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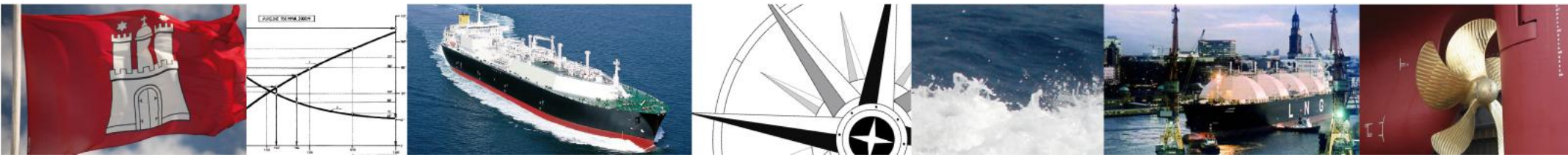
LNG as Fuel for Conventional Ships

Ship Efficiency

4th International Conference

Hamburg, September 23-24 2013



Agenda

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- Emission Reduction by LNG
- LNG Storage Tanks
- LNG Bunkering Systems
- LNG-Processing Systems
- Design Examples
- Summary

Emission Reduction by LNG

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CO_2, NO_x and SO_x Emission of Propulsion Systems					
Propulsion typ	MAN 51/60DF (Medium Speed Diesel)	MAN 51/60DF (Medium Speed Diesel)	MAN B&W S70ME (Slow Speed Diesel)	MAN B&W S70ME-GI (Slow Speed Diesel)	Solar Titan 130 SoLoNOx (Gas Turbine)
Fuel Typ	HFO	gas	HFO	gas	gas
CO_2 [g/kWh]	500	417	572	446	541
SO_x [g/kWh]	11	0.08	10.85	1.17	0.00
NO_x [g/kWh]	12.91	1.80	16.88	14.96	0.26
Thermische Effizienz	45%	48%	50%	50%	35%

LNG Consumers on Board

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Supply of fuel gas within given pressure and temperature limits to

- Main engines
  - Gas engines and dual-fuel engines: 5 to 6 bar
  - Slow speed engines with HP-injection: 300 bar
- Auxilliary engines: 5 to 6 bar
- Boilers: 0.5 to 2 bar

LNG Tank Types

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- Cylindrical type-C tanks
  - Pressure 6 to 10 bar
  - Vacuum insulated
  - Size up to about 500m³ per tank
- LNG Container
  - type-C tank and IMDG-tank
  - Pressure 6 to 10 bar
  - Vacuum insulated
  - Size about 40m³ per tank

Applied

- Bilobe-shaped type-C tanks
  - Pressure about 4 bar
  - Panel or foam insulated
  - Size up to about 10,000 m³ per tank
- Membrane type-A tanks
  - Pressure about 0.3 bar
  - Foam or boxes with perlite filling
  - Size up to 45,000 m³ per tank

Not yet applied

LNG Fuel Deck Tank

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LNG Fuel Tank Container

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40’ ISO LNG Tank Container

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- ISO LNG tank container:
  - IMDG container to use existing container infrastructure
  - IGC compliant Type C tank to allow use onboard as shipboard fuel bunker
  - Vacuum insulated to ensure long holding time
  - ESD Valves for vapor and LNG
  - LNG, vapor and safety valves with quick couplings

Vacuum Insulation

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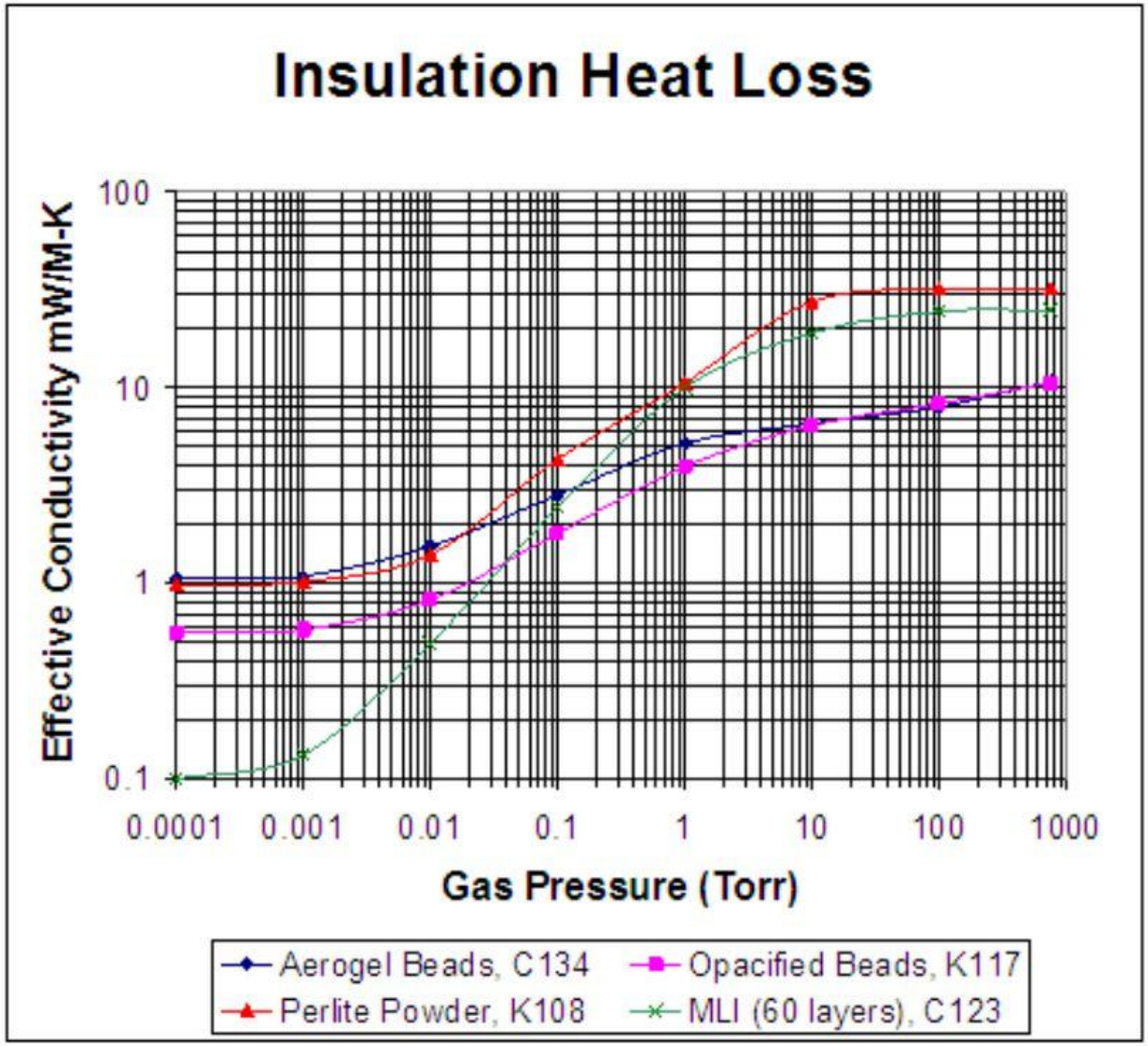

To achieve holding times of 80 days or more for the fuel gas tank, a vacuum pressure of 10^{-4} mbar is necessary

Vacuum Insulation

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Vacuum space with perlite filling

+ Remaining insulation effect if vacuum is lost
+ Simple to implement
- Higher heat conductivity
- Risk of compacting under vibration

Perlite filling compacted, blocking free movement of pipe expansion loops

Vacuum Insulation

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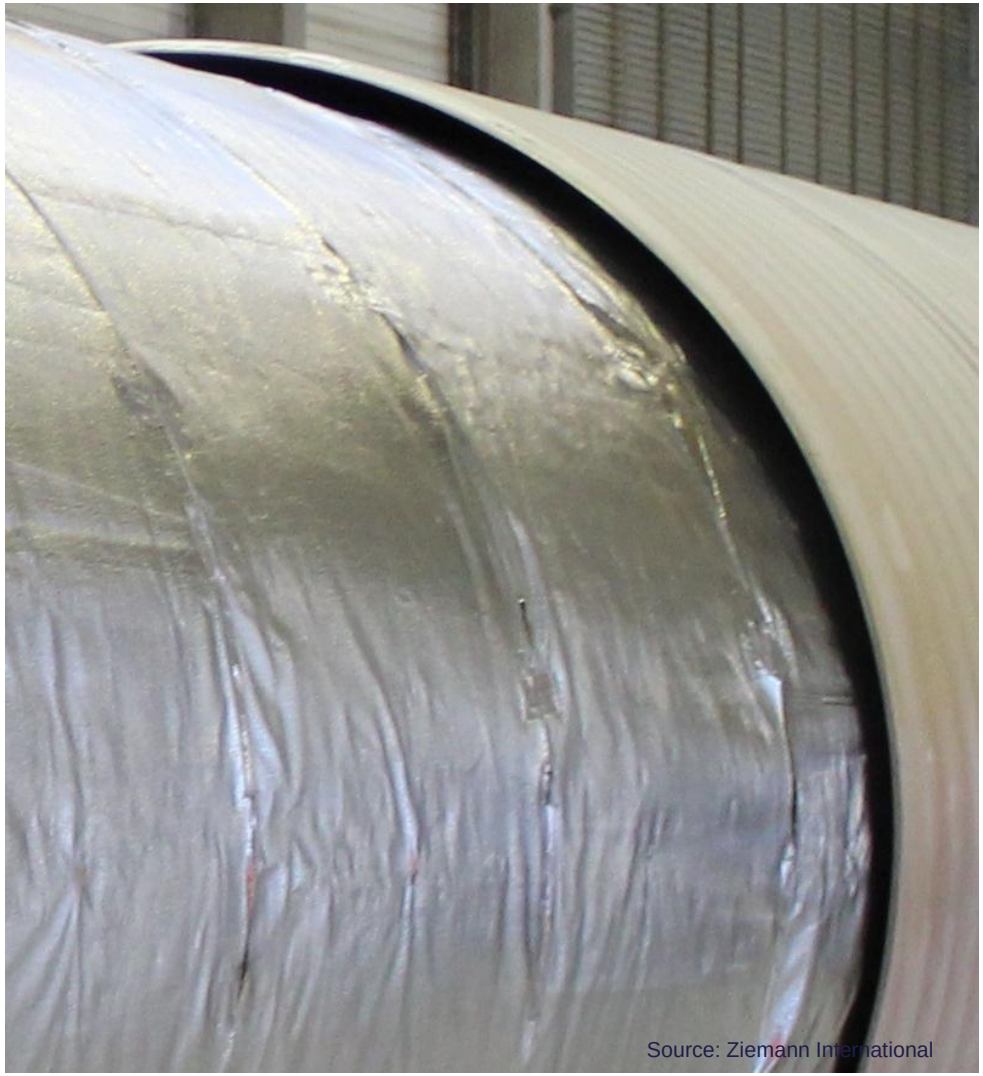

Vacuum space with radiation foil

+ Low heat conductivity
+ Free movement of pipes in vacuum space
+ Small vacuum space
- Higher heat conductivity in case of lost vacuum
- Accurate installation necessary

Bunkering v/s Containers

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- Bunkering:
  - LNG transfer with spill risk; most LNG incidents have occurred during LNG cargo handling
  - LNG bunkering permission in port
- Containerized LNG:
  - No transfer of LNG
  - Handling of IMDG containers is standard practice in container ports
  - Uses existing multi-modal infrastructure



Couplings & Hose

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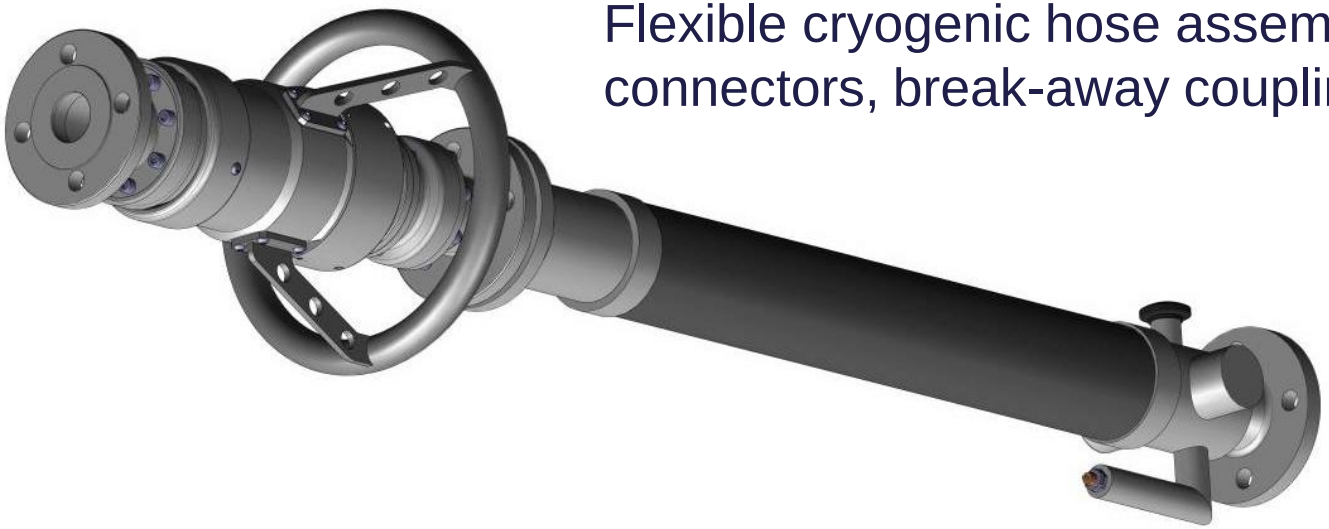
Flexible cryogenic hose assembly with dry quick connectors, break-away coupling and vacuum monitoring



Male connector

Female connector with break-away coupling

Double-walled vacuum insulated flexible hose

Coupling Test Video

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LNG-Processing Systems

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Functions:

- Supply of fuel gas within given pressure and temperature limits
- Control of storage tank pressure
- Handling of boil-off
- Bunkering support
- Gas freeing capability

LNG-Processing Systems

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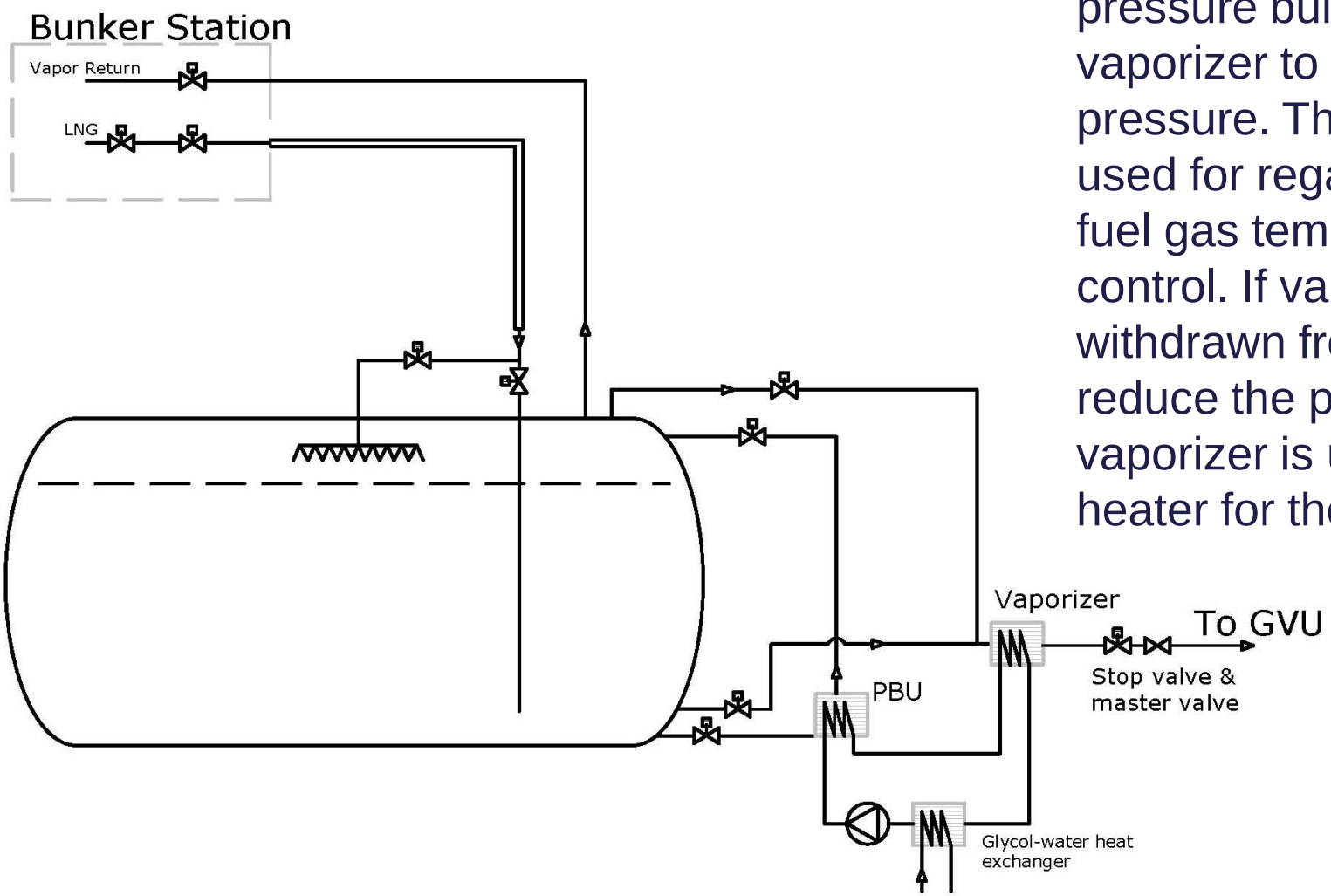

Most simple design with pressure build-up (PBU) vaporizer to raise tank pressure. The vaporizer is used for regasification and fuel gas temperature control. If vapor is withdrawn from the tank to reduce the pressure, the vaporizer is used as a heater for the vapor.

LNG-Processing Systems

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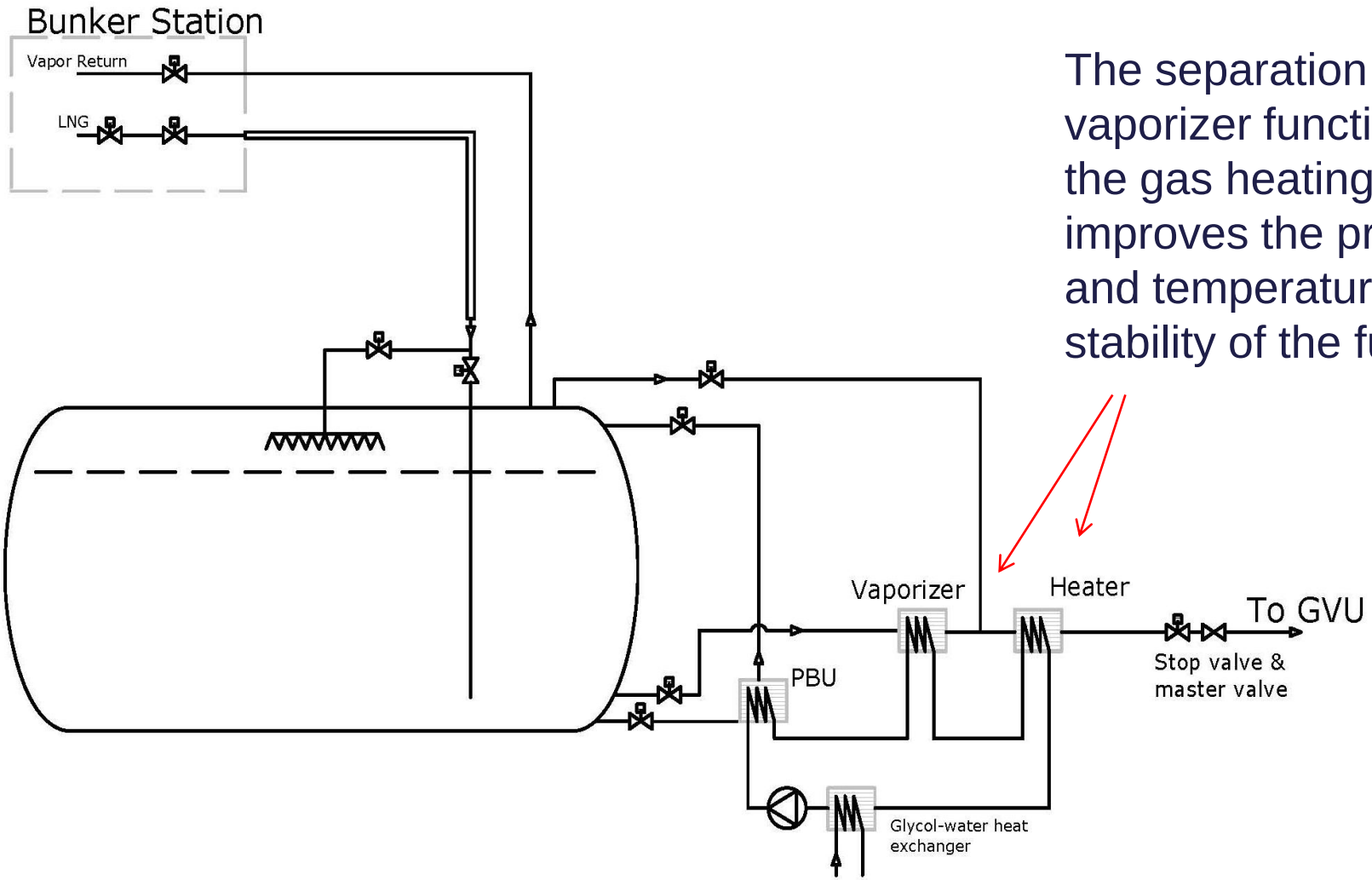

The separation of the vaporizer function and the gas heating function improves the pressure and temperature stability of the fuel gas.

LNG-Processing Systems

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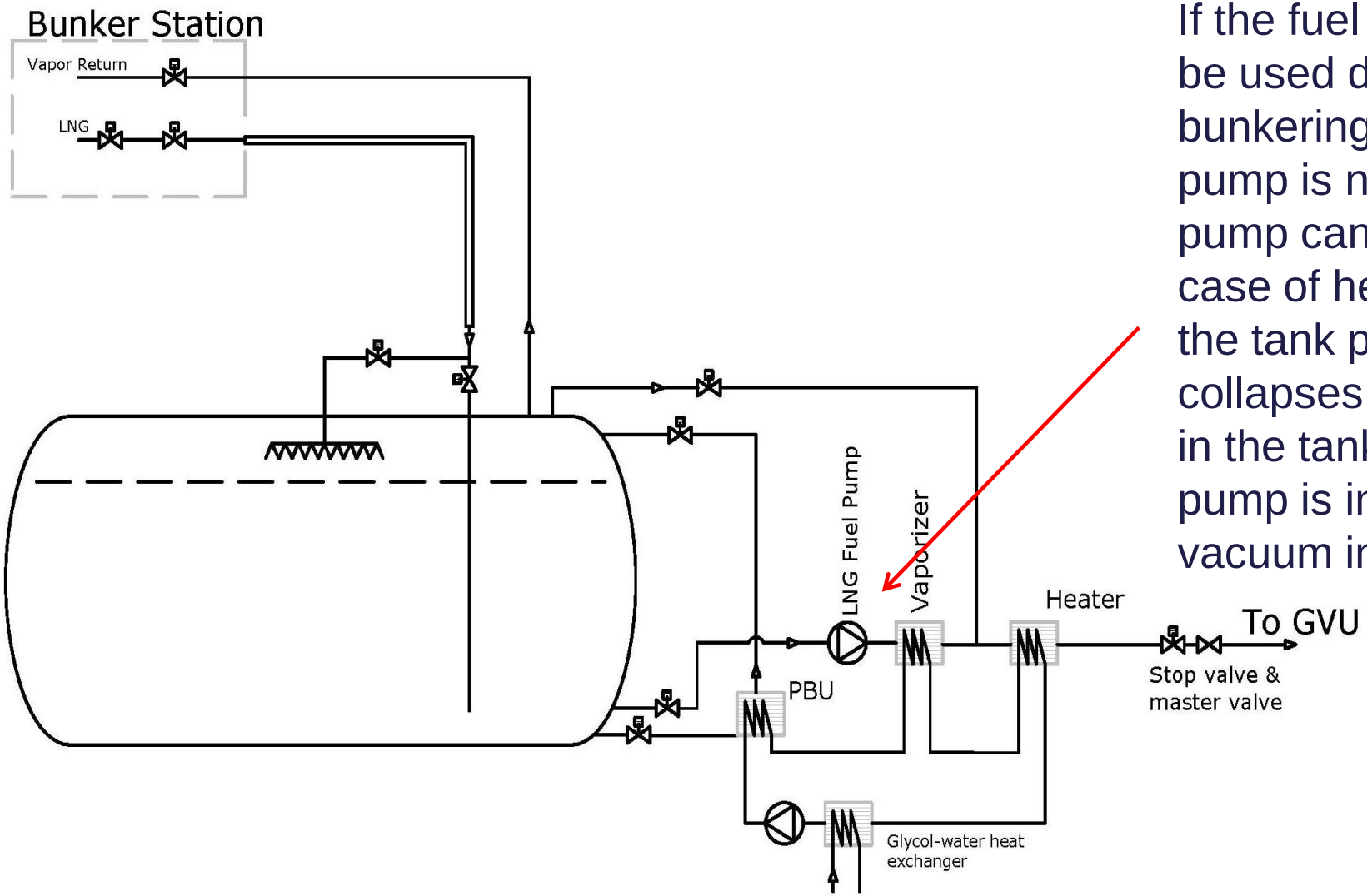

If the fuel gas shall also be used during bunkering, an LNG fuel pump is necessary. This pump can also be used in case of heavy weather if the tank pressure collapses due to sloshing in the tank. The LNG pump is installed in a vacuum insulated drum.

LNG-Processing Systems

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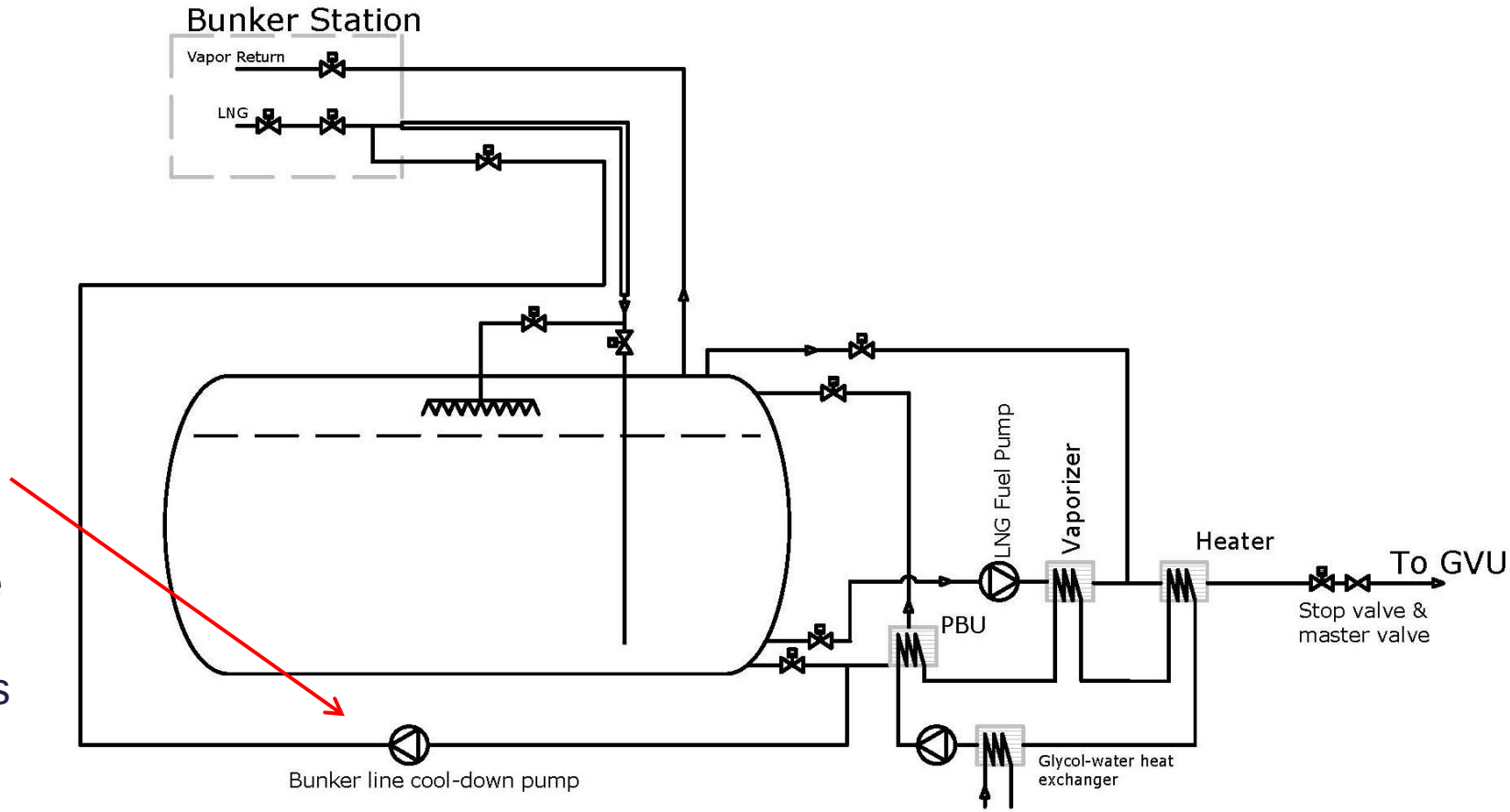
If the bunker pipe is long, a pre-cooling is required.
A line cool-down is required. The pump can also be used to spray the LNG tank prior to bunkering to reduce the back pressure and by this speeding up the bunkering.



Gas Handling Container

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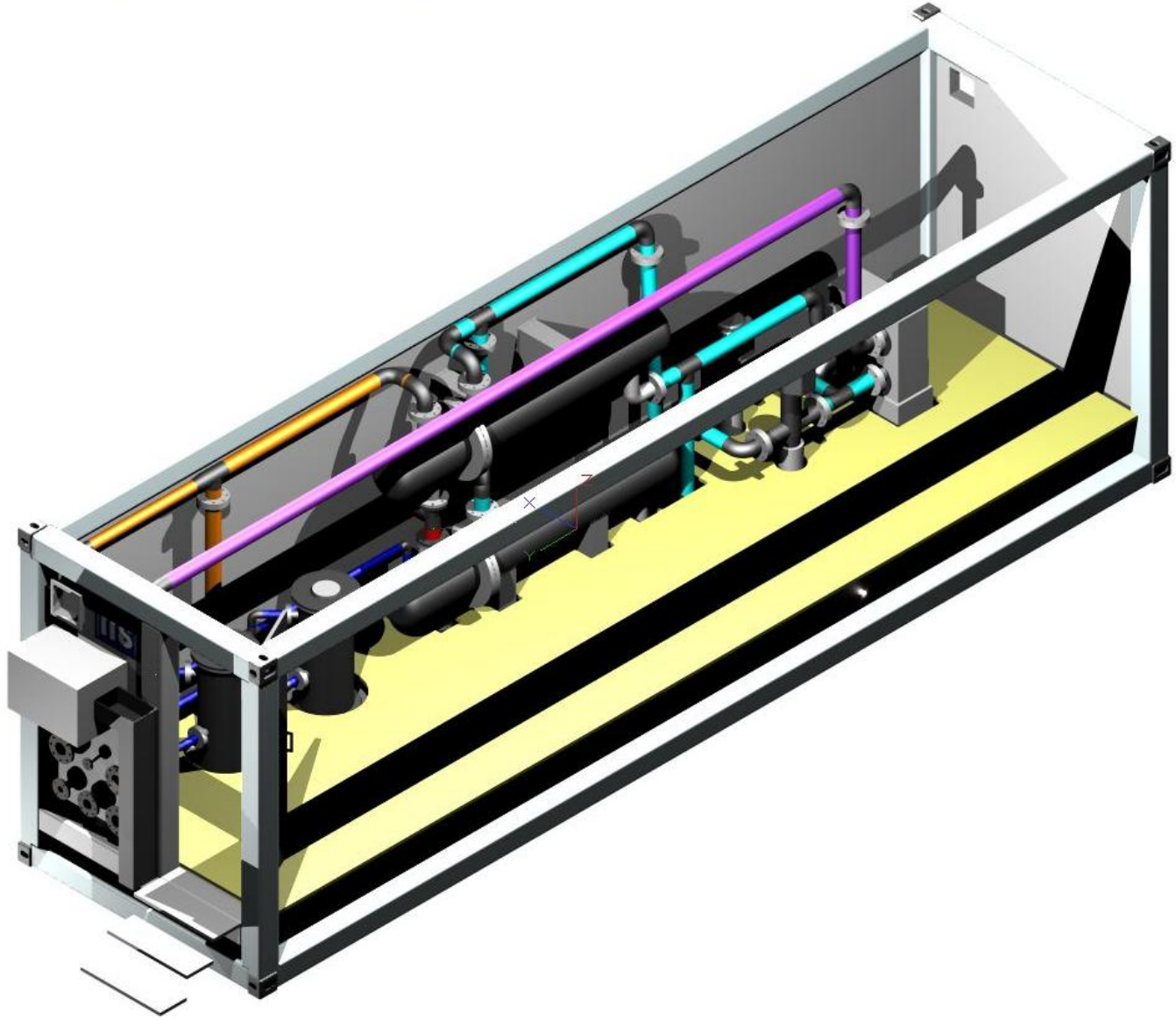

Container Feeder

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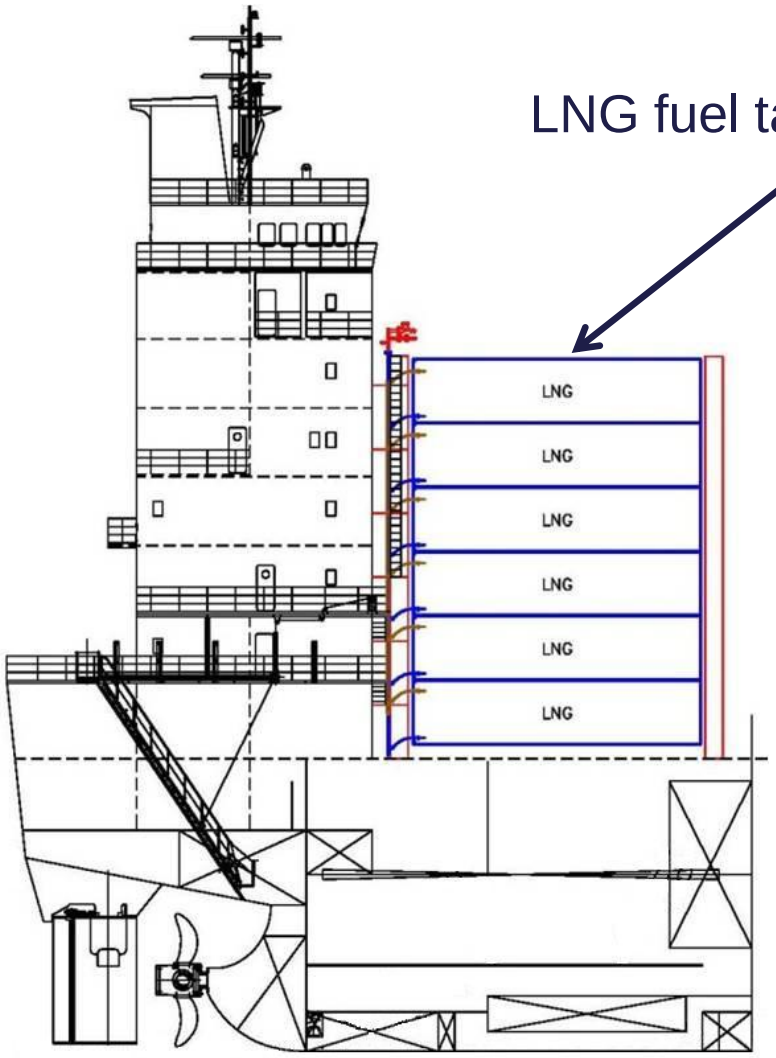
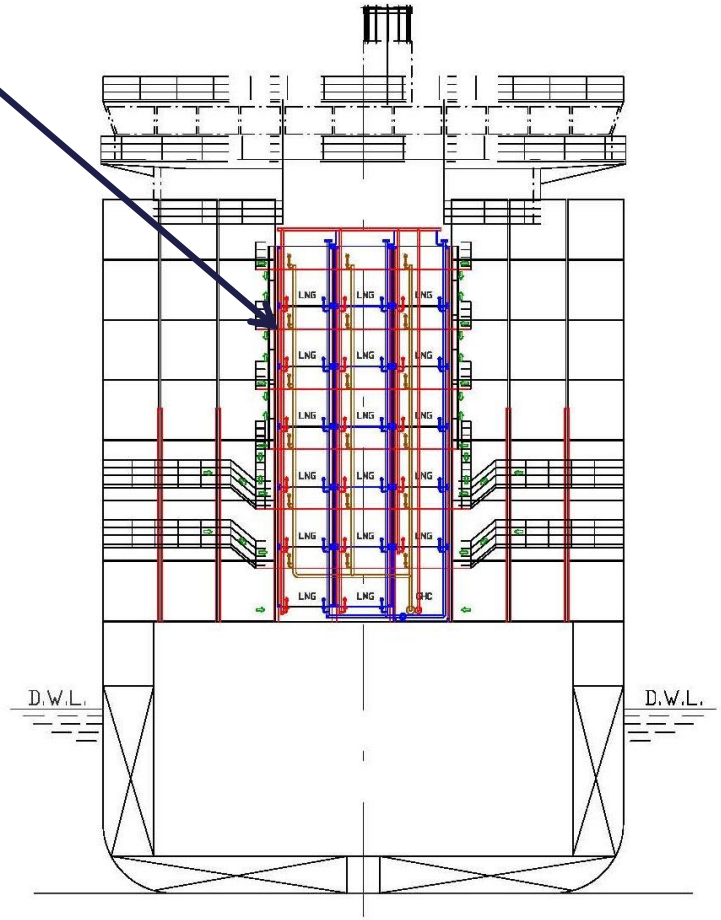
LNG fuel tank containers





LNG Fuel Tank Container

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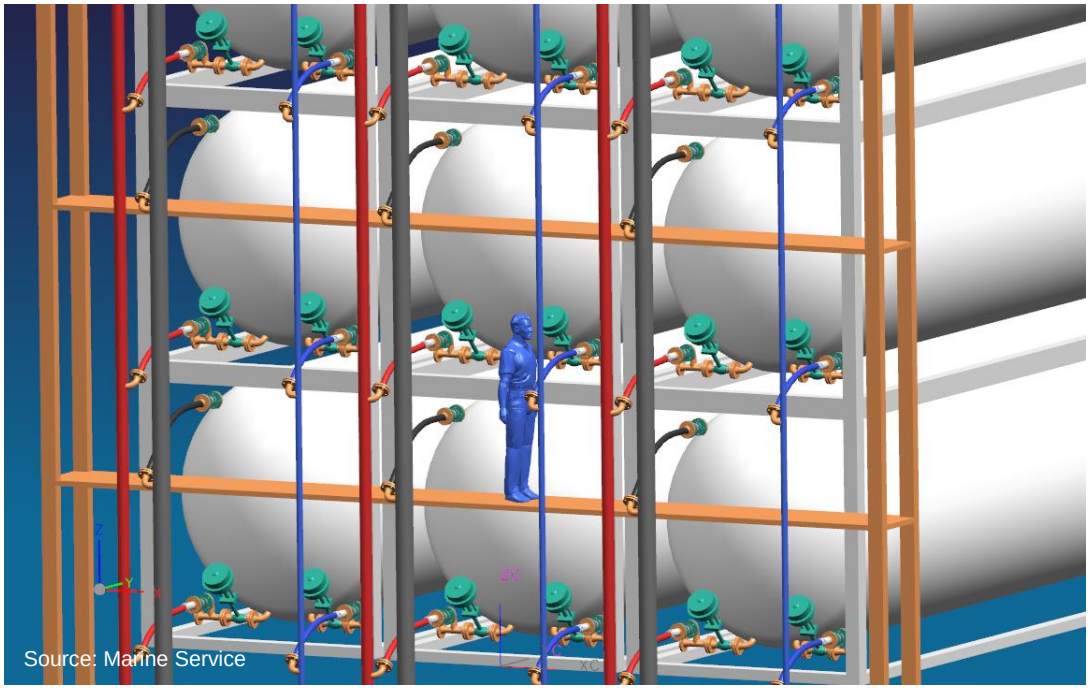
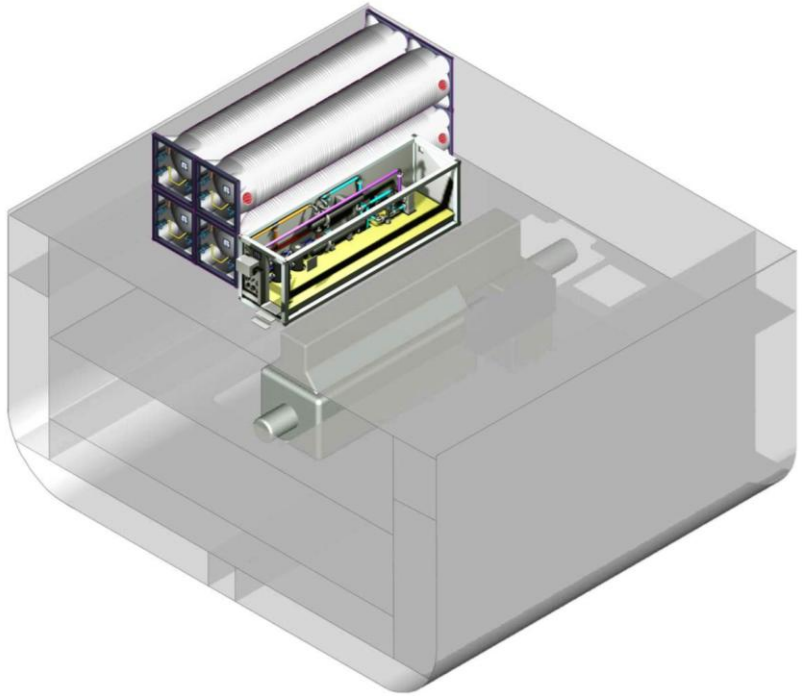
- Up to 6 LNG fuel tank containers in one stack
- LNG container hose connections in cell guides





RoRo Carrier

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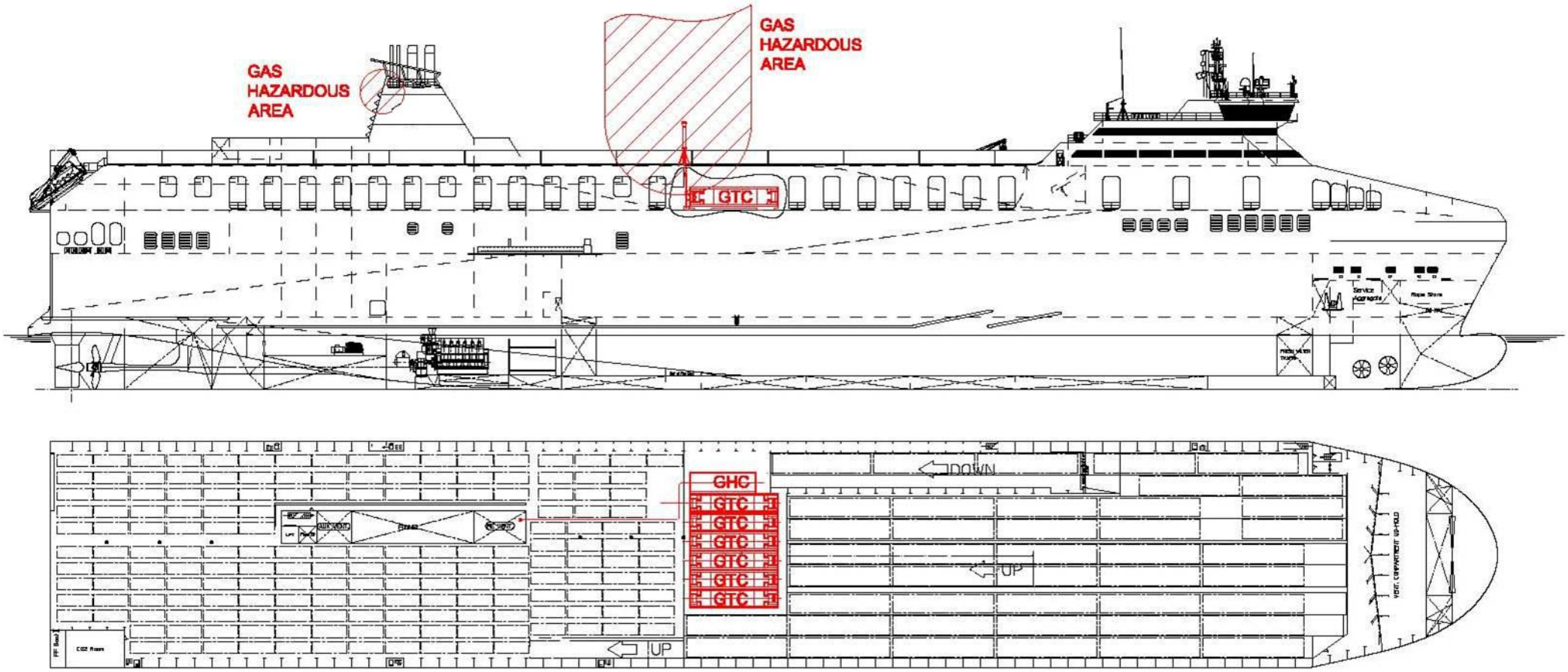

LNG Power Barge

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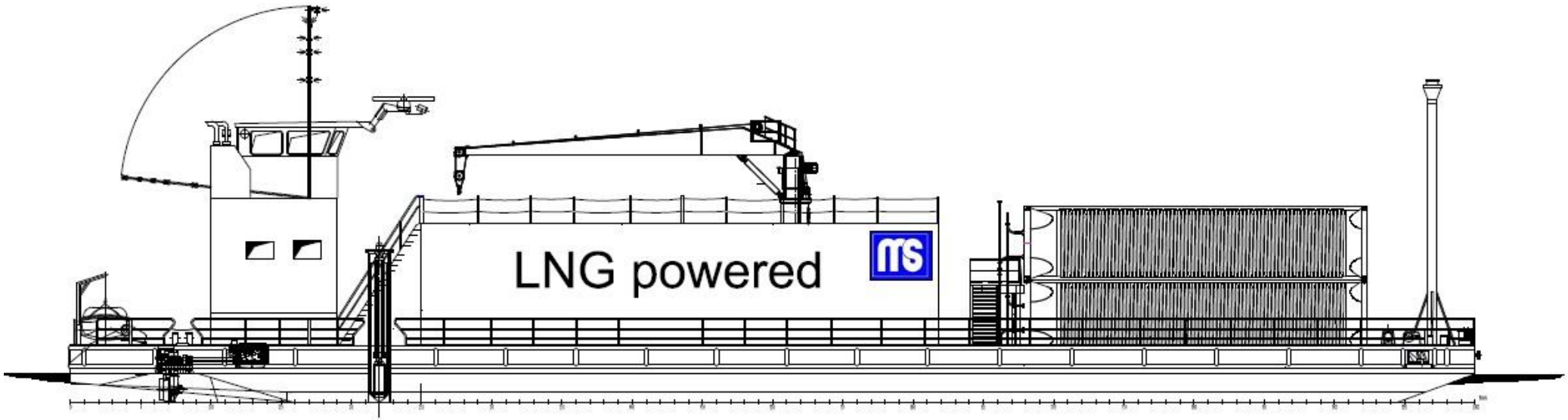

Summary

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- LNG as marine fuel is the only technically well-proven marine emissions legislation compliance strategy
- LNG tank technology is available and mature
- LNG Fuel Tank Container is a quickly implementable LNG as marine fuel solution that circumvents the LNG distribution issue by using existing container distribution infrastructure
- The processing of LNG has to consider the arrangement in the ship and there is not one solution for every purpose
- The coupling technology for quick bunkering and container connection is available

Thank you very much for your kind attention

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