Innovation for the track: Breaking new ground in LNG supply

LNG Transportation For Rail Pipeline
Concept For LNG Distribution
In Europe

Vilnius, 26th of April 2017

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VTG Deutschland GmbH
## Agenda

1. VTG Aktiengesellschaft
2. The LNG tank wagon
3. LNG supply chain
VTG: Leading European rail logistics and wagon hire company

<table>
<thead>
<tr>
<th>Wagon hire</th>
<th>Rail logistics</th>
<th>Tank container logistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>European leader for private-sector wagon hire with more than 80,000 wagons worldwide and further ambitions for growth.</td>
<td>Leading European rail logistics provider with tailor-made logistics solutions.</td>
<td>Global logistics and tank container hiring with a fleet of approx. 7,600 tank containers.</td>
</tr>
</tbody>
</table>

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VTG and Chart bring the transportation of LNG in Europe onto the tracks as an environmentally-friendly mode of transport.

### VTG

- Leading private wagon hire company in Europe
- Project management
- Definition of development goals
- Coordination of development and design activities
- Marketing and operation
- Logistics solutions

### Chart

- Leading manufacturer of storage, transportation and distribution systems for LNG
- Development and design
  - Cryogenic tank
  - Loading, unloading and safety technology
- Manufacture of cryogenic tanks

### Waggonbau Graaff

- 100 years of experience in developing and producing of premium quality railway wagons
- Development and design
  - Understructure
  - Complete wagon
- Manufacture of the understructure
- Final assembly of the wagon
- Testing and approval

Since 1914
The LNG tank wagon
Technical data for the LNG tank wagon

- Tank materials: inner tank stainless steel (1.4301), outer tank S355NL2
- Tank capacity (RID): approx. 111m³
- Tank code: R10, 4BN
- Calculation pressure (gauge pressure): 1.04 MPa = 10.4 bar
- Test pressure (gauge pressure): 1.04 MPa = 10.4 bar
- Operating pressure (inner tank): 0.7 MPa 0.7 bar
- Outer gauge pressure (outer tank): 0.1 MPa = 1.0 bar
- Operating temperature: -196 / +50°C
- Insulation: vacuum insulation
- Tare weight: approx. 45.7t

- 22.5t axle load  →  max. payload line category C: ~ 36.6t

- 22.5t axle load  →  max. payload line category D: ~ 42.0t
Technical equipment on the tank wagon

- Filling and drain valve
- Degassing valve
- Safety valve
- Pressure gauge
- WBG buffer override protection ACS 2013
- PBUC evaporator unit on the tank
- Probe on the tank for checking the vacuum
- Valve for monitoring the filling level when filling the tank
- Valve for extracting LNG samples
- Equipped with telematics system incl. pressure monitoring
<table>
<thead>
<tr>
<th></th>
<th>1 tank wagon</th>
<th>Block train (20 tank wagons)</th>
<th>1 ISO tank container (40 ft.)</th>
<th>1 Semi-trailer (40 t)</th>
<th>1 Semi-trailer (44 t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tare weight</td>
<td>≈ 46.2 t</td>
<td>≈ 924 t</td>
<td>≈ 11.5 t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. load</td>
<td>≈ 42.6 t</td>
<td>≈ 852 t</td>
<td>≈ 16 t</td>
<td>≈ 19.1 t</td>
<td>≈ 21.6 t</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5 ISO = 1 tank wagon</td>
<td></td>
<td>2.2 trailers = 1 tank wagon</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 trailers = 1 tank wagon</td>
<td></td>
</tr>
<tr>
<td>Total weight</td>
<td>Max 90 t</td>
<td>Max 1,800 t</td>
<td>Max 34.6 t</td>
<td>Max 52.5 t</td>
<td>Max 58 t</td>
</tr>
<tr>
<td>Volumes</td>
<td>≈ 111 m³</td>
<td>≈ 2,220 m³</td>
<td>≈ 43.5 m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calorific value</td>
<td>≈ 600,000 kWh</td>
<td>12,000,000 kWh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>Locomotive: 30-45 [g/t-km]</td>
<td></td>
<td></td>
<td></td>
<td>Semi-trailer: 60-80 [g/t-km]</td>
</tr>
</tbody>
</table>
**LNG tank wagon: Approval and regulations**

<table>
<thead>
<tr>
<th>General approvals for freight wagons</th>
</tr>
</thead>
<tbody>
<tr>
<td>- TSI certificate: Technical specifications for interoperability in rail transport in the European Union</td>
</tr>
<tr>
<td>- Series approval/authorisation for placing in service (APS) by the Federal Railway Authority</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Provisions for the LNG tank wagon</th>
</tr>
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<tbody>
<tr>
<td>- In accordance with RID, LNG has the UN No. 1972 and the Hazard Identification Number 223</td>
</tr>
<tr>
<td>- This means that the LNG wagon is subject to certain conditions, which it has to comply with,</td>
</tr>
<tr>
<td>- For example, the safety regulations TU 14, TU 38, TM 6, TA 4, TT 9, CW 30 and TE 22</td>
</tr>
</tbody>
</table>
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3 LNG supply chain
LNG: A fuel with a future

Demand for LNG will rise in the long-term

<table>
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<tr>
<th>Environmental protection</th>
<th>Efficiency</th>
<th>Safety</th>
<th>Regulatory compliance</th>
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</table>
| ▪ Up to 20% less CO2 emissions than for other fuels | ▪ The storage and transportation of LNG takes up 600 times less volume than natural gas in an ambient condition | ▪ Transport and storage risks lower  
▪ Flash point lies at 55° Celsius  
▪ In a gaseous state, LNG ascends and moves away from potential sources of ignition | ▪ SECA: Limits on sulphur in shipping  
▪ Euro IV, V, VI: Emission limits for heavy haulage  
▪ National and regional noise control guidelines |

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The LNG tank wagon creates a new volume segment within the LNG supply chain

LNG tanker  LNG terminal  Evaporation plant  Gas pipeline  Liquefaction plant
LARGE-scale LNG market

LNG tank wagon

Barge  Tank container  HGV
MID-scale LNG market

Industry  Shipping  Transport
SMALL-scale LNG market

End-customer
Advantages of transporting LNG by rail

- Transportation of large quantities per transport batch at low costs
- Flexible inland supply compared to ship
- Long distances can be bridged
- Direct delivery to the end-customer
- Permanent supply with LNG
### Mid-scale LNG supply chain: Necessary infrastructure

<table>
<thead>
<tr>
<th>Investments in transport modes</th>
<th>Rail-specific investments</th>
<th>Interface topics</th>
</tr>
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<tbody>
<tr>
<td>- LNG terminals</td>
<td>- Sidings</td>
<td>- LNG tank wagons as temporary storage units</td>
</tr>
<tr>
<td>- Tank depots</td>
<td>- Loading and unloading points for LNG</td>
<td></td>
</tr>
<tr>
<td>- Bunkers</td>
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Pan-European haulage in rail logistics
Many thanks for your kind attention.