Biofuels and Ammonia studies: Risk Assessment

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EMSA European Maritime Safety Agency

HAZID on biofuel – Introduction and Assumptions

Bio

Introduction

3 **Vessel types**

- Ro-Pax
- Tanker
- Bulk carrier

3 **Biofuels**

- HVO/FT-diesel
- FAME
- DME

Assumptions

- Biodiesels considered (FAME, HVO) have very similar properties to HFO/MGO – normal class rules/IMO rules will be sufficient.
- No major changes in the General Arrangement (GA) required.
- Vessels designed and built to Class/Statutory regulations
- Fire Fighting system, structural fire protection, etc. the SOLAS/Class requirements are sufficient
- No biofuel released to atmosphere in normal operations
- Bunkering operations similar to traditional fuels
- Cargo operations and bunkering can occur simultaneously.
- Fuel treatment/preparation room is very similar to that used by other marine fuels.
- Boilers and emergency gensets are not running on biofuel
- Lifeboats and fast rescue craft are not running on biofuel
- At least 10 modes of operation

HAZID RoPax using biofuel

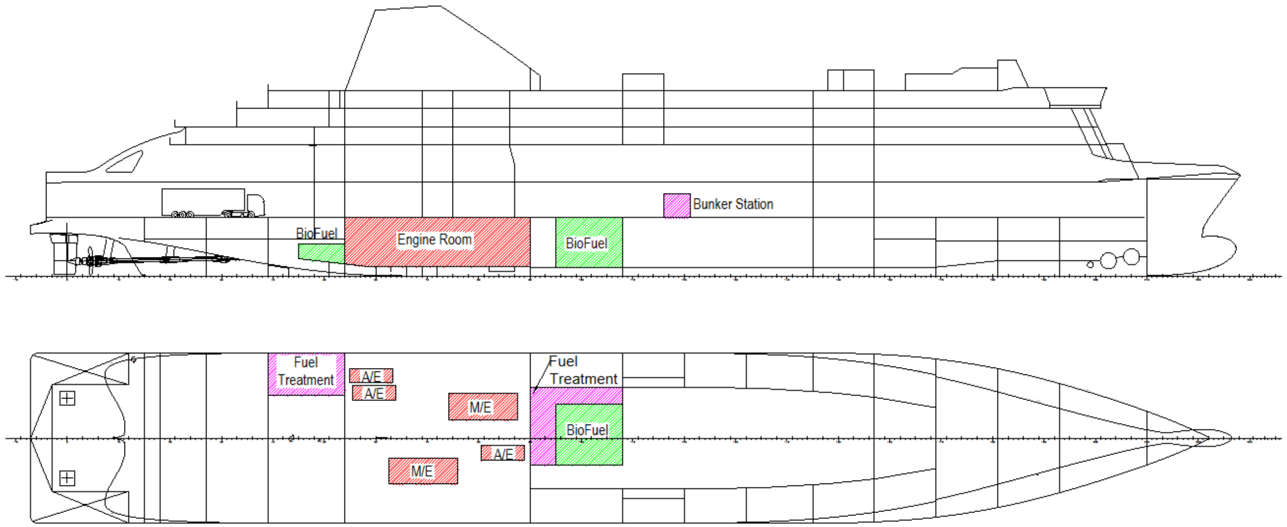
Bio

Ship specific assumption:

The biofuel was 100% HVO (ie., no blend with MGO or other low-sulphur diesels)

The RoPax meets regulations for a safe return to port .

Any biofuel bunkering will be done at port and in similar ways to standard practices for RoPax vessels



Key system level HAZID nodes	Risk Ranking of Hazards Identified			
	Low	Medium	High	Extreme
Node 1: Biofuel storage/tank	27	11	2	0
Node 2: Bunkering Arrangement	0	0	0	0
Node 3: Biofuel system / arrangement / preparation room	5	1	0	0
Node 4: Machinery Space	0	0	0	0
Node 5: Ventilation	0	0	0	0
Node 6: Safety System	0	0	0	0
Node 7: Ship's Operation	5	3	0	0
Node 8: Engines	7	4	2	0
Total per Risk Level (out of 67 risks)	44	19	4	0

HAZID VLCC using biofuel

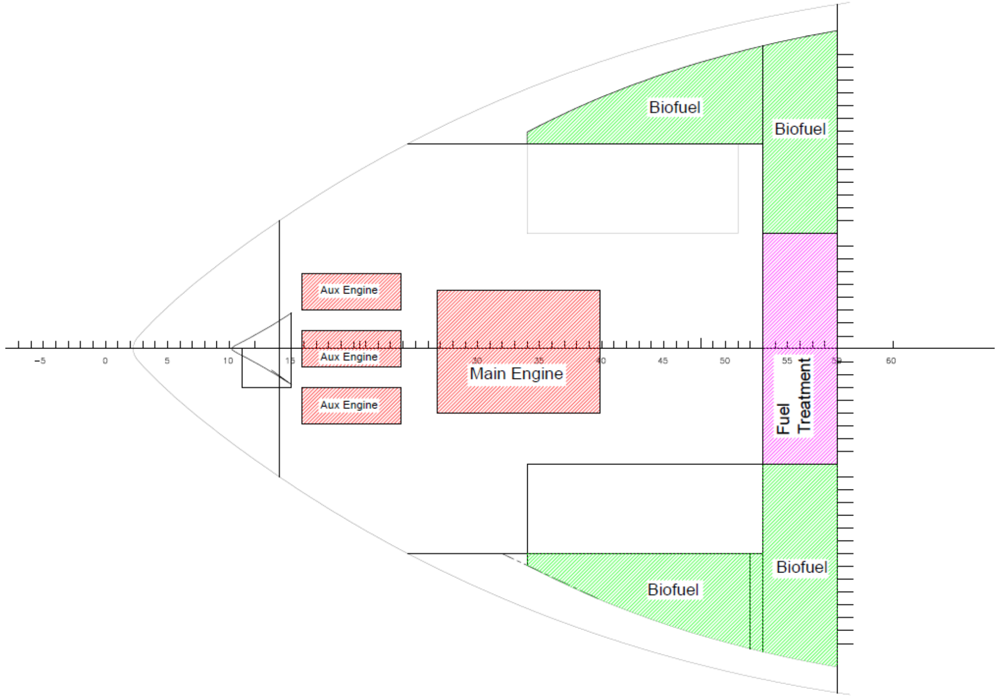
Bio

Ship specific assumption:

The biofuel used to fuel the VLCC was a blend of FAME and MGO, and proportions could vary between 50% and 100% FAME.

A standard fuel-oil system layout was considered for the VLCC

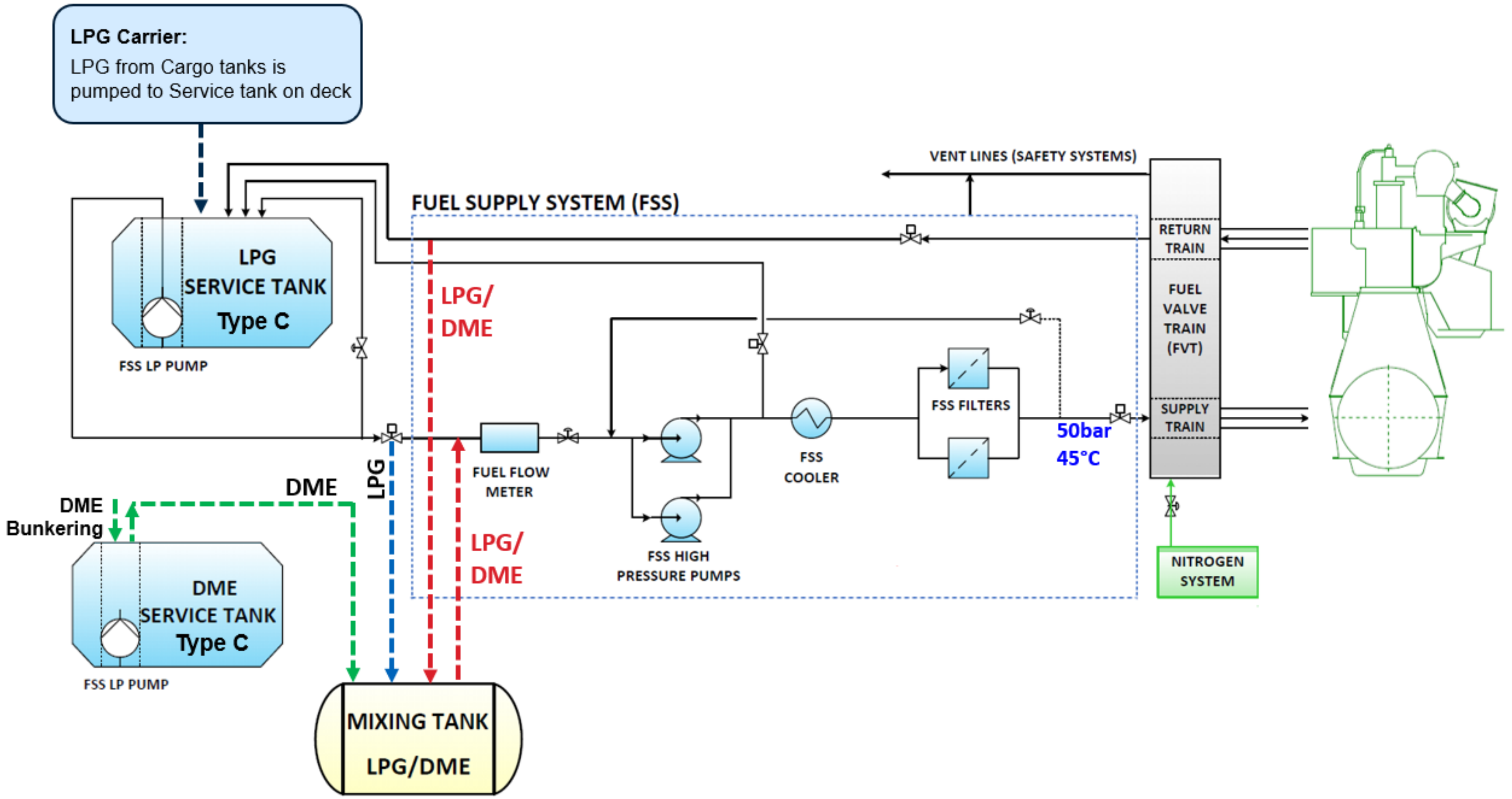
Proper fuel-oil temperature management and viscosity controls were in place



Key system level HAZID nodes	Risk Ranking of Hazards Identified			
	Low	Medium	High	Extreme
Node 1: Biofuel storage/tank	13	22	5	0
Node 2: Bunkering Arrangement	0	0	0	0
Node 3: Biofuel system / arrangement / preparation room	2	3	1	0
Node 4: Machinery Space	0	0	0	0
Node 5: Ventilation	0	0	0	0
Node 6: Safety System	0	0	0	0
Node 7: Ship's Operation	3	5	0	0
Node 8: Engines	7	2	4	0
Total per Risk Level (out of 67 risks)	25	32	10	0

HAZID VLGC blending in DME in LPG

Bio



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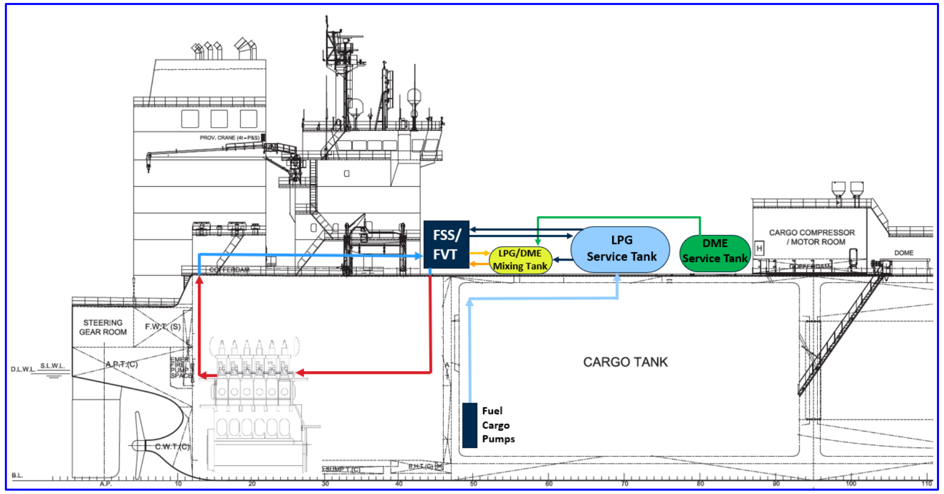
HAZID VLGC blending in DME in LPG

Bio

Ship specific assumption

- The fuel considered for the VLGC was a mixture of DME and LPG, at a maximum blending ratio of 30/70 (DME/LPG)
- The VLGC is a standard LPG carrier with no special fittings for DME
- DME is stored in Type C tanks located on deck in the cargo area and in compliance with IGC Code requirements
- DME is mixed with the LPG in a mixing tank to the required ratio and the mixture is pumped to the fuel-supply system of an LPG dual-fuel engine
- The mixing tank is a pressurised tank
- An additional bunkering manifold is to be installed for DME
- DME venting is independent by discharge and at the same common location as LPG



Key system level HAZID nodes	Risk Ranking of Hazards Identified			
	Low	Medium	High	Extreme
Node 1: General Arrangement	1	1	1	0
Node 2: DME storage tank	6	8	1	0
Node 3: Bunkering arrangement	3	1	2	0
Node 4: Fuel system/preparation	1	3	5	0
Node 5: Supply system/vapour handling	0	0	1	0
Node 6: Cargo Compressor/Motor Room	0	0	1	0
Node 7: Engines	0	0	4	0
Node 8: Ventilation and Venting System	0	0	0	0
Node 9: Safety System	0	2	0	0
Node 10: Ship's Operations	0	1	0	0
Node 11: Emergency Escape, Evacuation, Rescue (EER)	0	0	0	0
Total per Risk Level (out of 42 risks)	11	16	15	0

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Conclusions

Bio

No unresolvable or unmitigable risks identified

- Many of these biofuels can be readily applicable for marine applications
- The fully drop-in fuels scored the lowest in the HAZID’s
- There is a dependency of the fuel properties which in turn depend on their production pathway
- Need for fuel labelling and proper standardisation of fuels
- There is a need to extend knowledge among engine makers on the applicability of these fuels
- As experience grows, it is expected that frequency of inspections will also grow

	High	Medium	Low
HVO (FT Diesel)	4	19	44
FAME	10	32	25
DME/LPG	15	16	11

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HAZID on ammonia – Introduction and Assumptions

NH_3

3 **Vessel types**

- Ro-Pax
- Tanker
- Bulk carrier

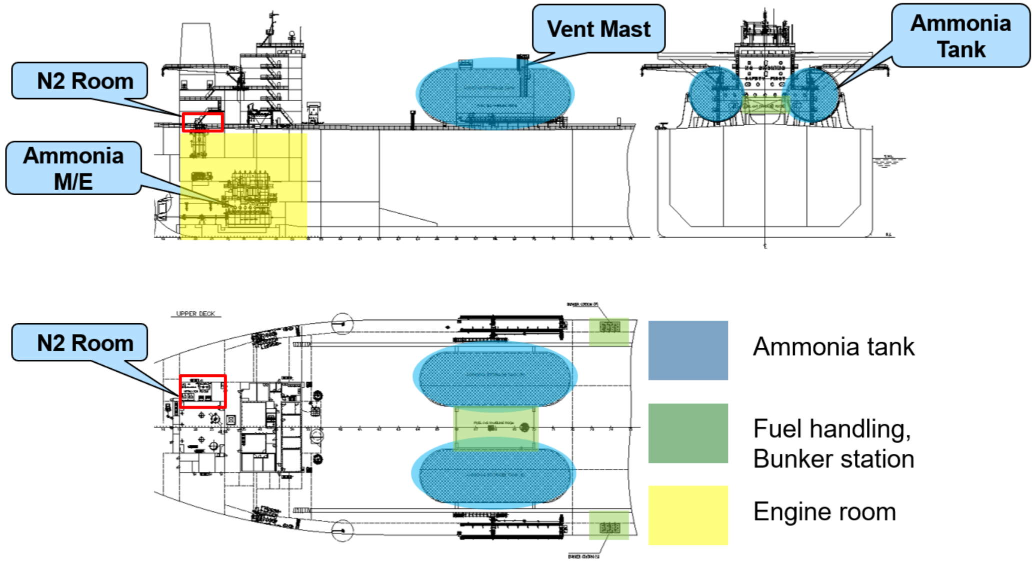
Assumptions

- Built-in compliance with class and statutory regulations
- In compliance with requirements of IMO IGF code, except those directly related to NH3
- No release of ammonia during normal operational conditions, only during emergency conditions.
- Relief valves capacity acc. to IGF Code and ABS Rules.
- relief valves releases goes to a single-vent mast.
- NH3 bunkering will be undertaken at anchorage or port, using an ammonia bunker barge or vessel in a side-by-side configuration by transfer hoses.
- Bunkering vessels will have fenders and hoses
- Cargo operations and bunkering will not occur simultaneously.
- A catch system for ammonia will be provided to capture and treat the chemical during normal operations.
- During gas shutdowns, nitrogen will purge the fuel lines.
- Heating and cooling systems have an intermediate water glycol circuit to avoid any contamination of the ship's cooling water.
- The bunker system will have a liquid-supply and vapour-return line, in most cases.

HAZID VLCC using ammonia

NH_3 Ship specific assumption:

- The FHR is 3 metres above the weather deck.
- All cargo and other piping near the fuel-preparation room will be under the FHR.
- The service tank is pressurised to ~20 bar to avoid cavitation in the high-pressure pump.
- The seawater/steam glycol heat-exchanger system is located in the FHR.
- An A-60 class wall with no entrance is used for the forward section of the deckhouse.
- Cargo-tank vents is moved to outside of the FHR area.
- The fuel system is only for the basic information required to identify high-level risks.
- Excess of ammonia vapour returns will go through re-liquification.



Key system level HAZID nodes	Risk Ranking of Hazards Identified			
	Low	Moderate	High	Extreme
Node 1: General Arrangement: Bunkering	1	4	4	0
Node 2: General Arrangement: Fuel Storage	0	4	6	5
Node 3: General Arrangement: Fuel Handling Room	0	0	4	5
Node 4: General Arrangement: Fuel Handling Room, Fuel transfer, Fuel preparation, Reliquification, pumps and piping	0	0	1	2
Node 5: GA Machinery space (ER)/Use of Fuel/ Engine Maintenance Activity/Engine	3	1	1	0
Node 6: Vent / Vent Liner / Vent Mast	0	3	6	4
Node 7: Safety System/Emergency - Not enough Information	0	0	0	0
Node 8: Ship's Operation /Simultaneous Operation	0	2	1	0

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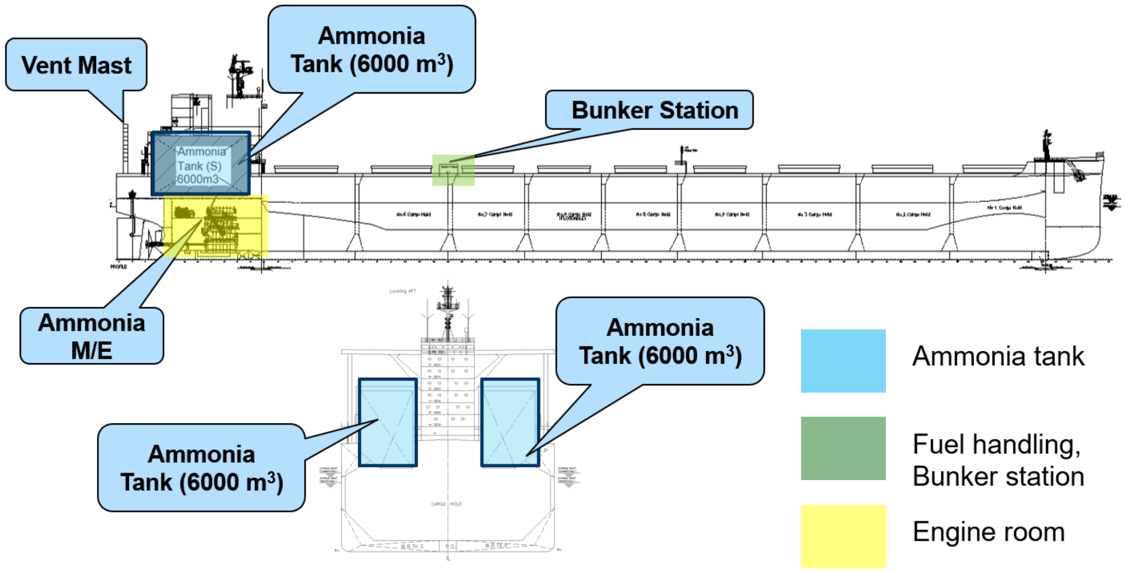
HAZID ammonia fueled Bulk-carrier / proposal 1

NH_3 Ship specific assumption:

- The service tank is pressurised to ~20 bar to avoid cavitation in high-pressure pumps.
- During an engine shutdown or similar situations, nitrogen will purge the fuel lines into the knockout drum or service tank.
- The seawater /steam glycol heat exchanger system is located in the FSS.
- All ammonia piping will be run on the main deck and protected against mechanical damage.
- Piping from the tank to the FPR – and from the bunker station to the tank – are installed between the Type A tank and the side wall of the accommodation room. It is single-wall piping.
- Piping from the FPR to the engine room is double-walled.



Bulk Carrier Vessel (Proposal I) Risk Profile				
Key system level HAZID nodes	Risk Ranking of Hazards Identified			
	Low	Moderate	High	Extreme
Node 1: General Arrangement: Bunkering	2	3	6	3
Node 2: General Arrangement: Fuel Storage	0	1	7	4
Node 3: General Arrangement: Fuel Handling Room	0	0	4	2
Node 4: General Arrangement: Fuel Handling Room, Fuel transfer, Fuel preparation, Reliquification, pumps and piping	0	3	2	1
Node 5: GA Machinery space (ER)/ Use of Fuel/ Engine Maintenance Activity/Engine	0	3	1	1
Node 6: Vent /Vent Liner/Vent Mast (Not risk ranked, recommendations provided to improve design)	0	0	0	0
Node 7: Safety System / Emergency	0	0	0	1
Node 8: Ship's Operation /Simultaneous Operation	0	0	2	0

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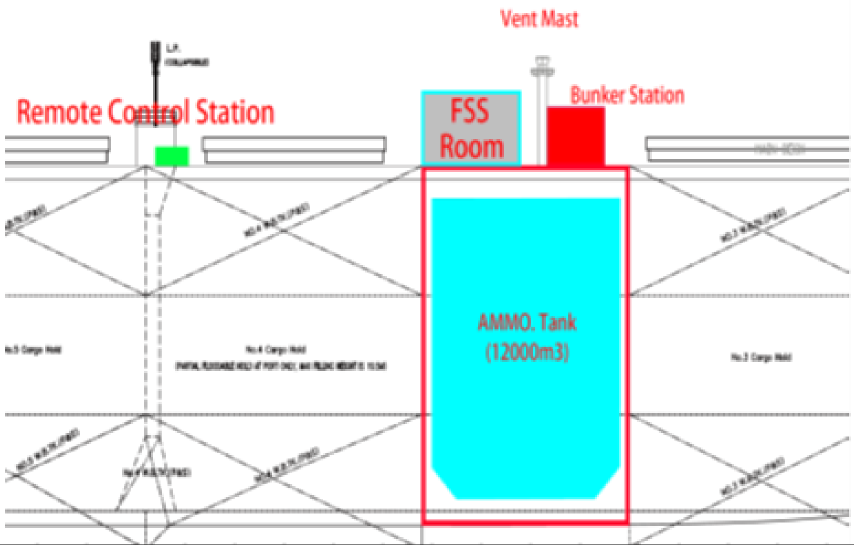
HAZID ammonia fueled Bulk-carrier / proposal 2

NH_3 **Ship specific assumption:**

- The service tank is pressurised to ~20 bar to avoid cavitation in high-pressure pumps.
- During an engine shutdown or similar situations, nitrogen will purge the fuel lines into the knockout drum or service tank.
- The seawater /steam glycol heat exchanger system is located in the FSS.
- All ammonia piping will be run on the main deck and protected against mechanical damage.



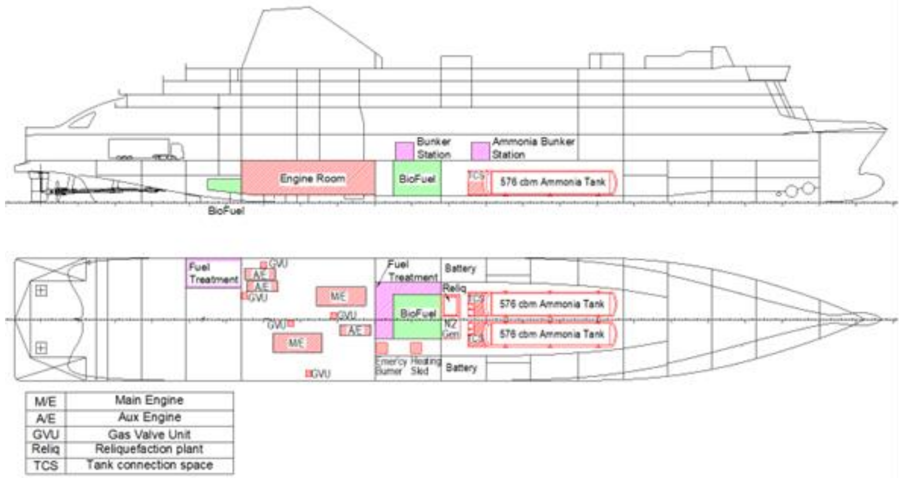
Bulk Carrier Vessel (Proposal II) Risk Profile				
Key system level HAZID nodes	Risk Ranking of Hazards Identified			
	Low	Medium	High	Extreme
Node 1: General Arrangement: Bunkering	2	4	8	2
Node 2: General Arrangement: Fuel Storage	0	4	6	3
Node 3: General Arrangement: Fuel Handling Room	0	1	4	0
Node 4: General Arrangement: Fuel Handling Room, Fuel transfer, Fuel preparation, Reliquification, pumps and piping	0	3	2	3
Node 5: GA Machinery space (ER)/Use of Fuel/ Engine Maintenance Activity/Engine	0	4	1	1
Node 6: Vent / Vent Liner/Vent Mast (Not risk ranked, recommendations provided to improve design)	0	0	0	0
Node 7: Safety System/Emergency (Not risk ranked, recommendations provided to improve design)	0	0	0	0
Node 8: Ship's Operation /Simultaneous Operation	0	0	0	1

HAZID ammonia fueled Ro-Pax

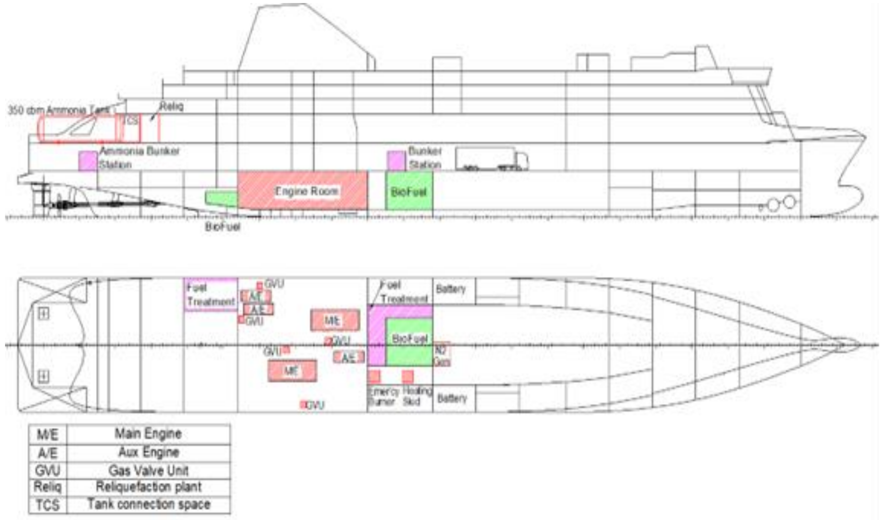
NH_3 Ship specific assumption:

- The tank connection space (TCS) is next to the tank, features gas/liquid-tight construction and is classified as a Zone 1 space.
- The TCS space is connected to the tank, with leak detection, designed to contain ammonia and is vented independently to the vent mast.
- Energy storage (battery: Li-ION) with 2x5 MWh capacity.
- The ammonia tank's first stop valve is welded to a connection on tank. Piping between the first stop valve and tank is a double-walled welded
- All piping for the TCS space is stainless steel and designed to the 'leak-before-fail' principle
- 2 types of tanks are considered: a single-wall tank with insulation and a double-wall tank with vacuum insulation (IGF/IGC-compliant Tank C)
- The ship is MGO only design and current technology suggests a high proportion of MGO will be used as pilot fuel
- Ammonia will not be used in port
- Wartsila engine using gaseous fuels (otto cycle)

Proposal 1 NH3 tank inside Hull



Proposal 2 NH_3 tank on aft Deck of RO-Pax



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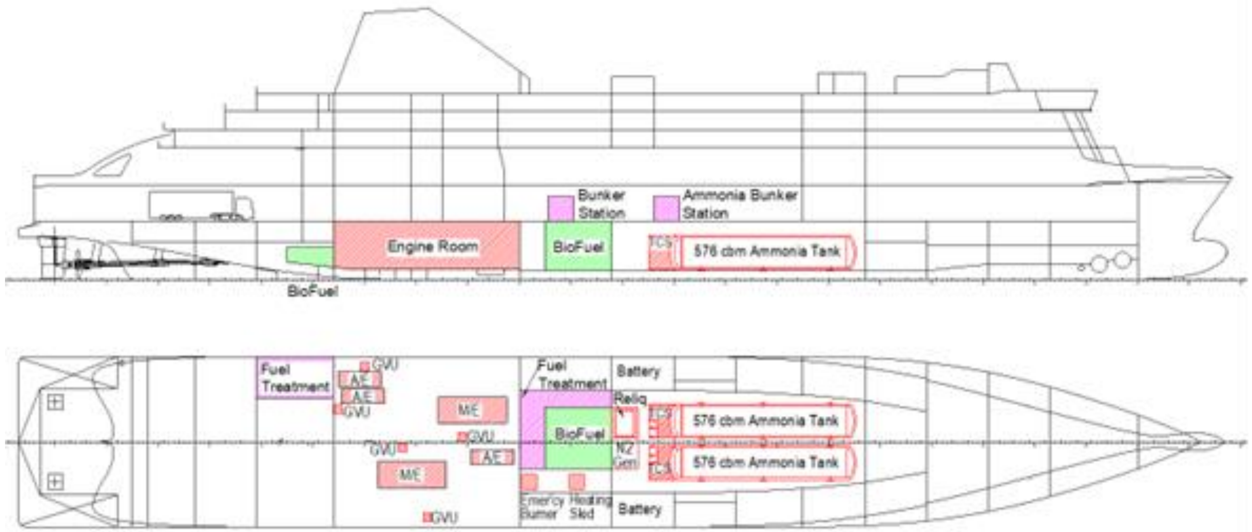
HAZID ammonia fueled Ro-Pax

NH_3

Proposal 1 NH3 tank inside Hull



M/E	Main Engine
A/E	Aux Engine
GVU	Gas Valve Unit
Reliq	Reliquefaction plant
TCS	Tank connection space

Proposal 2 NH_3 tank on aft Deck of RO-Pax

M/E	Main Engine
A/E	Aux Engine
GVU	Gas Valve Unit
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TCS	Tank connection space

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HAZID ammonia fueled Ro-Pax

NH_3

Proposal 1 NH_3 tank inside Hull

Proposal 2 NH_3 tank on aft Deck

Ro-Pax Vessel HAZID Risk Profile				
Key system level HAZID nodes	Risk Ranking of Hazards Identified			
	Low	Moderate	High	Extreme
Node 1: General Arrangement Ro-Pax (No new risk identified)	0	0	0	0
Node 2: NH_3 fuel storage tank A (engine room)	1	34	72	7
Node 3: NH_3 fuel storage tank B (on open deck)	0	5	8	2
Node 4: Bunkering Arrangement (tank in hold)	2	16	11	12
Node 5: Bunkering arrangement (on deck)	0	0	1	0
Node 6: Fuel preparation room	0	0	0	0
Node 7: Machinery space (ER)	3	17	8	2
Node 8: Ventilation (not risk ranked, recommendations provided to improve design)	0	0	0	0
Node 9: Safety Systems (not risk ranked, recommendations provided to improve design)	0	0	0	0
Node 10: Ship's Operation (not risk ranked, recommendations provided to improve design)	0	0	0	0
Node 11: Biofuels (no new risk identified)	0	0	0	0
Node 12: Engines (no new risk identified)	0	0	0	0

Conclusions

NH_3

Major concerns are related to its toxicity and gas dispersion issues

- Wider adoption of Ammonia as a fuel will add risks (increased interactions)
- Prevention of Ammonia dispersion and release will be an important safety precaution
- Its affinity with water may limit the dispersion of ammonia
- Additional risks are expected during bunkering of ammonia
- General arrangement of the accommodation should be a major concern
- There will be the need to introduce new training requirements industry-wide

	Extreme	High	Medium	Low
Ro-Pax	23	100	72	3
VLCC	16	23	14	4
Bulk Carrier	10-12	21-22	10-16	2

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Suggestions

NH$_3$

There is a need to further study the consequences of using Ammonia as a fuel

- There are multiple protective safeguards identified, to avoid damage to pipes and equipment
- Respiratory and protective equipment is to be available onboard
- Any gaseous slip will need to be kept under control, as long term exposure to low levels can be harmful
- Ventilation studies are necessary potentially increasing the air exchange rate
- Additional studies are required to understand the dispersion of ammonia close to ports
- Need to assess the impact of major releases of ammonia to the air and to the sea
- Potential impact to the marine life and water quality needs further consideration
- Regulations will need to be developed to cover for the safety of personnel
- Emergency response plans need to be developed for bunkering and operations of vessels close to shore or in port areas

Thank You

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