



Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

New Recommendations for Design and Operation of Ammonia-Fuelled Vessels

Safety risks of ammonia as a fuel can only be mitigated if effective technical and operational safeguards are implemented whilst addressing human factors considerations.

A joint study into ammonia safety onboard ships undertaken by the Lloyd's Register (LR) Maritime Decarbonisation Hub and the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS), has found that a range of mitigation methods, from ship design to crew training and operations, are required to keep toxicity risks to crew within published tolerable limits.

['Recommendations for Design and Operation of Ammonia-Fuelled Vessels based on Multi-disciplinary Risk Analysis'](#) presents the most comprehensive study to date of the effectiveness of risk mitigation measures in three ammonia-fuelled vessels – a container ship, a tanker and a bulk carrier.

Seen as one of the most promising alternative fuels for the maritime energy transition, ammonia can be combusted with almost no carbon dioxide (CO₂) emissions. However, using ammonia as a shipping fuel can create potential safety hazards, including toxicity. It is crucial for shipping's stakeholders to understand the risks of ammonia as a shipping fuel and the safeguards that can be implemented to reduce them to tolerable levels.

Using Quantitative Risk Assessment (QRA) analysis, a powerful data-driven method that allows users to assess risk in a quantitative and granular manner, the joint study has been able to identify vessel design and operational measures that would reduce ammonia risks to a tolerable level.

The QRA provides recommendations for design and operation of ammonia-fuelled vessels to embed higher levels of safety for crew. Recommendations included lower storage temperatures to reduce safety risk; provision for two or more separate spaces containing different groups of equipment that could leak ammonia; monitoring and minimising of access to and length of time spent in spaces containing ammonia equipment; ventilation outlets from spaces containing ammonia equipment placed in a safe location, adequately separated from areas accessed by crew; and installation of multiple sensors of different types to detect ammonia leaks.

To complement the QRA, the second section of this report summarizes insights from an analysis of human factors considerations that will be impacted by a transition to ammonia fuel use. These include competence and training needed to improve safety on ammonia-fuelled vessels; safe work practices and standard procedures that need to be implemented through systematic change management programmes; and effective occupational health safeguards, such as personal protective equipment (PPE).

Dr. Andy Franks, Senior Decarbonisation Risk Specialist, LR Maritime Decarbonisation Hub, said: “The global energy transition drives a move from fossil fuels to alternative energy sources, which inevitably brings about new safety challenges and the need for shipping to manage more complex hazards. Our approach to understanding and mitigating the risks of ammonia as a shipping fuel incorporates both a quantitative data-driven approach to ship design as well as a human factors approach to address crew safety. Through these two approaches we provide practical insights that will support the industry in managing safety risks to crew within published tolerable limits.”

Claus Winter Graugaard, Chief Technology Officer, Onboard Vessel Solutions, Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, said: "To enable sustainable and scalable new energy pathways such as ammonia as a marine fuel, we must advance technological developments. However, in the eagerness to transform, we must do so without compromising safety and reliability, by employing a strong risk-based change management approach. Care of our seafarers and strong safety management are imperative. This study has given us deep insights into risk and will provide critical understanding and intelligence to help guide the industry towards safe application of ammonia as a marine fuel.”

The two decarbonisation centres have been involved in a number of ammonia projects. LR is [undertaking key feasibility studies into using clean ammonia to refuel ships at the world-scale ports in the Pilbara region of Western Australia](#). The MMMZCS and its partners are jointly conducting [a feasibility study to establish a supply chain for the provision of green ammonia ship-to-ship bunkering at the Port of Singapore](#).

Download the report from: <webpage to be developed>

Ends

About the Lloyd’s Register (LR) Maritime Decarbonisation Hub

The LR Maritime Decarbonisation Hub is a joint initiative between Lloyd’s Register Group and Lloyd’s Register Foundation. Our mission is to accelerate the sustainable decarbonisation of the maritime industry, by enabling the delivery and operation of safe, technically feasible and commercially viable zero-emission vessels by 2030 and beyond.

We bring together thought leaders and subject matter experts with the skills, knowledge and capability to help the maritime industry design, develop and commercialise the pathways to future fuels required for decarbonisation.

For more information, go to www.maritimedecarbonisationhub.org.

About Lloyd’s Register (LR)

Trusted maritime advisers, partnering with clients to drive performance across the ocean economy.

Lloyd's Register (LR) is a global professional services group specialising in marine engineering and technology. Created more than 260 years ago as the world's first marine classification society, to improve and set standards for the safety of ships.

Today we are a leading provider of classification and compliance services to the marine and offshore industries, helping our clients design, construct and operate their assets to accepted levels of safety and environmental compliance.

We also provide advice, support and solutions on fleet performance and optimisation, voyage optimisation, enhancing our clients' digital capability. Our digital solutions are relied upon by more than 20,000 vessels.

In the race to zero emissions, our research, technical expertise and industry-firsts are supporting a safe, sustainable maritime energy transition.

Lloyd's Register Group is wholly owned by the Lloyd's Register Foundation, a politically and financially independent global charity that promotes safety and education.

For more information, go to www.lr.org

For media enquiries contact

Magdalene Tan, Marketing and Communications Manager
Lloyd's Register Maritime Decarbonisation Hub
T +65 3163 0888 M +65 9487 1206 E magdalene.tan@lr.org

Nicola Good,
External Communications Director
Lloyd's Register
T +44 20 7076 6452
M +44 7855 113 273
E nicola.good@lr.org

Lloyd's Register
71 Fenchurch Street, London EC3M 4BS, UK
T +44 (0)20 7709 9166
E news@lr.org
www.lr.org

Lloyd's Register and variants of it are trading names of Lloyd's Register Group Limited, its subsidiaries and affiliates.

About Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

The Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS) is an independent, not-for-profit research and development center established in 2020 with funding from the A.P. Møller Foundation. Our purpose is to guide and accelerate the decarbonization of the global maritime industry. This complex challenge requires unprecedented collaboration across sectors, industries, and geographies. Working with our partners, governments, authorities, public sector bodies, scientists, and organizations across the global maritime industry, we aim to inform, de-risk decision-making, and spark real climate action. We are technology-agnostic and have no vested

interest in specific decarbonization solutions. We explore free of commercial considerations and independent of partner strategies.

As a result, we deliver independent analyses of how the transition is progressing and offer clear, data-driven recommendations for accelerating maritime decarbonization. Furthermore, we are maturing solutions to the most pressing problems across the maritime value chain, from fuels to onboard solutions, regulations, and financing. Strategic Partners to the Center include: Alfa Laval, American Bureau of Shipping, A.P. Moller - Maersk, bp, Cargill, CF Industries, Equinor, DP World, Hapag-Lloyd, MAN Energy Solutions, Mitsubishi Heavy Industries, Mitsui, NORDEN, NYK Line, Rio Tinto, Royal Caribbean Group, Seaspac Corporation, Siemens Energy, Stolt Tankers, Sumitomo Corporation, Swire Group, Topsoe, TotalEnergies and V.Group.

For more information, please visit <https://www.zerocarbonshipping.com/>

For media enquiries:

Anders Kongstad, Media Partner
Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping
T +4553504179
E anders.kongstad@zerocarbonshipping.com