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C1Po3B-01: A comparison of the toxicity and asphyxiation risk during bunkering of LH2, LNG and NH3 by means of a quantitative risk assessment

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To achieve the GHG reduction goals, hydrogen, Natural Gas and ammonia are considered as marine fuel in their liquefied form. Hydrogen and Natural Gas need to be liquified at cryogenic temperatures, whereas ammonia can be liquefied through the application of moderate pressure, approximately 10 bar, or through the reduction of temperature to approximately -33 °C. LNG is already employed in maritime transportation in accordance with established safety protocols. In contrast, the utilization of liquid hydrogen (LH2) and ammonia is currently limited to pilot projects. Both liquid hydrogen and ammonia have the potential to be climate-neutral fuels, depending on the respective production pathway. However, concerns regarding their safety have been raised. Thus, the overarching aim of this investigation is it to addresses these concerns by conducting a comparative analysis of the safety of bunkering these fuels, with a particular focus on toxicity and asphyxiation hazards.
Risk is defined as the "combination of the probability of occurrence of harm and the severity of that harm" . A quantitative risk assessment is thus conducted in two steps: first, to identify the probability through a frequency analysis and second, to identify the severity through a consequence analysis. For this study, an event tree is introduced to combine reliability data for the occurrence of a leak with a model for the ignition probability. The second step of a quantitative risk assessment is the consequence analysis, which quantifies the severity of the harms identified through the event tree. This study will use the necessary safety distance as the threshold for the severity.
The approach outlined above for such a quantitative risk assessment is conducted to compare the toxicity risk of bunkering ammonia and the asphyxiation risk of bunkering liquid hydrogen and liquified natural gas. In the initial phase, a frequency analysis is undertaken. The results are employed to identify the events with the highest frequency of occurrence. In the second step, the events not resulting in an ignition are further investigated. The hazard arising from these events is usually the toxicity of ammonia or the asphyxiation, due to the displacement of oxygen by hydrogen or natural gas (i.e., both substances are not toxic). A Gaussian dispersion model is employed to calculate the safety distance necessary for the different fuels. Subsequently, both the necessary safety distance and the frequency of harmful events of all three fuels are then compared. Result of the study will be the comparison of the safety distances and the frequencies. A fuel that requires smaller safety distances and the harmful event occurs less frequent can be considered safer.

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