LNG Storage and Fuel Gas Systems

LNG: Fuel for Shipping, London 15-Feb-2011

Carriers & Offshore Units

Jürgen Harperscheidt
Sales Manager
CONTENT

- TGE Company Profile
- Small LNG carriers
- Bunkering
- LNG fuel gas systems for ships other than gas carriers
- LNG tanks and insulation
- BOG management
- Available technologies
- Conclusions
‘TGE Marine is a long established market leader in the design and construction of cargo handling systems for ships and offshore units carrying liquefied cryogenic gases (LNG, LPG and petrochemical gases)’

- Personnel: approx. 60 engineers & specialists plus temporary staff
- Turn-over: 82 M€ in 2007; 96 M€ in 2008; 72 M€ in 2009
- Main Office: Mildred-Scheel-Str. 1, 53175 Bonn, Germany
- Branch Office in Shanghai, China
Business activities and expertise

Cargo handling systems and cargo tanks for Gas Carriers
- LPG carriers, CO₂ carriers
- Ethylene carriers
- LNG carriers

Cargo handling systems for Offshore units
- FSO/FPSO for LPG
- FSRU and FPSO for LNG
- CO₂ liquefaction, storage and offloading units

Fuel Gas Systems for seagoing vessels
- Fuel gas supply systems
- Fuel gas tanks
- RoRo, Container, Ferries, …
- Bunker Barges, Bunker Boats
- LNG fuel storage systems
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19-May-2010 „Coral Methane“ loading at Zeebrugge,
First loading of a small carrier at a large import terminal.
Market drivers for small LNG shipping

- Remote areas requiring environmentally friendly energy (power plants, industry), like islands in Mediterranean or Caribbean Sea.
- Fuel gas for ships to be supplied close to the main traffic routes and ports, especially in ECA areas.
- “De-coupling” of LNG prices from oil price level based on alternative gas sources (e.g. shale gas US), developing spot market for LNG.
Small LNG Carriers

- Up to 10,000 cbm cylindrical tanks
- Up to 20,000 cbm bilobe tanks (patented supports)
- Ship sizes up to 75,000 cbm have been studied
- Tank pressure 2.7 to 4.0 barg
- BOG handling by pressure increase or fuel gas consumption
Main aspects for design of small LNG carriers

- Tank design: type C to allow for:
  - Partial loading, no secondary barrier
  - High loading rates
  - Pressure build-up possible
  - Separate tank erection and easy installation

- Tank insulation:
  - PS or PU panels
  - PU spray foam
  - sandwich vacuum panels

- Dual fuel, pressure build-up or reliquefaction for boil-off handling

- Combination with other cargoes possible (Ethylene, LPG…)}
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Bunkering

- Current practice (Norway): from shore/truck in dedicated areas by hose, no cargo operations simultaneously
- Requirements for future operations:
  - High loading rates due to tight time schedule
  - Large total amount of LNG for large vessels
  - Bunkering during cargo operations
  - Safe but easy handling of equipment
- This will only be possible with bunker vessels (small LNG carriers as above) coming alongside
- Special features like BOG absorber or re-condenser to increase bunker rate in case of no vapour return
- Additional services like first cooling, tank emptying/warming/inerting might be offered by bunker barge as well
- Regulations and standards for the bunker interface and related operations are under preparation by several international working groups
Bunker Connection

The bunker connection has to be suitable for the related infrastructure and can be designed accordingly:

- size, number and position of manifolds
- bunkering rate (size, vapour return)
- mechanical connection (hoses, loading arms)
- dry break couplings, emergency release couplings
- signal interface ship - shore
- ESD interface
“Pioneer Knutsen“ and “Coral Methane“ during LNG transfer, LNG bunkering could look like this in near future (Anthony Veder, Gasnor).
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LNG fuel gas systems for ships other than gas carriers

- Situation: Some ferries and offshore supply vessels mainly in Norway supplied by shore terminals and trucks
- Infrastructure and international standards (IMO IGF-Code) under development
- Focus on ECA/SECA areas like North Sea and Baltic
- Potential ship types (near future): Ferries, Ro/Ro, RoPax, passenger, container (feeder), superyachts
- A wide range of bunkering/storage/onboard fuel gas processing due to different type/size of ships
- Challenge: integrate LNG system to a ship, where LNG is only a utility, not the main cargo
Basic components of fuel gas systems

Auxiliary systems:
- water-glycol heating system
- inert gas system
- vent / ventilation
- valve remote operation
- safety systems
- automation & control
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# LNG tank types

<table>
<thead>
<tr>
<th>Tank type</th>
<th>Concept</th>
<th>Pressure</th>
<th>Partial Filling</th>
<th>2nd Barrier</th>
<th>Dis-Advantages</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Membrane; Semi-Membrane</td>
<td>Integrated in hull</td>
<td>&lt; 0.25 barg (max. 0.7)</td>
<td>No Some Yes</td>
<td>Yes</td>
<td>Very sensitive against pressure variations; Pressure holding necessary; Not gastight</td>
<td>Can be adapted to hull</td>
</tr>
</tbody>
</table>

**Independent type**

<table>
<thead>
<tr>
<th>Tank type</th>
<th>Concept</th>
<th>Pressure</th>
<th>Partial Filling</th>
<th>2nd Barrier</th>
<th>Dis-Advantages</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>prismatic with straight planes, adapted to hull shape</td>
<td>&lt; 0.7 barg</td>
<td>Yes</td>
<td>Yes</td>
<td>Pressure holding necessary; Very voluminous vent system due to low pressure</td>
<td>Can be approx. adapted to hull shape</td>
</tr>
<tr>
<td>B</td>
<td>prismatic with straight planes, adapted to hull shape spherical (Moss)</td>
<td>&lt; 0.7 barg</td>
<td>Yes</td>
<td>Partly</td>
<td>Pressure holding necessary; Very voluminous vent system due to low pressure</td>
<td>Can be approx. adapted to hull shape</td>
</tr>
<tr>
<td>C</td>
<td>Independent pressure vessel</td>
<td>&gt; 2 bar</td>
<td>Yes</td>
<td>No*</td>
<td>Space requirements volume factor 3-4 compared with HFO/MDO</td>
<td>- very solid design - Flexible pressure - Easy installation - No leakages occurred - No maintenance needed</td>
</tr>
</tbody>
</table>

* as per IGC code, under discussion for IGF code
TGE’s Tank fabrication expertise

Fabrication 8,200 m³ and 8,400 m³ Bilobe and Cylindrical Tanks for Ethylene Service

Fabrication Bilobe Cargotanks for 5x22,000 m³ Ethylene Carriers

Transportation of Stainless Steel cargo tanks for a 7,500 m³ LNG carrier on a heavy lift carrier to a shipyard in Europe

Cargo tanks type A for a 23,000 m³ Fully Refrigerated LPG Carrier
Typ-C Tank installation

Installation of 4000 m³ / 400 t cylindrical tank Ethylene Carriers
Tank Insulation

- Vacuum insulation for small cylindrical tanks
- PS or PU preformed slabs covered by steel sheets, allow for conical and bilobe shapes
- PU foam covered by polymeric protection layer
- Special panels for increased insulation efficiency
- Choice depending on requirements (operation/consumption schedule, possible tank shape)
## Foam insulation vs. vacuum

<table>
<thead>
<tr>
<th></th>
<th>Foam insulation</th>
<th>Vacuum insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>size</strong></td>
<td>cylindrical &lt; 10,000 cbm</td>
<td>&lt; 700 cbm per tank</td>
</tr>
<tr>
<td></td>
<td>bilobe &lt; 20,000 cbm</td>
<td></td>
</tr>
<tr>
<td><strong>shape</strong></td>
<td>cylindrical, bilobe, conical</td>
<td>cylindrical</td>
</tr>
<tr>
<td><strong>outlet</strong></td>
<td>all connections on top</td>
<td>min. 1 bottom outlet</td>
</tr>
<tr>
<td><strong>boil-off rate</strong></td>
<td>0.4 to 0.8 % per day</td>
<td>below 0.2 % per day</td>
</tr>
<tr>
<td><strong>in-tank equipment</strong></td>
<td>e. g. pumps, heaters</td>
<td>no manhole (usually)</td>
</tr>
<tr>
<td><strong>inspection</strong></td>
<td>5 years in-tank</td>
<td>no manhole (usually)</td>
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BOG management

- Boil-off gas will occur based on heat ingress
- Amount in relation to outer temperature, insulation efficiency and surface area
- Boil-off rate usually in weight-% of maximum filling per day, about 0.1 - 0.15 % for large carriers
- Small tanks have bad surface to volume ratio resulting in high boil-off rates, 0.4 to 0.8 % per day
- For fuel gas systems and small carriers the consumption is higher than BOG rate
- No consumption: pressure increase limited by MAWP and filling level
- Alternatives: Gas Combustion Unit (GCU) or reliquefaction (both CAPEX!)
Tank pressure of type C tank
No consumption

Pressure increase estimation for type C tanks

LNG composition:
N2: 2%
CO2: 0%
C1: 89%
C2: 5.5%
C3: 2.5%
C4: 1%

4 barg
max. level: 90.3 %

8 barg design
max. level: 86.0 %

Tank volume: 2 x 350 m³
Insulation: 300 mm PS/PU
Initial pressure: 140 mbar
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Fuel gas processing technologies

Pressurizing - options:
- Simple version: Tank vaporizer for pressurizing keeping tank at supply pressure (pump or vaporizer in-tank or bottom outlet)
- LNG pumps feeding fuel gas vaporizer (buffer required)
- Low pressure vaporization and fuel gas compressors (buffer volume to follow quick load changes, warming-up, loading rate)
- Main criteria: tank size, operation schedule

Vaporizing and heating:
- Water glycol heated S&T vaporizer
- Water glycol heated plate type gas heater
- Water glycol heated by low temperature engine cooling water

2 stroke version – 300 bar g required
- High pressure pump(s) and HP vaporizer/heater
Fuel gas processing

- Tank design pressure 8 to 10 barg
- Tank operation pressure 6 to 8 barg
- Small in-tank-pump avoiding bottom outlet.

- Typical vacuum tank design
- Equipment inside “cold box”
- Bottom outlet to feed tank vaporizer.
Fuel gas processing

- Tank design pressure 4 to 6 barg
- Tank operation pressure 1 to 5 barg
- Screw compressor with oil separator
- Buffer vessel to follow load changes
- Warming up, increased bunkering rate
- Flexible and reliable operation

Picture Source: Study Neptun Stahlkonstruktion, GL, MAN & TGE
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CONCLUSIONS

- Small LNG carriers are part of an existing and quickly developing market.
- Energy supply to remote areas and fuel gas systems for ships are the main drivers.
- LNG fuel gas is an environmentally friendly and commercially attractive way of propulsion.
- Technical solutions for small LNG transport and LNG as ships fuel are available – standard or tailor made.
- Excellent safety record of LNG business and proven safety systems limiting risks.
- LNG bunker infrastructure is the major challenge
Thank you for your kind attention