BRITANNIA LOSS PREVENTION

B!NSIGHT

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ALTERNATIVE FUELS - AMMONIA

THE MARITIME INDUSTRY ENCOUNTERS UNPRECEDENTED CHALLENGES AS IT STRIVES FOR DECARBONISATION AND THE ATTAINMENT OF NET-ZERO EMISSIONS.

Decarbonising shipping is not only an environmental imperative but also an emerging area of innovation, reflecting the industry's shift towards alternative fuels.

OUR PARTNER FOR THIS ISSUE

Waves Group is a leading, independent maritime and offshore consultancy with a global presence. We provide essential advice, analysis, and data to support clients in the shipping and offshore energy sectors, enhancing operational confidence and certainty in outcomes.

Our 24/7 worldwide response team assists clients in both planned projects and unforeseen circumstances. With a solid track record built on years of operational experience, we offer practical advice backed by detailed technical analysis and data, reducing uncertainty and solving problems effectively.

Our team of experts, including Master Mariners, Marine Engineers, Naval Architects, and Maritime Civil Engineers, offers specialised expertise in areas such as fires, marine salvage, offshore energy, cranes, alternative fuels and maritime data acquisition and analysis. From project inception to completion and beyond, we support clients in marine casualties, disputes, port operations, offshore energy infrastructure construction and decommissioning.

With offices located in London, Southampton, Singapore, Houston, and Rotterdam, we ensure swift and efficient support for projects worldwide.

LIQUEFIED NATURAL GAS (LNG) IS CURRENTLY TAKING THE LEAD AS A TRANSITIONAL FUEL; HOWEVER, SEVERAL POTENTIAL ZERO-EMISSION FUELS SUCH AS METHANOL AND HYDROGEN ARE ALSO ON THE RISE. IT IS UNCERTAIN WHICH FUEL WILL BE THE PREFERRED CHOICE OF THE FUTURE, AND IT IS LIKELY THAT A VARIETY OF ALTERNATIVE FUELS WILL BE REQUIRED TO MEET FUTURE DEMAND.

As part of their decision making, shipowners need to perform due diligence which includes a thorough risk identification and assessment when choosing an alternative fuel. As part of this assessment, several stakeholders will need to be consulted, for example the engine maker, fuel supplier, classification society, hull & machinery insurers and the ship's flag state.

CONSIDERATIONS THAT SHOULD BE TAKEN INTO ACCOUNT INCLUDE:

1. **SUITABILITY AND IMPACT ON THE ON BOARD ENGINES**
   The engine maker should be consulted to determine whether the on board engines are suitable for consuming the selected alternative fuel or whether the engine will require any retrofitting.

2. **FUEL MANAGEMENT**
   Handling alternative fuel on board is likely to present different operational hazards compared to other fuels. Therefore, it is essential to train the crew properly in handling these new fuels.

3. **HEALTH, SAFETY AND ENVIRONMENT (HSE)**
   While the alternative fuels may have their obvious environmental benefits, they may come with some increased safety risks. Therefore, any alternative fuel should be accompanied by a thorough assessment of its HSE risks, and this should form the basis of the on board safety measures for handling the fuel.

4. **QUALITY**
   With the current lack of international standardisation, a clear and detailed bunker specification needs to be developed by the shipowner to ensure suitable fuel is delivered.

Britannia's loss prevention department has collaborated with Waves Group to provide practical advice on the widely discussed alternative fuels: Biofuels, Liquefied Natural Gas, Methanol, Ammonia, and Hydrogen. The examination for each of these alternative fuel types will focus on good practices in storage, handling, bunkering, safety and emergency response.

In this guidance, we will focus on Anhydrous Ammonia (referred to as Ammonia in the rest of the document). Anhydrous means that the water content is negligible or nil. This fuel source can offer the significant advantage of producing no carbon dioxide during combustion (other than any produced by pilot fuel), positioning it as a key player in the transition to greener maritime operations. Additionally, its abundant supply and existing industrial infrastructure make it a feasible option for large-scale adoption. However, the use of ammonia is not without challenges. Its high toxicity poses serious health and safety risks, and the production process is energy-intensive, potentially offsetting some environmental benefits if not managed sustainably. Furthermore, ammonia's corrosive nature and storage requirements may cause challenges to ship design and infrastructure.

Regarding legal framework, ammonia as a fuel can use the guidance of the International Code of Safety for Ships using Gas or other Low-flashpoint Fuels (IGF) code, specifically addressing bunkering, storage, and on board handling. Efforts are also underway to amend the International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) to allow ammonia cargo to be consumed as fuel.

STORAGE

THE FUEL TANKS ON BOARD AN AMMONIA FUELLED SHIP WILL TYPICALLY BE EITHER TYPE A (NON-PRESSURISED) OR TYPE C (PRESSURISED) TANKS.

If a type A tank system is used, a reliquefication system must be fitted to the ship to contain the boil off gas (BOG) and return it as liquid back to the storage tank. Ammonia boils at -33 °C when at atmospheric pressure. Alternatively, the BOG could be managed using the ships engines, auxiliary engines, and boilers. BOG will still need to be managed when the ship is not sailing, so the design must be able to handle the boil off expected when only the auxiliary engines and/or boilers are in use.

Type C tanks have a pressure vessel design, and the design pressure can be as high as 18 bar, which corresponds to an ammonia vapour pressure at 45 °C.

Both tank types will require material that can withstand the low, -33 °C, temperatures for ammonia. Arrangements will need to be made available to purge and vent the storage tanks. The storage tanks will need to be inert before admitting liquid ammonia into them. Location of the fuel tanks will need to be selected carefully and if the fuel tanks are type C, then they could be placed on the open deck. Independent fuel tanks, of type C design could also be placed in Tank Connection Spaces (TCS) and from there connected to the ships piping systems via approved flexible hoses.

Due to the energy density being less than half of more convention fuels, it is clear that fuel storage tanks will require to be larger to provide the same amount of fuel endurance

BUNKERING

AN AMMONIA FUELLED SHIP IS AN IGF SHIP, AND THE BUNKERING PROCESS FOR AMMONIA WILL THEREFORE BE SUBJECT TO STRICT CONTROLS. THE MANAGEMENT OF BOG GENERATED WHILST BUNKERING MAY REQUIRE THE USE OF A SECOND HOSE CONNECTION (VAPOUR RETURN LINE) TO RETURN THE BOG BACK TO THE BUNKER SUPPLIER.

Given the highly toxic nature of ammonia the correct PPE should be worn by operators involved with the connection/disconnection of the bunkering hose. Further points to consider are:

1. Plan each bunkering operation individually, collaborating closely with the bunker supplier. This planning includes:
    a. Conducting a combined risk assessment
    b. Performing a compatibility assessment
    c. Developing a joint plan of operations
    d. Creating a separate plan and risk assessment for any simultaneous operations (SIMOPs)
    e. Confirming the methods of communication
2. Install an Emergency Shutdown System (ESD) on the vessel, connecting it to the bunkering sources ESD system during the bunkering operations
3. Test the ESD system after connecting the bunkering hose and before ammonia transfer
4. Fit a filter/strainer at the bunkering source to prevent the ingress of foreign objects
5. Purge bunker hoses and lines with nitrogen before starting bunkering, ensuring it is below the Lower Explosion Limit (LEL) of ammonia
6. Pressure test the manifold connection with nitrogen before commencing ammonia transfer to confirm there are no leaks
7. Agree on maximum transfer rates with the supplier
8. Continuously monitor the fuel tank levels and pressures, considering the tank pressure relief valve capacity
9. Drain and purge bunker hoses and lines upon completing bunkering and before disconnection
10. Constantly monitor the vessel's moorings throughout the transfer operation to avoid a breakout situation
11. Use a dry break-away coupling/self-sealing quick release to stop ammonia transfer and safely disconnect bunker hoses in case the vessel and source start moving apart (break out)
12. Maintain positive pressure in accommodation areas to prevent toxic ammonia ingress.

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The bunker station should also be fitted with the following:

a. A proper mechanical shielding of all potential leakage points on the bunker manifold including temporary mechanical shielding of the bunkering connection
b. Leakage detection with automatic closing of the bunker valve
c. A water spray system above the bunker manifold to reduce toxic vapours in the bunkering station
d. Suitable ventilation and gas detection systems, if the bunker station is enclosed
e. A spill tray fitted beneath the bunker connection to collect any leakages and to prevent the water/ammonia from washing overboard.

HANDLING

To prevent toxic vapours entering areas on the ship where personnel might be exposed, the ammonia fuel line should be double skinned. Areas such as the tank connection space and the fuel preparation room have the correct ventilation and gas detection systems so double skinned piping may not be required. The annular space in the double skinned pipe should be mechanically ventilated to a safe area in the open air, normally the ship's vent mast. The piping in the engine room will be required to be double skinned. Selection of the material for the fuel pipe and secondary skin must be chosen to ensure resistance to corrosion and low temperatures. To avoid unnecessary operational discharges of ammonia from the fuel system, the system should be designed with a minimum operating pressure of 18 bar. This corresponds to the vapour pressure of ammonia at 45 °C. This is the temperature the International Association of Classification Societies specify as the highest temperature in the temperature range that all machinery in the fuel system shall be designed to operate.

Every effort shall be made to minimise the time that personnel spend in spaces containing ammonia equipment, with access to these spaces strictly controlled.

The fuel system design must take into account the ability to adequately purge, prove clear and isolate all parts to allow invasive maintenance by personnel.

Combustion of ammonia in an internal combustion engine may generate NOx including N_2O which is a very powerful greenhouse gas. Selective Catalytic Reduction technology can handle the NOx issues however, engine manufacturers will need to find a solution to N_2O if ammonia is going to become a viable zero emission fuel.

SAFETY

The main safety issue with ammonia is the toxicity of the fuel. Ammonia is a toxic substance, and the human exposure limits are well defined by legislation. The Occupational Safety and Health Association set a limit between 25 and 50 ppm, which would be a readily detectable odour with dangerous consequences to concentrations of above 300 ppm. Ammonia is hygroscopic which means it will seek water from the nearest source including the human body. This places the eyes, lungs, and skin at the greatest risk because of their natural moisture content. Caustic burns will result when the ammonia dissolves into the body tissue. An additional concern is the low boiling point of the liquid which would cause burns on contact with the skin.

Emergency showers and eye wash stations will be required for personnel in case of exposure.

From a safety point of view the drainage of ammonia spills overboard and discharge of ammonia vapour underwater is preferable to keeping ammonia on board. However, as ammonia is classed as toxic to aquatic life the release of ammonia into the sea will have an impact on the environment. It is therefore estimated that a spill tray and separate storage tank will be required to contain ammonia mixed water.

Ammonia has a flammability range of 15% to 28% volume in air and burns with difficulty in open air and will generally need a supporting flame to maintain burning. Ammonia in a confined space could constitute an explosion risk and it should be noted that oil contamination of ammonia can increase the flammable properties of ammonia vapours. Therefore, there is no need to define hazardous zones on an open deck. In enclosed spaces electrical equipment should be certified for operation in zone one.

EMERGENCY RESPONSE

Ammonia gas is non-flammable, but it can explode if ignited at certain concentrations when mixed with air. A large intense energy source is necessary to ignite ammonia gas.

Ammonia fires can be extinguished by a variety of methods. Due to the low temperature of liquid ammonia, spraying water directly at a pool will result in rapid vaporisation, that could make the situation more hazardous. For small fires the recommendation is to use dry chemical or carbon dioxide. For larger fires water spray, fog, or appropriate foam is best suited.

THE EMERGENCY RESPONSE PLAN WILL NEED TO ACCOUNT FOR THE FOLLOWING SCENARIOS:

- **FIRE**
- **ENCLOSED SPILL**
- **LARGE SPILL AND RISK OF EXPOSURE TO PERSONNEL -** measure to include ventilation and isolation of ignition sources in case of gas cloud formation
- **FIRST AID -** in case of accidental exposure due to toxicity of the fuel through, inhalation, ingestion and skin absorption.

Additionally, having knowledge of specialised resources that are well-equipped and experienced in handling such leakages would be invaluable during emergency scenarios, especially where time is of the essence.

FURTHER INFORMATION

FOR FURTHER CONSIDERATIONS ON RISKS ASSOCIATED WITH ALTERNATIVE FUELS PLEASE SEE OUR GUIDANCE ON DECARBONISATION.

For further information, please do not hesitate to contact the loss prevention department.