Safety Requirements for Construction and Equipment of Ships Using Methanol as Fuel

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1. INTRODUCTION

In the international shipping sector, stricter regulations for prevention of air pollution and global warming have been applied in the recent years. In line with these trends, active study of the use of environment-friendly alternative fuels in place of fossil fuels is underway. In particular, development of LNG, LPG and methyl/ethyl alcohol as alternative fuels as a next-generation fuel for ships is progressing, and substantial reductions in SOx emissions are possible if they are used as fuels, as they do not contain sulfur. Moreover, reductions in CO_2 emissions are also expected. Achievement of net zero GHG emissions over the life-cycle of fuels by utilizing green methanol such as biomethanol derived from sustainable biomass or e-methanol produced using renewable energy, *etc.* is also being studied.

On the other hand, in order to use methanol as a fuel for ships, it is necessary to consider its safety. In comparison with conventional fuels, the properties of methanol include a wide combustion range, small minimum ignition energy (low flashpoint), toxicity to the human body and difficulty in confirming a flame when it ignites. The safety of methanol fuel must be verified for these factors.

Under the SOLAS Convention, Chapter II-1, Regulations 56 and 57, ships using methanol as fuel must satisfy the “International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels” (hereinafter, “the IGF Code”). However, the IGF Code does not describe the concrete safety requirements when using methanol as a fuel. Requirements are currently limited to MSC.1/Circ. 1621 “INTERIM GUIDELINE FOR THE SAFETY OF SHIPS USING METHYL/ETHYL ALCOHOL AS FUEL” issued by the IMO, and mandatory safety requirements have not been specified by international conventions, *etc*.

To contribute to the development of safety requirements for the construction and equipment of ships using methyl alcohol (methanol) as fuel, ClassNK (hereinafter, “the Society”) summarized the requirements for ensuring the safety of ships that use methanol as a fuel in Part A of the “Guidelines for Ships Using Alternative Fuels”.

This paper presents an overview of the guidelines for safety requirements for the construction and equipment of ships using methanol as a fuel, together with a commentary on the points that require attention when designing methanol-fueled ships.

2. GUIDELINES FOR SHIPS USING ALTERNATIVE FUELS, PART A

2.1 Overview

In August 2021, the Society issued Guidelines for Ships Using Alternative Fuels, Part A “Guidelines for Ships using Methyl/Ethyl Alcohol as Fuel”. Subsequently, the content of the IMO’s Interim Guideline, MSC.1/Circ. 1621 was incorporated in September 2021, and the Society released a partially-revised version of Part A as part of Guidelines for Ships Using Alternative Fuels (Edition 2.0) (hereinafter, “the Guidelines”) in June 2022.

2.2 Main Requirements of the Guidelines

2.2.1 Structure of the Guidelines

The Guidelines specify the safety-related requirements in case methanol is used as a fuel. Functional requirements are provided in Chapter 3, general requirements including risk assessment are provided in Chapter 4 and specific requirements for ships using methanol as a fuel are provided in Chapter 5 and thereafter.

2.2.2 Functional Requirements (Chapter 3)

Chapter 3 of the Guidelines specifies the functional requirements for the purpose of safe and environment-friendly design, construction and operation of propulsion machinery, auxiliary power generation machinery and/or other purpose machinery utilizing methanol.

The prescriptive requirements of these Guidelines are determined based on the totality of these functional requirements. Even in cases where a design deviates from the prescriptive requirements stipulated in the Guidelines, the design must be consistent with the functional requirements.

2.2.3 General Requirements (Chapter 4)

A risk assessment must be performed to verify the risks arising from the use of methanol fuel to persons on board, the environment, the structural strength or the integrity of the ship. Unlike LNG-fueled ships, the target scope of the risk assessment is not limited; that is, all potential hazards originating from methanol fuel must be studied. This is expected to make it possible to cope with dangers that cannot be addressed by the prescriptive requirements provided in the Guidelines.

In addition to this risk assessment, it should be noted that there may be cases in which demonstration of safety equivalence may be required as a deviation from the IGF Code, depending on the ship's flag country.

2.2.4 Ship Design and Arrangement (Chapter 5)

a) Tank arrangement

Methanol fuel tanks (hereinafter, "fuel tanks") can be integral fuel tanks or independent fuel tanks. To avoid the effects of heat due to external fire and prevent leakage of toxic, flammable methanol into other parts of the ship, integrated fuel tanks are to be surrounded by a protective cofferdam. However, installation of a protective cofferdam is not required for fuel tanks on surfaces bound by shell plating below the lowest possible waterline or other fuel tanks containing methanol, or surfaces that form the boundary with the fuel preparation space. Independent fuel tanks installed in the fuel storage hold space or on the open deck are acceptable.

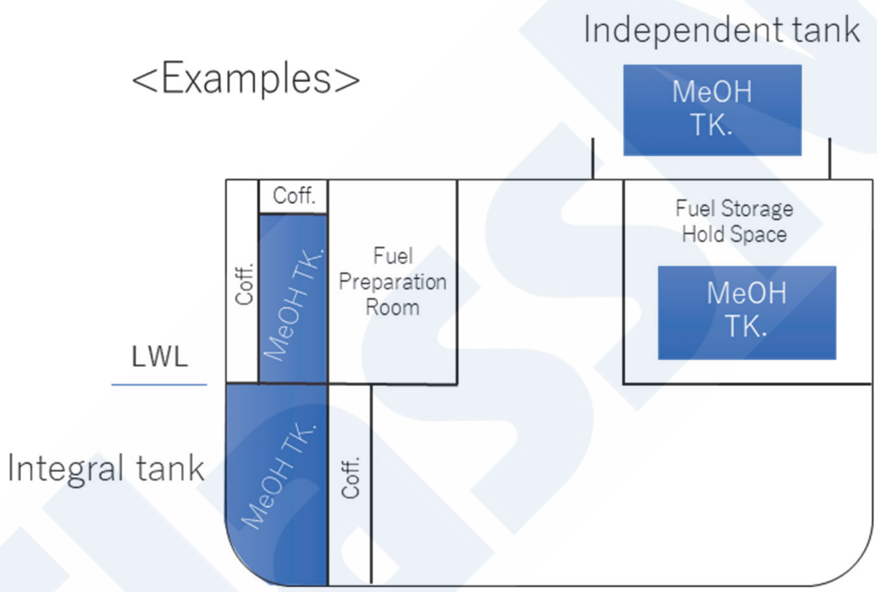

Fig. 1 Examples of arrangements of methanol fuel tanks

In case cargo-and-fuel tanks are installed in the cargo area of a chemical tanker, safety is considered to be guaranteed by the concept of the IBC Code, and the above-mentioned requirements notwithstanding, this is treated as a case in which a protective cofferdam around cargo-and-fuel tanks is not required.

To reduce the risk of damage due to collision, the fuel containment system is required to be arranged abaft of the collision bulkhead and forward of the aft peak bulkhead. This requirement is also applicable to fuel tanks on the open deck. Unlike the IGF Code, which is applicable to LNG-fueled ships, study of the fuel tank arrangement by probabilistic methods is not permissible.

b) Access to enclosed spaces containing fuel-related equipment

Direct access from non-hazardous areas to hazardous areas related to methanol fuel as provided in these Guidelines should not be permitted. In cases where such an opening is necessary for operational reasons, access by providing an airlock is permissible. However, as stipulated in Chapter 12, areas that are protected by an airlock during normal operation can be regarded as non-hazardous areas, but the equipment to be used in case the pressure differential between the protected area and the hazardous area is lost must be certified or demonstrated as suitable for use in hazardous area zone 1. Therefore, care is necessary in case of arrangements that provide direct access to the engine room from a hazardous area, even if an airlock is installed between those areas, because the equipment used in the engine room in case the pressure differential is lost is required to be an explosion-proof type suitable for hazardous area zone 1.

c) Leakage countermeasures

Drip trays are to be fitted in places where fuel leakage may occur, in particular, in way of single wall pipe connections. The capacity of drip trays must be sufficient to ensure that the maximum amount of spill according to the risk assessment can be handled. Means to safely drain or transfer methanol that has leaked into a drip tray to a dedicated holding tank are to be provided. In addition to collecting the leakage from drip trays, holding tanks must be able to collect the drain or possible leakage of methanol fuel from fuel pumps, valves and the inner pipe of double walled pipes installed in enclosed spaces. If methanol fuel is collected in holding tanks in normal operation, the Society basically thinks that it is necessary to apply the same conditions as those for fuel tanks to the holding tanks, and therefore does not accept installation in the engine room.

2.2.5 Fuel Containment System (Chapter 6)

The provisions of the Guidelines related to fuel containment systems partially incorporate the provisions of the IBC Code applied to chemical tankers that store and transport methanol as a cargo. Fuel tanks are to be fitted with a controlled tank venting system, pressure and vacuum relief valves are to be fitted on each fuel tank, and the vent outlet is to be fitted with a flame arrestor. Fuel tanks are required to be inerted with an inert gas at all times under the normal operation condition. Therefore, it should be noted that installation of the open air pipes fitted on ordinary fuel oil tanks is not acceptable.

To avoid exposure of the crew to methanol vapor, fuel tank vent outlets must be situated not less than 3 m above the deck, or not less than 3 m from the gangway if the vent outlet is located within 4 m from a gangway. Vent outlets are to be arranged at a distance of at least 10 m from the nearest air intake or opening to accommodation spaces and service spaces (living and working spaces) and ignition sources. Care is necessary in case of bulk carriers, *etc*., in which the fuel tanks and accommodation spaces tend to be located in close proximity to each other.

The availability (capacity) of inert gas to be used on a ship is to be decided taking into account the amount of inert gas necessary to achieve at least one voyage, considering the maximum expected fuel consumption and the length of the voyage, and the amount of inert gas necessary to keep the fuel tanks inerted for 2 weeks with minimum fuel consumption while in harbour. The Guidelines permit the use of an inert gas production plant and/or storage facilities to achieve this inert gas availability. In actuality, it appears that many shipbuilders and operators plan to providing onboard nitrogen generators.

2.2.6 Materials and General Pipe Design (Chapter 7)

The corrosiveness of the fuel is to be considered when selecting materials. In general, it appears that many plans use austenitic stainless steel as the material for fuel pipes and austenitic stainless steel or painted ordinary rolled steel for hull use as the material for fuel tanks. Because the methanol which is generally used as fuel contains additives and impurities, the Society also wishes to verify the methanol compatibility of the materials selected with the material or paint manufacturer from this perspective.

In determining the necessity of class materials in methanol fuel pipes, the items in connection with fuel oil in Table D 12.1 Classes of Pipes in the Society’s Rules for the Survey and Construction of Steel Ships (hereinafter, “the Rules”), Part D apply mutatis mutandis, and pipes are treated according to the classification of pipes by design pressure and design temperature. In accordance with the Rules, Part D 12.1.4-2(1), materials for pipes classified as Group I or Group II are required to conform to the Rules, Part K. Those classified as Group III may also be used according to Part D 12.1.4-2(2), provided they comply with a standard which is recognized as appropriate by the Society. For items related to the outer pipes of double walled fuel pipes, reference is to be made to the items for air as the type of medium in the Part D, Table D 12.1. Reference is to be made to the applicable provisions, corresponding to the grade of the pipe.

The inner piping of double walled pipes is to be full penetration butt welded and subjected to full radiographic testing. Flange connections are only permitted within the tank connection space, fuel preparation space or similar. However, use of flange connections is permitted in the outer piping of double walled pipes.

2.2.7 Bunkering Station (Chapter 8)

a) Prevention of vapour accumulation

The bunkering station is to be located on the open deck so that sufficient natural ventilation is provided. In case a bunkering station is to be installed in a closed or semi-enclosed space, in addition to providing mechanical ventilation, *etc*., its safety is to be verified by a risk assessment.

b) Prevention of hose breakage

To prevent breakage of bunkering hoses due to excessive loads, the connections at the bunkering station are to be of a dry-disconnect type (which does not allow fuel to spill in case of separation) equipped with a dry break-away coupling or self-sealing quick release function.

c) Bunkering lines

Bunkering lines are to be capable of inerting and gas freeing, and unless otherwise approved, bunkering lines must be in a gas-free condition when not being used in bunkering.

In chemical tankers equipped with cargo-and-fuel tanks, application of Chapter 8 of the Guidelines is not compulsory in cases where the cargo manifold and the bunkering manifold are used in common. In treating this case, the provisions of the Chapter 8 when the bunkering manifold is independent are applied. Furthermore, even in cases where the cargo manifold and bunkering manifold are used in common, the line used to load the cargo-and-fuel tanks is to be separated from other cargo lines by a removable spool piece or similar.

d) Mitigation of effects of methanol exposure

To mitigate the effects of exposure of personnel to methanol, emergency decontamination showers and eyewash stations must be arranged in close proximity to areas where there is a possibility of contact with fuel. It must be possible to use these facilities under all ambient conditions.

2.2.8 Fuel Supply to Consumers (Chapter 9)

In the basic design concept for methanol fuel, consideration is to be given to preventing of fuel leaks that expose the persons onboard, the environment or the ship to danger. Redundancy must be secured by arranging the propulsion, electric power and fuel supply systems in such a way that a single failure of fuel supply will not lead to an unacceptable loss of power.

Leakage is to be considered in fuel lines that pass through enclosed spaces in the ship. In surrounding spaces, such fuel lines are to be arranged inside a gas-tight and liquid-tight pipe or duct, and the annular space between the fuel pipe and the outer pipe or duct must be ventilated by mechanical underpressure ventilation with a capacity of at least 30 air changes per hour.

Regarding the dimensions of the outer pipe of double walled fuel pipes, the design pressure is not to be less than the working pressure of the inner pipe. In determining the dimensions of ducts, it is possible to use the calculated value of the maximum pressure in the duct in case the inner pipe ruptures. Because the current ship class rules do not provide calculation formulae for specifying the maximum pressure in ducts, appropriate formulae, analytical software, *etc*. may be selected and used.

The drain of double walled pipes in the engine room is to be led to a holding tank. As an alternative, when a drainage cock or similar is provided at the lowest part of the double walled pipe, connection to a portable drain tank and manual drain discharge by the crew is also permissible when leakage is detected. In this case, the portable drain tank containing the leaked fuel is to be stored in an area deemed to be appropriate in terms of safety, or the content of the portable tank is to be transferred to a holding tank. Portable drain tanks are not subject to the requirements for portable fuel tanks.

Installation of an automatically-operated master fuel valve may be mentioned as one requirement for the main engine fuel supply lines to individual fuel consumer or sets of consumers. These valves are to be situated in piping outside of the machinery space containing the fuel consuming equipment. Valves related to the safety function of the fuel supply equipment are required to be a fail-safe type that will operate prioritizing safety, even if power for valve operation is lost.

2.2.9 Use of Fuel (Chapter 10, Power Generation Including Propulsion and Other Energy Converters)

Chapter 10 of the Guidelines specifies the provisions for the use of dual-fuel engines and methanol single fuel engines as engines using methanol. In case use of methanol with other types of equipment is planned, it should be noted that those applications must also conform to the goal and functional requirements of Chapter 10.

2.2.10 Fire Safety (Chapter 11)

a) Containment of fire

In principle, the requirements for fire protection construction follow Chapter 9 of the Rules, Part R However, this chapter provides additional requirements for spaces that are specific to ships using methanol as a fuel. For example, since the fuel preparation spaces of methanol-fueled ships are regarded as category A for fire protection purposes, appropriate fire protection integrity is required at the boundaries with adjoining spaces. As for the fact that fuel preparation spaces are regarded as category A, this classification is only applied when studying fire protection construction. It is not necessary to regard fuel preparation spaces as category A machinery areas when providing the “means of escape” in SOLAS II, Chapter 2, Regulation 13. In this case, the same escape requirements as those for other machinery spaces can be applied.

b) Firefighting equipment

A fixed fire detection system and fire alarm system complying with the FSS Code is to be provided in all compartments containing the methanol fuel system. Based on the characteristics of methanol fires, devices which are capable of detecting methanol fires, such as heat-detection devices, *etc*. are required in addition to smoke detectors.

The representative requirements in cases where fuel tanks are located on the open deck and under the open deck are explained below.

1) On the open deck

Where fuel tanks are installed on the open deck, a fixed water spray system covering the exposed parts of the fuel tank is to be provided to dilute fuel which is accidentally spilled, cool the fuel tank and prevent fire. A fixed alcohol-resistant foam type extinguisher is also to be provided, assuming alcohol fires.

Any boundary of accommodation spaces up to the navigation bridge windows, service spaces, control stations, machinery spaces and escape routes facing fuel tanks on the open deck is to be provided with A-60 class heat insulation.

2) Under the open deck

To prevent heating of fuel tanks, fuel tank boundaries are to be separated from category-A machinery spaces and other spaces with a high risk of fire by a cofferdam of a least 600 mm, with heat insulation of not less than A-60 class.

2.2.11 Explosion Prevention and Area Classification (Chapter 12)

Certified safe type electrical equipment is to be used in hazardous areas. For use with methanol, explosion-proof electrical equipment with an explosion-proof grade of IIAT1 or higher is to be selected. In accordance with the Guidelines, Chapter 12.5, hazardous areas are classified as hazardous area zone 0, 1 or 2. In case application of the definitions in the hazardous area classification provided in Chapter 12 is to be deemed inappropriate, classification following IEC60079-10-1:2015 may be applied with special consideration of the Society.

2.2.12 Ventilation (Chapter 13)

a) Installation of ventilation systems

To avoid enlargement of the range of hazardous areas, all ducts used in ventilation of hazardous areas must be independent from ducts used in non-hazardous areas. Air inlets for hazardous enclosed spaces must be installed in areas that would be considered non-hazardous in the absence of that inlet.

An effective extraction type mechanical forced ventilation system must be installed in fuel preparation spaces and in ducts and double walled pipes including fuel piping, and must have a ventilation capacity of at least 30 air changes per hour. The ventilation inlets of double walled and duct ventilation systems are to be located in a non-hazardous area, in the open air, away from ignition sources. The inlet openings are to be protected from the ingress of water, and must be fitted with a suitable wire mesh guard.

b) Redundancy of ventilation fans

The number and power (output) of ventilation fans for fuel preparation spaces is to be such that the total ventilation fan capacity is not reduced by more than 50% if a fan with a separate circuit (power supply) from the main switchboard or emergency switchboard, or a group of fans with a common circuit becomes inoperable. In order to minimize the assumed risk, a ventilation fan configuration with redundancy is to be used, even in coastal ships in which the requirements for main switchboard busbar splitting and installation of emergency switchboards are relaxed considering route restrictions, *etc*.

2.2.13 Electrical Installations (Chapter 14)

In electrical installations, attention is to be paid to minimize the risk of ignition in the presence of a flammable atmosphere. The relevant provisions of the Rules, Part H concerning the selection of electrical equipment, laying of cables, *etc*. are to be observed.

2.2.14 Control, Monitoring and Safety Systems (Chapter 15)

a) Safety systems

The fuel safety system plays the role of preventing the spread of damage by cutting off the supply of methanol fuel by executing an automatic shutdown of corresponding tank valves, master fuel valves and bunkering valves when a fuel leak, *etc*. occurs.

As safety devices for fuel tanks, tanks are to be fitted with closed level gauging devices, arranged to ensure that a level reading is always obtainable. Two level gauges are to be installed so as to avoid opening the tank for gauge maintenance work while the fuel tank is in service. The purpose of this measure is to avoid the release of fuel outside the tank and exposure of personnel during maintenance work. However, where it is possible to carry out the necessary maintenance work while the tank is in service without releasing fuel, installation of redundant gauges may be omitted. Here, “necessary maintenance work” is considered to indicate all types of maintenance work carried out in case of a level gauge malfunction. In addition, fuel tanks should also be fitted with a visual and audible high level alarm. This device can be common with the level gauging system, but it is to be independent of the high-high level alarm.

b) Gas detection

As a means of detecting leaked methanol vapour, installation of gas detectors is required. The gas detectors required in this chapter are to be installed in order to detect the formation of a flammable atmosphere and formation of a toxic atmosphere by methanol vapour. However, the following describes the recommendations of the Society for detection of toxic atmospheres, as this is not described concretely in the guideline.

The recommended alarm setting for fixed gas detectors is TLV-TWA: 200 ppm, which is the allowable concentration in the working environment for 40 hours/week of work, assuming 8 hours/day. This is not mandatory if there is a rational reason, such as the unavailability of a fixed gas detector that can be set to an alarm setting point of 200 ppm. Since fixed type gas detectors are considered to be mainly devices which are installed to respond to leaks before damage reaches a fatal stage (e.g., fire, explosion, irrecoverable human injury or death, *etc.*), one proposal under consideration is setting the alarm at IDLH (Immediate Danger to Life and Health): 6000 ppm, this being the escape limit concentration, i.e., the limit concentration at which it is possible to avoid a condition in which escape becomes impossible or irrecoverable health damage occurs within 30 minutes.

Because Chapter 17 of the Guidelines recommends the use of portable gas detectors, portable gas detectors are also considered necessary in addition to fixed gas detectors. Since the main role of portable gas detectors is to confirm that the working environment is appropriate, the recommended setting is TLV-TWA: 200 ppm.

As actions to prevent misoperation, such as crew members entering a fuel preparation space without carrying a portable gas detector, *etc.*, installation of caution plates or labels and addition of notes to the manual required in Chapter 17.2 of the Guidelines may be necessary, depending on the circumstances.

c) Liquid leak detection

Liquid leak detectors are required as safety devices for the protective cofferdams surrounding fuel tanks, ducts installed around fuel piping, fuel preparation spaces and enclosed areas where single wall fuel piping and fuel equipment are installed. Since detection of the liquid itself is considered necessary in these leak detectors, it is not permissible to install gas detectors which can only detect vapour.

3. FUTURE TRENDS

3.1 Trends in the IMO

As mentioned in the Introduction, at present, the requirements for methanol-fueled ships are limited to the release of an IMO Interim Guideline as MSC.1/Circ.1621. Rules with compelling force have not been issued at this time.

As international discussions toward the establishment of requirements for ships using methanol as fuel, in the IMO, the 8th Session of the Sub-Committee on Carriage of Cargos and Containers (CCC8) in 2022 announced a schedule for discussions on developing mandatory requirements for methanol-fueled ships (UPDATED WORK PLAN FOR THE DEVELOPMENT OF THE IGF CODE AND SAFETY PROVISIONS ON ALTERNATIVE FUELS (CCC8/18 Annex 2)), as follows.

CCC9 (2023): If time permits, start to discuss the development of mandatory requirements for methyl/ethyl alcohol.

CCC10 (2024): Proceed with the development of mandatory requirements for methyl/ethyl alcohol.

CCC11 (2025): Finalize the mandatory requirements for methyl/ethyl alcohol.

3.2 Future Response of the Society

In 2022, the Society revised and released guidelines summarizing requirements based on MSC.1/Circ.1621 as Guidelines for Ships Using Alternative Fuels, Part A (Edition 2.0) to facilitate safety assessments in the development of fuels using methanol and provide convenience to the related parties.

In the future, it is thought that the requirements of the existing MSC.1/Circ.1621 Guidelines will be reviewed again in discussions on mandatory requirements for methanol-fueled ships in the IMO. In those discussions, the Society intends to contribute to the development of more rational requirements for methanol-fueled ships, making good use of the knowledge developed with the related parties to date.