MARITIME TECHNOLOGIES FORUM

LEADING THE MARITIME WORLD FORWARD

# PRELIMINARY DISCUSSION REPORT ON THE USE OF AMMONIA AS FUEL FOR SHIPS

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## 1. INTRODUCTION

Decarbonization is one of the major environmental issues being actively debated across the globe. Nations and organizations worldwide are committed to the setting and accomplishing of ambitious goals to achieve satisfactory levels of greenhouse gas (GHG) emission reductions for the future betterment of the environment.

The maritime industry is obviously one of the sectors that requires changes in the way it operates. Currently, a variety of methods and technologies are being investigated to achieve environmentally friendly solutions such as the use of alternative fuels as a substitute for conventional fossil fuels, the adoption of GHG reduction devices, market-based operational measures, etc. While the potential effects and consequences of these various solutions may vary, the advancement in maritime technologies will be undoubtedly be beneficial to the world.

Among such methods and technologies, the MTF has given focus on the use of ammonia as an alternative fuel. Ammonia, for which the chemical composition is NH3, has been acknowledged by the industry as a potential energy source that does not emit carbon particles upon combustion. However, there is neither a sufficient technological readiness level nor a concrete regulatory framework established at the present that will allow the use of ammonia as fuel for ships at sea. While the carriage of ammonia as cargo has been a common practice for many years, its chemical properties and characteristics—for instance, toxicity, flammability and corrosivity—mean that it very much differs from conventional fuels or alternative fuels that have already been well-discussed and established for maritime use. Moreover, when the entire supply chain of ammonia fuel is investigated from the well-to-wake perspective, there still are many challenges to overcome that are not only related to using ammonia as fuel but also related to efficiently producing the ammonia itself without generating GHG. Further long-term research is indispensable so as to acquire a sufficient understanding on the consequential environmental impact of such an endeavor.

Despite the above, ammonia is still considered to be one of the most promising alternative fuel candidates. In September 2021, the International Maritime Organization (IMO) Sub-Committee on Carriage of Cargoes and Containers (CCC) re-established its Correspondence Group on "Amendments to the IGF Code (International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels) and Development of Guidelines for Low-flashpoint Fuels" at its 7th session and instructed the group to collect information on the safe use of ammonia as fuel while waiting for decisions to be made by the IMO Maritime Safety Committee (MSC). In addition, the MSC at its 105th session has initiated relevant discussions as a new work output, taking into consideration the detailed proposal submitted by Japan et al. (MSC 104/15/9) on development of non-mandatory guidelines for safety of ships using ammonia as fuel.

At the industry level, there already has been a number of prospective research and other projects held around the world, such as the joint development of a marine ammonia fuel supply chain and the development of ammonia-fueled engine, but these efforts are at a much earlier stage than establishment of relevant regulations. Thus, based on the urgency of the matter and the current IMO and industry situations, it is very important to share views regarding the safe use of ammonia as fuel so as to achieve a broader consensus in advance as preparation for the more detailed discussions expected to take place later.

## 2. OBJECTIVES

Being aware of global expectations and technological progress, the MTF Project Ammonia was initiated to investigate how MTF members envision possible ways forward on the development of an international safety regulatory framework with regard to the use of ammonia as an alternative fuel for ships. The main objective of the discussions held between the project's members is simply to exchange views and ideas, but not necessarily to establish a collective position at this stage.

The forum solely provides an opportunity for MTF members to freely share available information and insights in parallel with progress at the industry level as necessary. Therefore, the following outcomes of the discussions only represent the individual member opinions and are not intended to prioritize any potential technological or regulatory developments or to suggest specific pathways.

## 3. DISCUSSIONS

Six MTF members actively participated in the discussions, which were mainly held in the form of questionnaires via email correspondences. The discussions focused on the following three points:

1. General discussion on the regulatory framework necessary for the use of low-flashpoint fuel and ammonia as fuel;
2. Assessing the basic properties of ammonia; and
3. Basic concepts for safety measures in accordance with the basic properties of ammonia.

### 1) General discussion on the regulatory framework necessary for the use of low-flashpoint fuel and ammonia as fuel

To start off, the members shared their understanding on the application of existing in-force regulations for general low-flashpoint fuels.

It is to be noted that SOLAS II-1 Reg. 56 and 57 stipulate that ships using low-flashpoint fuels contracted for construction on or after 1 January 2017 are required to comply with the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code). On the other hand, SOLAS II-1 Reg. 56.4 stipulates that the IGF Code does not apply to the following gas carriers:

- Those using their cargoes as fuel and complying with the requirements of the International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), as defined in regulation VII/11.1; or
- Those using other low-flashpoint gaseous fuels provided that the fuel storage and distribution systems design and arrangements for such gaseous fuels comply with the requirements of the IGC Code for gas as a cargo.

#### Q1.1 - Q1.3

Taking the above into consideration, the members were asked to suggest which of the current regulations, the IGF or IGC Code, would be more suitable to be applied to "ships other than gas carriers using low-flashpoint fuels" and "gas carriers using low-flashpoint fuels".

As a result, it was found that six members felt that the IGF Code would apply to "ships other than gas carriers using low-flashpoint fuels" and that six members felt that the IGC Code would apply to "gas carriers using low-flashpoint fuels" in principle. Some initial thoughts were also shared regarding the current regulatory framework on the use of ammonia as fuel.

Member views, on the other hand, varied as to whether the IGF Code (instead of the IGC Code) would be applicable to gas carriers using low-flashpoint gaseous fuels other than that being carried as their own cargo (e.g. LPG carriers using LNG as fuel). In this regard, some members pointed out that the IGF Code may be applied in cases in which a risk assessment of the fuel system and associated ancillaries/consumers is expected, or only when the fuel system is completely segregated from the cargo system, etc.

| Current applicable regulation for ships other than gas carriers using low-flashpoint fuels: | | |
|---|---|---|
| Q1.1) Is IGF code to be applied. | Yes | 6 |
| | No | 0 |
| Additional comments: | | |
| IGF is not to be used as it is currently written but IGF does serve as the best basis which can be amended to cover the use of Ammonia as fuel, noting that generic code Part A is applicable, but specific requirements for Ammonia are missing. Also IGF does not utilise Inherently Safe Design Methodologies which are considered necessary for the use of other alternative fuels. | | |

| Current applicable regulation for gas carriers using low-flashpoint fuels: | | |
|---|---|---|
| Q1.2) Is IGC code to be applied. | Yes | 6 |
| | No | 0 |
| Additional comments: | | |
| There are two paths possible with the use of Ammonia as fuel, which would benefit further discussion:<br>1) IGC code could be applied, but not with its current wording and would have to be modified.<br>2) IGC is not to be used with its current wording, but - where Ammonia is bunkered as fuel - IGC could be modified in a minor way, so that if references IGF for specific regulations pertaining to use of Ammonia as fuel (thus IGF covers the actual use). | | |
| Q1.3) Is it possible to apply IGF code instead of IGC code in the case gas carrier uses other low-flashpoint gaseous fuel (not as her cargo). | Yes | 3 |
| | No | 3 |
| Additional comments: | | |
| (Yes)<br>Currently, the IGC Code (Ch 16.9) only refers to the use of 'cargo' as fuel. As a minimum we would expect a risk assessment of the fuel supply system and associated ancillaries/consumers. | | |
| (Yes)<br>Provided that the fuel system is fully segregated from the cargo system. | | |
| (Yes)<br>See previous comment.<br>*"IGF is not to be used as it is currently written but IGF does serve as the best basis which can be amended to cover the use of Ammonia as fuel, noting that generic code Part A is applicable, but specific requirements for Ammonia are missing. Also IGF does not utilise Inherently Safe Design Methodologies which are considered necessary for the use of other alternative fuels."* | | |
| (No)<br>No, SOLAS Ch II-1 reg 56.4.2 allows the use of LFL other than cargo on gas carriers 'provided that the fuel storage and distribution systems design and arrangements for such gaseous fuels comply with the requirements of the IGC Code for gas as a cargo'. Our understanding is that gas carriers should apply the IGC Code regardless and that it prohibits the use of ammonia as fuel even if it is not carried as cargo. Before an amendment is made to the IGC Code to allow toxic fuel (or merely ammonia) to be used as fuel, the use of ammonia as fuel for gas carriers must be accepted by Flag as a deviation to the IGC code using an alternative design. | | |
| (No)<br>The fuel system (storage and distribution systems design and arrangements) shall comply with the requirements of the IGC Code even the fuel is not carried as a cargo. | | |

Q1.4 - Q1.5

As the next topic, the members discussed the regulations that would be applicable to ships using ammonia as fuel. Specifically, the discussion focused on whether the IGF Code may be applied to ships other than gas carriers using ammonia as fuel or whether a new, independent Code would need to be established for cases in which toxic products, such as ammonia, are used as fuel.

Based on the responses, four members were of the view that the IGF Code would be applicable in such cases. One member commented that, while the IGF Code does not prohibit the use of ammonia as fuel, the code itself would need to be amended since the detailed regulations stipulated in it currently only cover the use of LNG as fuel; therefore, until such an amendment is made, the alternative design approach outlined in MSC.1/Circ.1455 must be employed in order to use ammonia as fuel.

On the other hand, four members felt that an independent code would not need to be newly established to cover the use of toxic products including ammonia as fuel and that it would instead be preferable to have the use of ammonia covered by the IGF Code. In addition, one member commented that if ammonia does not fall under the category of low-flashpoint fuels—which is still a highly controversial topic at the moment—there may be a possibility to develop guidelines for application of alternative designs and arrangements in Part F of SOLAS II-2, taking into account the fact that SOLAS II-2 does not prohibit the use of ammonia as fuel.

| Regulations for use of ammonia in ships other than gas carriers: | | |
|---|---|---|
| Q1.4) Could IGF code be applied for use of ammonia as fuel, considering the following: | Yes | 4 |
| | No | 0 |
| | Neutral | 2 |
| AA) Ammonia is toxic. However, IGF code does not prohibit use of toxic substance. On the other hand, IGC code clearly prohibits use of toxic product as fuel. | | |
| BB) Ammonia is gaseous at ambient temperature and pressure. Usually, the term flashpoint is applicable to liquid or solid state substance. So, it is not clear whether the term flashpoint could be applied to gaseous substance and thus ammonia would be categorized as low-flashpoint fuel or not. | | |
| Additional comments: | | |
| (Yes)<br>Yes, BUT, IGF cannot be used without amendment. For example regulation is necessary to ensure double-walled/ secondary containment of ammonia. This regulation is needed due to the low storage temperature, 'ease' of ignition and explosive characteristics of hydrogen, and the toxicity of ammonia. There are other amendments to be made but are too many to list here. Also IGF does not utilise Inherently Safe design Methodologies which are considered necessary for the use of other alternative fuels.<br>BB)<br>Flash point closed cup test can be applied to ammonia. So, it could be considered a low-flashpoint fuel. | | |
| (Yes)<br>AA)<br>IGC does not allow toxic cargo to be used as fuel. However, if ammonia is bunkered for fuel then may be IGF could be used. Possibly revise IGC to reflect this.<br>BB)<br>Ammonia exists as a gas at ambient conditions - it is typically held as a pressurised/cooled liquid - and so will flash upon release. Hence, in a practical sense it can be considered as a 'low-flashpoint fuel'.<br>Furthermore, since IGF already includes natural gas which is also a gas at ambient conditions, then it is relatively clear that ammonia would also be considered as a low-flashpoint fuel and thus covered by IGF. | | |
| (Yes)<br>AA)<br>The IGF code does not prohibit the use of ammonia as fuel, but the IGF Code only covers LNG as fuel. Thus the alternative design approach as outlined in MSC.1/Circular.1455 must be employed, until the IGF Code is amended. | | |
| (Neutral)<br>AA)<br>The IGF code does not prohibit the use of toxic fuels.<br>Also when ammonia is not classified as "low-flashpoint fuel", there are no regulation to prohibit from using toxic fuel in SOLAS II-2.<br>BB)<br>There are no scientific research which report the flashpoint of ammonia.<br>Common understanding will be needed on whether ammonia could be treated as "low-flashpoint fuels" equivalent from the viewpoint of how flammable and explosive it is. This is because flashpoint is an index used to measure a level of fire risk.<br>SOLAS II-1/2.29 clearly defines "low-flashpoint fuel means gaseous or liquid fuel *having a flashpoint lower than otherwise permitted under regulation II-2/4.2.1.1.*". | | |
| Q1.5) Or, should another independent code/guidelines be established and applied with amendments to SOLAS to regulate the use of toxic fuel and to refer to such code/guidelines. | Yes | 0 |
| | No | 4 |
| | Neutral | 2 |
| Additional comments: | | |
| (No)<br>It would be preferable to include ammonia within IGF. | | |
| (No)<br>IGF should be used but will need to be amended. Whether or not any parts of SOLAS would need to be amended will need further check. | | |

| |
|---|
| (Neutral)<br>Up to the contents of mandatory requirements to ammonia. Toxicity is the first risk to be concerned and characteristics of ammonia fire differ from those of LNG and other gasses classified as low-flashpoint fuels.<br>There is a room to consider new Code when major revise of the IGF Code is needed.<br>There may be another possibility to develop guidelines for application of SOLAS II-2 Part F in case that ammonia is not regarded as low-flashpoint fuel taking into account SOLAS II-2 does not prohibit to use ammonia as fuel. |

Q1.6 – Q1.7

In a similar fashion, the members were asked which regulations would be applicable to gas carriers using ammonia as fuel. In this regard, it is well-known that 16.9.2 of the IGC Code stipulates that the use of cargoes identified as toxic products shall not be permitted and that ammonia is specifically listed as a toxic product in Chapter 19 of the IGC Code. Based on this premise, the discussion focused on whether gas carriers would be allowed to use ammonia as fuel under the IGC Code, given the approval from their respective Flag State Administrations.

Looking at the responses, two members were of the view that the IGC Code would be a suitable framework in its current form and not require any amendments. One member pointed out that a Flag State Administration may use the instruments contained in SOLAS for exemptions, equivalents or ADA processes, or the IGF Code may be applied subject to an amendment when a gas carrier bunkers ammonia for fuel. It was, however, further observed that six members consider that the IGC Code, if applied, would need to be revised to remove the strict prohibition of the use of toxic products as fuel.

| Regulation for use of ammonia in gas carriers: | | |
|---|---|---|
| IGC code 16.9.2 stipulates that the use of cargoes identified as toxic products shall not be permitted. Ammonia is listed as toxic. | | |
| Q1.6) Could ammonia be used as fuel by gas carriers given an approval from the flag administration under IGC code. | Yes | 2 |
| | No | 4 |
| Additional comments: | | |
| (Yes)<br>Yes, see Q1.2. | | |
| (No)<br>In a strict sense - no. | | |
| (No)<br>No, the IGC code does not allow this, but the Administration may use the instruments contained in SOLAS for exemption/equivalency/ADA process.<br>Also, if IGF code were used when a gas carrier bunkers Ammonia for fuel, then see comments further above with regard to referencing IGF code and not using IGC code to cover the use of ammonia as fuel. | | |
| Q1.7) For use of ammonia as fuel, should IGC code be revised to delete the prohibit use of toxic product. | Yes | 6 |
| | No | 0 |
| Additional comments: | | |
| (Yes)<br>Yes, provided that IGC is revised to require appropriate risk assessment/new provisions. | | |
| (Yes)<br>Yes, if IGF does not end up being referenced when a gas carrier bunkers ammonia for use as fuel. | | |

Q1.8 – Q1.10

Finally, the topic of an environmental regulatory framework was touched upon. The members were asked to state whether it would be allowed to release ammonia into the sea or atmosphere only in cases of emergency or also during normal operations.

Some members opined that such releases would be allowable in emergency cases but not during normal operations. One member expressed that the release of untreated ammonia should not be allowed even in emergency cases, but that such a thing should be subject to further investigations from various aspects. Furthermore, six members considered that there needs to be specific regulations controlling the releasing and discharging of ammonia to a certain degree, while it remains uncertain whether such regulation would be sufficient to be solely under MARPOL or whether the additional revision of SOLAS or the IGF Code would be necessary.

| Possibility of ammonia releasing/discharging: | | |
|---|---|---|
| Q1.8) Is it allowed to release ammonia into sea or atmosphere (emergency case, normal operation case). | | |
| Members' responses: | | |
| Discharge to sea/atmosphere should not be allowed under normal operation or reasonably foreseeable abnormal operation (most emergencies). All efforts should be taken so that ammonia is not discharged to the sea or atmosphere. There may be some emergency cases where this might be necessary (i.e. to prevent imminent loss of life). | | |
| Emergency situation only. Release in normal operation should be prohibited | | |
| Discharge to atmosphere:<br>Normal operations (including purging fuel pipes) should not result in discharges to atmosphere exceeding 30ppm). This is corresponding to EPA's AEGL-1 limit for exposure of ammonia. This necessitates a system able to handle ammonia purges and the like.<br>Leaks from fuel pipes into secondary enclosures should be safely vented to a toxic zone arranged in a safe distance to air intakes, outlet, openings to enclosed spaces and mustering stations and escapeways.<br>Pressure relief valves from tanks may be routed to a vent mast in a fire scenario. Dispersion analysis may be a relevant tool to investigate consequences of releasing ammonia through vent mast.<br>Discharge to sea: Discharge of ammonia to sea is currently not allowed by class rules. However, investigations should be made whether vent mast arrangements to discharge ammonia under water can be allowed to utilize the hydrophilic properties of ammonia in an emergency scenario. | | |
| Current answer is 'not without treatment,' subject to further investigation. Investigation is required to determine when/if ammonia needs to be 'treated' before being led to sea or atmosphere. This 'treatment' may involve some form of 'scrubber' or 'water-bath' to reduce the ammonia concentration at the outlet. The applicability of a scrubber or water-bath for emergency venting requires study, alongside considerations of equipment weight and space requirements, and storage/disposal of waste liquids. In addition, the separation from vent outlets to other areas/spaces needs to be investigated with regards to ammonia toxicity. Emergency cases need to be considered especially where there is imminent loss of life. | | |
| Emergency case: Yes,<br>Normal operation: No | | |
| Emergency case: Yes<br>Normal operation case: -<br>In case of emergency such result in fatality, it should be allowed to release ammonia to atmosphere and/or sea.<br>*Note that ammonia is lighter than the air.<br>At normal operations;<br>a). Leakage gas should be safely vented to a toxic zone<br>b). It is needed to restrict emission to the atmosphere from safety perspective<br>c). Further research and discussion will be needed to consider restriction from environmental perspective | | |
| Q1.9) Is releasing/discharging of ammonia to be regulated by any regulation. | Yes | 5 |
| | No | 0 |
| | Yes or No | 1 |
| Additional comments: | | |
| (Yes)<br>If further investigation finds release to be acceptable. | | |
| (Yes)<br>Yes, it is preferrable to regulate it by the regulation | | |
| (Yes)<br>For safety, yes.<br>For environment, further investigation will be needed to decide necessity and permissible range. | | |
| (Yes)<br>It would need to be regulated. | | |
| (Yes or No)<br>Yes, emissions to air as part of IGF (relating to safety) and MARPOL (relating to environment)<br>For discharge to sea, see MARPOL 73/78, Annex II. | | |

| Q1.10) If Q1.9 is Yes, which IMO regulatory framework would be appropriate: MARPOL, IGF, SOLAS? |
|---|
| Members' responses: |
| (MARPOL/IGF/SOLAS)<br>Needs to be included in IGF which is concerned with both safety and environment. Further investigation required. |
| (MARPOL/IGF)<br>In principle, MARPOL as eg. OIL in MARPOL annex 1, ch. 1 reg. 4.1. However the MARPOL does not describe any provisions for the release of eg. Natural gas(methane) use under the provisions of the IGF code. |
| (MARPOL/IGF/SOLAS)<br>See above.<br>"Yes, emissions to air as part of IGF (relating to safety) and MARPOL (relating to environment)<br>For discharge to sea, see MARPOL 73/78, Annex II." |
| (MARPOL)<br>To some extent all three, but mainly MARPOL and also IGF. There are two considerations, release into air, and release into sea. Ammonia released in the atmosphere (ignoring where it comes into direct contact with humans as Ammonia) comes into combines with nitrogen oxides released by vehicles and industry and derives into ammonium nitrate, which is a tiny particulate matter than can lodge into lungs and cause premature death. Hence, the release of ammonia to the atmosphere should be regulated by MARPOL Annex VI Chapter III on air pollution. MARPOL should also be used for ammonia being discharged into the sea. Also, IGF code should cover some aspects too. |
| (MARPOL/IGF)<br>No specific comment was provided. |
| (MARPOL/SOLAS)<br><Safety perspective><br>Release to the atmosphere: SOLAS or Code(s) under SOLAS<br>Release to the sea: NA<br><Environmental perspective - MARPOL><br>Further investigation needed. |

## 2) Assessing the basic properties of ammonia

Q2.1 – Q2.5

Before investigating the safety measures to be considered when using ammonia as fuel, the members shared their ideas with regard to the basic properties of ammonia, and toxicity, corrosivity, explosivity and flammability were some of the major properties that were pointed out as being obviously related to safety issues and other concerns.

Among the aforementioned properties, toxicity was generally regarded as the primary critical hazard that required particular attention, whereas explosivity and flammability were mentioned by some members as properties that may require less stringent regulations in the IGF Code, especially considering the risk of fire associated with ammonia in comparison to LNG. In addition, there were comments that further investigation is necessary for identifying appropriate requirements. Another point raised was that some of the requirements for LNG (i.e. where boundaries of accommodation spaces, service spaces, control stations, escape routes and machinery spaces facing fuel tanks on open decks are required to be separated by A-60 insulation) would not be necessary for ammonia-fueled ships since ammonia is very difficult to burn on open decks.

| Basic properties assessment of ammonia: | | |
|---|---|---|
| Q2.1) Is it clear that toxicity of ammonia to be considered in the regulation. | Yes | 6 |
| | No | 0 |
| Additional comments: | | |
| (Yes)<br>Exposure and inhalation of personnel must be avoided in any way. | | |
| (Yes)<br>This is the principal hazard that needs to be addressed. | | |
| (Yes)<br>It is critical that toxicity is addressed in the regulation. | | |
| Q2.2) Is it clear that corrosivity of ammonia to be considered in the regulation. | Yes | 6 |
| | No | 0 |

| | | |
|---|---|---|
| Additional comments: | | |
| (Yes)<br>Specific regulations with regard to the material of fuel containment/transfer systems may be necessary. | | |
| Q2.3) Is it clear that explosivity/flammability of ammonia to be considered in the regulation. | Yes | 6 |
| | No | 0 |
| Additional comments: | | |
| (Yes)<br>Yet application of the requirement for limitation of explosion consequences should be considered together with the other safety measures against explosion, which are prevention of leakage of fuel, elimination of sources of ignition and prevention of formation of explosive atmosphere by means of detection, shutdown and ventilation. Flammability and explosivity of ammonia are considered to be less compared to those of LNG. | | |
| (Yes)<br>Further investigation may be necessary. | | |
| (Yes)<br>Yes, but with less stringent requirements than what IGF code requires for LNG, due to the fact that ammonia is much less flammable than LNG. | | |
| Q2.4) Which degree of requirements against explosivity/flammability is adequate.<br>For example, for open deck space with adequate natural ventilation, are requirements of IGF Code on measures against fire in open deck area (i.e. A-60 fire insulation of the boundaries of the superstructures and deck houses facing fuel tank, and ammonia fire extinguishing systems on open deck) to be applied to ammonia-fueled ships or not. | | |
| Members' responses: | | |
| To be investigated further (smaller distances or less stringent requirements may be appropriate). Any investigation should establish which of the requirements for natural gas relate to its characteristics (e.g. ignition energy and flammable range) and process conditions (e.g. storage/operating pressures and temperatures). This will provide further understanding when selecting appropriate requirements in respect of ammonia characteristics and process conditions. | | |
| We do not support to discuss the concrete requirements without clarifying what type/design of ships to be considered.<br>For example, there are differences between dedicated ammonia fuelled ships and dual fuel ships with ammonia.<br>Safety measures should be taken according to hazard identification and analysis. | | |
| Our understanding is that ammonia is very difficult to burn on open deck. We do not require boundaries of accommodation spaces, service spaces, control stations, escape routes and machinery spaces facing fuel tanks on open deck to be separated by A-60 insulation.<br>We require fixed and portable dry-powder fire extinguishing for bunkering stations also on open deck. | | |
| For open deck space, we do not require A-60 fire insulation to boundaries of accommodation etc. and dry chemical powder fire-extinguishing system at bunker station unless it is closed or semi-enclosed. | | |
| Q2.5) Is there any other ammonia property to be potentially considered in the regulation. | | |
| Members' responses: | | |
| To be further investigated. | | |
| Not at this moment. | | |
| Not specifically at this point. | | |
| Further investigation required. | | |
| Other chemical properties such as dew point and vapour pressure are taken into consideration. Regulations differ from IGF Code for LNG due to differing properties. Water solubility is another property that is relevant. | | |
| This needs looking at further. | | |

## 3) Basic concept for safety measures in accordance with the basic properties of ammonia

### Q3.1 – Q3.3

Taking into account the discussion on the basic property assessment of ammonia in 2) above, the next discussion focused on the basic concepts of safety measures for using ammonia as fuel.

It became apparent from this discussion that a number of the members feel that the segregation of spaces between gas safe areas and gas hazardous areas (including the elimination of gas emission sources from gas safe areas) may be necessary. Some of the comments mentioned that arrangements of spaces with respect to possible ammonia leakages would need to be duly considered more in terms of the risk from toxicity than that from fire or explosion. The mitigation of the effects of ammonia leakages through means such as ventilation, detection and isolation was also recognized as one of the key factors.

| Basic concept of safety measures: | | |
|---|---|---|
| Q3.1) Is segregation of spaces between gas safe area and gas hazardous area including elimination of gas emission source from gas safe area necessary. | Yes | 6 |
| | No | 0 |
| Additional comments: | | |
| (Yes)<br>Should follow area classification according to IEC 60079-10. | | |
| (Yes)<br>Please refer the comment on "Is it clear that explosivity/flammability of ammonia to be considered in the regulation.", above.<br>*"Yet application of the requirement for limitation of explosion consequences should be considered together with the other safety measures against explosion, which are prevention of leakage of fuel, elimination of sources of ignition and prevention of formation of explosive atmosphere by means of detection, shutdown and ventilation. Flammability and explosivity of ammonia are considered to be less compared to those of LNG."* | | |
| (Yes)<br>Yes, spaces at which leaks of ammonia may occur (single walled pipes, flanges etc, TCS, Fuel preparation room, etc) shall always be arranged with secondary containment able to contain any leaks that may occur. This is necessary to protect crew and passengers for hazardous or lethal consequences of an ammonia leak. The philosophy is in line with safety philosophy of IGF code for methane, but more due to toxic risk than risk of fire/explosion. | | |
| Q3.2) Is mitigating the effect of leakage of ammonia (ventilation, detection and isolation of leakage) necessary. | Yes | 6 |
| | No | 0 |
| Additional comments: | | |
| (Yes)<br>Yes, the safety philosophy is in line with IGF code safety philosophy of keeping a leak away from crew and personnel, however more stringent than IGF code due to toxic properties of ammonia. | | |
| (Yes)<br>Absolutely. This is strongly linked with Q2.1, as a result of toxicity in particular. And is also linked with other environmental and wider / less direct health issues, as a result of release of $NH_3$. | | |
| Q3.3) Is introduction of conceptualized toxic hazard zone and establishment of restrictions/ prohibitions for such zone necessary. | Yes | 5 |
| | No | 0 |
| | Yes or No | 1 |
| Additional comments: | | |
| (Yes)<br>To avoid ammonia exposure to the personnel, it seems necessary to define the area which may exist ammonia and impose some restriction there. | | |
| (Yes)<br>Yes, toxic zones (=distance requirements from toxic ammonia discharge or leak points from air inlets, outlets and openings to enclosed spaces on the vessel) is necessary to mitigate risk of toxic ammonia entering spaces on the vessel where personnel may be present. | | |
| (Yes)<br>Yes, and needs investigating as to how it translates across differing ship types and setups. | | |
| (Yes or No)<br>Further discussion will be needed.<br>There is no "toxic hazard zone" in other codes under SOLAS and it directly connects to serious event (such as fatality) once unignorable amount of ammonia got leaked in the zone. | | |

### Q3.4 – Q3.5

In Q3.3, five members expressed the need for the introduction of a conceptualized toxic hazard zone at this point, while some of the other members also commented that further investigation is necessary. With this in mind, further ideas were sought regarding the adequate degree of requirements necessary for vent mast arrangements.

Although some Member responses mentioned that prescriptive requirements would be necessary, others were of the opinion that Flag State Administrations may require dispersion analysis as part of any alternative design approach. Other notable suggestions included the need for appropriate means to reduce the ammonia in the gases being released from vent outlets, considering that it may be impracticable to reduce ammonia concentrations in case of fire just by segregation distance and other measures.

| Introduction of conceptualized toxic hazard zone: |
|---|
| Q3.4) Which degree of requirements about vent mast arrangements is adequate. For example: |
| AA) as for arrangement of vent exit (outlet of PRV and outlet of ventilation of spaces where ammonia may exist), is gas diffusion analysis mandatory in addition to prescriptive requirements (standard distance).<br>a) only prescriptive requirements (standard distance) are necessary, and gas diffusion analysis is only required in the case deviating from above<br>or<br>b) gas diffusion analysis is mandatory, in addition to prescriptive requirements |
| BB) as for prescriptive requirements of distance between outlet of PRV and the nearest air intake, outlet or openings to enclosed spaces, is the current IGF Code requirement (10m) to be applied or is greater distance, such as the IGC Code requirement (B or 25m, whichever is less) to be considered. |
| Members' responses: |
| To appropriately set prescriptive requirements (i.e. standard distances), representative venting scenarios need to be agreed and dispersion modelling undertaken. Such modelling will require agreement to a ppm limit (or received dose wrt venting duration) and agreement to the modelling approach and assumptions. This modelling could then be used to set default distances based on established criteria, with alternative distances possible where supported by case specific and appropriate dispersion modelling. The criteria could also provide the basis for determination of acceptable arrangements on 'small' vessels which may not be able to satisfy the standard distances. |
| It is needed to clarify what is the goal for "toxic hazard zone".<br>Toxic hazard zone may differ from hazardous area defined in IGF in many points, such that permissible range of leakage and the standard applied for electrical equipment.<br>With regard to venting, it may be impracticable to reduce the concentration of ammonia to the criterion, e.g., 400 ppm, just by segregation distance, in particular, in case of fire. So, appropriate means to reduce the ammonia in the gas from vent outlet may be necessary.<br>Therefore, it is deemed premature to discuss the concrete requirements. |
| AA)<br>We consider it necessary to have prescriptive requirements for distances from openings to enclosed spaces to e.g. vent mast, bunkering station, ventilation outlets from enclosures where ammonia may leak, and other leakage sources.<br>We do however expect that flag administrations will require dispersion analysis as part of the alternative design approach to verify the safety distances given by prescriptive rules.<br>BB)<br>We have taken prescriptive requirements from IGC code into our rules, 25m or B. The IGF code does not take into account the toxicity of ammonia at very low concentrations. |
| AA)<br>We require item a).<br>BB)<br>We consider that further investigation is necessary. |
| Q3.5) A member mentioned that there is no definition of "toxic hazard zone" in other codes under SOLAS.<br>It was also mentioned that air inlets, outlets and openings to enclosed space are not to be located in toxic hazard zone. |
| AA) Which space is to be considered as toxic hazard zone. Is current conventional fire hazardous area zones (Zone 0/1/2) as stipulated in 12.5 of IGF Code to be adequate, or is further extended space to be defined as toxic hazard zone. |
| BB) What restriction/prohibition in such zone to be imposed, e.g.:<br>- openings to enclosed spaces are not to be located in the zone<br>- escape route is not to pass through the zone<br>- firefighting control station and access to it are not to be located within the zone |
| Members' responses: |
| AA)<br>These zones need to be determined using modelling in a similar manner to that described above.<br>BB)<br>To be further discussed, and informed by modelling results. |

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| See above.<br>*"It is needed to clarify what is the goal for "toxic hazard zone".*<br>*Toxic hazard zone may differ from hazardous area defined in IGF in many points, such that permissible range of leakage and the standard applied for electrical equipment.*<br>*With regard to venting, it may be impracticable to reduce the concentration of ammonia to the criterion, e.g., 400 ppm, just by segregation distance, in particular, in case of fire. So, appropriate means to reduce the ammonia in the gas from vent outlet may be necessary.*<br>*Therefore, it is deemed premature to discuss the concrete requirements."* |
| AA)<br>We assume this point does not consider the flammability of ammonia, but toxicity. Zone 0, 1 and 2 are not relevant terms when toxicity is discussed. We do not consider IGF Code requirements for hazardous zones to be adequately large to consider the toxic aspect of ammonia.<br>BB)<br>To us, none of the mentioned in the list should be within toxic zone, also air intakes or outlets. |
| AA)<br>Tentatively we define toxic hazard zone similar to conventional hazardous area zone, but we consider further investigation is necessary.<br>BB)<br>We require all items mentioned in the list are not located in the toxic hazard zone. |

Q3.6

Finally, the members were asked to provide suggestions on additional basic concepts that may potentially need consideration for safety measures with respect to using ammonia as fuel.

While there is a plenty of room for further discussion, some of the following things were suggested: the consideration of operational safety measures to protect the crew and others in charge of operations involving ammonia; designing ammonia fuel containment and fuel supply systems which do not release certain concentrations of ammonia into the atmosphere (not greater than 30 ppm for instance) except in some situations like in the case of a fire; and, the containment of ammonia itself together with associated processes and hazards.

| Q3.6) Is there any other basic concept to be potentially considered for safety measures. |
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| Members' responses: |
| To be further investigated. |
| It may be necessary to consider operational safety measures to protect crew and other persons in charge of works related to ammonia*.<br>*Refer to MSC 104/15/9 and MSC 104/15/30 |
| Not specifically at this point. |
| Further investigation required. |
| There are many considerations to take. The most important aspect is that both a ammonia fuel containment system and the ammonia fuel supply system shall be designed to not release ammonia to the atmosphere in a greater concentration than 30ppm (except in fire cases where the tank vent valves may discharge ammonia to the vent mast). |
| Further investigation is needed and many considerations. Containment itself - because of the toxicity - is key.<br>The realities of obvious processes which need to be undergone (e.g. maintenance) and what hazards need to be avoided during that - are another consideration.<br>The actual methodology/structure of IGF needs revision with the introduction of Ammonia (and Hydrogen). Also, the 'neighbourhood risk' that exists (as a result of proliferation across a plethora of ship types and nations, as well as because of the nature of the fuels themselves) needs agreeing as to whether this is considered within IGF code updates or whether it should be covered elsewhere. |

With the above, the MTF Project Ammonia discussions ended, at least for the time being.

## 4. CONCLUDING REMARKS

Having shared the ideas and suggestions from various parties comprising the MTF (i.e. Flag State Administrations and classification societies), it was found that there are certain topics on which the members share a common understanding, whereas further investigations and discussions in detail may be necessary for those areas in which there are still differences in opinions.

Although many uncertainties and concerns remain in terms of the best way forward regarding the development of an international safety regulatory framework on the use of ammonia as an alternative fuel for ships, the MTF hopes that the observations and findings from this project would contribute to future discussions on alternative fuels and help promote further decarbonization efforts within the maritime industry.

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