Methanol as a Marine Fuel

Mark Penfold | December 11, 2018
Outline

- Background
- Rules and Regulations
- Safety Concepts
- Fuel Gas Supply Systems
- Prime Movers
ABS Mission

- Is to serve the public interest as well as the needs of our members and clients by promoting the security of life and property, and preserving the natural environment.
Compliance Options

DISTILLATE OR BLENDED FUELS
- MGO 0.1%S
- MDO 0.5%S

HIGH SULPHUR FUELS
- With EGCS

ALTERNATIVE FUELS
- LNG
- Methanol
- LPG
- Ethane

NEW FUELS
- New marine fuels
- ‘Hybrid’ - residual or distillate source
- Bio-fuels
- GTL
- Synthetic fuels
Methanol as a Marine Fuel

- Technically feasible
- Lifecycle NOx reductions (45% of conventional fuels)
- Lifecycle SOx reductions (8% of conventional fuels)
- Methanol is produced from natural gas but can be substituted by bio methanol in the future - source of methanol important for GHG reductions
- Commercially viable with high MGO prices
- Methanol as fuel on methanol carriers and pilot project
  - Waterfront Shipping (MOL, Westfal-Larsen, Marinvest)
  - Stena Germanica

Source: IMO MEPC 69/INF.10
Alternative Low Flashpoint Fuel Challenges

- Supply infrastructure
- Cost
- Lack of marine fuel quality standards and other regulations
- Low experience level
- Fuel properties !!
- Similar safety concepts to natural gas (double barriers, ventilation, gas detection, hazardous areas, etc.) but …. no single safety framework – fuel specific solutions – risk assessment

<table>
<thead>
<tr>
<th>Chemical Composition</th>
<th>MGO</th>
<th>HFO</th>
<th>Methane</th>
<th>Ethane</th>
<th>Propane</th>
<th>Butane</th>
<th>DME</th>
<th>Methanol</th>
<th>Ethanol</th>
<th>Hydrogen</th>
<th>Ammonia</th>
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<tbody>
<tr>
<td>Boiling Point, deg C</td>
<td>1bar</td>
<td>180-360</td>
<td>180-360</td>
<td>-166</td>
<td>-89</td>
<td>-43</td>
<td>-1</td>
<td>-25</td>
<td>65</td>
<td>78</td>
<td>-253</td>
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<td>Density, kg/m³ liquid</td>
<td></td>
<td>900</td>
<td>981</td>
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<td>600</td>
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<td>LHV, MJ/kg</td>
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<td>42.7</td>
<td>40.2</td>
<td>46</td>
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<td>46.3</td>
<td>45.7</td>
<td>28.7</td>
<td>19.9</td>
<td>20.8</td>
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<td>Auto ignition temp, deg C</td>
<td></td>
<td>250</td>
<td>250</td>
<td>650</td>
<td>515</td>
<td>470</td>
<td>365</td>
<td>350</td>
<td>450</td>
<td>420</td>
<td>535</td>
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<tr>
<td>Flash point, deg C</td>
<td>&gt;60</td>
<td>&gt;60</td>
<td>&gt;188</td>
<td>&gt;135</td>
<td>&gt;104</td>
<td>&gt;60</td>
<td>&gt;41</td>
<td>&gt;11</td>
<td>&gt;16</td>
<td>&gt;132</td>
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<tr>
<td>Flammable Range, % vol in air</td>
<td>0.6-7.5%</td>
<td>0.6-7.5%</td>
<td>5.15%</td>
<td>2.9-13%</td>
<td>1.9-9.5%</td>
<td>1.5-8.5%</td>
<td>3.3-18%</td>
<td>5.5-26%</td>
<td>3.5-15%</td>
<td>4.74%</td>
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<td>Energy density, MJ/l</td>
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<td>38.4</td>
<td>39.8</td>
<td>21.6</td>
<td>27.2</td>
<td>23.2</td>
<td>27.4</td>
<td>19.2</td>
<td>15.7</td>
<td>21.2</td>
<td>9.2</td>
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<td>Volume comparison MGO</td>
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<td>1</td>
<td>0.96</td>
<td>1.78</td>
<td>1.41</td>
<td>1.66</td>
<td>1.40</td>
<td>2.00</td>
<td>2.44</td>
<td>1.82</td>
<td>4.16</td>
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<td>3.206</td>
<td>3.114</td>
<td>2.750</td>
<td>2.927</td>
<td>3.000</td>
<td>3.030</td>
<td>1.911</td>
<td>1.375</td>
<td>1.913</td>
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<td>Carbon content</td>
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<td>0.8744</td>
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<td>0.7989</td>
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<td>0.5217</td>
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<td>CO₂, kg CO₂/kWh</td>
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<td>0.2701</td>
<td>0.2787</td>
<td>0.2061</td>
<td>0.2205</td>
<td>0.2331</td>
<td>0.2385</td>
<td>0.2397</td>
<td>0.2486</td>
<td>0.2568</td>
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</tbody>
</table>
Outline

• Background
• Rules and Regulations
• Safety Concepts
• Fuel Gas Supply Systems
• Prime Movers
Current Rules and Regulations

- **IGC Code**
  - Gas carriers
  - Revised Code effective July 2016
  - Alternative fuels considered under 16.9
  - IGC Code incorporated under 5C-8 of SVR

- **IGF Code**
  - Adopted June 2015 – MSC.391(95)
  - EIF 1 January 2017
  - IGF Code does not apply to gas carriers using cargoes or other low flashpoint fuels as fuel
  - Detailed requirements for natural gas only
  - Methyl/ethyl requirements under development – IMO CCC 5 Sep 2018 completed draft Interim Guidelines for methyl/ethyl alcohol fuels – referred to MSC 100 and CCC 6
  - IGF Code incorporated under 5C-13 of SVR
Current Rules and Regulations

**ACTION REQUESTED OF THE SUB-COMMITTEE**

32 The Sub-Committee is invited to approve the report in general and, in particular, to:

.1 approve the draft amendments to regulation 9.5.6 of the IGF Code, as contained in annex 1 to document CCC 4/12, for submission to MSC 100 as an urgent matter (paragraph 5);

.2 agree, in principle, to the draft interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel, and invite MSC 100, as an urgent matter, to endorse referring safety topics identified by the group to other technical sub-committees for consideration and advise to CCC 6 (paragraphs 18 to 20 and annexes 1 and 2);

The basic philosophy of these interim guidelines is to provide provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems using methyl/ethyl alcohol as fuel to minimize the risk to the ship, its crew and the environment, having regard to the nature of the fuels involved.

Source: IMO CCC 5/WP.3
Current Rules and Regulations

- MSC 99 invited ISO to develop a standard for methyl/ethyl alcohol as marine fuel
- Some concerns on lack of sufficient experience as a marine fuel
- ISO marine fuel standards fall under the TC 28 technical committee
- The TC 28 sub-committee SC4 is developing the marine fuel standard for LNG

Source: IMO MSC 99/22
IMO GHG Strategy

• Vision
  - IMO remains committed to reducing GHG emissions from international shipping and, as a matter of urgency, aims to phase them out as soon as possible

• Ambition
  - ... to reduce CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008 ...
  - ... to peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 ...
Class and Government

• The role of classification has been recognized in SOLAS and the International Convention on Load Lines.

• Classification societies also act as Recognized Organizations (ROs) performing statutory inspections on behalf of flag States.

• This statutory activity is distinct from but complementary to Class requirements.
ABS Rules - IMO IGF Code

- IGF Code incorporated under 5C-13 of the SVR
- ABS GFS Guide incorporated in 5C-13 from July 2017
- Notations now available for other low flashpoint fuels, e.g. LFFS(DFD – Methanol)

PART 5C
CHAPTER 13 Vessels Using Gases or other Low-Flashpoint Fuels
SECTION 1 General (ABS)

1 Classification Notations (ABS) (1 July 2017)
1.1 Gas Fuelled Ship
The GFS notation may be assigned where a vessel is arranged to burn natural gas as fuel for propulsion or auxiliary purposes and is designed, constructed and tested in accordance with the requirements of this Chapter of the Rules. The GFS notation will be assigned in association with one or more of the following additional notations (e.g., GFS(DFD, GCU)). Upon special consideration, the equipment notations referenced below may be assigned on an individual basis for specific ship types.

1.2 Alternative Low Flashpoint Fuelled Ship (2018)
The LFFS notation may be assigned where a vessel is arranged to burn a low flashpoint fuel other than natural gas for propulsion or auxiliary purposes and is designed, constructed and tested in accordance with the requirements of this Chapter of the Rules. The equivalence of the design is to be demonstrated by application of the Alternative Design criteria defined under 5C-13-2.3. The LFFS notation will be assigned in association with the specific low flashpoint fuel and one or more of the following additional notations (e.g., LFFS(DFD, Methanol)).

1.3 Reliquefaction System
Where a Reliquefaction System is designed, constructed and tested in accordance with 5C-13-69-1 and 5C-13-69-3, the RELIQ notation will be assigned.
IGF Code – Fuels other than Natural Gas

- IGF Code ‘Part 1’ covers natural gas only
- Other fuels can be used provided they meet the intent of the goals and functional requirements and provide equivalent level of safety
- Alternative design
- Equivalence to be demonstrated as specified in SOLAS regulation II-1/55
- II-1/55 refers to the IMO Guidelines for alternative design and arrangements, MSC.1/Circ.1212 – Risk Assessment
- This approach is already in the SVR under 5C-13-2/3
IMO IGF Code – Risk Assessment

- For ships using natural gas as fuel (part A-1 of the IGF Code) and complying with the detailed prescriptive requirements contained within the Code, a risk assessment need only be conducted where explicitly required by the prescriptive parts of the Code.

- Other low flashpoint fuels must apply risk assessment approach.

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**Table A3. Risk Levels**

<table>
<thead>
<tr>
<th>Likelihood Categories</th>
<th>Consequence Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Almost Certain (E)</td>
<td>Medium</td>
</tr>
<tr>
<td>Likely (D)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Possible (C)</td>
<td>Low</td>
</tr>
<tr>
<td>Unlikely (B)</td>
<td>Low</td>
</tr>
<tr>
<td>Rare (A)</td>
<td>Low</td>
</tr>
</tbody>
</table>
IMO IGF Code – Methanol RA

4.2 Risk assessment

4.2.1 A risk assessment shall be conducted to ensure that risks arising from the use of low-flashpoint fuels affecting persons on board, the environment, the structural strength or the integrity of the ship are addressed. Consideration shall be given to the hazards associated with physical layout, operation and maintenance, following any reasonably foreseeable failure.

4.2.2 For ships to which part A-1 applies, the risk assessment required by 4.2.1 need only be conducted where explicitly required by paragraphs 5.10.5, 5.12.3, 6.4.1.1, 6.4.15.4.7.2, 8.3.1.1, 13.4.1, 13.7 and 15.8.1.10 as well as by paragraphs 4.4 and 6.8 of the annex.

4.2.3 The risks shall be analysed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion and electric shock shall as a minimum be considered. The analysis shall ensure that risks are eliminated wherever possible. Risks which cannot be eliminated shall be mitigated as necessary. Details of risks, and the means by which they are mitigated, shall be documented to the satisfaction of the Administration.
Risk assessment as required by the IGF Code

1.1 General

To help eliminate or mitigate risks a risk assessment is required by the IGF Code\(^1\). In this regard it requires that the risk assessment is undertaken using acceptable and recognised techniques, and the risks and their mitigation are documented to the satisfaction of the Administration.

It is recognised that there are many acceptable and recognised techniques and means to document a risk assessment. As such, it is not the intent of this document to limit a risk assessment to a particular technique or means of documentation. This document does, however, describe recommended practice and examples to help satisfy the IGF Code.

1.2 Risk assessment - Objective

The objective or goal of the risk assessment, as noted in the IGF Code, is to help “eliminate or mitigate any adverse effect to the persons on board, the environment or the ship”\(^2\). That is, to eliminate or mitigate unwanted events related to the use of low-flashpoint fuels that could harm individuals, the environment or the ship.

Source: IACS Recommendation No.146
Roadmap for Approval

• Agree with flag and Class the approval roadmap to address safety and environmental aspects
  - Class compliance – Rules
  - Statutory safety – IGF Code
  - Statutory environmental – MARPOL Annex VI SOx, NOx, EEDI

• Low flashpoint fuels other than natural gas must apply risk assessment approach

FLOWCHART

CONCEPT DISCUSSIONS -> APPROVAL ROADMAP AGREED -> HAZID -> FINAL APPROVAL STATUTORY AND CLASS ASPECTS -> DOCUMENTATION FOR APPROVAL – ENGINEERING ANALYSES

HAZID ACTIONS ADDRESSED -> DETAILED DESIGN WITH HAZID ACTIONS ADDRESSED

FLAG ACCEPTANCE AND IMO GISIS NOTIFICATION

HAZOP, FMEA, ?
Outline

• Background
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IGF Code – Functional Requirements

- Minimize Hazardous Areas
- Minimize Equipment in Hazardous Areas
- Prevent Gas Accumulation
- Propulsion & Power Redundancy
- Prevent Asphyxiation and Toxic Concentrations
- Minimize Ignition Sources
- Prevent Leaks and Overpressure
- Fire and Explosion Protection
- Ventilation and Gas Detection
- Fire Detection and Extinguishing
- Commissioning & Gas Trials
- Inspection and Maintenance Procedures
- Single Failure Criteria

EQUIVALENT LEVEL OF SAFETY
Safety Concepts and Challenges

- **Prevention of leakage**
  - Double barriers
  - Sealing systems

- **Prevention of explosive atmosphere**
  - Ventilation and gas detection
  - Block and bleed
  - Purge and inert
  - Hazardous area classification

- **Explosion mitigation**
  - Design for worst case
  - Pressure relief systems

- **Toxicity**
  - Double barriers
  - Cofferdams
  - Air Locks

- **Prevention of explosive atmosphere**
  - Inert blanket for fuel tanks
  - P/V valves
  - Vents
  - Fuel prep/pump room – category A
  - Master fuel valve - FVT
  - Drain and purge

- **Fi-fi**
  - Invisible flame
  - Alcohol resistant foam
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Fuel Gas Supply Systems
Fuel Gas Supply Systems

- Oil unit:
  - Sealing oil 700 bar
  - Control oil 350 bar

- Methanol tank and LP feed system:
  - Methanol pump
  - Methanol 600 bar

- Water tank for dilution of fuel return

- Nitrogen generator
  - Nitrogen purge
  - 10 bar

- Diesel pump

- SSV: Shutdown and Safety Valve
- EHSV: Electro-Hydraulic Solenoid Valve

* All methanol lines can be flushed with nitrogen.

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DF and Gas Prime Movers

• Dual fuel engine technology introduced to the marine market since 2005
  - Primarily through medium speed engine applications to LNG carriers
  - Also with spark ignited gas engines installed on ferries and patrol craft in Northern Europe

• Type and application of DF and gas engines is expanding

• Use of slow speed DFs for main propulsion on LNGC and other ship types is emerging
DF and Gas Engine Safety Concepts

- Prevention of gas leakage
  - Double barriers
  - Sealing systems

- Prevention of explosive atmosphere
  - Ventilation and gas detection
  - Master gas valve and block and bleed valves > master fuel valve and shut off valve
  - Purge and inert
  - Hazardous area classification

- Explosion mitigation
  - Design for worst case
  - Pressure relief systems

- Suitable redundancy
  - Fuel supply systems
  - Switch to oil mode (DF engines)

- Stable combustion
Methanol, LPG and Ammonia as Fuels

- MAN 2-stroke high pressure Diesel combustion concept for burning Methanol, LPG, DME or ammonia – the ME-LGI engine
- Diesel type injection system, as HFO injectors
- Fuel supply pressure 8-40 bar
- NOx Tier II compliance - combined with SCR for ECAs

Cylinder cover with LPG injection valve and gas block – same system to be used for NH3

Valve control block:
- ELWI-valve (fuel pressurization)
- ELGI-valve (injection timing)
- Hydraulic accumulator
- Hydraulic and sealing oil connections

Double wall gas piping:
- LPG inlet
- LPG return
Methanol, LPG and Ammonia as Fuels

- MAN predicts 100% LPG as fuel take up on LPG carriers by 2028.
- Diesel combustion process gives similar heat release and firing pressures to fuel oil.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>NOx</th>
<th>SO2</th>
<th>PM</th>
<th>CO2</th>
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<tbody>
<tr>
<td>LNG</td>
<td>20-30%</td>
<td>90-99%</td>
<td>90%</td>
<td>24%</td>
</tr>
<tr>
<td>LPG</td>
<td>10-15%</td>
<td>90-100%</td>
<td>90%</td>
<td>13-18%</td>
</tr>
<tr>
<td>Methanol</td>
<td>30-50%</td>
<td>90-97%</td>
<td>90%</td>
<td>13-18%</td>
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<tr>
<td>Ethane</td>
<td>30-50%</td>
<td>90-97%</td>
<td>90%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Note: For methanol, Tier III can be met by blending with water.

- Compared with Tier II engines on HFO
- Based on estimates
- Tier III can be met with EGR or SCR

© MES
Methanol as a Marine Fuel

• Wartsila 4-stroke high pressure Diesel combustion concept for burning methanol
• Fuel supply pressure of 600 bar required (Diesel type injection system, as HFO injectors)
• NOx Tier II compliance - combined with SCR for ECAs
• Capability to operate fully on MGO/HFO

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Conclusions

- Main Class and regulatory framework in place
- Established safety principles adapted for specific fuel characteristics
- Risk assessment is part of the approval process
- Experience with dual fuel technologies growing
  - LNG on LNG carriers
  - Methanol on methanol carriers
  - LPG on LPG carriers
  - Ethane on ethane carriers
- All alternative low flashpoint fuels can provide solution for SOx compliance
- Zero and low carbon fuels, from sustainable sources, may be the roadmap to IMO and global ambitions on limiting global warming
ABS Support

• Rules, Guides and Advisories
• Techno Economic Evaluation
Thank you
www.eagle.org