Ammonia Supply and Safety System (MAmmoSS®) Changing the Future of Ships - Definitive Step Toward Carbon Neutrality -

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The 80th session of the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) was held in July 2023 and adopted the 2023 IMO GHG Reduction Strategy to achieve net-zero GHG emissions from international shipping by 2050. This was followed by MEPC 83, which approved the IMO Net-Zero Framework as "mid-term measures" for reducing GHG emissions in line with the aforementioned strategy. However, an extraordinary MEPC session, which was convened in October 2025, decided to postpone its adoption by one year, despite the expectation that the movement toward decarbonization of international shipping would be accelerated through the mid-term measures such as "more stringent regulations on GHG emissions from marine fuels" and "facilitation of decarbonization by the IMO Net-Zero Fund."

Meanwhile, we have been placed in a now-or-never situation regarding reducing GHG emissions. Emitting no CO_2 when burned, ammonia is attracting attention as one of the next-generation marine fuels that can significantly contribute to the reduction of GHG emissions in the shipping industry. Because it is a toxic fluid, ammonia requires on-board technology for safe handling and an ammonia gas abatement system to safely dispose of excess ammonia.

This report presents the ammonia fuel handling system of Mitsubishi Shipbuilding Co., Ltd. called "MAmmoSS®", which is indispensable to ammonia-fueled ships.

1. Current situation

Mitsubishi Shipbuilding Co., Ltd. (hereinafter referred to as MHIMSB) has developed Mitsubishi Ammonia Supply and Safety System "MAmmoSS®" by leveraging its liquefied gas handling technologies established through building multi-purpose gas carriers which are also capable of transporting ammonia and providing the LNG fuel gas supply system (LNG FGSS). A demonstration test facility for an ammonia gas abatement system (hereinafter referred to as AGAS), which was installed at the Nagasaki District Research & Innovation Center of Mitsubishi Heavy Industries, Ltd., was used to verify the processing performance under various scenarios of on-board ammonia operations. The AGAS demonstration facility is shown in **Figure 1**.

Figure 1 AGAS demonstration facility

Based on these verification results, MHIMSB successfully entered a market for ammonia-fueled ships ahead of its competitors. Moreover, our aspiration as a maritime system integrator is to offer high-value-added services tailored to the needs of each customer, including shipbuilding engineering and construction support for ammonia-fueled ships built by other shipyards.

2. Features

2.1 Ammonia fuel handling system (MAmmoSS®)

It is essential for ammonia-fueled ships to be equipped with not only a dual-fuel engine, but also an appropriate ammonia fuel handling system designed in consideration of the ship's specifications and operations. For example, the system's specifications and configuration depend on the type/size of engine, the specifications of the ammonia fuel tank, the ship's general arrangement plan and so on.

MAmmoSS® consists of the ammonia fuel supply system (hereinafter referred to as AFSS), in which the fuel valve train (FVT) is included, AGAS and the AFSS control system (AFCS) that integrates and controls these systems. As each component equipment is modularized for delivery, combining modules with different model numbers enables MAmmoSS® to be customized to a wide range of ships or any ammonia-fueled internal combustion marine engines. Thus, it is possible to provide a system with optimum specifications and configuration to meet the above-mentioned various conditions.

Regardless of the model number, all modules have the same equipment configuration and layout. Moreover, as each module can be divided into a few parts separately, flexibility is allowed even under various limitations due to the ship's arrangement plan.

2.2 Ammonia fuel supply system (AFSS)

AFSS is the system that supplies ammonia fuel to the engine after the temperature and pressure of ammonia fuel are adjusted to their available design ranges for engines. In accordance with the demand signal from the engine, ammonia fuel is automatically supplied from the ammonia fuel tank to the engine through the AFSS module and AFSS control system. AFSS is generally installed in the fuel preparation room, separately from the engine room. Double-walled pipes are used for fuel transfer between these two rooms.

As shown in **Figure 2**, AFSS is classified into two types depending on the physical state of ammonia fuel that is supplied to the engine. If supplied as gas, it is called LP AFSS and is used for generator engines and boilers. In the case of liquid, on the other hand, it is HP AFSS whose application is intended for main engines.

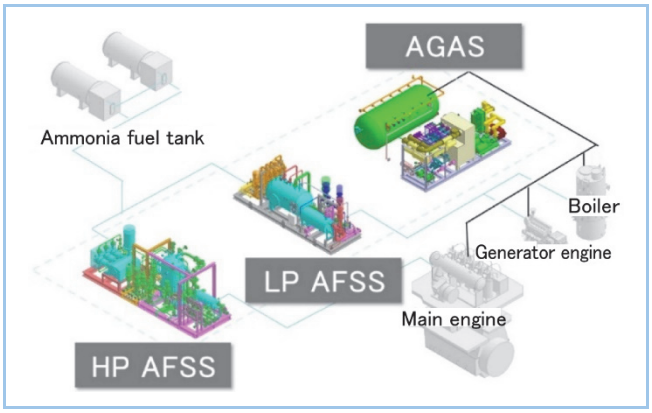

Figure 2 Ammonia fuel supply system (AFSS)

2.3 Ammonia gas abatement system (AGAS)

AGAS is a general term for the equipment enabling safe treatment and disposal of residual ammonia in an ammonia combustion system and the related pipes. For example, when engine fuel is switched from ammonia to heavy oil, residual ammonia gas is purged through the valve unit by displacing it with inert gas. If fuel is LNG, direct discharge of purged gas into the air through the vent post is possible. However, the concentration of ammonia released into the air must abide by the regulations because of its toxicity. It is therefore required to go through the abatement process with AGAS, before being discharged.

Utilizing its property of high water solubility, ammonia is absorbed in water in this abatement process. By letting the purged gas pass through AGAS, ammonia emissions can be abated to such an extent that the atmospheric emission standards can be satisfied. Ammonia water, which is the product of this process, has to be unloaded at a port of call, although it can be used as an NO_x reductant for the engine exhaust SCR system. While industrial disposal of ammonia water is required to follow the correct procedures, an ammonia wastewater treatment system that MHIMSB has been developing will enable ammonia water recycling, eliminating the need of going through the tasks necessary for disposal.

Table 1 summarizes when the abatement treatment for excess ammonia gas needs to be performed on which component of the on-board equipment. Especially, sudden fuel changeover in emergencies such as blackout involves treating a large amount of ammonia gas within a short period of time. The composition of the gas to be treated changes greatly in the course of ammonia displacement purge with inert gas. The ammonia gas concentration, which is high at the initial stage, gradually decreases until the gas undergoing abatement treatment is almost totally comprised of inert gas. Under such operating conditions, water absorption-based AGAS is suitable because of the high responsiveness and capability to handle a wide range of ammonia gas concentrations. In contrast, in the case of scheduled disposal of a large amount of ammonia gas from the fuel tank before/after docking, incineration using a gas combustion unit (GCU) is more appropriate.

Table 2 compares different types of abatement treatments. Among the regular treatment methods based on water absorption of ammonia, the packed tower scrubber is widely known. However, if ammonia gas is to be treated in large quantities, installing in a ship's limited space is difficult as it becomes necessary to increase the cross-sectional area of the packed tower or install multiple packed towers. Moreover, packed tower scrubbing requires wetting the filling with an absorbent solution. However, if the ship is tilted, the filling is only partially wet, resulting in a significant decrease in absorption performance. Therefore, our system adopts an abatement process consisting of a first dilution tank that receives a large amount of gas in a short time and roughly absorbs ammonia without being affected by the ship's tilt, and then a second dilution tank to absorb and dilute ammonia gas after rough absorption to a dischargeable concentration.

Table 1 When to perform ammonia gas abatement treatment

When to perform	Target component	Equipment for treatment
Normal fuel changeover	Fuel supply piping	AGAS
Emergency fuel changeover (during blackout, etc.)	Fuel supply piping	
Maintenance	Maintenance parts such as engine and AFSS	
After fuel bunkering	Bunker station to fuel tank	On-board gas combustion unit or onshore treatment system
Gas-free operation for fuel tank before docking	Fuel tank	
Gassing up operation for fuel tank after docking	Fuel tank	

For certain amounts of residual NH_3 gas

Table 2 Comparison of abatement treatment methods

Item		Our AGAS	Packed tower method (scrubber)
Abatement performance	(with ship motions)	Remain unaffected	May decline substantially (*1)
	(during blackout)	Remain unaffected (*2)	Pump shutdown leads to loss of abatement function.
Abatement wastewater amount		Relatively small (*3)	Relatively large (*3)
Use of liquid chemicals		No	Yes (when sulfuric acid is used as the absorbent solution)
Use of seawater		No	Yes (when used as the absorbent solution)
Corrosiveness of abatement wastewater		Relatively low (*4)	Relatively high (if abatement wastewater contains liquid chemicals or seawater)

*1. Incomplete wetting of packing materials caused by ship motions may lead to a substantial drop in the abatement performance.
*2. Absorption of ammonia gas into the absorbent solution takes place in the dilution tanks even during blackout.
*3. In our AGAS, ammonia gas is effectively stirred in the dilution tanks and is absorbed into the absorbent solution.
On the other hand, the packed tower method requires a large amount of absorbent solutions to be sprinkled in the tower, often producing a relatively large amount of wastewater.
*4. The abatement wastewater concentration is controlled considering corrosiveness.

3. Future directions

In the ammonia fuel handling system, top priority is given to safety and reliability, which has been made possible by our advanced design/analysis technologies and quality control systems. Together with fine-tuned engineering services, MHIMSB helps ammonia-fueled ships to be widely introduced and promotes decarbonization in the shipping industry. Striving to go beyond the boundaries of the shipping industry, the business will be actively expanded to achieve a carbon-neutral society and reduce the global environmental impact.

Please visit our website for more information about the products.