SEAGAS LNG distribution to Viking Grace | “Make a Difference”
Jonas Åkermark
2013-05-20

Co-financed by the European Union
Trans-European Transport Network (TEN-T)
- AGENDA -

Background
LNG Bunkering approval process
SEAGAS
Summary
- AGA – Who we are

- Since 2000 AGA is a part of the Linde Group.

- The Linde Group is a world leading supplier of industrial, process and speciality gases and is one of the most profitable engineering companies.

  - Active in more than 100 countries
  - Over 60 000 employees
  - Revenue of EUR 15.280 bn in 2012.

- Clean Energy, including LNG and Biogas, is a focus area.

- Linde Group is a world leader in all phases of LNG, from production to customer processes.
AGA´s LNG-terminal in Nynäshamn started up in March 2011.

AGA signed a contract with Viking Line in January 2012 regarding the delivery of LNG to Viking Grace.

AGA signed a contract with Sirius in June 2012 regarding the operation of SEAGAS.
IMO Directive 2015 – reduction of sulphur dioxide emissions, limiting the maximum sulphur content of marine fuel to 0.1% in SECA* from 2015

LNG is the cleanest marine fuel with substantial environmental- and health advantages compared to oil

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>-25%</td>
<td>NOₓ</td>
<td>-80%</td>
</tr>
<tr>
<td>SO₂</td>
<td>-100%</td>
<td>Particles</td>
<td>-100%</td>
</tr>
</tbody>
</table>
- LNG - properties

### Natural gas, a mix:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>~ 90%</td>
</tr>
<tr>
<td>Ethane</td>
<td>~ 9%</td>
</tr>
<tr>
<td>Propane</td>
<td>~ 0.6%</td>
</tr>
</tbody>
</table>

LNG boiling point: -163 °C
Liquified /gas: 1/600 litres

### Safety:

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>0.78 kg/Nm³</td>
</tr>
<tr>
<td>Density (LNG)</td>
<td>0.45 ton/m³</td>
</tr>
</tbody>
</table>

Combustibility in air: 4.7-14.4% (gasform)

Non toxic
Odourless – smell added

### Combustion:

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating value</td>
<td>10.73 KWh/Nm³</td>
</tr>
<tr>
<td></td>
<td>13.7 KWh/kg (NCV)</td>
</tr>
</tbody>
</table>

Emission levels compared to oil:
- CO₂: 20-30% lower
- NOₓ: 75% lower
- Sulphur & particles: low

Termisk tändtemperatur:

Termisk tändtemperatur för olika ämnen.
AGA | Distribution av LNG till Viking Grace

- LNG distribution to VG today -
AGA | Distribution av LNG till Viking Grace

- LNG distribution to Sthlm tomorrow… -

"SEAGAS 2"
In December 2010 AGA applied to the Swedish Transport Agency for permission to perform bunkering in the Port of Stockholm

A lack of regulation and support documents covering the handling of LNG in a maritime environment is the reason why AGA have performed a number of risk & safety analyses to better understand and handle potential risks related to LNG operations.
AGA | Distribution of LNG to Viking Grace

- Stakeholders -

Approval process

AGA
Viking Line
Sirius Shipping
Swedish Transport Agency
County Administrative Board
Ports of Stockholm
City of Stockholm
Fire Brigade
The Swedish Police
Swedish Coast Guard (KBV)
Swedish Civil Contingencies Agency (MSB)

SEAGAS

AGA
Sirius Shipping
Cryo
Swedish Transport Agency
Fiskerstrand Verft
Viking Line
DNV
Mann-Teknik
Risk analyses - Content

1. RISK ANALYSIS PART 1 - General ("generic") risk analysis studying the LNG supply vessel movements in Stockholm harbor → vessel movements, operational instructions

2. RISK ANALYSIS PART 2 – Risk analysis (generic and platform independent) related to the bunkering operation. Dissemination calculations → Safety zones, Bunkering procedure, Vessel design, Cryo installation design

3. RISK ANALYSIS PART 2b – Risk analysis where collision and seakeeping between LNG fuelling vessel and another vessel were studied. → Vessel design
Safetyzone 25 m around LNG fuelling vessel

Figur 1: Säkerhetszon (orange) och riskområde vid tow-away händelse med break-away koppling 6”. Vit: 25% LEL, blå: LEL, röd: UEL, cyan: jetbrand (3kW/m2)
Swedish Transport Agency 2013-03-19

"Transportstyrelsen have no objections to the risk identification and the analysis”.

City of Stockholm 2012-04-05

"No other actions are needed besides those suggested”

County Administrative Board – “The proposed activity does not risk polluting or affecting the quality of water”.
NOTE:
Cold box is defined as cargo area.
LNG tank is a double walled, vacuum insulated tank.
All gas connections from tank are located in cold box.
AGA | Distribution of LNG to Viking Grace

- SEAGAS -

DNV +1A1 R4 E0 ICE-C Tanker for liquefied gas (LNG)
AGA | Distribution av LNG till Viking Grace

- SEAGAS jan 2013 -
AGA Distribution av LNG till Viking Grace

- SEAGAS march 2013 -
AGA | Distribution av LNG till Viking Grace

- Dry Disconnect Coupling -
AGA | Distribution av LNG till Viking Grace

- LNG handling in the Port of Stockholm for Viking Line

- LNG/year 22500 ton = 50000 m³
  Bunker barge capacity ~ 70 ton
  Bunkering to Viking Grace 6 times/week → 5 times /week
  LNG truck capacity 25 ton
  Trucks/day 2-3
AGA | Distribution av LNG till Viking Grace

- Bunkring Truck-to-ship -
AGA has contributed to a new infrastructure solution for handling of LNG in the Port of Stockholm which allows for the following bunkering procedures:

- Ship-to-ship bunkering
- Truck-to-ship bunkering
- Stationary LNG tank on the quay is also possible

The processes are flexible and can be adapted to local conditions and other ports.
- The future -

• The belief in LNG as a viable fuel increases
• Many ship owners are investigating and planning for the use of LNG as fuel. Cruise ships → All types ships
• New design regulations for LNG-powered ships will facilitate their development
• "All" ships can be powered by LNG
AGA | Distribution of LNG to Viking Grace

- The future -
Thank you!

Jonas Åkermark

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