SUMMETH

SUMMETH – Sustainable Marine Methanol

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Report on general recommendations for conversions of specific ship types

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Authors: Joakim Bomanson, Bengt Ramne, ScandiNAOS

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ABSTRACT

For large ships regulations and procedures for using methanol as fuel is available from two class societies and regulations from IMO are under way. The requirements are to a large extent based on requirements for LNG and provide a safe design for converting a large ship to methanol. For smaller ships, e.g. road ferries and fishing boats, some of the requirements are not directly applicable or possible to fulfil due to space limitations or limitations of the on-board systems. In order to design a safe and reliable system the design requirements in the available rules can be used as reference when scaling back to a reasonable level for smaller boats.

This report in brief describes the major requirements for using methanol as fuel according to the current regulations and give recommendations on how to convert smaller ships in different categories to methanol. Which requirements to keep and where alternative solutions are more suitable, according to ship type.

SUMMETH PROJECT SUMMARY

SUMMETH, the **Su**stainable **M**arine **Meth**anol project, is focussed on developing clean methanol engine and fuel solutions for smaller ships. The project is advancing the development of methanol engines, fuel system installations, and distribution systems to facilitate the uptake of sustainable methanol as a fuel for coastal and inland waterway vessels through:

- developing, testing and evaluating different methanol combustion concepts for the smaller engine segment
- identifying the total greenhouse gas and emissions reduction potential of sustainable methanol through market investigations
- producing a case design for converting a road ferry to methanol operation
- assessing the requirements for transport and distribution of sustainable methanol.

The SUMMETH project consortium consists of SSPA Sweden, ScandiNAOS, Lund University, VTT Technical Research Centre of Finland, Scania AB, Marine Benchmark, Swedish Transport Administration Road Ferries, and the Swedish Maritime Technology Forum.

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Co-authors	Bengt Ramne, Patrik Molander
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1 INTRODUCTION

Introducing a new fuel to ships and boats will inevitably lead to design differences compared to conventional installations. As the chemical properties of methanol are significantly different from those of the diesel fuels commonly used by commercial ships, the design requirement will as a consequence also be rather large in order to secure reliable and safe operation on the new fuel.

A large difference for methanol that will impact the safety systems used is the low flashpoint at 11 degrees C. Diesel fuels have a higher flashpoint, 56 degrees C for MK1 and at least 60 degrees C for MGO. Below the flashpoint the fuel will not produce enough vapours to form a combustible atmosphere above the liquid level and will not ignite from a spark or open flame until it is heated. Gasoline, like methanol, has a low flashpoint and is easily ignited. For ships gasoline is not used as a fuel but it is an alternative for some smaller boats, mainly recreational crafts. The rules for using methanol as a fuel are to a large degree aimed at addressing the challenges of the low flashpoint in order for the design to be at least as safe as a conventional design using diesel fuels.

If the fuel is ignited the characteristics of the fire will also be somewhat different for methanol. Pure methanol burns with an almost invisible flame and forms no smoke which means that exclusive use of smoke detectors is not sufficient. However, in case of fire smoke will form from secondary material such as cables, paints and oil residue and smoke detectors should be used in combination with other means of fire detection. An advantage of methanol on the other hand is the much lower heat radiation and the possibility to extinguish the fire with water. Other conventional means of fire suppression also work for methanol fires but when using foam it is important to use an alcohol resistant foam agent. Gas systems and powder extinguishers work well for methanol fires.

In terms of rules for methanol the major class societies DNV GL and Lloyd's Register have rules in place. IMO are working on rules for low flashpoint liquid fuels (LFL) as part of the IGF code that covers both use of LNG and LFL. Part A covering LNG is finalised whereas Part B for LFL is still a work in progress. The IGF code and class rules are similar and the rules are at a mature state where the requirements are straightforward and clear.

For smaller ships the regulatory situation is different. While the available rules are good to use as reference they are not fully applicable. In part as the ships are generally not covered by SOLAS and class rules but also because the available rules are not suitable for smaller vessels in terms of available space on board and other practical challenges, e.g. in terms of installed onboard systems. For small boats on the other hand regulations exist for gasoline installations which are suitable to use as a reference for methanol installations. Some of the properties of methanol are sufficiently different from gasoline, however, to warrant the inclusion of some special systems to ensure safe operation.

This report aims to give general recommendations for methanol installations on different types of ships. The recommendations are general and for any installation appropriate risk analysis will be necessary.

In addition to the specific requirements highlighted in this report, component selection for an installation need to consider the properties of methanol. Stainless steel is generally recommended as a safeguard towards corrosion. Selecting appropriate sealing materials compatible with methanol is also important as standard sealing materials used for petroleum products are usually not compatible with methanol. As methanol is a common chemical, valves and other components are available but active selection is necessary.

1.1 DEFINITIONS

EX	Classification of electrical equipment to not induce sparks
EX-zone	Space or area with requirements on EX-classed equipment
LEL	Lower Explosion Limit
LFL	Low flashpoint fuel
MGO	Marine gas oil
MK1 Diesel	Diesel quality suitable for light and medium sized diesel engines
SOLAS	Safety of Life at Sea Convention
IGF code	International Code of Safety for Ships using Gases or other Low-flashpoint Fuels
IBC code	The International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk

2 General Requirements for methanol installations

Based on the IGF code and class rules the basic requirements for methanol installations are identified. The requirements partly derive from the IBC code that covers bulk transport of chemicals, and rules for LNG. LNG is similar in terms of combustion characteristics and both fuels will introduce requirements for use of explosion proof equipment (EX). The liquid state of methanol, in contrast to LNG where the fuel will boil off in case of spillage, will have an impact on the design. Safety measures to protect the ship from cryogenic induced damages are also not an issue for use of methanol.

To compare the different ship types and design requirements the key requirements are identified below. A table with the requirements and ship types is thereafter presented and discussed.

1. Fuel pumps to be located inside pump room

External fuel pumps for methanol are not allowed in the engine room and shall be located inside a special pump room. The reason for this requirement is the low flashpoint and likely leakage from pumps as bearing and seals get worn in combination with the low flashpoint. As the engine room cannot practically be an EX zone pumps and other equipment are isolated to a special compartment.

2. Pump room ventilation of underpressure type

To ensure that no methanol vapours enter the compartments surrounding the pump room, ventilation of underpressure type is a requirement. In case of methanol vapour detection in the pump room, ventilation will increase in order to prevent the creation of a flammable atmosphere.

The ventilation system shall also be separated from ventilation ducts and fans for other compartments.

3 Access to pump room from open deck or through air-lock

Access to the pump room shall when practical be arranged from open deck. As this is often not possible an alternative arrangement is through an airlock. The airlock shall have separate ventilation with underpressure and alarm if both doors are open simultaneously. The airlock shall also have vapour detection.

4 Double walled fuel pipes in all non-hazardous areas

Outside of the pump room and other potential safe areas fuel pipes containing low flashpoint fuels need to have a tight secondary barrier to contain potential leakage of methanol.

5 Mechanical ventilation of annular space

The annular space of double walled fuel pipes shall be equipped with mechanical ventilation of underpressure type with capacity of at least 30 air changes per hour.

6 Separate bilge system in LFL areas

The bilge areas for LFL areas need to be separate to isolate any potential spillage of fuel from the rest of the bilge system.

7 Pump room to have separate bilge system operated from outside

A separate bilge system is required for the pump room and is to be operated from the outside.

8 Integrated fuel tanks to have cofferdams on all side except towards bottom shell plating

In order to ensure that no methanol can leak from the fuel tanks cofferdams are mandatory around structural methanol tanks except towards the bottom shell plating if located in the double bottom. The cofferdams need to be 760 mm wide to allow for inspection. The cofferdams shall also be equipped with methanol vapour and liquid leak detection. In the case of Stena Germanica the surrounding cofferdams are permanent ballast water tanks and pressure sensors are used to detect leakage from the ballast tank to the methanol tank. Suggestions to allow for alternative solutions are being discussed such as an inner tank bladder to contain the fuel thus fulfilling the requirement for double barriers between the fuel and rest of the ship.

9 Automatic fuel shutoff valves

The fuel tank shall be equipped with automatic shutdown valves as close to the tank as possible. Each engine shall also be equipped with fuel shutoff valves outside of the machinery room.

10 All tanks containing LFL to be inerted

In order to secure that no flammable atmosphere can form inside the fuel tanks, inert gas, usually nitrogen, is used to fill the void space above the liquid level. Inert gas is also used to purge piping from methanol. Nitrogen is either generated on board by filtering out oxygen from air or supplied in high pressure bottles. Inertion with nitrogen is common when transporting methanol in chemical tankers and is required by international conventions for transporting gasoline. Inertion is not normally used for transportation on inland waterways or in road transports. Storage tanks on land can be equipped with inertion but this is usually primarily for purity protection, with the added benefit of protection from flammable vapours.

11 Tank P/V valves shall be located at least 1.5 m above weather deck

In order to sustain an overpressure of nitrogen in the fuel tank pressure vacuum valves are used. During normal operation the valve will only open during bunkering when excess nitrogen is exhausted from the tank. In case of failure of the nitrogen system the valve can also allow for air to enter the tank when a high enough vacuum pressure is reached.

12 Fixed gas detectors to be installed in

Fixed gas detection is to be installed where leaks are likely to occur such as in the pump room, engine room and cofferdams surrounding the tanks. The vapour detectors shall be monitored from the bridge and engine control room and be of continuous type. In case of detection of vapours actions are required at 15% and 30% LEL, eventually requiring shutdown of the affected system. The common action at the lower level is to ramp up the ventilation in order to dilute the vapour concentration.

3 SHIP TYPES

Depending on ship type the particulars of the design will depend amongst other things on the size of the vessel. For a general overview possible ships are divided in four categories based on size and regulatory differences.

- Type 1 - Large ship with SOLAS certificate
- Type 2 - Smaller ship with national speed certificate
- Type 3 - Smaller ship/working boat
- Type 4 - Small working boat/recreational craft

Type 1 - Larger ship with SOLAS certificate

For larger ships in international traffic SOLAS certificate and class certificates are mandatory. For these ships methanol regulations are partly in place in the form of the IGF code (specific part on low flashpoint liquid fuels not finished) and class rules from DNV GL and Lloyd's Register. Eight commercial ships have been built/converted to run on methanol: seven chemical tankers and one ropax ship.

These types of ships have advanced automation and alarm systems in place as well as high internal fire fighting capacity. Space and power capacity should not be a principal concern for any of the necessary systems. Fuel tanks are often integrated with the hull together with ballast water tanks and other auxiliary tanks.

Large tugs and offshore supply vessels are other types of ships that are also part of this category.

The engines are full size two or four stroke marine engines.

Regulations: SOLAS, IGF-Code, Class Rules, National statutes
Inspection bodies: Flag state, Classification society

Type 2 - Smaller ships with national speed certificate

Smaller ships in national traffic do generally not have SOLAS certificate. The vessel might not have class certificate but is constructed according to a set of requirements that might be based on class rules. The engines are similar to engines found in trucks and land based machinery but adapted for marine use.

The on board systems are scaled down from the large ships and the machinery room is not always attended. Fuel tanks can be integrated with the hull or independent. Ballast water systems are not necessarily available. Separation of engine room from fire pumps and electric switchboard is likely.

Road ferries, fishing vessels, local transport ferries are typical in this category.

Regulations: National statutes, class rules can be optional
Inspection bodies: Flag state. Classification society if classed

Type 3 - Small ships and working boats

Small ships and working boats are much smaller ships in commercial use. The machinery space is much smaller and maintenance during operation is generally not possible. Engines, switchboard and fire station are usually installed in the same compartment. Alarm panels, some degree of automation and advanced navigation and communication systems on board are usual as well as AIS and official call sign.

Typical members of the group are pilot boats, police boats, small transportation boats and some working boats.

Regulations: National statutes
Inspection bodies: Flag state

Type 4 - Small working boat/recreational craft

The smallest vessel group contains recreational crafts and small working boats. The engines can be similar to the other smaller vessels but are also somewhat smaller. The engine compartment is small and is not entered during operation. The on board systems are limited. The fuel is stored in independent tanks not readily accessible for inspection. In case of recreational crafts the design is dictated by EU Directive and associated ISO standards. Approval is done by an accredited organ, in northern Europe often DNV GL. Small working boats can be classed as recreational crafts.

The directive has special requirements for using gasolines. As gasoline, like methanol, is a low flashpoint fuel the requirements should also be fulfilled for methanol installations, in addition to some additional adaptions.

Regulations: EU directive and associated standards
Inspection bodies: Accredited organisation, e.g. DNV GL

4 TYPE DEPENDENT CONVERSION REQUIREMENTS

A general assessment of the system design requirements for the different types of vessels is presented in the table below. The results are general and for a conversion the specific ship still needs to be analysed. Area of operation, number of passengers and general arrangements will be key areas of interest when looking at the individual ship to determine what is safe and what is not. The table should still give a good indication of the general requirements.

		Type 1	Type 2	Type 3	Type 4
1	Fuel pumps to be located inside pump room	✓	✓[1]	✓[1]	[2]
2	Pump room ventilation of under pressure type	✓	✓[3]		[2]
3	Access to pump room from open deck or through air lock	✓	[4]		
4	Double walled fuel pipes	✓	✓	✓	✓[5]
5	Mechanical ventilation of annular space	✓	✓[6]		
6	Separate bilge system for LFL areas	✓	✓[7]		
7	Separate bilge system for pump room operated from outside	✓			
8	Integrated fuel tanks to have cofferdams/second barrier	✓	✓[8]		
9	Automatic fuel shutoff valves	✓	[9]	[9]	[9]
10	All tanks containing LFL to be inerted	✓	✓[10]	✓[10]	[10]
11	Tank P/V valve to be located above weather deck	✓	✓[10]	✓[10]	[10]
12	Fixed vapour detection of continuous type	✓	✓	✓	✓[11]

[1] By containing the fuel pumps inside steel chests with gas detection a similar level of safety is achieved. The pump box can be located inside the machinery room and be separate for each engine for redundancy.

[2] For gasoline installations all equipment in the engine compartment needs to be spark proof and procedures are mandated where the compartment is ventilated before and after use of the engines to ensure that no flammable levels of gases are present in the compartment during operation of the engines. Using methanol requires similar procedures. Spark proof equipment is similar to equipment of EX-type but is certified according to other standards, generally to somewhat lower requirements and lower price.

[3] For smaller engines the fuel flow will also be lower and the potential leakage much smaller. Ventilation of potential vapours is therefore less critical. By monitoring formation of vapours ventilating the space when needed is advised in order to detect potential leakage faster.

[4] If possible access from open deck is advised for smaller ships but is often not practical. Arrangement with air locks is also not practical on a smaller ship due to space limitations. As the quantity of fuel and fuel flow through pumps and pipes is also much smaller the potential risk of a large leak resulting in large amounts of vapours is also less likely.

[5] Double walled fuel pipes are generally recommended and there is commercial piping on the market that allows for practical installations for smaller ships and thus the recommendation is to have double walled pipes to as large an extent as possible. For the smallest segment fuel piping might need to be exchanged for hoses partly for fitting purposes but also to allow for enough flexibility when the hull bends and twists.

[6] Ventilation of the annular space in double walled piping is not practical for small pipe diameters as the pump losses will be significant and the arrangements overly complex for a smaller vessel. For the smaller engines the fuel flow will also be smaller and the potential consequences of leakage smaller. If the pipes are routed through critical areas pressure monitoring of the annular space can be used to monitor the pipe integrity. Without monitoring the outer pipe is used purely as a second barrier.

[7] Smaller vessels don't have advanced bilge systems. Methanol compartments should be inside watertight compartments with arrangements for disposal of methanol leakage through special arrangements but not necessarily during operation of the vessel. In emergency situations with water ingress the content can be pumped overboard with no harm to the environment.

[8] For small fuel tanks the cofferdams would intrude on much of the available space.

[9] Without sufficient redundancy on smaller vessels automatic shutdown of the engines can result in introduction of more danger. This includes limited leakage of methanol in safe locations. Alarms that call on immediate shutdown when safe are advised for smaller vessels. Mechanically operated remote closing of fuel valves will also be the advised means of closure for small vessels without extensive automation systems.

[10] Inertion should be considered on a case by case basis. For ships such as road ferries an inertion system might be feasible but for some cases it might not be possible to install an inert gas generator and not practical to use large numbers of spare bottles. The risk analysis should include arrangements during bunkering and possible repercussions in case of accidents.

For the smallest vessels flame arresters on ambient pressure tanks should suffice. Similar arrangements as storage in land based tanks.

P/V valves are only used in combination with tank inertion.

[11] Vapour detection should generally be used to monitor the atmosphere in critical areas. For vessels without advanced automation systems simplified detectors with a single alarm and no level indicator can be used to monitor the atmosphere, similar to gas alarms used to detect leakage from gas storage in caravans and recreational crafts.

5 Discussion and Conclusions

Each ship is different; many factors will influence the final design and recommended systems for the individual ship. The conclusions about necessary systems and design choices in this report are very general in nature and are based on previous work, discussions and risk analysis done for a small number of ships in different sizes. The results should not be viewed as definitive requirements but rather a possible general level of system complexity for different sizes of ships. Many different aspects will influence the design and requirements other than size such as operational profile, area of operation and passenger arrangements.

In general, special arrangements for methanol will be less for smaller vessels. In particular the smallest category where gasoline is today an alternative to diesel requirements would be very similar to requirements for gasoline. For larger ships diesel fuel is the alternative, consequently the requirements on a methanol installation will be higher to account for the much lower flashpoint. As requirements on safety systems in general are higher for larger ships as a result of larger consequences in case of failure, so are the requirements on the methanol systems.

6 REFERENCES

DIRECTIVE 2013/53/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on recreational craft and personal watercraft

IGF Code: International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels, 2016 Edition (I109E)

DNV GL Rules for classification - Part 6 Chapter 2 Section 6