LNG as Marine Fuel: The Moment of Truth

LNG, CNG AND LPG IN SMALL VESSELS

16 March 2016

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3. LNG, CNG AND LPG
4. WORLD FLEET
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SEAPLACE

- SEAPLACE is an engineering consultancy company offering its service to the shipbuilding and offshore industry since 1980.

- Highly qualified personnel (more than 40 engineers) whose expertise, knowledge and experience combination allow us to face new challenges and achieve success.


MAIN ACTIVITIES

- Technical office
- Special studies
- Customer support team
Conceptual and Basic engineering

Model test

Detail engineering

Special studies
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LNG, CNG AND LPG IN SMALL VESSELS

SMALL SHIPS
SMALL SHIPS

Class Society – Structural point of view:
Bureau Veritas:
L less than 65 m (cargo ships)
L less than 90 m (non-cargo ships)
Lloyds Register:
L less than 65 m
DNV:
L less than 100 m
ABS:
L less than 90 m
SMALL SHIPS

Mv Greenland. HPPinsinght
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Why these fuels?

• Comply with Environmental Regulations
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- Comply with Environmental Regulations
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LNG, CNG and LPG

Natural Gas

• Mainly Methane 80-95% plus ethane, propane, butane
• Different compositions according to extraction geographical area
• Specific Energy about 11.41 KWh/kg *
• Non toxic
• Lighter than air
• Produced from gas fields
• Tc ~ -83 °C *
LNG, CNG and LPG

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LNG

- Natural gas in liquid form
  - Liquid at $-162 \, ^\circ C$ at atmospheric pressure.
- Density 450 kg/m$^3$ *
- Energy Density 22.2 MJ/l *
- Stored in cryogenic tanks
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- Different compositions according to % Propane – Butane
- Specific Energy about 13,34 KWh/kg *
- Low Toxicity (very high concentrations)
- Heavier than air
- Produced as by-product of refining process and also extracted as associated gas
- Tc Propane = 97 °C *
- Tc Butane = 152 °C *
- Liquid at ~18 bar at ambient temperature *
- Density 510 kg/m³ *
- Energy Density 26 MJ/l *
- Stored in liquid in cylindrical bottles pressurized, semi-pressurized or fully refrigerated
**LNG, CNG and LPG**

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<table>
<thead>
<tr>
<th></th>
<th>PROPANE</th>
<th>BUTANE</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Chemical Formula</td>
<td>$C_3H_8$</td>
<td>$C_4H_{10}$</td>
<td>$C_4H_{10}$</td>
</tr>
<tr>
<td>Energy Content MJ/kg</td>
<td>49,58</td>
<td>47,39</td>
<td>45,59</td>
</tr>
<tr>
<td>Boiling Temperature °C</td>
<td>-42</td>
<td>-0,4</td>
<td>-11,75</td>
</tr>
<tr>
<td>Vapor Pressure at 21°C kPa</td>
<td>858,7</td>
<td>215,1</td>
<td>310,9</td>
</tr>
<tr>
<td>Expansion m$^3$/L</td>
<td>0,270</td>
<td>0,235</td>
<td>0,234</td>
</tr>
<tr>
<td>Specific Volume m$^3$/kg</td>
<td>0,540</td>
<td>0,405</td>
<td>0,402</td>
</tr>
<tr>
<td>Gas density 15°C</td>
<td>1,899</td>
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* Composition dependant

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**Boiling Temperature °C**

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**Vapor Pressure at 21°C kPa**

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**Specific Volume m³/kg**

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**Gas density 15°C**

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LNG, CNG and LPG - Engines
LNG, CNG and LPG - Engines

MAN Diesel & Turbo

Wärtsilä
LNG, CNG and LPG - Engines

MAN Diesel & Turbo

Wärtsilä

Rolls-Royce
LNG, CNG and LPG - Engines

MAN Diesel & Turbo

WÄRTSILÄ

ROYCE

CAT
LNG, CNG and LPG - Engines

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Wärtsilä

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CAT
LNG, CNG and LPG - Engines
LNG, CNG and LPG - Engines

MAN Diesel & Turbo

Wärtsilä

Rolls Royce

CAT

ABC

mtu

Mitsubishi Marine Engine
Comparison of emission levels shows that there are benefits in the full range when using LPG as fuel: a 17 per cent reduction in CO₂, 12 per cent reduction in NOₓ, a 92 per cent reduction in SOₓ and a 37 per cent reduction in particulates.

Table 7-1 Emission comparison between HFO burning K50MC-C and LPG burning S50ME-GL.

<table>
<thead>
<tr>
<th></th>
<th>Estimated emissions</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HFO 3500 S. RW 6K50MC-C</td>
<td>8% pilot oil – 46% propane &amp; 46% butane</td>
</tr>
<tr>
<td>Load 100%</td>
<td>g/kwh</td>
<td>Load 100%</td>
</tr>
<tr>
<td>CO₂</td>
<td>556</td>
<td>CO</td>
</tr>
<tr>
<td>O₂ (%)</td>
<td>1223</td>
<td>O₂ (%)</td>
</tr>
<tr>
<td>CO</td>
<td>0.71</td>
<td>CO</td>
</tr>
<tr>
<td>NOₓ</td>
<td>11.97</td>
<td>NOₓ</td>
</tr>
<tr>
<td>HC</td>
<td>0.28</td>
<td>HC</td>
</tr>
<tr>
<td>SOₓ</td>
<td>10.57</td>
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Source: (MAN Diesel & Turbo 2011)
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WORLD FLEET - LNG

At present there are around 85 LNG Gas fuelled vessels in operation: Ferries, Barges, Chemical tankers, Platform support vessels, Ro-Ro, RO-PAX, tugs, etc. Around half of them could be catalogued as "Small Vessels" (L<100 m)
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With harvest.

Hoydal

Viking Lady

Helgoland

Haichuan 3
WORLD FLEET - LNG

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WORLD FLEET - CNG

Texelstroom
WORLD FLEET - CNG

Texelstroom

Damen CNG tug
WORLD FLEET - CNG

Accolade II

Damen CNG tug
WORLD FLEET - CNG

Mv Klatawa

Accolade II

Damen CNG tug
WORLD FLEET - CNG

- *Damen CNG tug* (Mv Klatawa)

- *Sistership Mv Kullet*

- *Accolade II*
WORLD FLEET - CNG

Mv Klatawa

Sistership
Mv Kullet

Accolade II

Damen CNG

James C. Echols
WORLD FLEET - CNG

Mv Klatawa
Sistership
Mv Kullet

Accolade II

Canal boats

James C. Echols
World Fleet LPG

A series of 12 sister vessels.
8000 m³ Ethylene/LPG/VCM carrier vessels.
Owner-Lauritzen Kosan
First vessel- Isabella Kosan in 2007
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Why LPG is not developing in the same way than LNG or CNG?

Studies shall be carried out to select the most suitable type of fuel for our ship considering power requirements, % use, route, autonomy, idle time, availability, infrastructure, price, etc.
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• How much LNG, CNG and LPG as marine fuels could be scale down?
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LNG as Marine Fuel: The Moment of Truth

THANK YOU
GRACIAS

16 March 2016