MARITIME TECHNOLOGIES FORUM

LEADING THE MARITIME WORLD FORWARD

GUIDELINES FOR CONDUCTING SAFE INSPECTION OF METHANOL DUAL-FUEL SHIPS

Executive Summary

The maritime industry is experiencing a significant transition towards alternative fuels, driven by increasingly stringent IMO emissions regulations. Among the alternative fuels, Methanol has emerged as a particularly attractive option, with 59 methanol dual-fuel ships in operation and 369 ships on order as of May 2025. However, the unique properties and characteristics of methanol including its flammability, toxicity and corrosivity present distinct challenges for ship inspectors.

This report, developed by the Maritime Technologies Forum (MTF) in collaboration with relevant industry stakeholders, provides comprehensive guidelines for conducting safe inspections of methanol dual-fuel ships addressing critical aspects across the three main phases of an inspection.

- **Pre-inspection preparations,** emphasising inspector competency requirements and specialized training, thorough ship familiarization, emergency awareness and preparedness as well as proper Personal Protective Equipment (PPE) selection and use.
- **During inspection protocols,** focusing on situation awareness and Dynamic Risk Assessment (DRA), safe testing of Control, Monitoring, Emergency Shutdown and Safety systems (CMES), hazardous area management, methanol fuel system inspection procedures as well as incident response protocols.
- **Post-inspection considerations,** highlighting decontamination procedures, health monitoring (particularly given methanol's delayed symptom onset) as well as PPE maintenance and disposal.

The term 'Inspector' used throughout this report refers to individuals who in their course of work also carry out inspection-like or surveying activities on methanol dual-fuel ships. These include but are not limited to Flag state control officers, Port State control officers, Class Surveyors, Insurance surveyors, Company's technical superintendents, 3rd party inspectors. Similarly, the term 'inspections' includes regulatory surveys, damage surveys, P&I, H&M surveys, etc.

While the guidelines and recommendations presented in this report are primarily designed to safeguard the safety of inspectors conducting inspections aboard methanol dual-fuel ships, they may also prove valuable to other professionals who regularly visit or board these vessels. This includes port stevedores handling cargo operations, port agents coordinating vessel activities, service engineers performing maintenance and repairs, suppliers delivering consumables and equipment, and maritime pilots providing navigation services. These stakeholders can benefit from understanding the specific safety considerations, hazard awareness protocols, and risk mitigation measures outlined herein, as their work may involve similar exposure to methanol-related risks and operational environments aboard these specialised vessels.

A total of 41 safety recommendations across three main phases of the inspection process have been identified and provided in the guidelines. They serve as a robust foundation for organizations to develop new safety protocols or strengthen existing Standard Operating Procedures (SOP).

These guidelines are designed to complement rather than replace existing inspection protocols while addressing the specific risks associated with methanol as a marine fuel. They aim to safeguard inspector's health and safety while ensuring effective inspection processes for this growing segment of the maritime fleet.

The safety recommendations provided are based on MTF member's experience and industry best practices. As the industry gains more experience with inspection of methanol dual-fuel ships, these guidelines can be further refined and adapted to ensure they remain current and effective.

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Abbreviations and Definitions

Abbreviation	Definition
AFI	Alternative Fuels Insight (DNV's database)
BA	Breathing Apparatus
CCR	Cargo Control Room
CII	Carbon Intensity Indicator
CMES	Control, Monitoring, Emergency Shutdown and Safety Systems
DRA	Dynamic Risk Assessment
ECR	Engine Control Room
EEBD	Emergency Escape Breathing Device
EEXI	Energy Efficiency Existing Ship Index
ERP	Emergency Response Plan
GHG	Greenhouse Gas
H&M	Hull and Machinery (Insurance)
IMO	International Maritime Organization
ISM	International Safety Management (Code)
LED	Light Emitting Diode
LEL	Lower Explosive Limit
LNG	Liquefied Natural Gas
MEPC	Marine Environment Protection Committee
MFSS	Methanol Fuel Supply Systems
MGO	Marine Gas Oil
MTF	Maritime Technologies Forum
NOx	Nitrogen Oxides
OCIMF	Oil Companies International Marine Forum
P&I	Protection and Indemnity (Insurance)
PM	Particulate Matter
PPE	Personal Protective Equipment
RA	Risk Assessment
SMS	Safety Management System
SOPs	Standard Operating Procedures
SOx	Sulphur Oxides

Background and Objective

The Maritime Technologies Forum (MTF) has been established to provide technical and regulatory expertise for the maritime industry. MTF's role is to publish research based on its members' expertise and offer unbiased advice to the maritime industry to promote safe adoption of alternative fuels and new technologies.

The maritime industry is experiencing a significant shift towards alternative fuels, driven primarily by increasingly stringent International Maritime Organization (IMO) emissions regulations. At MEPC 80, the IMO's GHG strategy was revised and set more ambitious targets compared to the 2018 strategy. Key changes include: i) reaching net-zero GHG emissions from international shipping by or around 2050, ii) the intermediate goals of reducing total annual GHG emissions by at least 20%, striving for 30% by 2030 compared to 2008 levels, and iii) reducing total annual GHG emissions by at least 70%, striving for 80% by 2040 compared to 2008 levels[1]. These targets, coupled with the existing IMO 2020 sulphur cap of 0.5% and newly entered into force regulations such as the Carbon Intensity Indicator (CII) and Energy Efficiency Existing Ship Index (EEXI), are forcing shipowners to seek cleaner fuel alternatives.

Methanol has emerged as a particularly attractive option for shipowners due to its environmental credentials and practical advantages. As a low-carbon fuel that produces zero sulphur emissions and significantly reduced NOx and particulate matter emissions, methanol enables immediate compliance with current IMO 2020 sulphur regulations while also providing a pathway towards meeting future GHG reduction targets if produced on basis of renewable energy sources.

As of beginning May 2025, there are 59 methanol dual-fuel ships in operation (DNV's Alternative Fuel Insights (AFI))[2]. The numbers are expected to increase significantly over the next three years as shipyards are delivering retrofitted and new built methanol dual-fuel ships to shipowners progressively. According to DNV's AFI, 369 methanol dual-fuel ships are on order (status May 2025) mainly comprising of containerships (60%), bulk carriers (15%) and tankers (10%). The technology is also being considered in modular compact sizes for retrofit or new builds on non-convention sized ships such as workboats, tugs, and fishing vessels.

Methanol dual-fuel ships, like conventional ships, are subjected to statutory inspections and surveys under the IMO's inspection framework. These include regulatory and statutory surveys by Classification Societies on behalf of the Flag Administrations, inspections by Flag States and Port Authorities, and Company's internal inspections as required by ISM code. Additional inspections may also be carried out by thirdparty inspectors, such as maritime insurers (H&M, P&I clubs), Rightship and OCIMF. Currently, there are no clear and specific guidelines for inspectors and surveyors on how to carry out inspections and surveys for methanol dual-fuel ships safely, and this is an identified gap by the MTF.

This guideline aims to safeguard the health and safety of inspectors by providing guidance and recommendations to inspectors throughout the different stages of the inspection. Proposed guidelines can be used to develop new or strengthen existing organization's safety inspection protocols or SOPs.

While the guidelines and recommendations presented in this report are primarily designed to safeguard the safety of inspectors conducting inspections aboard methanol dual-fuel ships, they may also prove valuable to other professionals who regularly visit or board these vessels. This includes port stevedores handling cargo operations, port agents coordinating vessel activities, service engineers performing maintenance and repairs, suppliers delivering consumables and equipment, and maritime pilots providing navigation services. These stakeholders can benefit from understanding the specific safety considerations, hazard awareness protocols, and risk mitigation measures outlined herein, as their work may involve similar exposure to methanol-related risks and operational environments aboard these specialised vessels.

Disclaimer

The findings and recommendations in this report represent a collaborative effort between participating MTF members. While the advice given in this report has been developed using the best currently available information, it is intended to be used solely as a guidance. No responsibility is accepted by MTF or its members for any consequences resulting directly or indirectly from the adoption of any of the recommendations in this report. This report does not stop MTF members from having independent opinions or conclusions.

Introduction to Guidelines

These guidelines were developed following extensive discussions, thorough reviews, collation and sharing among MTF project team members, including experience gained from pilot trials and best practices.

The use of methanol as a marine fuel presents distinct challenges due to its inherent characteristics of flammability, toxicity and corrosivity. These properties create a significantly different operational environment and design on methanol dual-fuel ships compared to conventional fuel oil powered ships. The ship design and arrangements are governed by MSC.1/Circ.1621 interim guidelines, which employ a goal-based approach to address the chemical properties and associated risks of using methanol as an alternative fuel[3]. Notably, ships designs may deviate from these interim guidelines, provided the alternative design and arrangements meet the intent of the goal and functional requirements concerned and demonstrate to provide an equivalent level of safety to the satisfaction and approval of the flag administration. This flexibility in design, while necessary for innovation, introduces additional complexity and uncertainty for inspectors conducting inspections on methanol dual-fuel ships.

It is critical that the physical and chemical properties along with the risks and hazards associated with methanol are well understood so that appropriate guidance can be developed to support inspection activities safely. This guidance includes hazards identification, as well as recommended control measures for mitigating or minimizing the risks to inspectors throughout the course of inspection.

The content containing the assessment and key recommendations of the report is split into three sections, covering the whole inspection process:

a) Pre-inspection;

b) During inspection; and

c) Post inspection.

Each section provides a brief description of the expected work, background information and the points for consideration at different phases of the inspection. A table of safety recommendations is compiled at the end of every section, for the reader's easy reference.

The safety recommendations outlined in this document serve two primary purposes for relevant organisations and stakeholders: firstly, to establish foundational safety protocols for inspectors conducting these specialised inspections, and/or, secondly, to enhance existing safety protocols by addressing identified gaps through the implementation of these guidelines.

It is important to emphasise that these guidelines and safety recommendations complement, rather than replace, standard industry and best practices for conventional fuelled ships. These guidelines should be implemented alongside current best practices to establish comprehensive inspection protocols that safeguard inspectors from the heightened risks and hazards associated with methanol dual-fuel ships. This document is specifically designed for maritime professionals with substantial inspection experience, and therefore assumes familiarity with standard industry practices, which are not detailed herein.

Methanol as Marine Fuel

What is methanol?
Methanol (CH_3OH), also known as methyl alcohol, is a simple aliphatic alcohol comprising one carbon atom, one oxygen atom and four hydrogen atoms. At ambient temperature and atmospheric pressure, it exists as a clear, colourless liquid with a distinctive alcoholic odour and is completely miscible with water.

Applications
Methanol serves as a crucial industrial chemical feedstock, with its largest application being the production of formaldehyde, accounting for approximately 30% of global methanol consumption[4]. It is a fundamental component in manufacturing various products including plastics, resins, and biodiesel, while also being commonly used in everyday applications such as paint removers and cleaning products. In the energy sector, methanol plays a significant role as a fuel additive, in power generation, and as a fuel source for automotive and marine ships.

Chemical properties
Methanol possesses distinct chemical properties and characteristics that make it particularly suitable as an alternative marine fuel. In its pure form (CH_3OH), methanol contains no sulphur, resulting in zero sulphur oxide (SOx) emissions during combustion. Compared to conventional marine fuels, methanol burns more cleanly and produces significantly lower levels of particulate matter (PM) and nitrogen oxides (NOx) emissions. With minimal formation of carbon particles during combustion, methanol burns with a low light and is near-invisible in daylight.

Storage
Methanol is a liquid fuel (at temperatures between -98°C and 65°C (0.1MPa) and it can be stored in slightly modified fuel tanks on existing ships unlike other alternative fuels such as Ammonia, LNG and Hydrogen. Storage of alternative fuels like ammonia, LNG and liquid hydrogen requires energy intensive cryogenic storage systems from low temperature of -33°C (Ammonia) to extremely low temperatures of -161.5°C (LNG) and -253°C (Hydrogen) respectively or high-pressure tanks if stored at normal temperatures.

Environmental impacts
As methanol is soluble and biodegradable in marine environments, it will rapidly dissolve in seawater thus reducing environmental risks and impacts from accidental spills.[5,6]
These environmental advantages, coupled with its practical handling properties, have led to methanol gaining considerable traction as a favourable alternative fuel in the maritime industry, particularly as shipping companies seek to comply with increasingly stringent emissions regulations. The key properties of methanol in comparison to MGO and other alternative fuels LNG and Ammonia are shown in the table below.

Table 1: Properties of different maritime fuels (at 0.1 MPa)

Properties	Methanol	MGO	Methane/LNG	Ammonia
Chemical Formula	CH_3OH	$C_{10} – C_{22}$	CH_4	NH_3
Flash Point (°C)	12	> 60	NA	NA
Boiling Point (°C)	64.6	170 - 350	-161.5	-33
Auto ignition temperature (°C)	470	250	539	651
Flammable range in dry air (%)	6 to 36	0.7 to 5	5 to 15	15 to 28
Energy Density (MJ/kg)	19.7	42.7	48	18.6

Challenges

Methanol as a marine fuel has its challenges compared to conventional fuels which is illustrated in Table 1 above. Amongst its notable challenges are its colourless nature, high flammability risks, corrosive nature, its relatively lower energy density and vapour density[7].

Methanol fires pose a significant risk due to their nearly invisible flames in daylight[8] and could require the use of thermal imaging camera to complement the conventional firefighting requirements.

Methanol exhibits mild to moderate corrosive properties, is incompatible with lead and aluminium, and requires specific materials such as carbon steel and stainless steel 316L for safe containment and storage[9].

With a lower energy density per kilogram of approximately 15.8 GJ/m^3 as compared to Marine Gas Oil's (MGO) 36.6 GJ/m^3, this means that twice as much methanol is required to provide the same amount of energy generated by MGO during combustion[10].

Methanol with a vapour density of 1.11 kg/m^3 relative to air (where air = 1 kg/m^3)[11], means that methanol vapour will sink and accumulate in low-lying and lower decks (non-open space area). Coupled with its wide flammability range, accumulated vapours pose a high risk of forming potential explosive mixture in poorly ventilated areas.

Health Hazards

Methanol is highly toxic in nature, and it requires extreme care with handling. With acute exposure, methanol poisoning may cause mild discomfort from headaches, dizziness to severe toxic effects such as blindness, organ failure and death in severe exposure cases[12]. Methanol has four primary routes of entry into the human body; namely: 1) Inhalation of vapour, 2) absorption through skin as a result of physical contact, 3) eye contact, and 4) ingestion by either eating or drinking[13]. It is thoroughly important to understand that the onset of signs and symptoms from methanol exposure do not occur immediately[14] and close self-monitoring is required after potential exposure.

Table 2: Hazardous substance fact sheet and health effects – New Jersy Dept. of Health (2016)

Routes of entry	Effects
Inhalation of vapour	Irritate the nose, throat and lungs causing coughing, wheezing and/or shortness of breath Prolonged exposure can also cause headache and dizziness
Absorption through skin contact	12 Contact can cause skin irritation. Prolonged or repeated contact can cause a skin rash, dryness and redness
Eye contact	Eye irritation, blurred vision and blindness
Ingestion by either eating or drinking	Nausea, vomiting, diarrhea and abdominal pain. Exposure to high concentrations can cause drowsiness, fatigue, loss of consciousness and death.

In terms of toxicity, methanol presents a risk to personnel through inhalation, particularly in enclosed or poorly ventilated spaces. The severity of the health effects depends on the concentration of methanol, duration or frequency of expose, route of exposure and the individual's vulnerability due to pre-existing health conditions. Several global agencies and organizations have established exposure limits and guidelines such as Acute Exposure Guideline Levels (AEGL)[15] to ensure the safety of workers and the public who may be exposed to methanol in various work, industrial, or other settings.

AEGLs are threshold exposure limits for the general public and are used for emergency planning and response to chemical releases. There are three AEGL levels and each AEGL level has five exposure periods with the corresponding signs and symptoms from exposure. They are developed by the U.S. Environmental Protection Agency and the National Research Council and was referred to by the IMO, Sub-committee CCC 10 in their discussions when developing the 'interim guidelines for the use of ammonia fuel' – MSC.1/Circ.1687 (2025)[16].

The methanol concentration and the duration of exposure, with corresponding toxic effects are summarized in table 3 below.

Table 3: AEGL levels for methanol – United States Environmental Protection Agency (EPA, 2025)

Levels (Exposure)	Exposure time					Signs and symptoms
	10 mins	30 mins	1 hr	4 hrs	8 hrs	
AEGL 1 (Non-disabling) In ppm	670	670	530	340	270	Notable discomfort, irritation, or certain asymptomatic nonsensory effects. Reversible
AEGL 2 (Disabling) In ppm	11,000*	4,000	2,100	730	520	Irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape
AEGL 3 (Lethal) In ppm	40,000**	14,000*	7,200*	2,400	1,600	Life-threatening health effects or fatal

** indicates value is 10-49% of LEL. Safety considerations against explosion must be taken into account*

*** indicates value is 50-99% of LEL. Extreme safety considerations against explosion must be taken into account.*

Key Recommendations Pre-inspection

Prior to conducting any inspection on methanol dual-fuel ships, there are several critical aspects that need to be considered to safeguard the inspector and ensure a safe and effective inspection process. This chapter discusses the fundamental aspects which form the foundation of a professional and safety-conscious approach before inspections, and each aspect will be elaborated in detail in the relevant headers of this chapter. It is to be noted that the safety recommendations arising from this chapter are non-exhaustive and are meant to complement the standard safety best practices or safety inspection protocols for the inspector.

Inspectors Competency

The safe inspection of ships using methanol as fuel demands the inspector to have a thorough understanding of this hazardous substance's unique properties and characteristics. Inspectors should possess comprehensive knowledge through advanced methanol-related training to ensure their safety and effectively execute their duties. Methanol presents distinct challenges due to its colourless nature, high toxicity, and flammability, making it particularly dangerous if proper safety protocols are not followed.

Therefore, it is imperative that inspectors undergo rigorous training to recognise potential hazards, understand proper emergency response procedures, and have proficiency, knowledge and skills in utilising safety equipment such as emergency escape breathing devices (EEBD) in case of emergency. This knowledge becomes crucial not only for personal safety but also for identifying potential safety violations or hazardous conditions during inspections.

Regular refresher training and competency assessments should be maintained to ensure inspectors remain competent and current with safety protocols and best practices, ultimately contributing to safer inspection processes and safeguarding the health and safety of inspectors.

Table 4: Safety recommendations for competency

No.	Safety recommendations
1	Inspectors are required to complete additional training covering the characteristics / properties, hazards, routes of entry, emergency response actions, effects of methanol and effective PPE implementation for methanol.
2	Inspectors are to have a good working knowledge of methanol fires, understanding the characteristics of methanol fire and methods of control and extinguishing. Inspectors are not expected to be involved in firefighting but knowledge of such the characteristics is essential for the immediate detection of a fire and the preventing of its further spread.
3	Inspectors are recommended to receive some form of basic first aid instructions and be knowledgeable in the effects and first aid treatment of methanol, ingestion or inhalation or dermal exposure.
4	Inspectors are to be competent in using the personal protective equipment (PPE) in particular portable gas detectors, and *EEBDs* set (including the checks).
5	In addition to inspector's competency, inspector should also determine whether the crew holds certificates of competency or proficiency, and relevant documentation, required for operating a methanol dual-fuel ship and handling methanol.

Ship Familiarization

Ship familiarization is a critical preliminary step that significantly influences the safety and effectiveness of inspections on methanol dual-fuel ships. Prior to conducting any inspection, inspectors should develop a comprehensive understanding of the ship's characteristics, status, operational profile, and potential hazards. This preparation phase requires thorough research using available resources such as Classification Society records, Port State Control databases, and maritime information systems to gather vital information about the ship's history, compliance records, and any previous incidents or deficiencies.

Upon boarding, a detailed safety briefing and toolbox talk with the ship's crew and safety officer becomes essential to establish clear understanding of the ship's safety protocols. This briefing should cover crucial elements including emergency response arrangements, muster points, escape routes, and alarm systems. Of particular importance is the identification of hazardous zones where methanol release might occur, and the location of all areas where methanol is stored, transferred, treated, or combusted, including bunker storage tanks, cofferdams, tank connection spaces, fuel preparation rooms, bunker stations, and engine rooms including piping and air locks

The unique properties of methanol present additional challenges that demand special attention during familiarization. Inspectors should be particularly vigilant about the possibility of proximity contamination, where methanol may have affected areas or systems not typically associated with its use.

Understanding the ship's specific design features, including any Alternative Design & Arrangements (AD&A), is crucial for safe navigation around the ship as these deviations from the guidelines, although approved by its Flag administration[17], may pose issues and present methanol-related hazards for inspectors if the designated safeguards are not effectively in place. For example, the Flag administration may approve a ship design with methanol fuel tank vent outlets located less than 3 m above the deck, with a view to protect the vent from damage due to cargo operations, provided there are appropriate safe guards (e.g. installation of devices in vent line to reduce probability of vapour release, fitting of vapour return line, implementation of operational procedures in SMS to avoid personnel work in the areas) in place to meet the functional requirements of the Interim guidelines while providing an equivalent, or higher level of safety. However, if these safeguards are not practiced or in place, the safety of the personnel onboard (including the inspector) may be compromised by the 'approved' AD&A.

Furthermore, inspectors need to identify the ship's enclosed spaces, especially if the inspection scope includes these areas, as methanol vapours can accumulate in enclosed spaces and create hazardous conditions. This comprehensive familiarization process ensures inspectors can anticipate potential hazards, plan their inspection route effectively, and maintain appropriate safety measures throughout their inspection activities.

Table 5: Safety recommendations for ship familiarization

No.	Safety recommendations
6	Prior to boarding a ship, the inspector should utilise every available resource to become familiar with the ship and its purpose. Such resources may include for example Classification Society records, Port State Control Records, IMO GISIS, Equasis or Sea-Web.
7	A Safety briefing and toolbox talk is to be held on board with ship's crew and ship safety officer. This safety briefing is to include: • The ship's emergency response arrangements with identification of muster point, escape routes and audio / visual warning. • Identification of all hazardous zones and the probability of methanol release in those areas. • All ongoing work on board such as equipment maintenance, cargo operations, bunkering, loading of stores etc. • All areas of the ship where Methanol is stored, transferred, treated or combusted. Such areas will include bunker storage tanks, tank connection space, fuel preparation room, bunkers stations and engine rooms.
8	Inspectors should be aware that due to proximity contamination, methanol may have contaminated other areas or systems which may not normally be associated with the use of methanol.
9	Awareness of ship's design, layout and Alternative Design & Arrangements (AD&A) if any, and understanding of its designated safeguards.
10	Identify enclosed spaces onboard and whether scope of inspection would be in these areas.

Emergency Awareness and Preparedness

Before commencing any inspection, inspectors should thoroughly familiarize themselves with the ship's emergency alarms, emergency exits, escape routes, and emergency response plans (ERP) as each methanol dual-fuel ship has unique emergency response protocols specifically developed for its particular design, fuel system configuration and safety system. This includes identifying the locations of critical safety equipment such as eyewash stations and decontamination facilities, particularly in areas where methanol exposure risks are higher.

Additionally, inspectors should be well-versed in immediate response actions should they encounter a methanol fire or exposure, including the proper execution of emergency techniques such as stop, drop, and roll, and the safe removal of contaminated clothing.

This comprehensive emergency preparedness ensures inspectors can react swiftly and appropriately in critical situations, potentially preventing severe injuries or fatalities during methanol-related incidents.

Table 6: Safety recommendations on emergency awareness & preparedness

No.	Safety recommendations
11	Inspectors should be familiar with ship's emergency alarms, emergency exits and the emergency response plans (ERP). Inspectors should follow any specific safety instructions given to them during an emergency.
12	Inspectors should make themselves aware of the location of any safety equipment/facilities such as eye wash stations and decontamination stations onboard or in the vicinity of the locations where they will be inspecting.
13	Inspectors should know how to respond if they are inadvertently caught in methanol fire, such as the stop, drop, and roll technique and remove contaminated clothing when safe to do so.

Personal Protection Equipment (PPE)

The proper selection and use of Personal Protective Equipment (PPE) is crucial for inspectors' safety when conducting inspections on methanol dual-fuel ships, given methanol's unique hazard profile including missing warning signals (odourless, colourless flame). Methanol's ability to be absorbed through skin contact, inhalation of vapours, and its highly toxic nature necessitates comprehensive personal protection.

Depending on the scope of the inspection (locations inspected) inspectors should wear appropriate chemical-resistant protective clothing, safety goggles or face shields for eye protection, and chemical-resistant gloves to prevent dermal exposure. It is important that the equipment is specifically intended for toxic protection and not just flammable gases (e.g. LEL), as the LEL for methanol is 60,000 ppm, while the recommended limit for airborne toxic exposure should not exceed 250 ppm within 15 minutes (US National Institute for Occupational Safety and Health), respectively lower values for longer exposure times.

The invisible nature of methanol flames and its colourless characteristics make it particularly dangerous, emphasising the importance of proper PPE as the last line of defence against accidental exposure. Furthermore, inspectors should ensure their PPE is properly maintained, correctly fitted, and suitable for the specific areas they plan to inspect, as inadequate or improperly worn PPE or incorrect calibrated gas detector could result in severe health consequences or life-threatening situations during methanol-related emergencies.

Table 7: Safety recommendations for Personal Protective Equipment

No.	Safety recommendations
14	All inspectors should be trained and competent in the proper use of personnel protective equipment (PPE).
15	Inspector should check and ensure their PPE is in good working condition.
16	In addition to the standard PPE, the inspector should carry a properly functioning and calibrated intrinsically safe personal gas detector in accordance with the applicable standards* and functions, • Low Oxygen Concentrations, • Methane, • High Carbon Monoxide Concentrations. The meter should also be suitable for use in hazardous areas and provide at least three means of alerting the user such as Light Emitting Diode (LED) lights, vibration and audible tone.
17	PPE should be properly maintained and promptly cleaned if suspected of contamination.
18	All PPE should be manufactured to international standards** and have flame retardant and antistatic properties. Inspectors should be aware that these properties may degrade with time and number of washes.

Standards

** - IEC 60079-29-1, IEC 60079-0, IEC 60079-1, IEC 60079-11, EN 45544 Workplace atmospheres – Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours*

*** - ISO 11612 & ISO 13688 (See Reference from MCA Code of Safe Working Practices Section 7, PPE and MSN 1870 5th Amendment), EN ISO 374 Protective gloves against dangerous chemicals and micro-organism, EN 1149-5 Protective clothing*

Key Recommendations during Inspection

During the inspection of methanol dual-fuel ships, inspectors should remain mindful of several critical aspects throughout their inspection process. This chapter addresses the essential safety considerations that inspectors need to observe while conducting their inspection activities.

These considerations adhere to safe inspection practices. The chapter will elaborate on these aspects through relevant headers, providing detailed guidance on safe inspection procedures and specific precautions when inspecting methanol-related systems and equipment. It should be noted that the safety recommendations presented in this chapter are non-exhaustive and should be implemented in conjunction with established safety protocols and standard operating procedures. These recommendations aim to enhance inspector safety while ensuring thorough and effective inspections of methanol fuel systems and associated equipment.

Situation Awareness

The dynamic nature of shipboard operations, combined with the inherent hazards of methanol fuel systems, demands that inspectors remain acutely aware of all ongoing activities in their vicinity. This includes being mindful of simultaneous operations such as maintenance work, bunkering activities, or cargo operations that could potentially increase risk levels or create unexpected hazards.

The implementation of Dynamic Risk Assessment (DRA) principles throughout the inspection process is particularly crucial, as conditions can change rapidly in the maritime environment. DRA requires continuous monitoring of the situation and identification when a situation is or could change to an unsafe situation and determining of appropriate risk control measures. This continuous assessment process includes monitoring for signs of methanol release, changes in operational status, movement of personnel, and any other factors that could affect safety. To be effective DRA must be based on sound operational practices and experiences, i.e. typically based on training. DRA enables inspectors to continuously evaluate their surroundings, identify emerging hazards, and make informed decisions about whether to proceed, pause, or modify their inspection approach.

By maintaining high situational awareness and regularly performing dynamic risk assessments, inspectors can better anticipate potential hazards, implement appropriate control measures, and ensure their safety while conducting thorough and effective inspections of methanol dual-fuel ships.

Table 8: Safety recommendations for situation awareness

No.	Safety recommendations
19	Inspectors should always be aware of all on-going work around them which may be hazardous / present a danger
20	Inspectors are to always be mindful of the principles of dynamic risk assessment (DRA) throughout the course of inspection. A DRA can be defined as *"a continuous safety practice that allows workers to quickly identify hazards 'on the spot'*, and either to remove them or implement mitigating measures to proceed with the work safely. DRAs are performed by regularly observing and analysing high-risk or changing work environments and making quick yet considered decisions. The inspector should be empowered to make decisions for their own personal safety based on the situation they find themselves in at the time.

Control, Monitoring, Emergency Shutdown and Safety Systems (CMES)

Testing of CMES is often a significant part of an inspection for any type of ship. Any organization that has introduced alternative fuels in their fleet will normally have prepared a management of change plan, part of which would be the update of all procedures and documents affected by such a change.

Therefore, the procedure for testing any of the systems on board will be updated to accommodate for the changes that Methanol has on both the system and the procedure. The same applies for the Risk Assessment (RA) standard documentation and methodology that the crew will follow before any task, test or inspection is carried out. Part of the RA will need to be the review of the critical systems and current

operations at the time of inspection to ensure that no aspect of the inspection or testing will jeopardise the operation or any critical system of the ship.

Having determined the crew competency and relevant training on Methanol during Pre-inspection, the inspector will not interfere with crew while they proceed with the operation or test of any ship's equipment.

It is recommended that inspections and tests are done remotely as far as practicable from a safe and controlled environment such as the bridge, the ECR or CCR.

The inspector should have reviewed the recent maintenance status and keep in mind during the inspection that systems and machinery which were recently overhauled but have not been tested since may pose a higher risk. Same consideration and subsequent mitigating measures are to be included in the RA prior any testing or inspection.

Table 9: Safety recommendations for CMES

No.	Safety recommendations
21	To attend RA with ship crew prior to testing of any equipment
22	Ensure a responsible senior member of the ship crew accompany the inspector throughout inspection process
23	At all times, operating and testing of equipment to be conducted by crew
24	Confirm with crew that the testing to be performed is safe, in compliance with terminal regulations and or restrictions, and will not impair the functions of other critical equipment including but not limited to cargo operations and ensure redundancies for machineries / systems.
25	As far as practicable, verification and testing of equipment and system functions should be performed remotely in a safe and controlled environment such as bridge, the ECR or CCR.

Hazardous Areas

Standard procedures for the safe inspection of hazardous areas are always applicable such as precautions for the flammability and toxicity of Methanol, confirmation of ventilation for enclosed spaces and that no ignition sources are in the vicinity of any hazardous areas.

Table 10: Safety recommendations for management of hazardous areas

No.	Safety recommendations
26	Confirm ventilation system is in good working order at its designed air change rate. Proper ventilation of space prior to entry, and that space is gas free.
27	Adhere to ship's rules prior entering hazardous zone and do not carry equipment with probable ignition source. Carry only intrinsic safety equipment.
28	Appropriate PPE (at least in compliance with ship's requirements) to safeguard from the four routes of methanol entry (Table 2) to be worn during inspection / tests where presence of methanol is possible (or where methanol could be present), wear portable gas detector and have EEBD set on stand-by.
29	Reduce time spent in spaces containing methanol equipment and conduct remote monitoring as far as practicable and reasonable
30	Always test the control, monitoring, emergency shutdown and safety systems (CMES), gas and liquid detection systems first and confirm that they are working as intended prior entry into hazardous areas

Methanol Fuel Supply Systems (MFSS)
If possible, any testing or inspection should take place after the consumers have been changed over to diesel and not in methanol. In case this is not possible, the inspector should first check the safety devices, emergency shut-off valves and emergency shut down systems as well as the nitrogen supply are operating properly.

Table 11: Safety recommendations for MFSS

No.	Safety recommendations
31	Verify that the MFSS is not in operation and that MFSS has been purged after changeover to conventional fuel
32	In situations where inspection must proceed while the MFSS is in operation (with methanol), the functionality of safety, detection and emergency shut-down systems are to be ensured and safety protocols are critical.

Incident/Accident/leakage
In the event of any alarm, leakage or other incident, the inspector should stop any inspection or test and allow the crew to respond to the occurrence. First priority during any incident will be to move to a safe area without any obstruction to the crew response. The inspector may provide details and assist with the incident investigation later after the incident.

Table 12: Safety recommendations for incident management

No.	Safety recommendations
33	Stop inspection activities immediately and allow crew to respond to the incident.
34	Move to a safe area / location within the ship as demarcated as discussed with crew (see pre-inspection). No re-entering the affected area until declared safe by the relevant authorities.

Key Recommendations Post-inspection

Typically, PPE is cleaned and prepared for the next use after an inspection and standard procedures are expected to be in place for this. Due to the properties of methanol, e.g. colourless and odourless, particular attention should be paid to potential contamination of the PPE and, more importantly, the inspector, and the recommended actions below should be followed in the event of contamination or suspected contamination. It should be noted that the initial symptoms from inhalation are less severe than from ingestion.

The first priority should be health protection, e.g. limit the impact of contamination by removing any methanol residues from contaminated body surfaces. In the event of methanol ingestion, seek medical assistance immediately. Thereafter, the issue of limiting potential contamination of third parties should be addressed by appropriate decontamination of all items that have been contact or are likely to have been in contact with methanol.

Typically, the following post-inspection situation could be distinguished, a) cancellation of an inspection due to an incident, e.g. leakage or spillage and b) scheduled completion of the inspection.

Case a) requires immediate actions as follows:

- Inhalation of methanol: proceed to fresh air and keep yourself warm and at rest, and monitor respiration. In case of breathing difficulties seek medical assistance;
- Remove contaminated clothing and shoes;
- Skin contact with methanol: rinse the contaminated skin immediately for at least 15 minutes with (tepid) water using a safety shower. Afterwards wash the area thoroughly with soap and water;
- Eye contact with methanol: eye wash for at least 20 minutes with (tepid) water holding the eyelid apart to ensure that all parts are adequately flushed;
- Ingestion (swallowed) of methanol: seek immediately medical assistance,

For Case b) the PPE used for the inspection should be cleaned, e.g. gloves should be rinsed and inspected for any damages, clothing should be cleaned if it could be contaminated.

In addition to the normal aftercare measures for PPE, particular attention should be paid to the well-being or state of health of the inspector, bearing in mind that symptoms of a methanol poisoning may only become noticeable up to 72 hours after exposure.

The immediate effect of contact with methanol is irritation of the eyes (burning, tearing, redness and swelling), the skin (conjunctivitis, corneal burns) or the respiratory tract.

A particular feature of methanol intoxication is that after an initial short period of intoxication with a slight depression of the central nervous system, the symptoms subsidise or diminished for a period of up to 12 or 14 hours[18]. After this, the initial physical symptoms of poisoning can be observed, such as:

- Headache,
- Dizziness,
- Nausea,
- Vomiting,
- Disturbances of visual system (excessive sensitivity to light, misty or blurred vision, dramatic reduced visual acuity up to blindness),
- Lack of coordination/confusion.

After this period, secondary symptoms of methanol poisoning may occur, usually ten to thirty hours after the initial exposure:

- blurring,
- photophobia,

- snowstorm vision or complete loss of vision,
- acidosis,
- putaminal hemorrhages.

In the event of health problems, medical assistance must be sought as soon as possible.

Table 13: Safety recommendations for inspector's health post-inspection

No.	Safety recommendations
35	The onset of symptoms due to methanol exposure may not appear immediately (usually much later). Inspector should monitor own health after the inspection and seek medical attention if there are symptoms of methanol exposure (headache, dizziness, nausea etc).
36	In case of skin contact with methanol, flush the area with water for at least 15 minutes and wash thoroughly with soap afterwards.
37	If methanol splashes in eyes, flush with water for at least 20 minutes and seek immediate medical attention.
38	Wash hands thoroughly after inspection, even if gloves were worn.
39	Decontaminate any PPE that may have been exposed to methanol. Wash thoroughly.
40	Properly dispose of any contaminated materials, if it cannot be cleaned.
41	Maintain and update occupational health records after each inspection. Record keeping details such as, and but not limited to: a) record details of contamination events (if any), b) disposal measures and methods (if any), c) PPE status.

Conclusions

The maritime industry is experiencing a significant transition towards methanol as an alternative fuel, driven by increasingly stringent environmental regulations. With 59 methanol-dual-fuel ships currently in operation and 369 ships on order as of May 2025, the need for standardized safety protocols for inspections has become critical. This report addresses this need by establishing comprehensive guidelines for inspectors conducting safe inspections of methanol dual-fuel ships.

The guidelines present a structured framework encompassing three crucial phases: pre-inspection, during inspection, and post-inspection. Each phase has been carefully developed to address specific safety considerations and risk mitigation strategies, ensuring inspector safety while maintaining inspection effectiveness. The framework emphasises the fundamental importance of inspector competency, specialized training, and thorough understanding of methanol's unique properties and hazards.

A key aspect of these guidelines is the emphasis on practical implementation measures. These include prioritizing remote inspection and testing where practicable, establishing and understanding clear protocols for emergency response and incident management, and implementing proper Personal Protective Equipment (PPE) selection and usage. The guidelines also stress the importance of Dynamic Risk Assessment (DRA) throughout the inspection process, enabling inspectors to respond effectively to changing conditions and emerging hazards.

Particular attention has been given to post-inspection health monitoring, recognizing the potentially delayed onset of methanol's toxic effects. This aspect of the guidelines ensures that inspectors remain vigilant about their health even after completing their inspection duties, with clear protocols for responding to potential exposure symptoms.

These guidelines represent a collaborative effort between MTF members and industry stakeholders, complementing existing inspection protocols while specifically addressing methanol-related risks. A total of 41 safety recommendations across the thorough inspection process have been identified and provided in the guidelines. They serve as a robust foundation for organizations to develop new safety protocols or strengthen existing Standard Operating Procedures (SOP). As the industry gains more experience with inspection of methanol dual-fuel ships, these guidelines can be further refined and adapted to ensure they remain current and effective.

By implementing these guidelines and following the 41 safety recommendations, inspections of methanol dual-fuel ships can be conducted safely and effectively, supporting the broader transition towards alternative fuels while protecting the health and safety of inspectors.

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