Recent Information on the Development of IMO Guidelines for the Safety of Ships Using Ammonia as Fuel and Initiatives of ClassNK for Practical Application of Ammonia-Fueled Ships

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1. INTRODUCTION

In recent years, with the strengthening of regulations to prevent air pollution and suppress global warming, the international shipping sector has actively conducted studies on the use of alternative fuels such as low-carbon fuels and decarbonized fuels, which have low environmental impacts, in place of petroleum fuels as fuels for next-generation ships.

At present, introduction of ships that use LNG, LPG, methanol/ethanol, etc. is continuing to expand in order to respond to SOx and NOx regulations. Although it is possible to reduce CO_2 emissions from ships that use conventional fuel oil by 10 % to 25 % by using these fuels, heightened expectations are placed on ammonia and hydrogen fuels, which do not contain carbon, to realize net-zero GHG emissions by or around 2050, which is the target level set by the International Maritime Organization (IMO) in its Strategy on Reduction of GHG Emissions from Shipping.

In these circumstances, the IMO issued Interim Guidelines for the Safety of Ships Using Ammonia as Fuel in February 2025, specifying safety requirements when using ammonia as a fuel for ships.

This paper introduces recent information on the development of the IMO's Guidelines for the Safety of Ships Using Ammonia as Fuel, and the initiatives of ClassNK (hereinafter, the Society) for practical application of ammonia-fueled ships.

2. STATUS OF DEVELOPMENT OF GUIDELINES FOR THE SAFETY OF SHIPS USING AMMONIA AS FUEL AT THE IMO

2.1 Status of Development of Safety Guidelines for Ammonia Fuel

At its meeting in September 2024, the 10th session of the Sub-Committee on Carriage of Cargoes and Containers (CCC10), a subordinate organization of the IMO's Maritime Safety Committee (MSC), finalized Draft Interim Guidelines for the Safety of Ships Using Ammonia as Fuel for ships other than liquefied gas carriers. Subsequently, the Guidelines finalized at CCC10 were approved at the 109th session of the Maritime Safety Committee (MSC109) in December 2024, and the IMO Interim Guidelines (MSC.1/Circ.1687) were issued in February 2025.

The details of discussions on the Guidelines in CCC10 will be explained in the following Chapter 3. The discussions on the provisions (i.e., specific provisions for achieving the functional requirements) of all chapters of the Guidelines were not completed at CCC10 due to time limitations. The items discussed at that meeting were mainly the goals and functional requirements of each chapter. While some of the specific provisions were discussed, other requirements were basically finalized by adding special requirements related to ammonia, referring to the International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF Code). Ongoing reviews of the Guidelines in future sessions of Sub-Committee on Carriage of Cargoes and Containers based on appropriate information collection and technical discussions are planned.

2.2 Status of Development of Guidelines for the Safety of Liquefied Gases Carriers Using Ammonia as Fuel

In addition to the above-mentioned Guidelines for the Safety of Ships Using Ammonia as Fuel, the IMO is also currently developing safety guidelines for liquefied gas carriers using ammonia as fuel, to which the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) applies. A proposal for these guidelines was submitted in CCC10, and in the future, work related to the development of the Guidelines will be carried out by the Correspondence Group etc. The draft Guidelines are scheduled to be finalized in CCC11 in 2025.

3. COMMENTARY ON IMO GUIDELINES FOR THE SAFETY OF SHIPS USING AMMONIA AS FUEL

3.1 Discussions on Development of Guidelines for the Safety of Ships Using Ammonia as Fuel

This section presents an overview of the discussions on the Guidelines for the Safety of Ships Using Ammonia as Fuel (hereinafter, referred to as "the Guidelines") in CCC10. Based on the draft, the Guidelines were discussed in CCC10 from various viewpoints, including the scope of application, goals and functional requirements of the Guidelines, ship design and arrangement, the ammonia fuel containment system, prevention of exposure to toxicity, etc.

The Guidelines comprise Chapter 1 to Chapter 20. However, as mentioned above, due to time constraints, discussions on the provisions of each chapter of the Guidelines was not completed at CCC10. The discussions focused mainly the goals and functional requirements of each chapter, and the document was finalized by agreement on the goals and functional requirements. However, some provisions (e.g., Chapter 5 through Chapter 6, 6.9, Chapter 12bis) were discussed, and those provisions were included in the Guidelines. Other requirements were basically finalized by adding only special requirements related to ammonia, referring to the requirements of the IGF Code. A list of the chapters of the Guidelines and the status of the discussions are shown in Table 1.

Table 1　Composition of IMO Interim Guidelines and status of discussions on each chapter

Chapter No.	Chapter title	Goal	FR (Functional Requirements)	Provisions (specific requirements)
1	INTRODUCTION	Agreed at CCC9 (2024)		
2	GENERAL	Agreed at CCC9 (2024) + Agreed on remaining items		
3	GOAL AND FUNCTIONAL REQUIREMENTS	Agreed at CCC9 (2024) + Agreed on remaining items		
4	GENERAL PROVISIONS	Agreed at CCC9 (2024)		
5	SHIP DESIGN AND ARRANGEMENT	Agreed	Agreed	Agreed
6	FUEL CONTAINMENT SYSTEM	Agreed	Agreed	Partially agreed
7	MATERIAL AND GENERAL PIPE DESIGN	Agreed	Agreed	Partially agreed
8	BUNKERING	Agreed	Agreed	Partially agreed
9	FUEL SUPPLY TO CONSUMERS	Agreed	Agreed	Partially agreed
10	POWER GENERATION INCLUDING PROPULSION AND OTHER FUEL CONSUMERS	Agreed	Agreed	Agreed to refer to IGF Code
11	FIRE SAFETY	Agreed	Agreed	Agreed to refer to IGF Code
12	EXPLOSION PREVENTION	Agreed	Agreed	Agreed to refer to IGF Code
12bis	PREVENTION OF EXPOSURE TO TOXICITY	Agreed	Agreed	Agreed
13	VENTILATION	Agreed	Agreed	Agreed to refer to IGF Code
14	ELECTRICAL INSTALLATIONS	Agreed	Agreed	Agreed to refer to IGF Code
15	CONTROL, MONITORING AND SAFETY SYSTEMS	Agreed	Agreed	Partially agreed
16	MANUFACTURE, WORKMANSHIP AND TESTING	Agreed to excerpt Chapter 16, B-1 of IGF Code		
17	DRILLS AND EMERGENCY EXERCISES	Agreed	Agreed	Agreed to refer to IGF Code
18	OPERATION	Agreed	Agreed	Agreed to refer to IGF Code
19	TRAINING	Agreed	Agreed	Agreed to refer to IGF Code
20	PERSONNEL PROTECTION	Agreed	Agreed	Agreed to refer to IGF Code

*Chapter 12bis is a new chapter, but because consistency with the existing IGF Code was prioritized, this chapter was not assigned a new number.

Since sufficient discussions on the provisions of each chapter were not carried out, some members expressed opposition to finalizing the draft Interim Guidelines. However, since projects involving ships using ammonia as fuel are already in progress in various countries, and prompt issuance of the Guidelines is required, the majority favored finalizing the Guidelines, as a result,

the Interim Guidelines were finalized at CCC10. Considering the "provisional status" of the Guidelines, the Introduction includes a note to the effect that the Guidelines "may not include specific provisions with details on how to achieve these functional requirements in all cases."

It was also agreed that the Interim Guidelines will be reviewed in the future after more detailed technical discussions and accumulation of information.

3.2 Overview of the IMO Guidelines for the Safety of Ships Using Ammonia as Fuel

This section introduces the main content of the discussions in the development of the IMO Guidelines for the Safety of Ships Using Ammonia as Fuel, and the provisions of the guidelines related to those points.

3.2.1 Application of the Guidelines

It was agreed that the scope of application of the Guidelines excludes liquefied gas carriers, which are subject to application of the IGC Code. As mentioned above in 2.2, preparation of separate safety guidelines for ships subject to the IGC Code is planned.

3.2.2 Prevention of Exposure to Toxicity (Classification of Toxic Areas and Toxic Spaces)

To limit the risk of direct exposure to ammonia for persons on board, it was agreed to classify the areas and spaces of a ship as "toxic areas" (areas in which ammonia is or may be expected to be present on the open deck) and "toxic spaces" (enclosed or semi-enclosed spaces in the ship where leakage of ammonia may occur) in order to arrange life-saving appliances, escapes routes, air intakes and outlets, openings for accommodations, etc. in safe areas. The related requirements are provided in the Guidelines.

"Toxic areas" are defined as areas where ammonia leaks may occur and the distance (range) from those areas is within 10 m of flanges, valves and other potential leakages sources in ammonia fuel piping systems and within 25 m of vent posts, etc. "Toxic spaces" are defined as the interiors of fuel storage equipment and enclosed or semi-enclosed spaces in which potential sources of release, such as single-walled piping containing fuel, are located. (also including the interiors of fuel tanks, fuel preparation rooms and secondary enclosures, and potential sources of leakage).

In toxic areas, in addition to the prescriptive distance requirements, the Guidelines also stipulate that a gas dispersion analysis should be carried out to demonstrate that an unacceptable ammonia concentration (220 ppm) will not exceed the normative distance and reach nontoxic areas such as the air intakes of accommodations, etc. The image of a toxic area is shown in Fig. 1.

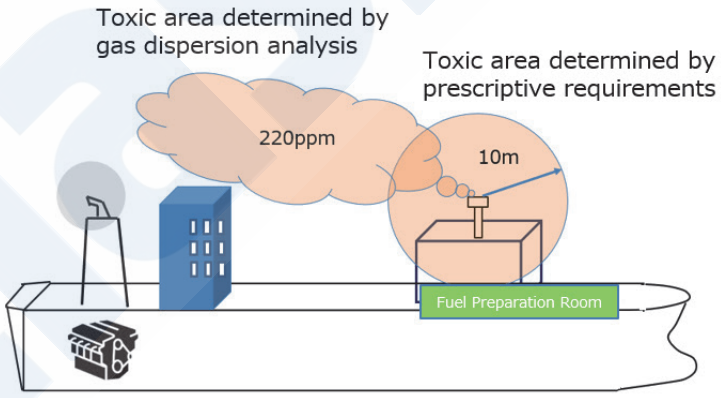

Fig. 1 Image of toxic area

3.2.3 Safe Havens

In preparation for potential ammonia leaks, it was agreed that "safe havens" capable of accommodating all persons on board the ship should be arranged in one or more enclosed spaces. The Guidelines stipulate that safe havens are to be arranged in locations that are essential for the ship's operation (e.g., the bridge and the engine control room), and are to be places where it is possible to maintain the environment within the space (e.g., spaces with a self-sustaining air supply), so that ammonia will not be flowed from outside.

3.2.4 Ammonia Exposure Limit and Activation of Alarms and Safety System

Discussions were held on the ammonia exposure limit and the thresholds for the activation of alarms and safety equipment. However, agreement on the exposure limit for persons on board was not reached, as there are differences in the work standards

in each country, such as the available standards for exposure limits, the Acute Exposure Guideline Levels (AEGLs) and the National Institute for Occupational Safety and Health (NIOSH) exposure limit guidelines.

The activation levels for alarms and safety systems were also discussed, including the action to be taken in case ammonia liquid or vapor is detected in each space, and the threshold values for the concentration and the response when that concentration is detected were specified as follows.

- Visual alarms are to be provided at the entrance to toxic spaces, and the alarm setting value (activation level) is an ammonia concentration of 25 ppm in the space.
- When a gas concentration exceeding 110 ppm is detected, visual and audible alarms are activated in spaces where persons are present. Visual and audible alarms are given on the navigation bridge, in the continuously-manned central control station, and inside and outside the space where the leak is detected.
- When a gas concentration exceeding 220 ppm is detected, the safety system is activated.

3.2.5 Ammonia Releases

As a basic principle, it was agreed that direct releases of ammonia under the normal operating condition are not allowed. Under controllable conditions, it was agreed that the amount of releases should basically kept to the minimum by using the ammonia release mitigation system. It was also agreed that uncontrollable releases of ammonia are to be limited to catastrophic conditions such as activating of the pressure valve of a fuel tank, etc. In foreseeable and controllable events, the Guidelines specify that the ammonia concentration must be reduced to less than 110 ppm by the ammonia release mitigation system. As used here, releases due to “foreseeable and controllable events” mean gas bleeds from double-block bleed valves of the fuel piping system, releases from safety valves of the fuel piping system, releases of purging gas and discharge of drain from fuel pipes, and the like.

3.2.6 Ship Design and Arrangement

Regarding the ship design and arrangement, it was agreed that requirements are to be specified for each ammonia-related space and area, including fuel preparation rooms, tank connection spaces, bunkering stations, etc. From the viewpoint of preventing exposure to toxicity, the Guidelines stipulate that openings of escape routes and openings of accommodations shall not be arranged in toxic areas. The Guidelines also specify that engine rooms are allowed only in gas-safe machinery spaces, and the fuel pipes in engine rooms are to be protected by a gas-tight secondary enclosure.

3.2.7 Fuel Containment Equipment

In pressurized or semi-refrigerated, semi-pressurized ammonia storage, the danger of ammonia spewing out when a leak occurs in the ammonia containment system is a concern, whereas in the case of low temperature ammonia, the evaporation rate is extremely low, even if a leak occurs. For this reason, it was agreed that the development of the Guidelines should be preconditioned on storage at atmospheric pressure and in a fully-refrigerated condition. Thus, even though pressurized type and semi-refrigerated, semi-pressurized type ammonia storage are not described in the Guidelines, it was agreed that those storage methods are not prohibited, and they may be allowed based on alternative designs. In discussions on the tank pressure and temperature control, it was agreed that the temperature of the liquefied ammonia in fuel tanks is to be maintained at no more than -30 °C at all times.

3.3. Study Items Related to the Requirements of the Guidelines

As mentioned above in 3.1 and 3.2, although safety requirements for ammonia-fueled ships are provided in the IMO’s Interim Guidelines, there are many remaining points that were not discussed sufficiently because priority was given to finalizing the Guidelines. Therefore, in actual ship construction, it is considered necessary to adjust the safety requirements of the ship with the Administration on a case-by-case basis. For reference, this section describes the main items among those which the Society believes will require consultation with the Administration in actual ship construction. Because these items are related to the basic design, consultation as early as possible in the design stage is recommended.

3.3.1 Ammonia Temperature in Fuel Tanks

Section 6.9.1.1 of the Guidelines specifies that “The temperature of the liquefied ammonia in the fuel tanks should be maintained at a temperature of no more than -30°C at all times by means acceptable to the Administration.” The interpretation of “at all times” was discussed in the Working Group (WG) of CCC10. For example, since the temperature of the ammonia supplied during bunkering is approximately -33 °C, it can be assumed that the temperature will temporarily exceed -30 °C, even if the tanks are cooled down. Therefore, the CCC10 attempted to confirm whether this requirement is also applicable during

bunkering. Although the conclusion was unclear, some Administrations also included the temperature during bunkering. On the other hand, assuming this requirement is to be achieved, it will be necessary to reduce the temperature of the ammonia which is actually supplied to an extremely low level. Thus, as a practical matter, it is assumed that the temperature of the ammonia will temporarily exceed -30 °C. As an additional issue, it is also necessary to confirm the meaning of "at all times" in this requirement with the Administrations, assuming abnormal conditions such as blackout, etc.

3.3.2 Pressurized or Semi-Refrigerated, Semi-Pressurized Ammonia Storage

In the development of the Guidelines, it was agreed that the Guidelines would be preconditioned on storage of ammonia at atmospheric pressure and in a fully-refrigerated condition. However, in the WG, there seemed to be many participating members who thought that pressurized or semi-refrigerated, semi-pressurized storage should be recognized. This is due to the fact these are recognized storage methods for liquefied gas carriers that current transport ammonia as a cargo, and the existing infrastructure facilities, which are expected to be candidates for infrastructure to supply ammonia fuel in the future, perform storage by the pressurization method or the semi-refrigerated, semi-pressurized method. Under these circumstances, how to establish the safety of the pressurization method and semi-refrigerated, semi-pressurized method is an issue. Three methods for demonstrating safety exist: a method using performance criteria, which are generally set based on the applicable rule, a method using specific risk assessment criteria, based on a relative comparison with the rule design ship risk (both shown in Fig. 2), and a comprehensive risk assessment using an allowable standard of total risk (Fig. 3). Although a detailed explanation will be omitted here, among these three methods, it is thought that the comprehensive risk assessment method should be used in demonstrating the safety of alternative designs for these requirements. When this method is used, it is essential to note that it is necessary to set the allowable risk standard, and it is necessary to decide this standard through consultation with the Administration. In actuality, there are no actual results of calculations of this type of risk for the refrigeration method, the semi-refrigerated, semi-pressurized method, or the pressurization method, and whether a risk standard agreeable to the ship operator and the Administration can be worked out is unknown. Therefore, we recommend that demonstrations of safety for these methods should be completed in the previous stages of basic design.

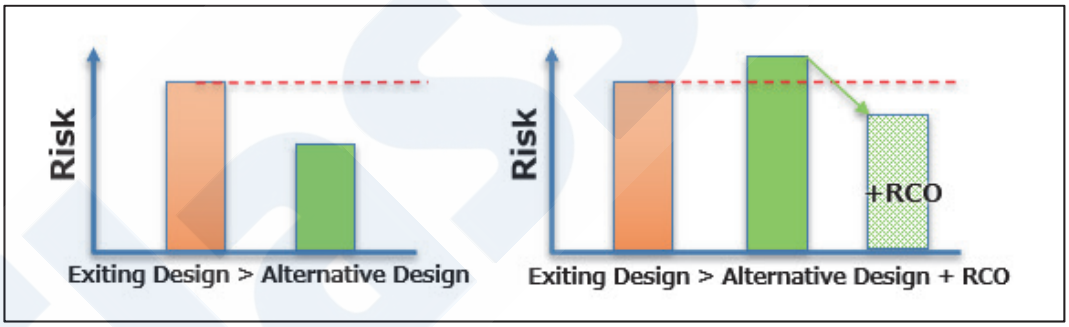

Fig. 2 Evaluation methods using specific risk assessment criteria

Fig. 3 Comprehensive risk assessment method

3.3.3 Foreseeable and Controllable Events

The WG in the CCC10 also conducted discussions on the question of whether leaks from piping, etc. are "foreseeable and controllable events." Some WG members asserted that, assuming leaks from pipes, etc. are foreseeable and controllable events, even leaked ammonia should not be discharged directly into the atmosphere, but should be discharged after treatment through

the ammonia release mitigation system. On the other hand, there were also members who argued that even assuming leaks from pipes, etc. are foreseeable, they cannot be controlled leading to the conclusion that the Administration should decide whether the leaked ammonia must be treated or not when a leak accident occurs. Since whether leaked ammonia is treated or not will also affect the basic design, it is necessary to confirm the interpretation of this point with the Administration at an early timing. Since the Society assumes that leaked ammonia will be released into the atmosphere from a safe location as a precondition, we think that release via the ammonia release mitigation system is not necessarily required. Since a gas dispersion analysis is carried out in order to set toxic areas in either case, it is essential to decide whether to implement ammonia mitigation measures or not, considering the range and degree of the effect.

3.3.4 Gas Dispersion Analysis Methods

When carrying out a gas dispersion analysis, the analysis conditions have a large influence on the results. For example, in the dispersion analysis to set the toxic area, the range of the toxic area will differ greatly depending on how the wind direction and wind velocity are set. The setting of the leakage rate also has a large influence on the results. In the discussions in the WG of the CCC, there was an argument to the effect that the approval of the Administration should be obtained for the analysis conditions used in gas dispersion analyses by CFD analysis, etc. Generally, the analysis conditions in CFD analyses indicate boundary conditions such as Dirichlet conditions, Neumann conditions, wall conditions, etc., but it is necessary to bear in mind that the items discussed with the Administration are the conditions assumed in the above-mentioned analysis, rather than the general boundary conditions of a CFD analysis.

3.3.5 Fire Protection and Fire Fighting

The requirements related to fire protection and fire fighting in Chapter 11 of the Guidelines are specified to refer to Chapter 11 of the IGF Code. The fire protection and fire fighting requirements in Chapter 11 of the IGF Code were developed for LNG. However, the fire risk of ammonia is overwhelmingly lower than that of LNG, suggesting the possibility that the requirements of Chapter 11 of the IGF Code are excessive for ships which handle ammonia as a fuel. For example, the Society considers that a flammable atmosphere cannot be formed on an open deck from the range of ammonia combustion, which implies that fire protection and fire fighting requirements for open decks are not necessary, so these requirements are not contained in our Guidelines. Because Chapter 11 of the IMO Interim Guidelines was not discussed due to time constraints, the Society believes that this item should also be decided through consultation with the Administration.

4. FUTURE ACTIONS OF THE SOCIETY

The content of provisions (Chapter 5 to Chapter 6, 6.9, Chapter 12bis, etc.) in the IMO Interim Guidelines introduced in this paper which were discussed in detail in CCC10 are also planned for inclusion in Part C-1 of the ClassNK Guidelines for Ships using Alternative Fuels.

In future work to develop guidelines for liquefied gas carriers using ammonia fuel and revisions of Guidelines for the Safety of Ships Using Ammonia as Fuel, the Society also intends to contribute actively to the discussions using the results of survey studies carried out up to the present. In the future, the Society will continue to review its Guidelines regularly, considering the most recent status of discussions in the IMO and the rapid development of new technologies, and will work to develop guidelines that will be useful for developers.

REFERENCE

1) IMO, MSC.1/Circ.1687 INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING AMMONIA AS FUEL