Can the Toxicity of Ammonia be Overcome When Used as a Ship Fuel?

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Safety concerns regarding the use of ammonia as a ship fuel

New alternative fuels or emission reduction technologies are being developed to meet the IMO GHG Strategy, and ammonia is recognized as one of the most promising fuels as a carbon-free form of energy. However, there are still uncertainties about the use of ammonia as a ship fuel, and toxicity is the most questionable factor in whether ammonia will become a mainstream marine fuel in the future. The use of toxic gas as a shipping fuel is unprecedented, and is prohibited under the IGC Code and MARPOL Annex VI/18.

Risks of using ammonia as a marine fuel

- Ships have limited space compared to land-based systems, so there are restrictions on evacuation when a leakage happens. There is no external support available to assist with an accident, so incidents need to be handled by onboard crew.
- Cargo ammonia is isolated in the cargo tank during ship operation, but fuel ammonia flows into the engine room during ship operation, and the ammonia is burned in the engine. This means there is a greater possibility of crew members being exposed to ammonia.

The new challenge of using toxic gas as a ship's fuel raises the question of whether it is possible to completely control the leakage of ammonia from the ammonia facility installed on the ship. Another question is – if it is not possible to have complete control of the leakage – is it possible to protect the crew from the leakage? This is because ammonia can be fatal to humans, even at low concentrations.

On the other hand, some claim that ammonia can be used safely as a ship fuel, based on experience with the use of ammonia in land-based industries and the transport of ammonia cargoes by ship. While this is also a possibility, it is not so easy to jump to conclusions as there are distinct differences between land and marine environments, the ammonia cargo systems and the ammonia fuel systems as outlined below.

To safely use ammonia as fuel, it is necessary to identify all possible leakage scenarios that may occur on a vessel. Based on the identified scenarios, a ship needs to be prepared with safe equipment and aligned to prevent a dangerous situation. This raises the question on whether safety measures for potential leakage scenarios would be effective in the limited space onboard a ship.

Effective and enforceable safety regulations, a key to overcoming the hazards of ammonia and enabling its use as a marine fuel.

Measures to protect seafarers from ammonia gas

The concept design of the ammonia engine and fuel supply system is proposed by the manufacturer, and the concept is similar to that of low flash-point fuels. Based on this design concept, all possible leakage scenarios can be identified. Safety measures for leakage scenarios should be based on the concentration for toxicity as well as the concentration for flammability (LEL). The permissible exposure limit, which is the concentration that does not affect health, should be determined, taking into account the duration and the frequency of exposure. Concentration reference values already exist for various exposure conditions on land, and concentration reference values under conditions similar to the exposure environment of vessels can be applied to ships. The exposure limit value of 25 ppm (PEL-TWA by NIOSH), which does not result in serious health effects after repeated exposure for 8 hours, is being discussed as a possible value for the permissible exposure limit reasonable to apply to ships. In addition, the concentration that causes serious health effects even after short-term exposure should be determined to prevent detrimental exposure on board a ship. It is reasonable to set the AEGL-2 concentration at 220 ppm.

Assuming the above concentrations are applied to ships, how can long-term exposure to an ammonia concentration of 25 ppm and short-term exposure to 220 ppm be avoided? The simple answer to this question is that a gas detector installed in a hazardous gas environment will sound an alarm at 25 ppm ammonia, shut down fuel systems at 220 ppm and activate gas treatment systems.

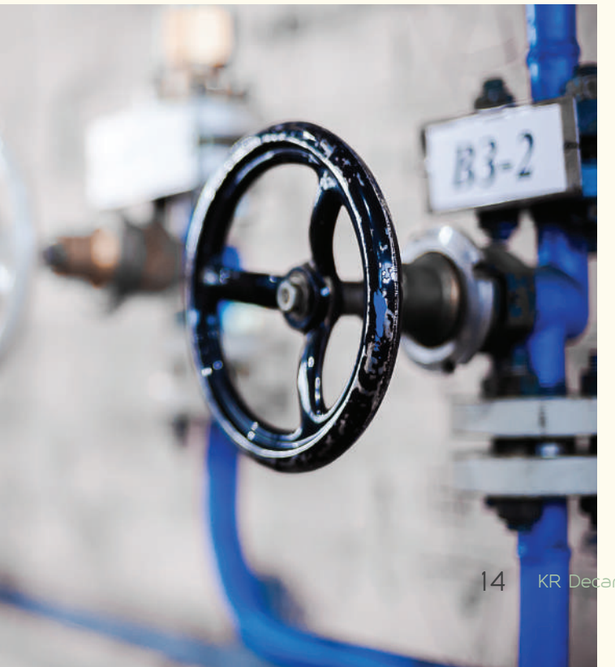
The characteristics of each leakage scenario, including the amount of leakage, can be inferred from the design. The safety of seafarers can be ensured by taking the following safety measures for major sources of leakage:

- The machinery space can be implemented as a complete gas-safe space by applying the concept of gas-safe machinery space in the IGF Code. In this case, gas detection in a double-walled pipe shall activate an alarm at an ammonia concentration of 25 ppm and shut down fuel systems at 220 ppm.
- In the fuel preparation room and the tank connection space, the gas detector in the space will activate an alarm at an ammonia concentration of 25 ppm, shut down the fuel systems and activate the gas treatment systems at 220 ppm. This limits the gas concentration in the space and the gas concentration of the ventilation to the open deck.
- During bunkering, access to the hazardous area around the bunkering station shall be prohibited. The gas detector around the bunkering manifold will activate an alarm at an ammonia concentration of 25 ppm, activate gas treatment systems to limit the gas concentration and shut down the bunkering operation.
- Ammonia leakage into the air during purging of the fuel pipe should be limited to 220 ppm by the ammonia treatment systems.

For the leakage scenario during normal operation, as described above, the valid gas treatment systems can remove the ammonia gas to the permissible exposure limit. However, in an emergency, if the pressure relief valve of the tank is opened due to a fire or collision around the tank, a large amount of leakage may occur. This could be prevented by protecting the tanks against collision and fire. In addition, feasible gas treatment systems shall be installed, and an effective emergency response plan shall be established for the emergency case.

Toxic zones shall be defined for all release gas sources, and the gas-safe area shall be located away from the toxic zone and isolated to prevent ammonia gas from flowing into the gas-safe area. The ammonia toxic zone should be defined as the 25 ppm limit.

In addition to the above, there are many other toxicity safety issues that need to be considered in detail. However, the protection of seafarers from hazardous concentrations of ammonia gas can be achieved through these measures.



Development of safety provisions

Whereas the safety regulations for fuels have so far only dealt with flammability, the toxicity of ammonia must be dealt with in addition to its flammability. For the new hazard characteristic of toxicity, an acceptable level of safety must be agreed. The functions required for ships to meet this level of safety will then be defined. Finally, detailed requirements for the implementation of the functions will have to be developed.

The IMO has started to develop the safety provision for ammonia fuel from the 8th CCC and is accelerating the work with a plan to complete the development in 2024 and adopt the interim guidelines in 2025. During the development process, the focus is on ensuring safety against the toxicity of ammonia, and Member States and industries in various fields are raising issues on risks and sharing opinions on ensuring safety. In addition, it has been decided to develop standards for the discharge at sea of ammonia bilge, which is generated during the treatment of ammonia gas, in cooperation with the MEPC.

While the safety regulation for ammonia fuel is being developed as the IGF Code, it is expected that the safety regulation for ammonia cargo as fuel (IGC Code) will be developed based on the IGF ammonia fuel safety regulation when it is finalized. As in the case of LNG and LPG fuel, the first application of ammonia fuel is expected to be an ammonia carrier, which is more straightforward than an IGF ship. Therefore, along with the development of the safety provisions for IGF ammonia fuel, the development of the safety provisions for IGC ammonia fuel should also be carried out as a matter of urgency.

A safety provision shall ensure the effectiveness and feasibility of safety measures. This means that the required safety measures must be effective in eliminating the risk and feasible to implement on the ship. To this end, it is essential to obtain opinions from various fields related to ammonia fuel, such as ammonia chemists, ship operators, shipbuilders and safety experts, in the process of developing the safety provision. KR is closely working with ammonia fuel experts across various fields to develop ammonia fuel regulations that ensure effectiveness and feasibility.

The era of ammonia fueled ships is not far away

The IMO Interim Guidelines for Ammonia Fueled Ships are expected to come into force, and the development of ammonia engines will be completed by 2025. In addition to safety provision and technology development, human factors such as crew training, maintenance and inspection of ammonia equipment and operating manuals are also important for the safe use of ammonia as a ship fuel. There are industry concerns surrounding the safety of ammonia-fueled ships. However, just as the safety concerns over the use of low flashpoint fuels were overcome in the past, the use of toxic fuels will likewise be overcome through cooperation between regulators and industry. With confidence, ammonia can be safely used as ship fuel.