facilitates the opportunity for both responses and adaptive measures to reduce URN during navigation, including through optimized route planning that may also improve efficiency and reduce GHG emissions. Promoting the use of this type of system could support reductions in URN without substantial modifications to existing ships, while also facilitating the collection of real operational data on the URN levels, which could contribute to improved URN mapping and assessment.[10]

Invitation to contribute

15 Member States, international organizations and industry stakeholders are invited to submit feedback, relevant data and concrete proposals to support the continued refinement of this technical guidance on the co-optimization of URN and EE measures. In particular, submissions under the IMO URN experience-building phase are encouraged to address the following four technical objectives:

.1 Benchmarking URN and EE outcomes for specific approaches applied to newbuilds and retrofits across ship types and operational modes (e.g. categorized by URN reduction levels: 0 to 5 dB, 5 to 10 dB, and over 10 dB), to support updates to existing matrices and shared community resources.

.2 Design-stage case studies that advance URN specifications, including URN limits relative to baseline measurements, with the aim of supporting class notations and other URN performance-based design incentives.

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[9] Energy Efficiency and Underwater Noise Technologies.pdf (section 10).

[10] https://pubs.aip.org/asa/jasa/article/152/3/1547/2839412/A-functional-regression-analysis-of-vessel-source

.3 Studies covering the verification, validation and comparison with conventional measurement methods on onboard and autonomous URN monitoring and estimation systems, and establishment of empirical models for estimating the amount of URN reduction, including comparative data and integration with onboard EE monitoring tools, as well as emerging digital URN frameworks that combine models, observations and measurements across different ship types and regions. These insights will inform future applications and support alignment with future policy needs.

.4 Studies on the measurement of URN, taking into account shipping routes and regional characteristics such as bathymetry and seabed features, sound propagation models and ambient noise, within a ship's operating area.

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