Evaluation of Methanol

MethaShip
Methanol as fuel for engines in passenger shipping

Methanol Technical Workshop
Copenhagen, 20. March 2018
MEYER WERFT at a glance

- Family owned in 6th generation
- 3200 employees in Papenburg
- Two ship building docks, laser centre
- 1986: first cruise ship new build
MEYER group

MEYER TURKU
SHIPYARD 1737

NEPTUN WERFT
ROSTOCK 1850

EMS PreCab

PIIKKIO WORKS

MAC Hamburg
MARINE AIRCONDITIONING CENTRE
Portfolio

Cruise ships

River cruise ships

(Cruise)ferries

Passenger ships

Research ships

Island ferries

Gas tankers

Livestock carriers

Container ships
(1) MethaShip project
(2) Methanol ship design
(3) Some property highlights
(4) Sustainability & infrastructure
(5) Conclusion
MethaShip is ...

- Nationally funded German research project
- Partners from Shipbuilding, ship-safety, marine engines, methanol trading & production
- Project from 09/2014 to 05/2018

→ Examine methanol as fuel for cruise ships and RoPax ferries.

Associated partners:
Motivation

• Avoid emissions by use of clean fuels
• Environmental awareness
• Operate more eco- and energy-efficient
• Alternative fuel that is “practicable”
• Evaluate Methanol regarding sustainability (Paris agreement)
• Support the IMO rule development
Work Packages

WP 1: Fuel Infrastructure
WP 2: Ship systems
WP 3: Onboard conversion
WP 4: Thermal Energy Usage
WP 5: Development & Design
WP 6: Rules & Safety
WP 7: Eco-balance & LCA
Methanol cruise ship

<table>
<thead>
<tr>
<th>Main data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>238.0 m</td>
</tr>
<tr>
<td>Width</td>
<td>32.2 m</td>
</tr>
<tr>
<td>Tonnage</td>
<td>62 800 GT</td>
</tr>
<tr>
<td>Passengers</td>
<td>2050 + 570 Crew</td>
</tr>
<tr>
<td>Engines</td>
<td>4 x 9 MW medium speed engines</td>
</tr>
<tr>
<td>Main fuel</td>
<td>Methanol</td>
</tr>
</tbody>
</table>
GAP cruise ship

Tank plan:
MeOH Storage
Diesel (Pilot)
Exemplary tank arrangement

- Ambient conditions
- Room saving, structural tanks
- In hull & double bottom
- Mild steel
• Methanol content in gas phase depends on temperature

Atmospheric tank
\[ p_{\text{abs}} = 1 \text{ bar} \]

Evaporation is slow process (not boiling!). Little “driving force”.

- Max. 13% gaseous
  - 20 °C liquid

- Max. 22% gaseous
  - 30 °C liquid

\[ t \uparrow \rightarrow N_2 \downarrow \]

\[ t \downarrow \rightarrow N_2 \uparrow \]
Crucially different behaviour of gas and liquid fuel

- immediate pressure release
- less medium released
- locally bound
- easy detection & mitigation

Methanol is to be treated as “liquid fuel system”
 IMO Rule Recommendations

Documents to IMO CCC Sub-Committee

• CCC 3/INF.23  “Information on a German project called MethaShip”
• CCC 3/3/1    “Proposals [...] for safety of ships using [...] alcohol as fuel”
• CCC 4/3/4    “Boundaries for methyl and ethyl alcohol-fuelled ships”

Copenhagen, 20.03.2018
MEYER WERFT – Daniel Sahnen

SUB-COMMITTEE ON CARRIAGE OF CARGOES AND CONTAINERS
3rd session
Agenda item 3

AMENDMENTS TO THE IGF CODE AND DEVELOPMENT OF GUIDELINES FOR LOW-FLASHPOINT FUELS

Proposals for further amendments to the draft technical provisions for the safety of ships using methyl/ethyl alcohol as fuel, based on findings from the German project MethaShip

Submitted by Germany
IMO Rule Recommendations

Application of Secondary barriers
IMO Rule Recommendations

Vent & Ventilation arrangement
The beneficial properties of methanol result from being liquid.

- No potential of pressure build-up
- Slow evaporation
- Easy and safe spill mitigation (ventilation)
- Detection from 2 ppm onwards (MAC: 200 ppm for 8 h)
  → ideal for preventive surveillance
- ... and many more: water soluble (mitigation), bio degradable, ESD-protected spaces, vent outlets, small hazardous zones, high auto-ignition temperature, high heat capacity, ...)

By physics, Methanol is superior to fuels not naturally liquid.
### Hazard comparison

<table>
<thead>
<tr>
<th>Hazard pictograms (CPL)</th>
<th>METHANOL</th>
<th>DIESEL</th>
<th>GASOLINE</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Hazard pictograms" /></td>
<td><img src="image" alt="Hazard pictograms" /></td>
<td><img src="image" alt="Hazard pictograms" /></td>
<td><img src="image" alt="Hazard pictograms" /></td>
</tr>
</tbody>
</table>

### Signal word: (CPL)
- **DANGER**

### Hazard statements (CPL)
- **METHANOL**
  - 1223: Highly flammable liquid and vapor.会展中心：火灾时极易形成爆炸性混合物
  - 1332: Toxic if inhaled.会展中心：吸入有害
  - 1461: Toxic to organs.会展中心：器官有害

- **DIESEL**
  - 1120: Flammable liquid and vapour.会展中心：火灾时极易形成爆炸性混合物
  - 1405: Poison by inhalation.会展中心：吸入有害
  - 1461: Toxic to organs.会展中心：器官有害

- **GASOLINE**
  - 1224: Extremely flammable liquid and vapour.会展中心：火灾时极易形成爆炸性混合物
  - 1332: Toxic if inhaled.会展中心：吸入有害
  - 1461: Toxic to organs.会展中心：器官有害

### Precautionary statements (CLP)
- **METHANOL**
  - 1102: Keep away from heat.会展中心：远离热源
  - 1103: Keep out of reach of children.会展中心：儿童勿接触

- **DIESEL**

- **GASOLINE**

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**Hazard Statements** describe hazards of chemical substances and mixtures by standardized phrases. **Precautionary Statements** give advice for the safe handling.

**Methanol not classified “more dangerous” than other fuels.**
**U.S. EPA – fire safety**

**Methanol’s advantageous over gasoline**

- (1) lower volatility
- (2) higher flammability requirements
- (3) lower vapour density
- Less severe (heat release $\frac{1}{8}$ th, burning 75% slower)

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**Superior fire safety over Gasoline**
Flammability and Toxicity

Table adapted from Machiele, 1998; \(^{a}\) 1-No concern. 2 to 3 = Low Level concern. 4 to 6 = moderate concern. 7 to 8 = high-level concern. 9 to 10 = extreme hazard. \(^{b}\) Numbers in parenthesis reflect hazard reductions resulting from design changes. \(^{c}\) Number in parenthesis incorporates the lowered likelihood of ingestion due to the presence of additives.

MeOH overall less dangerous than Gasoline, which everyone knows from daily life.
A case of poisoning

_Methanol_ (CH\textsubscript{3}OH) is a chemical feedstock of increasing importance as well as a commonly used solvent. In the early 1980s methanol production was introduced at a new petrochemical complex in the Saudi port of Jubail. A case is presented of a consultant supervising tank cleaning prior to methanol loading. He wore positive pressure breathing apparatus but no protective clothing. After 2–3 hours working in the confined space of the tank, he worked on deck and continued to wear his methanol-soaked clothing which eventually dried out. Visual symptoms of acute methanol toxicity presented some 8 hours after exposure. The appropriate treatment (with ethanol provided by the ship bond) was carried out in hospital and the individual recovered completely. Most reported cases of methanol toxicity are social in origin, arising from ingestion. This particular case, though unusual, does present some interesting lessons.

**Easy and reliable treatment with full recovery.**
Lethal dosis (fish)

(LC50, LC=Lethal Concentration): Concentration in water, at which half the population died within a specified test duration.

- **Methanol**[1] 15400 (mg/l)
- **Methane**[5] 49,9 (mg/l)
- **Heavy Fuel Oil**[3] 79 (mg/l)
- **Diesel**[4] 65 (mg/l)
- **Gasoline**[2] 8,2 (mg/l)

**Methanol** better than
- **Diesel** by factor 240
- **Gasoline** by factor 1900

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[2] Petrobras/Statoil ASA, Safety Data Sheet, ECHA registration dossier Gasoline
[3] GKG/ A/S Dansk Shell, Safety Data Sheet
**Effect dose (algae)**

(EC50, EC = Effect Concentration):
Concentration in water, at which half the population shows change in growth rate after a specified test duration.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>EC50 (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
<td>22000</td>
</tr>
<tr>
<td>Methane</td>
<td>19.4</td>
</tr>
<tr>
<td>Heavy Fuel Oil</td>
<td>1</td>
</tr>
<tr>
<td>Diesel</td>
<td>78</td>
</tr>
<tr>
<td>Gasoline</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Methanol better than
- **Diesel** by factor **280**
- **HFO** by factor **22000**

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[2] Petrobras/Statoil ASA, Safety Data Sheet, ECHA registration dossier Gasoline
[3] GKG/ A/S Dansk Shell, Safety Data Sheet
MeOH spill simulations

Simulation 1 [8]:
• Release of 10,000 tons Methanol at open sea
  – Concentration of 0.36 % after 1 hour

Simulation 2 [8]:
• Release of 10,000 l/h from a coastal pier
  – Concentration < 1 % after 2 hours
  – Concentration of 0.13 % after 3 hours

Comparison to LC/EC50 values

Methanol dilutes so rapidly that EC/LC times will not even be reached.

Source: Malcolm Pirnie, Inc., Technical Memorandum
## Impact of accident

<table>
<thead>
<tr>
<th></th>
<th>Maritime accident</th>
<th>Maritime accident</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship</td>
<td>Erika</td>
<td>Tanio</td>
<td>-</td>
</tr>
<tr>
<td>Fuel</td>
<td>Heavy Fuel Oil</td>
<td>Heavy Fuel Oil</td>
<td>Methanol</td>
</tr>
<tr>
<td>Released amount</td>
<td>19 000 t</td>
<td>13 500 t</td>
<td>10 000 t</td>
</tr>
<tr>
<td>Affected coastline</td>
<td>400 km</td>
<td>200 km</td>
<td>0 km</td>
</tr>
<tr>
<td>Total damage:</td>
<td>$914M</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cleaning</td>
<td>$100M</td>
<td>$50M</td>
<td>$0</td>
</tr>
<tr>
<td>Fishing industry</td>
<td>$98,3M</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tourist industry</td>
<td>$400-500M</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Claim for damages</td>
<td>$120M</td>
<td>$17M</td>
<td>-</td>
</tr>
<tr>
<td>Killed birds</td>
<td>≈ 60,000</td>
<td>≈ 40,000</td>
<td>-&gt; 0</td>
</tr>
</tbody>
</table>

Source: economic, social and environmental effects of the „Prestige“ oil spill; international scientific seminar
„Even in the event of a large scale spill these times of exposure are unlikely to occur due to the rate at which methanol dissipates.“

Source: Plasma Fusion Center, Massachusetts Institute of Technology

„Methanol is significantly less toxic to marine life than petroleum fuels, and many of the effects of short term exposure are temporary and reversible.‟

„[…] and the U.S. Department of Energy considers gasoline to be ‘overall’ more hazardous to health than neat methanol.“

Source: Malcolm Pirnie, Inc., Technical Memorandum
Conclusion Properties MeOH

• For humans not more poisonous than diesel or gasoline
• Poisoning is reliably treatable by simple means. In particular Methanol is not carcinogenic
• Far less hazardous to the environment than gasoline, diesel or heavy fuel oil. Large scale spills at sea would rapidly disperse
• Aquatic plants and bacteria biodegrade Methanol readily and rapidly without residue
• No Global Warming Potential, unlike LNG (methane slip)
Major challenge “climate change”

2°C-limit (acc. RCP 2.6) requires

- **Peak of CO₂** by 2025, **negative emissions** towards 2070

Source: IPCC 2013 (WGI), SPM, page 27
Conclusions LCA

• **Today**: Methanol from natural gas or coal
  → No advantage in Life Cycle Assessment

• **Future** renewable production: Alcohols best in LCA

• Wind & solar becomes primary energy source in global scale
  → Fast steps towards renewable methanol needed

• Industrial scale production of Methanol since 1923 (BASF)

**Great outlook for Methanol to become the favoured E-fuel**
Power to X

Power yield from comparison

- **Wind**: 500 - 1000 GWh/(km²a)
- **Photovoltaics**: 170 - 300 GWh/(km²a)
- **Hydropower**: 12 GWh/(km²a) (Ilisu Dam)
- **Cultivated biomass**: 2 - 2.5 GWh/(km²a)

Source: „Energiewende zu Ende gedacht“, Ulf Bossel, 2014

Sun & Wind yield substantially more, sensible land use compulsory.
Infrastructure

- Infrastructure plays a major role (*costs!*)
- Methanol infrastructure already present
  → It can vastly be extended by adjustments to existing tanks.

- Bunkering workshop conducted

A world wide spread fleet could practically be existent.
Conclusion

- Physics of Methanol surpasses other alternative fuels
- Ship design: Easy, advantages, practicable, understandable
- Methanol should be treated as “liquid fuel system”
- Compelling environmental properties
- Most promising in LCA when renewably provided
- Infrastructure could become a key enabler

Appeal: Utilise Methanol’s advantages
Thank you for your attention.