LNG as Fuel – Bunkering, Storage and Processing

STG International Conference
"Ship Efficiency"

Hamburg,
26/27-September-2011

Carriers &
Offshore Units

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TGE Marine Gas Engineering

CONTENT

- **TGE Company Profile**
- Small LNG carriers
- Bunkering
- LNG fuel tanks
- LNG fuel gas systems
- 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
- 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
- Ethylene carriers
- CO_2 carriers
- LNG carriers

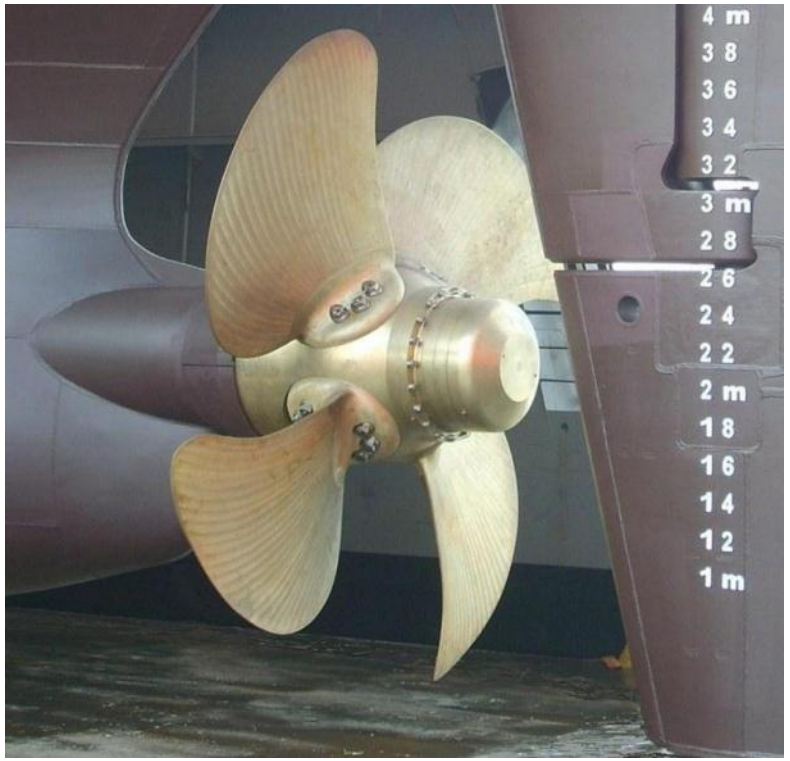
Cargo handling systems for Offshore units

- FSO/FPSO for LPG
- FSRU and FPSO for LNG
- CO_2 liquefaction, storage and offloading units

Business activities and expertise

Fuel Gas Systems for seagoing vessels

- Fuel gas supply systems.
- Fuel gas tanks.
- RoRo, Container, Ferries, Tug boats …
- Bunker Barges, Bunker Boats
- LNG fuel storage systems



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Current Situation

Upcoming regulation on SO_x, NO_x, PM and CO_2 emissions require adequate changes in ship propulsion. LNG as fuel is one solution to cover all mentioned pollutants. The same is valid for energy supply in some remote areas that could be done by LNG.

Available Infrastructure

- Large scale terminals and shipping
- Regional LNG distribution networks (Norway)
- Few number of small LNG Carriers

Missing Infrastructure

- Satellite terminals close to bunkering locations
- LNG feeder ships with sufficient capacity
- Bunker ships/barges/vessels

Small LNG carriers

19-May-2010 „Coral Methane“ loading at Zeebrugge,
First loading of a small carrier at a large import terminal.

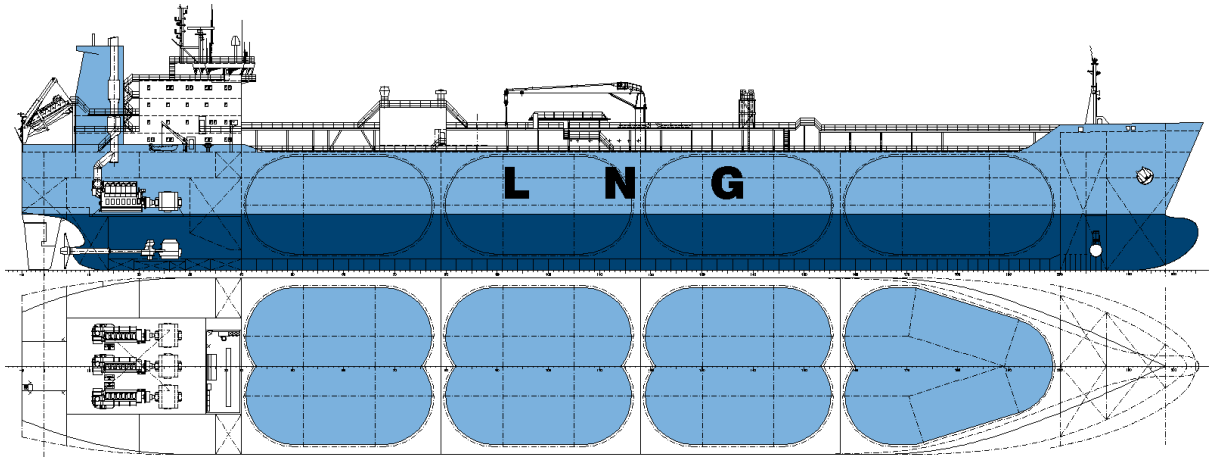
Small LNG Carriers

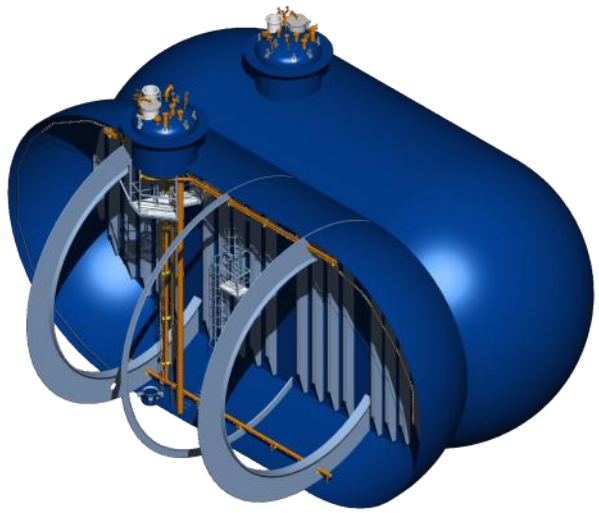
New generation **15,600 cbm LNG carrier**

- Concept developed by TGE-Marine in close cooperation with Dutch owner Anthony Veder Group
- LNG propulsion – Dual Fuel system
- To be built at Meyer Werft (Germany)
- Ship delivery in December 2012

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





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Bunkering

- Requirements for future operations:
  - High loading rates due to tight time schedule
  - Large total amount of LNG for larger vessels
  - Safe but easy handling of heavy equipment
  - Dry-break emergency couplings
  - Bunkering during cargo operations
  - data/ESD connection
  - avoid spool pieces/reducers
- This will only be possible with bunker vessels (small LNG carriers as above) coming alongside
- Regulations and standards for the bunker interface and related operations are under preparation by several international working groups

Bunkering (Artist impression)

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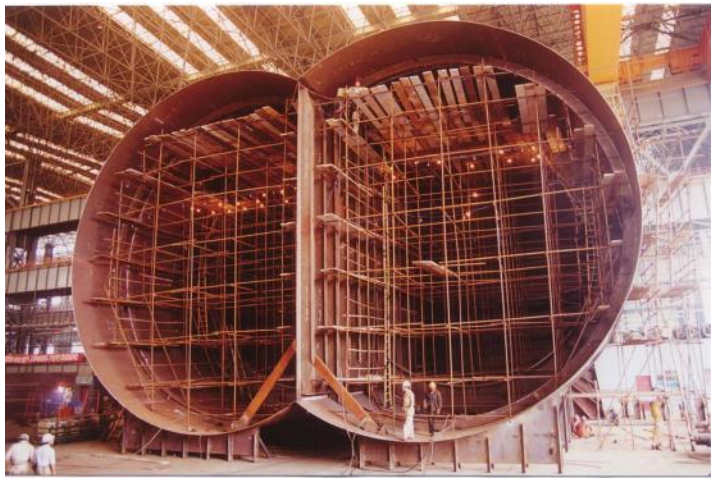
LNG fuel tanks

- All independent types (A, B and C acc. to IMO IGC) possible following IGF guideline. BLG 15 also deleted restriction on membrane tanks
- Type A and B and membrane with low pressure, therefore BOG problem to be solved
- Secondary Barrier required for membrane as well as type A and B tanks
- Type C preferred solution due to high design pressure 4 to 10 barg
- High operation flexibility regarding loading and BOG pressure increase
- Disadvantages: Tank shape resulting in bad volume efficiency (factor 3 to 4), filling limits

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

Cargo tanks type A for a 23,000 m³ Fully Refrigerated LPG Carrier

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

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

	Foam insulation	Vacuum insulation
size	cylindrical < 10,000 cbm bilobe < 20,000 cbm	< 700 cbm per tank
shape	cylindrical, bilobe, conical	cylindrical
outlet	all connections on top	min. 1 bottom outlet
boil-off rate	0.2 to 1.0 % per day	below 0.1 % per day
in-tank equipment	e. g. pumps, heaters	no manhole (usually)
inspection	5 years in-tank	no manhole (usually)

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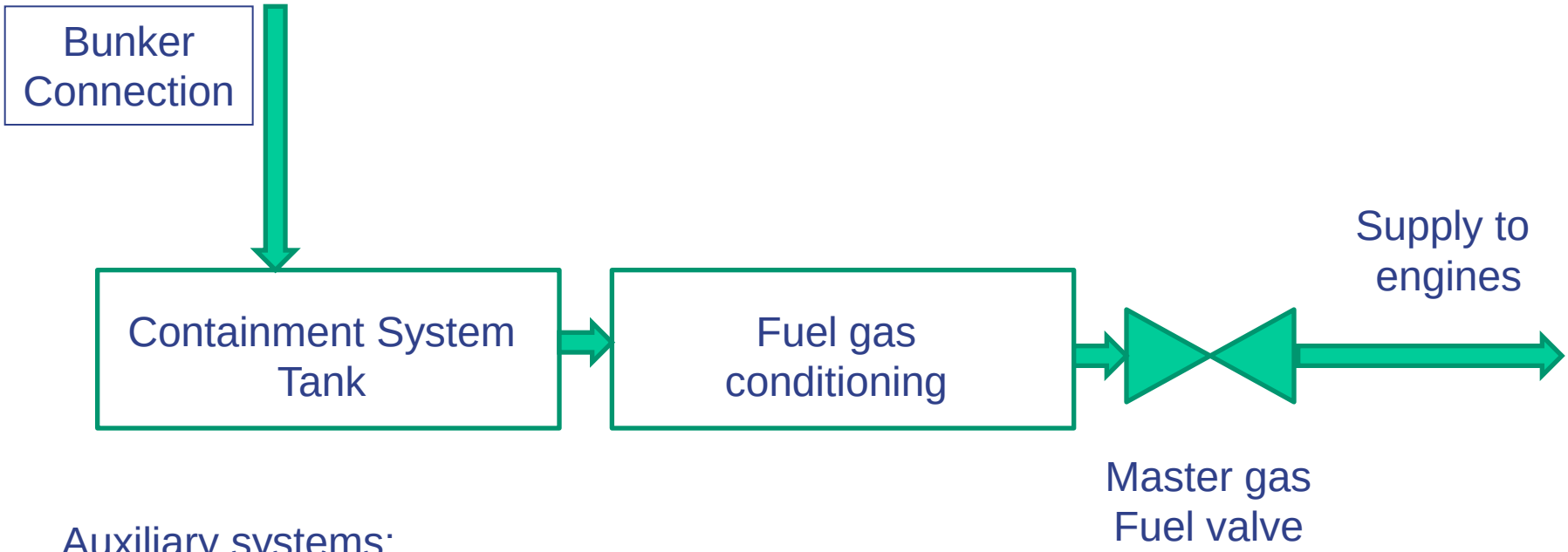
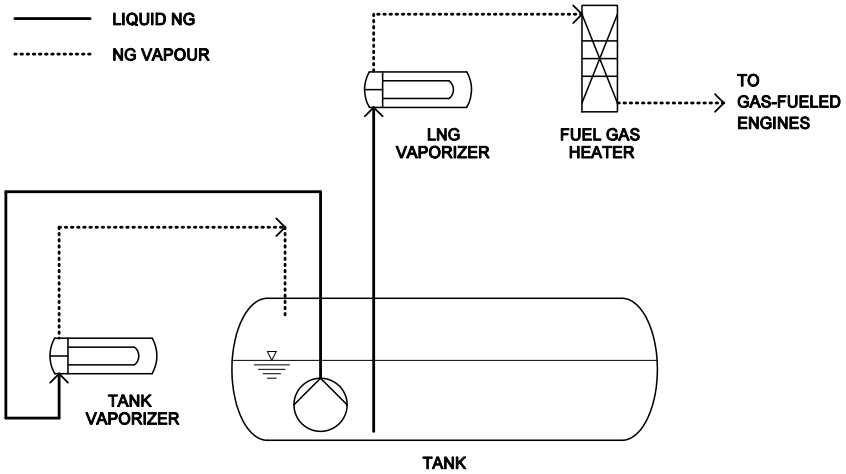
Basic components of fuel gas systems



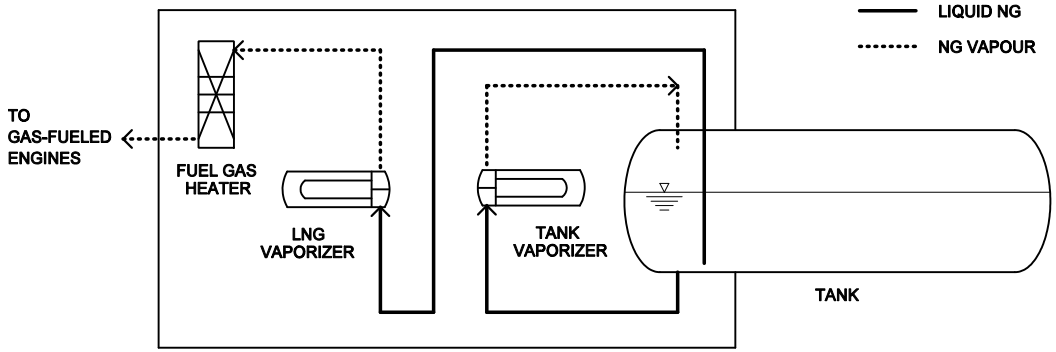
Auxiliary systems:
- water-glycol heating system
- inert gas system
- vent / ventilation
- valve remote operation
- safety systems
- automation & control

Fuel gas processing

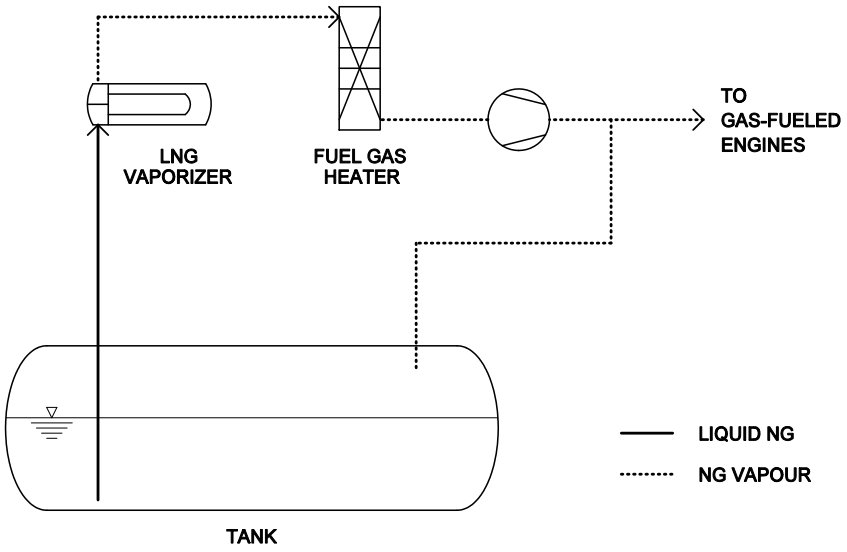


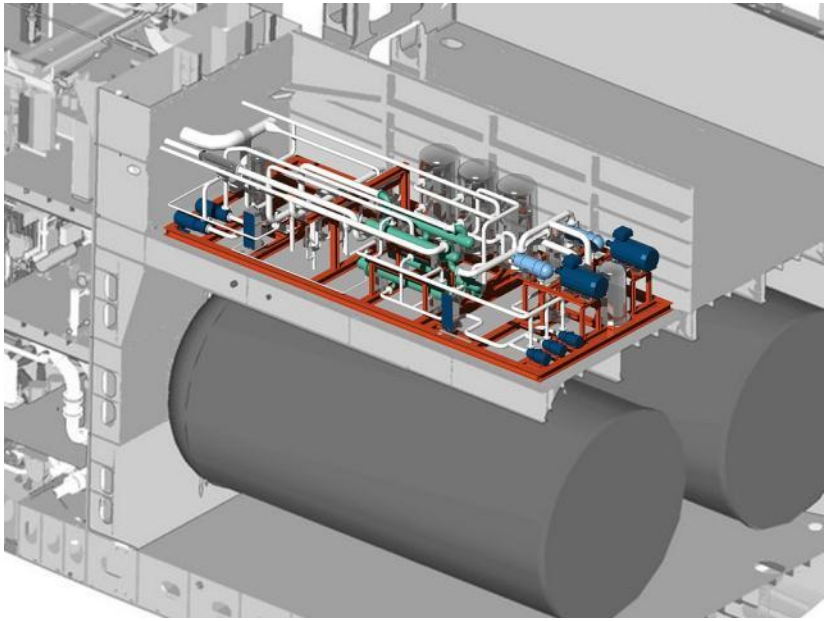
- Tank design pressure 8 to 10 barg
- Tank operation pressure 6 to 8 barg
- Small in-tank-pump avoiding bottom outlet.

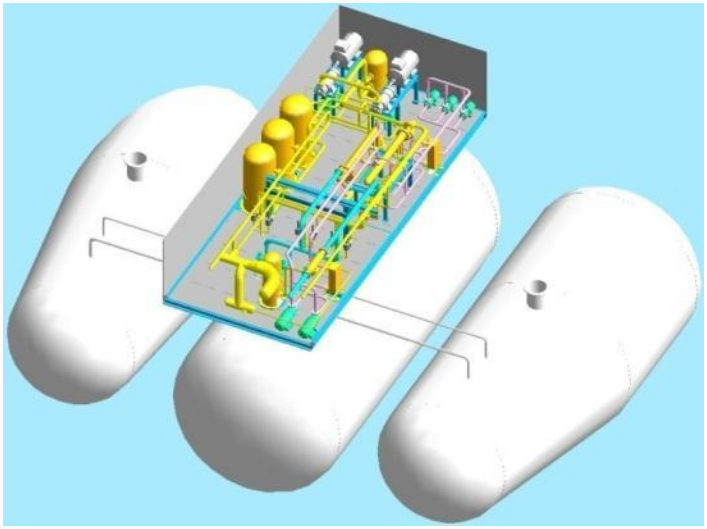
- Typical vacuum tank design
- Equipment inside “cold box”
- bottom outlet to feed tank vaporizer.



Fuel gas processing





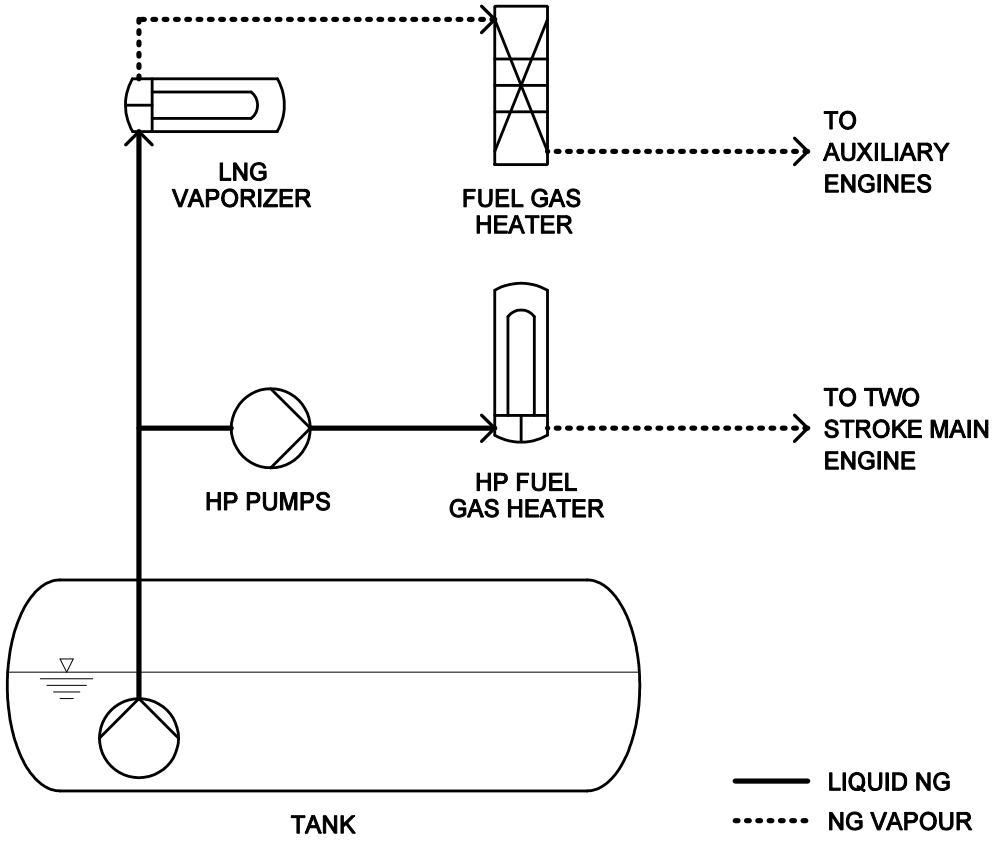


- Tank design pressure 4 to 6 barg
- Tank operation pressure 1 to 5 barg
- Screw compressor with oil separator
- Buffer vessel to follow load changes
- Warming up, increased bunkering rate
- Flexible and reliable operation

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

Fuel gas processing for two stroke main engine

- 2 stroke DF engines like MAN ME-GI require high injection pressure (150 – 300 barg)
- HP compressor solutions only feasible for LNGC
- HP pumps and heater
- Tank design pressure 3 to 6 barg
- Tank operation pressure 0 to 4 barg
- Booster pump inside tank
- Optional design with process tank for pump kick-back for better system control



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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 as fuel is an environmentally friendly and commercially attractive way of propulsion.
- Technical solutions for small LNG transport and LNG as ships fuel are available.
- Excellent safety record of LNG business and proven safety systems are limiting risks.
- Development of bunkering infrastructure and regulatory framework is the main challenge.

Thank you for your kind attention

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