LNG Bunkering Solutions

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Business Development Manager Europe
Agenda

- **LNG is HOT & 2015 is closing in..**
- Bunkering LNG – Custody Transfer
- Bunkering LNG – what to measure & how
- Bunklering LNG – Installation
Green Shipping – Governmental Interest

- Kyoto Protocol – 2020 – 5.2% of 1990 level
- EU Emissions Trading Scheme – Road, Air
- International Maritime Organization:
  - MARPOL
  - (Sulphur) Emission Control Area

<table>
<thead>
<tr>
<th>Regulation</th>
<th>2012</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARPOL</td>
<td>3.5</td>
<td>3.5</td>
<td>0.5 (0.1)</td>
</tr>
<tr>
<td>ECA</td>
<td>1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Liquefied Natural Gas (LNG) – An Alternative Marine Fuel

- Natural gas is a conventional energy source
- Cheaper than HFO or low sulphur fuels
- Available & reaching regulations
- Easy to transport
- 600x compressed in volume
- Natural gas made clean of freezable gases, like CO₂.
- Non-explosive in an unconfined environment & Non-polluting when spilled

![Figure 14: Emissions across engine type](image)
Ship Types & technology options

Savings potential by vessel type & optional technology

- Deep Sea Container (>3000 teu)
- Deep Sea Tanker
- Bulk Carrier
- Offshore Supply Vessel
- Short Sea Container (<3000 teu)

MEC Intelligence Report, October 2011
Market expectation for CY2020 is 4500 New-build vessels which consume 4.8 Million Ton LNG/yr
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- Bunkering LNG – Custody Transfer
- Bunkering LNG – what to measure & how
- Bunklering LNG – Installation
**Custody Transfer – MID**

- MID stands for Measuring Instruments Directive
- EU harmonization & standardization around the transfer of ownerships of liquids and gases and the method of tax paying around it:
  - 1 European union, 1 set of rules for custody transfer – 27 EU countries + CH, NO & TR
  - Introduction– transfer time – Obligation by October 31, 2016
  - Local regulations may continue to apply to pay taxes over fuels and liquors.

- Liquids (other than water) and Gases
- Type approval
- System certificate
- Accuracy classes

Applications:
- Loading / unloading, pipeline
- % alcohol measurement
- Cryogenics

Read the brochure: MC-001070
What is OIML and MID?

A set of Measuring System requirements to guarantee:

- You get what you are paying for and you can prove it
- You deliver what you are being paid for and you can prove it

- OIML is global standard and MID is European Directive.
- NMi and Emerson cooperated (with system-owners) to achieve fulfillment of MID (and OIML) for Legal applications.
**MID, in-use installations**

- What does it mean for existing installations
  - In–use & unmodified, no problem
  - Modification means upgrade

- What does it mean for new installations
  - Pre-MID National legislation, or
  - MID
MID Responsibility

- Two steps process, responsibility of the “MID manufacturer”
  - 1st Obtain an EC Type Examination Certificate for each model code
  - 2nd Initiate the initial verification for each serial number

- New installation only; maintenance outside MID scope (National regulated)

- Measuring System for liquids, other than water
  - End user / Contractor / Emerson / Skid Builder to obtain System certificate
  - Incl. Flow meters & computers, temperature & pressure sensors, valves, etc.

- LNG is liquid; BOG = gas (manufacturer step 1 only)
- Boil Off Gas – outside OIML / MID scope
**Scope of instruments under MID for liquid**

**Typical measurement set up:**

- **DCS/ host**
- **Operator Interface**
- **Bill of Lading Printer**
- **Transfer Point**

**MID scope for liquid:**

CT display; local printer; memory etc. AND installation between meter and transfer point

**Do not include DCS; host/management computers which generate the invoices**
MID Verification in Practice

- **System Certificate**
  (EC Type Examination Certificate)
  Description of:
  - Installation
  - Application
  - Functionality

- **System Verification**
  (Initial Verification)
  Field verification for:
  - Installation integrity
  - Components integrity
  - Functional integrity

**Practice according Certificate?**
# MID covered applications

<table>
<thead>
<tr>
<th>Accuracy Class</th>
<th>Types of Measuring system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meter: 0.2;</td>
<td>0.3: Measuring systems on pipeline</td>
</tr>
</tbody>
</table>
|                | 0.5: All measuring systems if not differently stated elsewhere in this Table, in particular:  
|                | – fuel dispensers (not for liquefied gases),  
|                | – measuring systems on road tankers for liquids of low viscosity (< 20 mPa.s)  
|                | – measuring systems for (un)loading ships and rail and road tankers (!)  
|                | – measuring systems for milk  
|                | – measuring systems for refuelling aircraft |
| Meter: 0.3;    | 1.0: Measuring systems for liquefied gases under pressure measured at a temperature equal to or above −10 °C  
|                | Measuring systems normally in class 0.3 or 0.5 but used for liquids  
|                | – whose temperature is less than −10 °C or greater than 50 °C  
|                | – whose dynamic viscosity is higher than 1 000 mPa.s  
|                | – whose maximum volumetric flowrate is not higher than 20 l/h |
| Meter: 0.6;    | 1.5: Measuring systems for liquefied carbon dioxide  
|                | Measuring systems for liquefied gases under pressure measured at a temperature below −10 °C (other than cryogenic liquids) |
| Meter: 1.0;    | 2.5: Measuring systems for cryogenic liquids (temperature below −153 °C) |
| Meter: 1.5;    | (!) However, Member States may require measuring systems of accuracy class 0.3 or 0.5 when used for the levying of duties on mineral oils when (un)loading ships and rail and road tankers.  
|                | Note: However, the manufacturer may specify a better accuracy for a certain type of measuring system.
Agenda

- LNG is HOT
- Bunkering LNG – Custody Transfer
- **Bunkering LNG – what to measure & how**
  - Mass vs Volume
  - Energy content – Gross Caloric Value
  - LNG Quality – methane number
- Bunkering LNG – Installation
Volume or Mass

Question: What do you get if you put 0,5l water together with 0,5l alcohol?

Answer: 0,9L

Why: Alcohol is hydroforbic

Consequence: 0,5 + 0,5 ≠ 1,0L

Why important to you: 1L LNG ≠ 1kg. Temperature & Pressure has the same effect.

Conclusion: Measure in mass!
Energy densities – L vs kg

Selected Energy Densities

- Aluminum
- Silicon
- Anthracite
- Magnesium
- Polystyrene
- Lithium Borohydride
- Polyethylene
- LPG Butane
- LPG Propane
- Gasohol E85
- Ethanol
- Kerosene
- Butanol
- Gasoline
- Diesel
- Fat Metabolism
- Sugar Metabolism
- Alcohol
- Zinc
- Iron
- Biogas
- Natural Gas (250 bar)
- Natural Gas
- Liquid Natural Gas
- Liquid Hydrogen
- Hydrogen Gas
- Sodium
- Methanol
- Zinc-Air Battery
- Lithium Ion Battery
- Hydrogen Gas (700 bar)
**Gross Caloric Value (GCV)**

- MJ/kg – trading value
- How to know it:
  - On the contract / delivery note
  - Gas chromatograph
  - Coriolis + SG meter = SG
- Storage Energy content 1m³ @ -163°C > 1m³ @ -126°C
LNG – Behavior – density shift

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Bunker Capacity</th>
<th>Range @ full power (-162°C)</th>
<th>Range @ full power (-126°C)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Ferry</td>
<td>50m³</td>
<td>39 hours</td>
<td>34 hours</td>
<td>- 5</td>
</tr>
<tr>
<td>Offshore Vessel</td>
<td>1500m³</td>
<td>236 hours</td>
<td>203 hours</td>
<td>-33</td>
</tr>
<tr>
<td>Cont Vessel</td>
<td>10,000m³</td>
<td>793 hours</td>
<td>681 hours</td>
<td>- 112 (4.5 days)</td>
</tr>
</tbody>
</table>
**LNG Composition – Methane Number**

- Two ways to fill tanks
- Filling time 1 is slower than filling time 2
- @ 1 – MN drops, @ 2 hardly any BOG return
- Future: method 2 & loading full tanks.
## BOG Creation by Design

<table>
<thead>
<tr>
<th>Tank Size</th>
<th>60m³</th>
<th>1000m³</th>
<th>1000m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity in Tank at Start (Heel) (m³)</td>
<td>6</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Pressure (Bar)</td>
<td>9</td>
<td>9</td>
<td>Atms</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>-126</td>
<td>-126</td>
<td>-162</td>
</tr>
<tr>
<td>Loading Rate (m³/hr)</td>
<td>2</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Loading Time (hrs)</td>
<td>30</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Boil of Gas Generated (m³)</td>
<td>3.25</td>
<td>2.97</td>
<td>53.8</td>
</tr>
<tr>
<td>Average Boil Of Gas Rate (m³/hr)</td>
<td>0.1</td>
<td>2.97</td>
<td>5.4</td>
</tr>
<tr>
<td>Max BOR (m³/hr)</td>
<td>7</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Min BOR (m³/hr)</td>
<td>1</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Boil of Gas Generated (kg) @-162</td>
<td>2</td>
<td>1.8</td>
<td>33.2</td>
</tr>
<tr>
<td>Boil Off Gas as CO₂ Equivalent (kg)</td>
<td>42</td>
<td>37.8</td>
<td>697</td>
</tr>
</tbody>
</table>

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LNG Dispensing – Control Process

Whole Dispenser Control system
Recycling Process - Standard Filling Station Asia

Flow meter
- First recycling loop
  - Pre cooling the filling head and the meter
- Second recycling loop
  - Pre cooling the meter only
Vapor return from the cylinder of the vehicle
Advantages of Elite meter

- MODBUS Direct connection
  - Drive gain
  - Slug Flow
  - Density
  - Temperature
  - Mass Flow
  - Volume flow
  - Pump Start
  - Fluid Status
  - Measurement

- Traditional technology or other Coriolis
  - Analog Hz or 4—20mA
  - No fluid status can be described
  - MODBUS to be more time developed
Flow Sensor choice

- Flow requirements:
  - Payment – Mass – Euro/kg
  - Flow condition – Temperature, Pressure, Density reading
  - Flow rate indication – Volume - m3/h
  - Energy content – GCV - MJ/kg
  - LNG Quality – MN - Gas Chromatograph

- To consider:
  - Custody Transfer – MID / OIML
  - Accuracy & allowable uncertainty
  - Line Size, Flow Rate & Flow Conditions, installation
  - Energy Content Calculation & density
Saga
Fjordbase Ship Bunkering Terminal

- Located in Flora, Norway
- Terminal commissioned July 1st, 2009
- Allows bunkering of ships and trucks
- Terminal connects to local gas grid
- LNG stored in 500 m3 tank
Some LNG related business partners

Viking Line Orders LNG-Powered Cruise Ferry

STX Finland Oy and Viking Line ABP have signed an agreement for the construction of the most environmentally friendly big passenger vessel to date, for Viking Line, with delivery early 2013. The new generation cruise ferry uses LNG as fuel: it has no marine emissions and its aerial emissions are extremely low. The vessel has been specially designed to operate in the delicate and shallow waters of the Finnish and Swedish archipelago. The agreement includes an option for a sister ship. The contract price is about
THANK YOU!

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