LNG

Technical Services

Commercial Advisory Services

Offshore Wind Power

MT LNG

Marine Service GmbH

LNG Infrastructure and Shipbuilding

Dipl.-Ing. Michael Kraack

Klaipeda, 10. Dezember 2015

GO LNG – Final Conference to the SBSR Project „MarTech LNG“

History of Marine Service

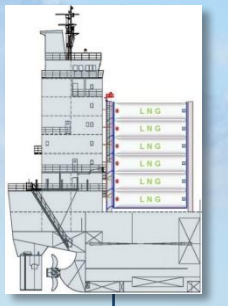
Marine Service GmbH

1958
Foundation of
Marine Service GmbH
by
Dr. Karl-Heinz Kraemer

1959
Plan Approval and Construction
Supervision of the first Dry Cargo Vessel

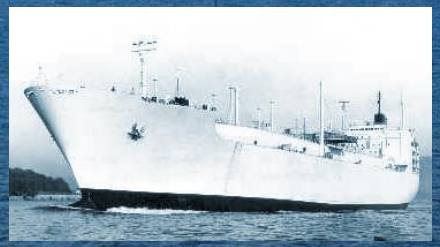
since 1970
Technical Planning and
Construction of more than
20% of the existing LNG
Carrier Fleet worldwide

2009 – 2010
Approval in Principle of LNG fueling and
bunkering systems for marine fuel supply



since 2010
Design, Project Management, Plan
Approval and Maintenance Planning
of Offshore Converter Platforms

’60 ’70 ’80 ’90 ’2000 ’10



1969
Design, Plan Approval and Construction
Supervision of the first LNG Carrier

since 1974
Feasibility studies, planning of location, safety
regulations, etc. for LNG Terminals worldwide

2010 – 2013
Type Approval – Design of an
LNG Fuel Tank Container

LNG CONSUMERS ON BOARD

Marine Service GmbH

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
- Auxiliary engines: 5 to 6 bar
- Boilers: 0.5 to 2 bar

LNG TANK TYPES: TYPE “C”

Marine Service GmbH

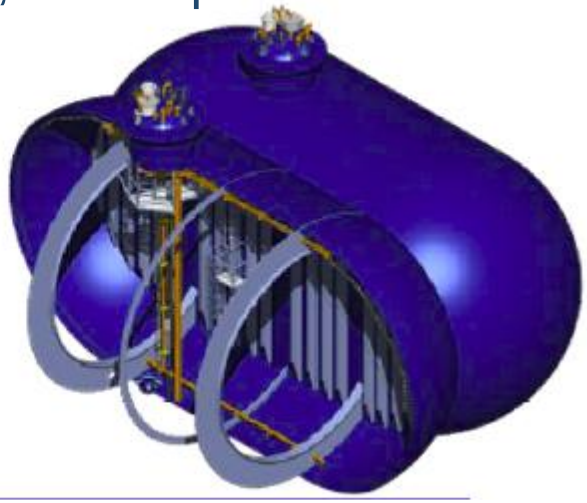
- Cylindrical type-C Tanks
  - Pressure 6 to 10 bar
  - Vacuum, or PU panel insulated
  - Size up to about 500m³ per Tank
- Bilobe- type-C Tanks

  Pressure approx. 4 bar

  Panel or foam insulated

  Size up to about 10,000 m³ per Tank

- LNG Container
  - Type-C Tank and IMDG-Tank
  - Pressure 6 to 10 bar
  - Vacuum insulated
  - Size about 40m³ per Tank



LNG TANK TYPES: TYPE “C”

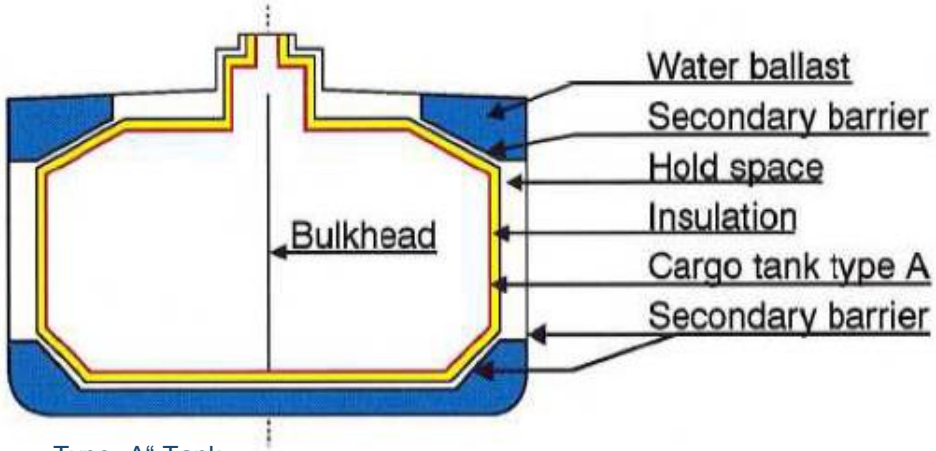
Marine Service GmbH

- Trilobe- Type-C Tanks
  Pressure approx. 4 bar
  Panel or foam insulated
  Tank size: volume improvement up to 30%

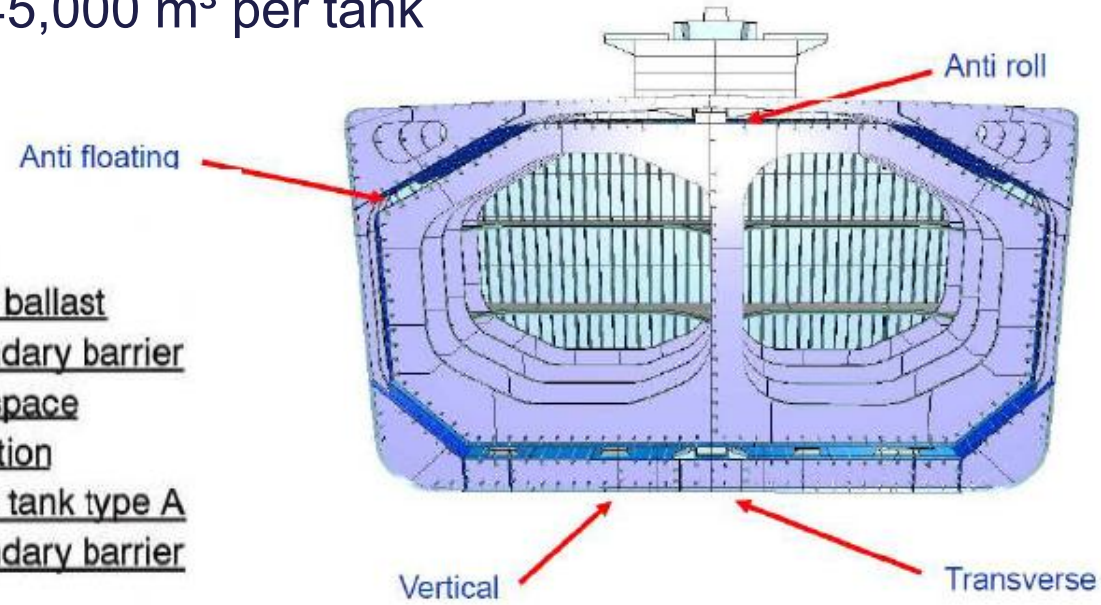
LNG TANK TYPES: TYPE “B” / “A”

Marine Service GmbH

- Type-A and B Tank
  - Pressure < 0.7 bar
  - Self-supporting construction with inner structure
  - Panel insulation with only partial second barrier Type „B“
  - Panel insulation without second barrier Type „A“
  - Size up to 10,000 – 45,000 m³ per tank



Type „A“ Tank



Type „B“ Tank

LNG TANK TYPES: MEMBRANE

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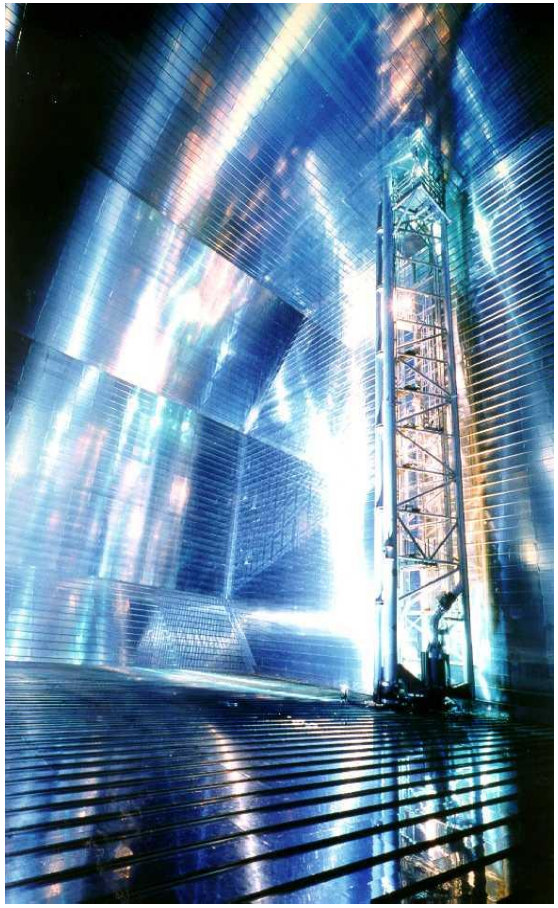
- Membrane
  - Pressure approx. 0.3 bar max 0.7 bar
  - Foam or boxes with perlite filling with secondary barrier
  - Adapts to outer shell
  - Size up to 45,000 m³ per tank



Membrane Type Tank

Type „A“ Tank

LNG TANK INSULATION

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Insulation	Advantages	Disadvantages
PU-Foam Insulation	Cost efficient	Risk of icing Inflammable Expensive waste disposal Needs a second barrier
Vacuum Perlite Insulation	Noninflammable Low thermal conductivity Simple processing Has a second barrier Remaining insulation after vacuum loss	Risk of vacuum loss due to leakages High insulation costs with industrial vacuum
Aerogel Mats	Noninflammable Low thermal conductivity Each layer has a vapour barier	High material costs Risk of icing Needs a second barrier
Radiation Foil Vacuum Insulation	Noninflammable Lowest thermal conductivity Has a second barrier	Risk of vacuum loss due to leakages Highest insulation costs due to high vacuum, about 10 x more expensive

PANEL SYSTEM MOSS TYPE

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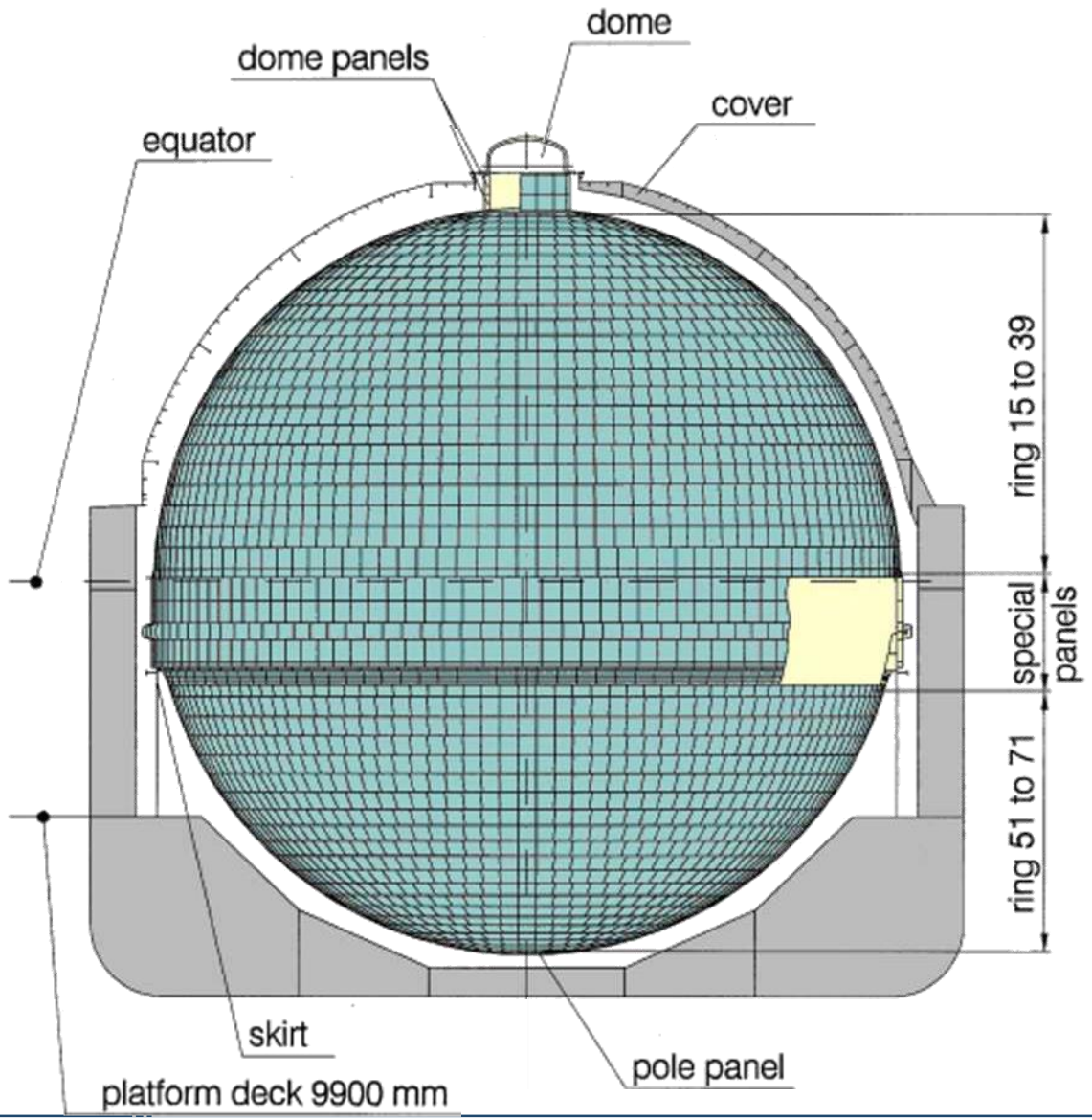
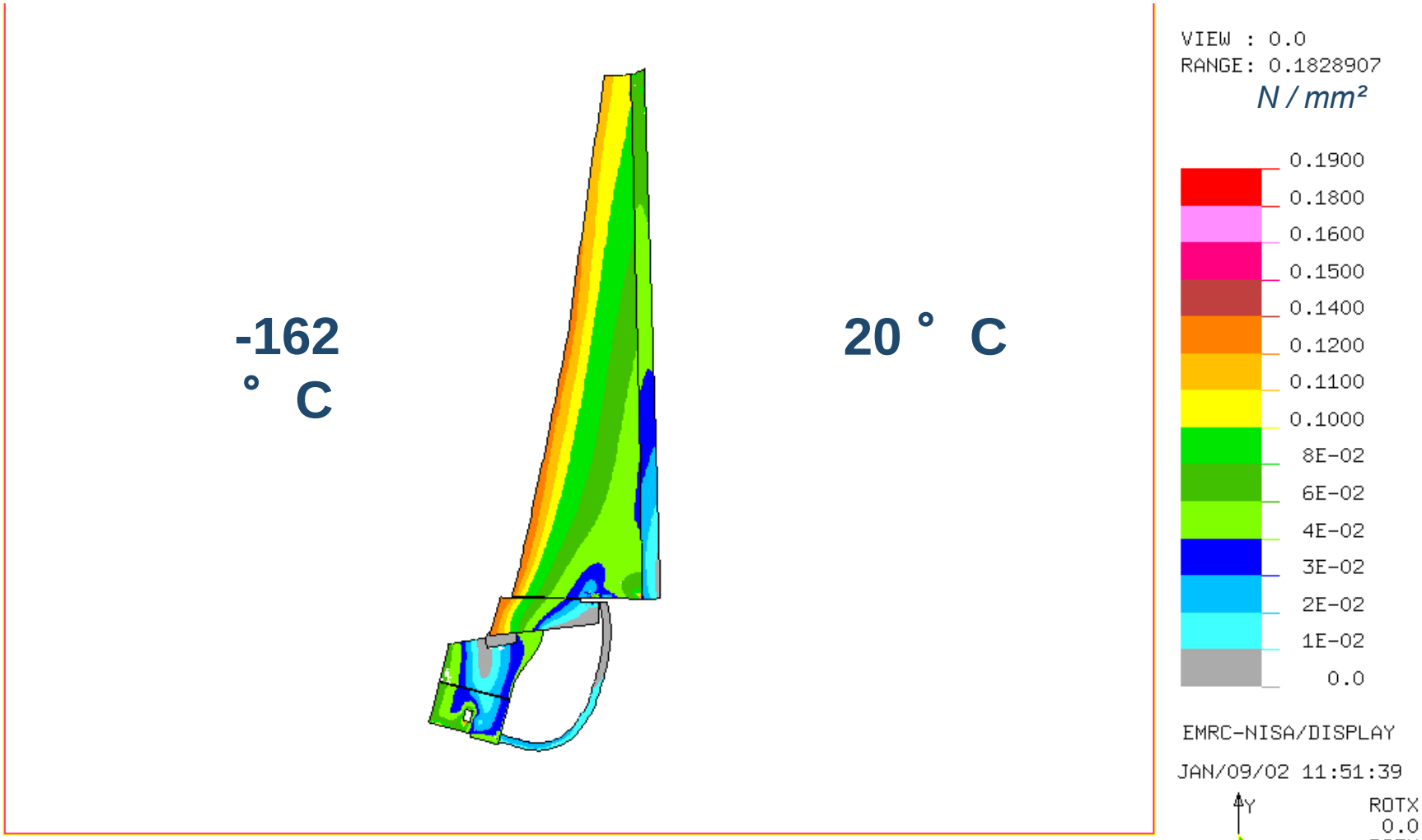


Source: KAEFER

STRENGTH MOSS TYPE PANELS

LNG Skirt: Stress and deformation between 20 ° C and –162 ° C

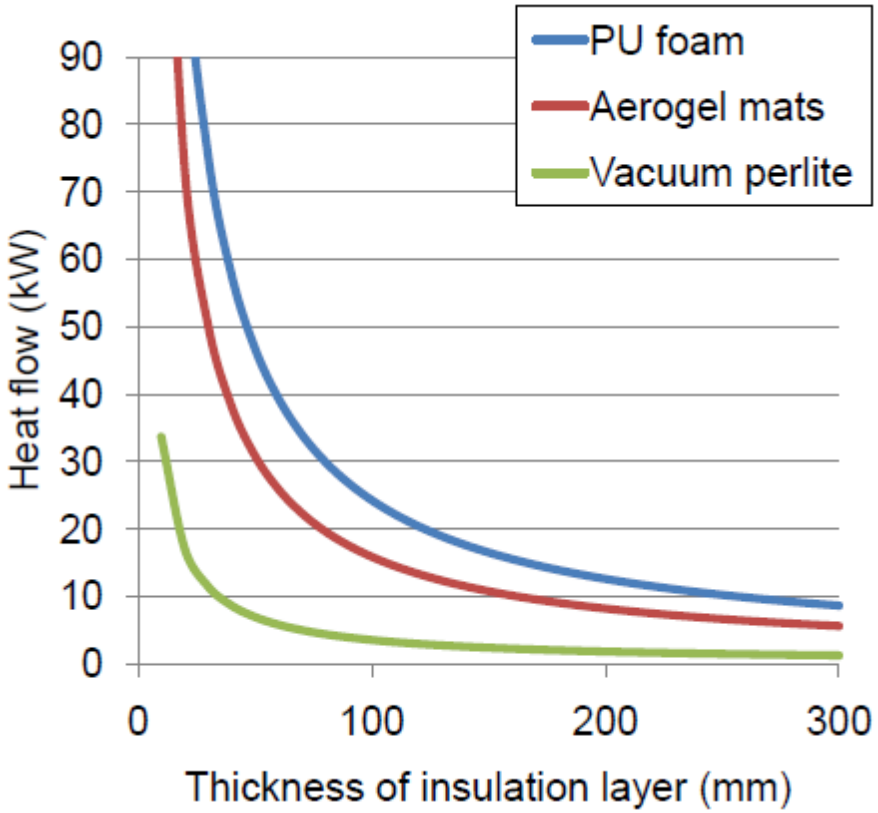


Source: KAEFER

LNG TANK INSULATION

Marine Service GmbH

Heat Input LNG Tank



- Bunker pressure 1.1 bar (a)
- Ambient temperature: 45°C
- LNG temperature: -161°C

Effective heat conductivity (W/mK)

- PU-foam aged: ≈ 0.02
- Vacuum perlite: ≈ 0.0025
- Aerogel mats: ≈ 0.013

LNG TANK INSULATION

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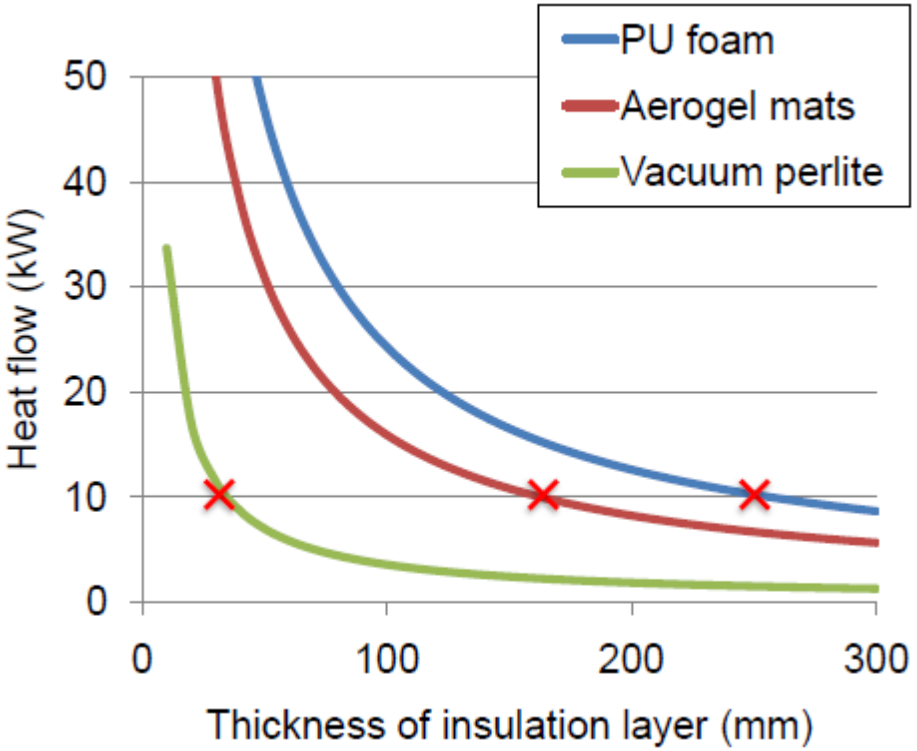
Minimum possible insulation quality



Heat input into tank should not exceed 10 kW:

- PU-foam: ≈ 260mm
- Vacuum perlite: ≈ 35mm
- Aerogel mats: ≈ 165mm

VACUUM INSULATION

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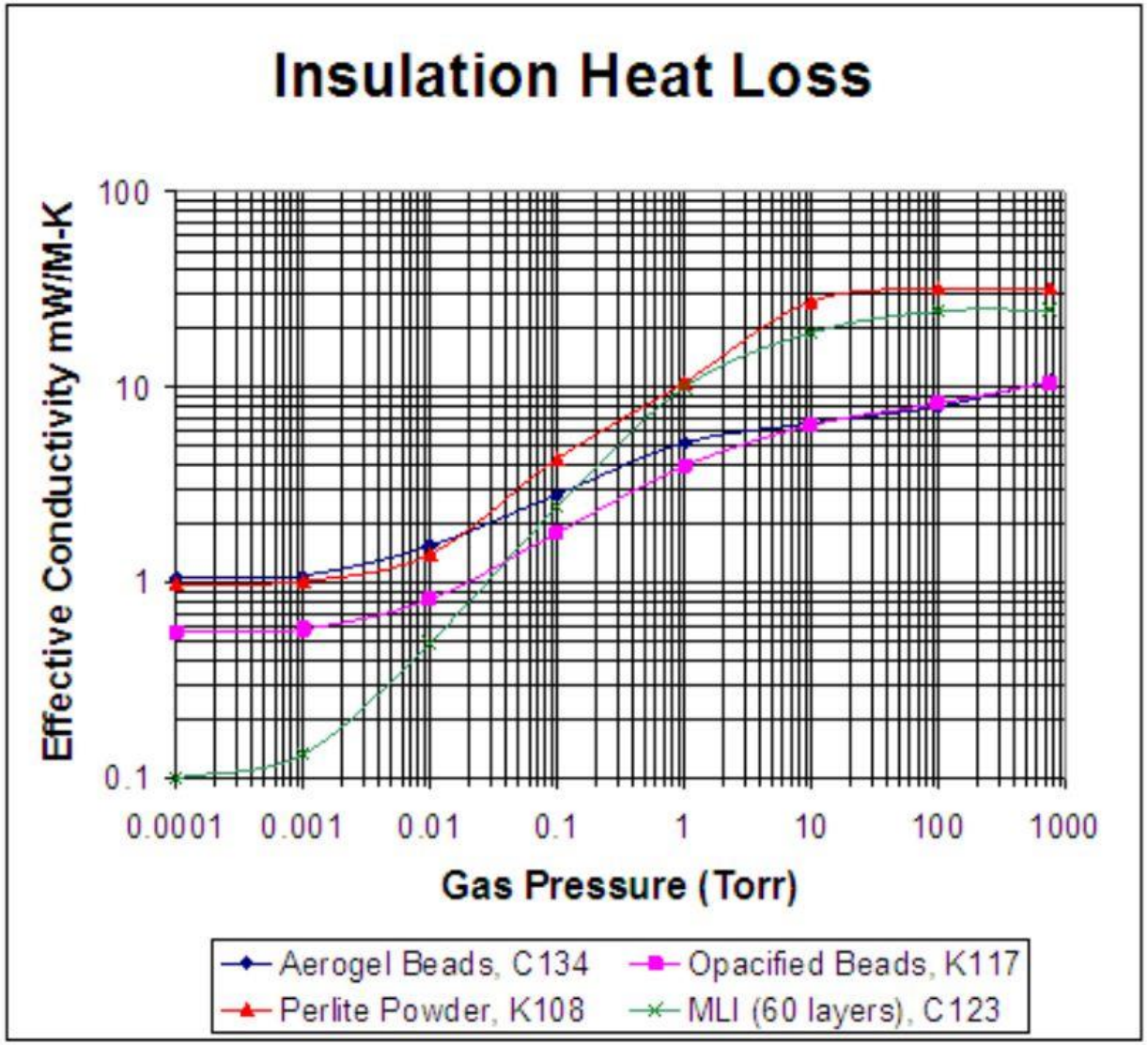

To achieve holding times of 80 days or more for the fuel gas tank, a vacuum pressure of 10^{-4} mbar is necessary.

VACUUM INSULATION

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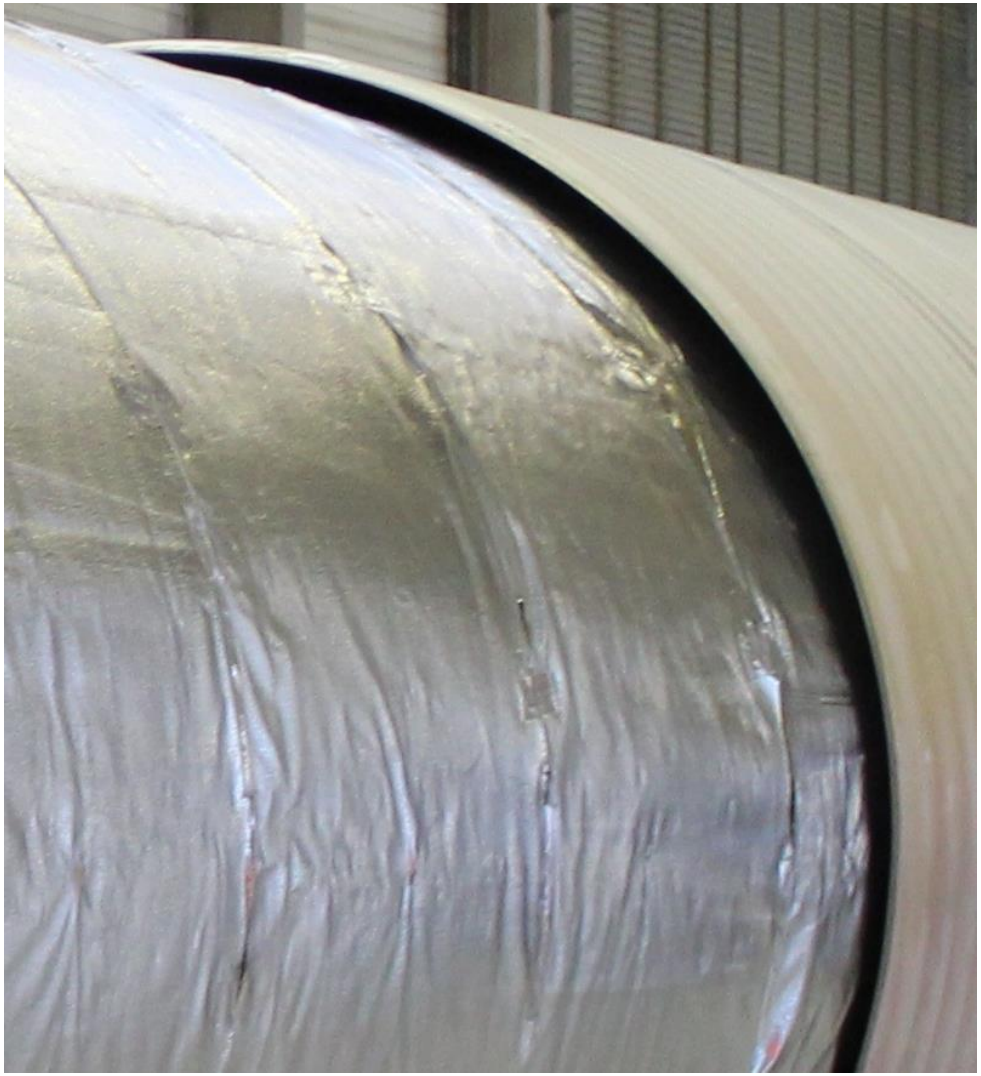
Vacuum space with perlite filling

+ 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

Marine Service GmbH



Vacuum space with radiation foil

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

LNG FUEL TANK LAYOUT

Marine Service GmbH

Source: motorship

INLET TANK DESIGN

Marine Service GmbH

How much energy is required?

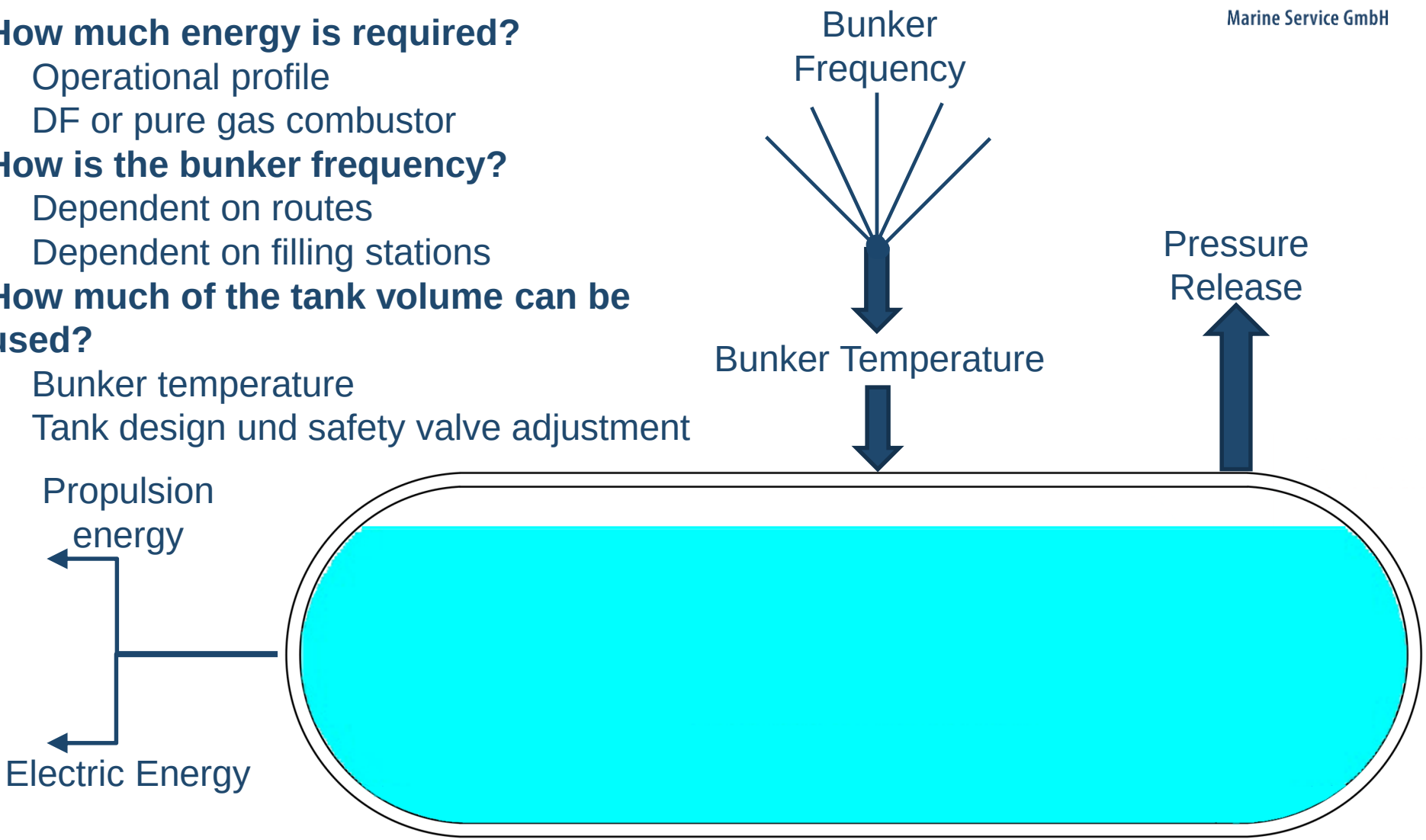
- Operational profile
- DF or pure gas combustor

How is the bunker frequency?

- Dependent on routes
- Dependent on filling stations

How much of the tank volume can be used?

- Bunker temperature
- Tank design und safety valve adjustment



LNG FUEL TANK TYPE C

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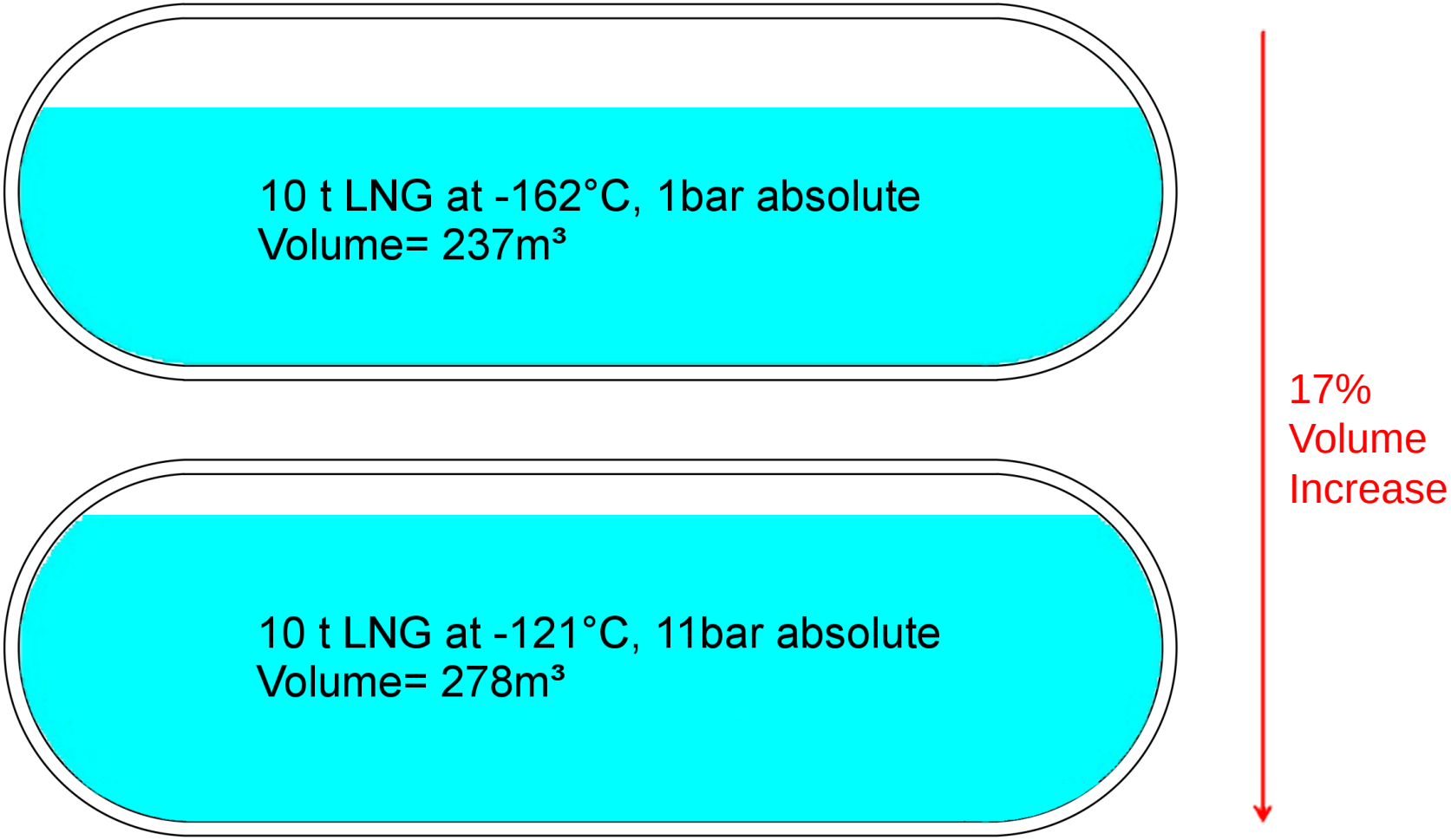

LNG FUEL TANK TYPE C

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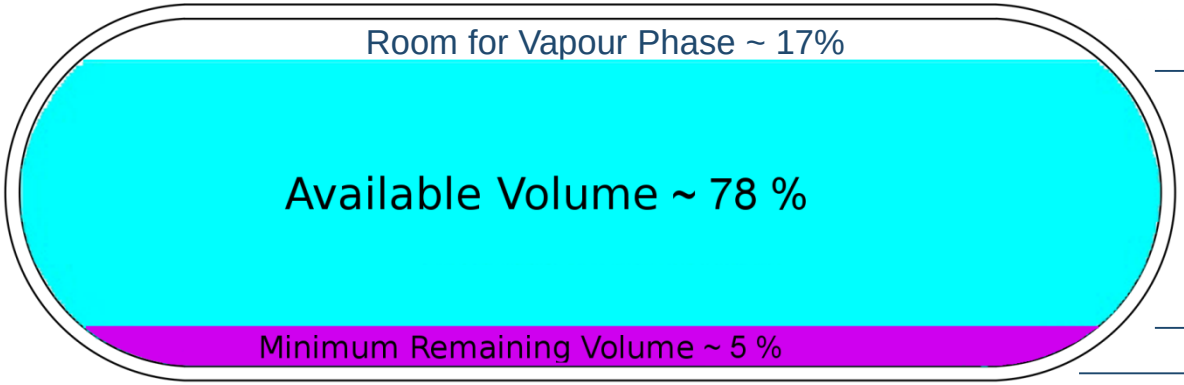
Case	Temp. (°C)	Pressure (bar absolute)	Density (kg/m³)
Loading temperature	-162,0	1,00	422,6
Reference temperature	-121,0	11,00	359,6
Relative density, reference, PR	359,6	kg/m³	
Relative density, loading: PL	422,6	kg/m³	
Loading part	98%		
Volume load: VL	83%	of total tank volume at -161,6°C	

Safety Valve Adjustment

In this case < 80% of the volume can be used!



Maximum liquid level

$$VL = 0{,}98V\,\frac{PR}{PL} = 83\%$$

Minimum liquid level

LNG Processing Systems

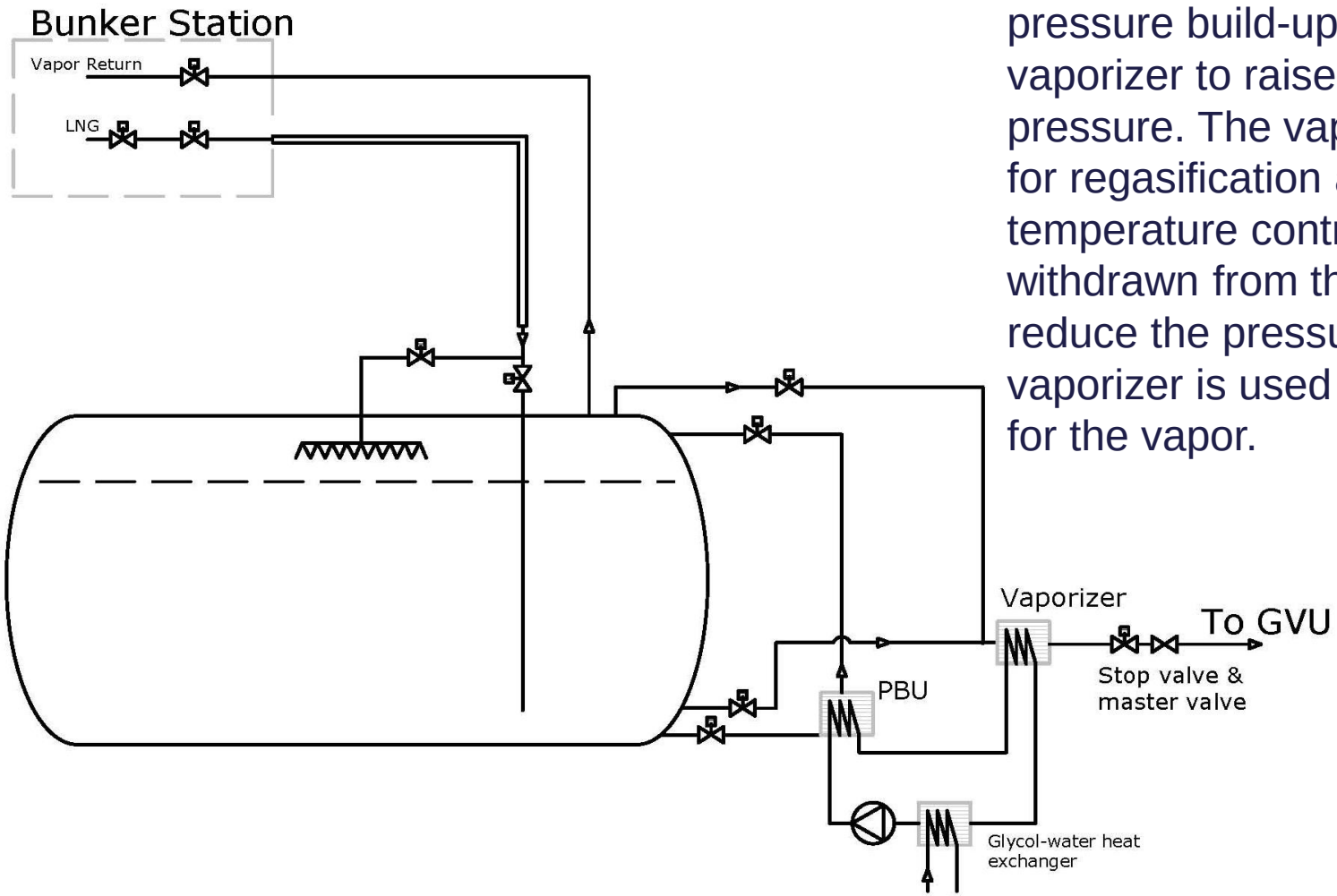
Marine Service GmbH

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

Marine Service GmbH



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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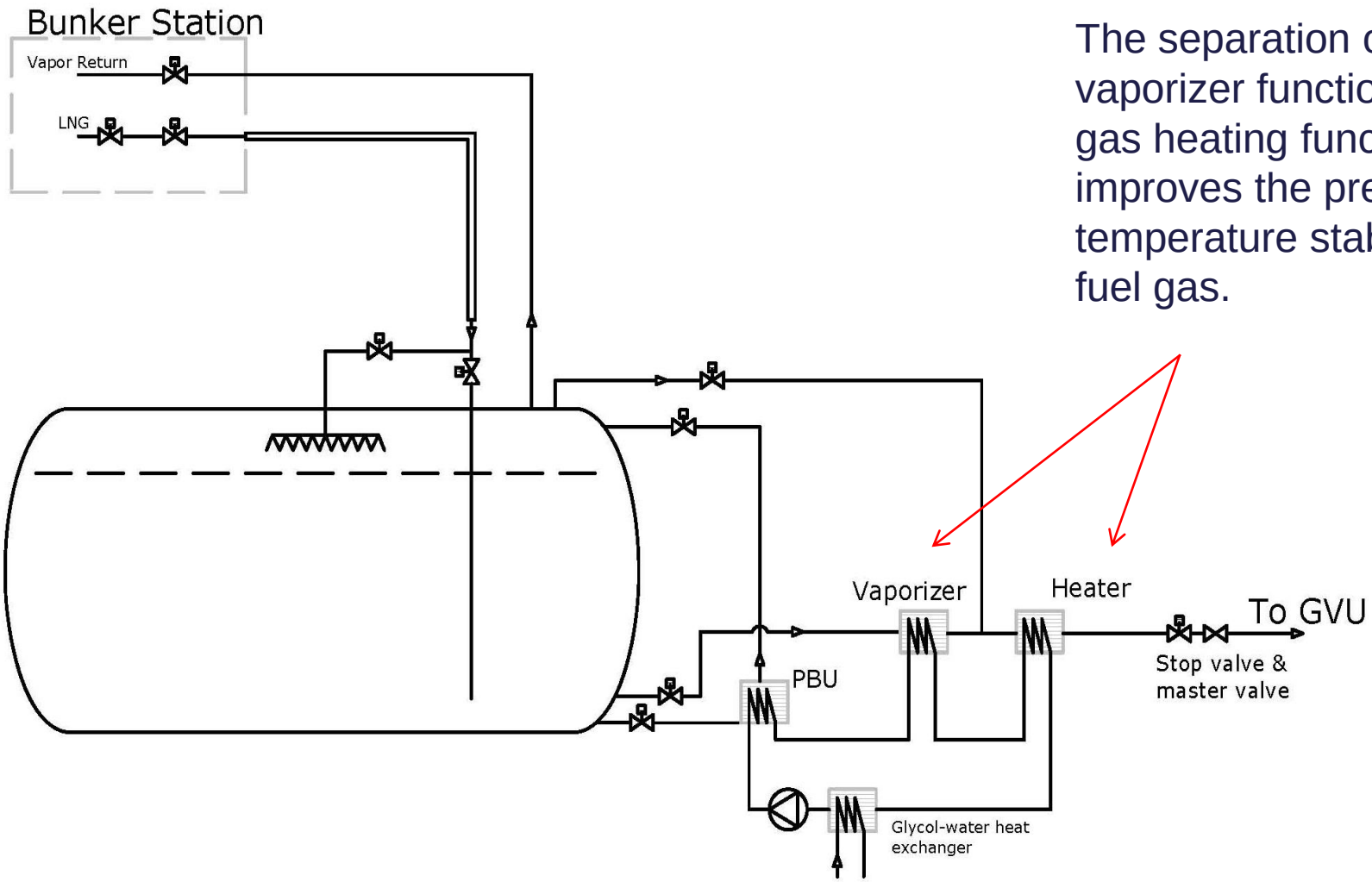
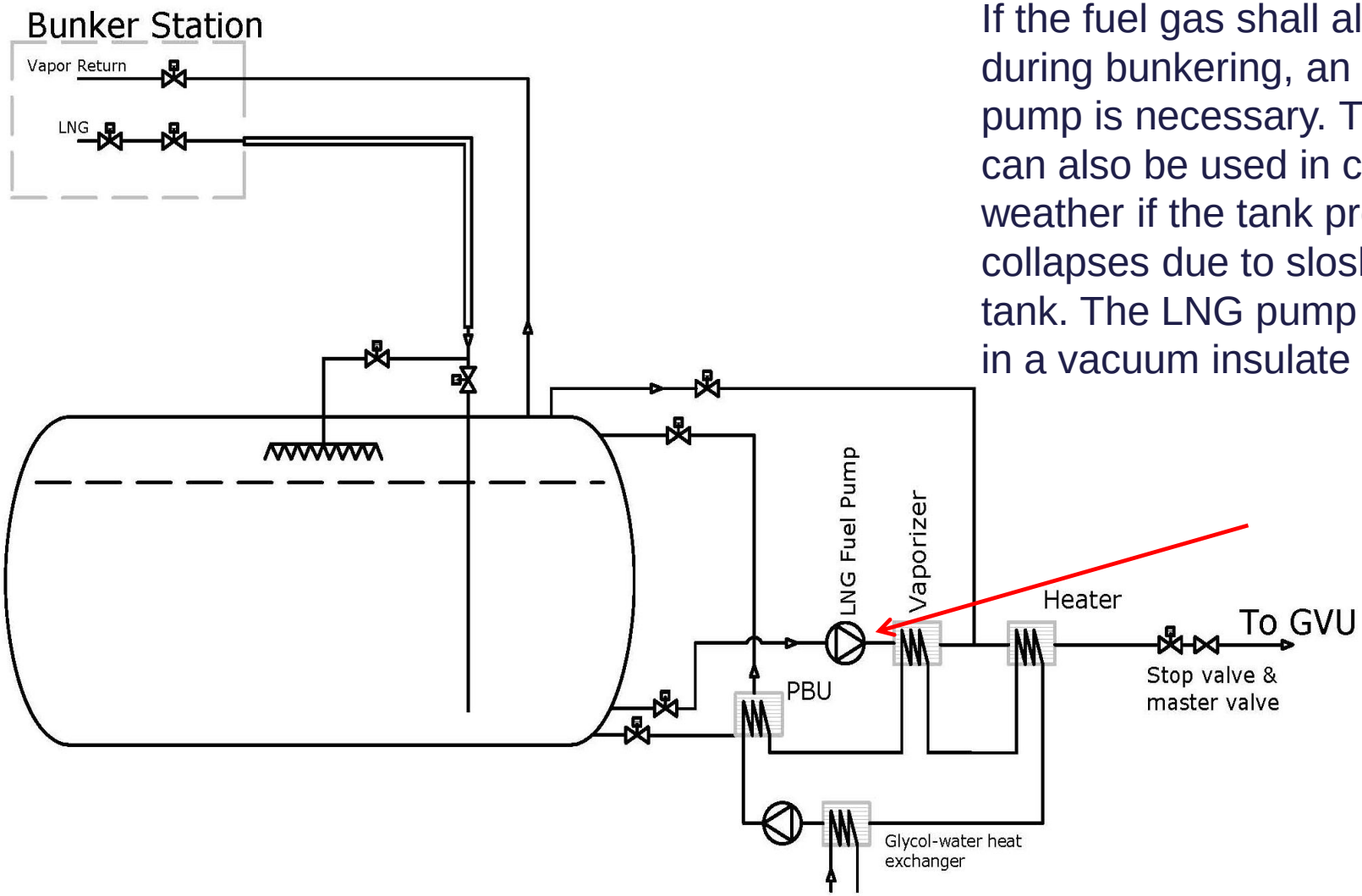


The separation of the vaporizer function and the gas heating function improves the pressure and temperature stability of the fuel gas.

LNG Processing Systems

Marine Service GmbH

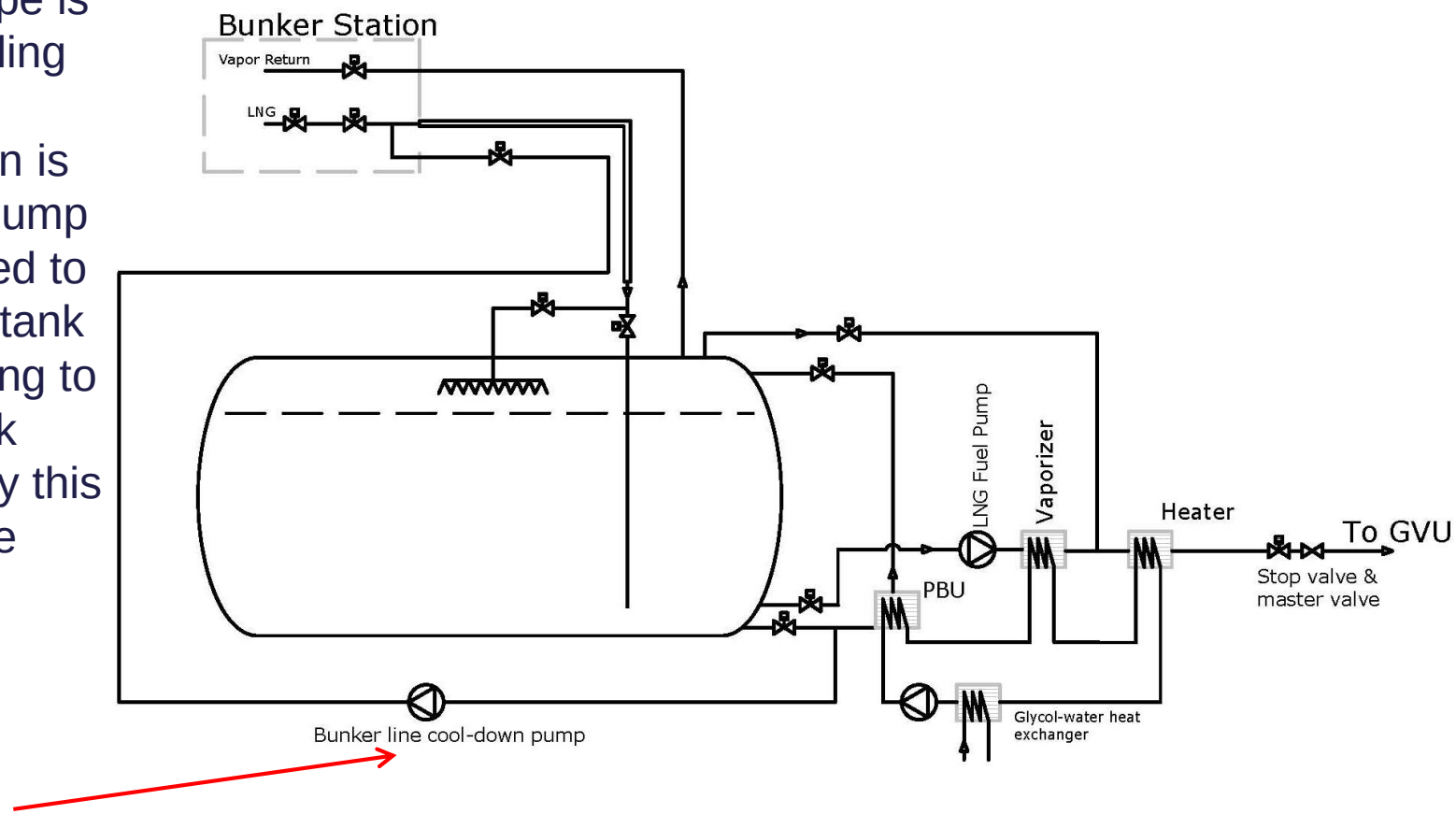


If the fuel gas shall also be used during bunkering, an LNG fuel pump is necessary. This pump can also be used in case of heavy weather if the tank pressure collapses due to sloshing in the tank. The LNG pump is installed in a vacuum insulate drum.

LNG Processing Systems

Marine Service GmbH

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.



The pump can also be used for discharging the tank (gas freeing).

LNG GAS HANDLING SYSTEM

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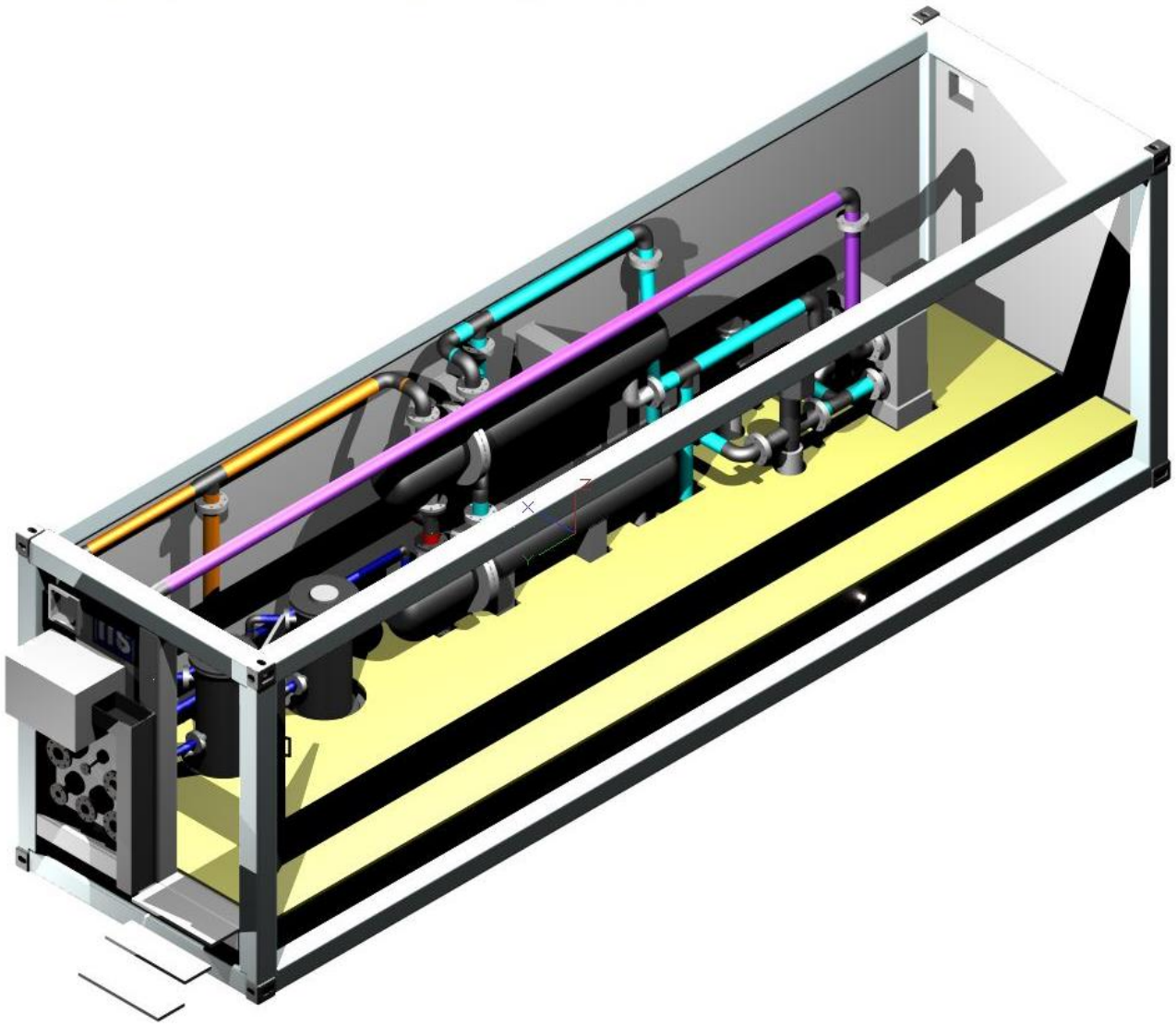


LNG FUEL TANK CONTAINER

Marine Service GmbH

- **ISO LNG Tank Container:**
  - IMDG hazardous goods container
  - IGC compliant Type C Tank (pressure tank) to allow use onboard as shipboard fuel bunker
  - Vacuum insulated to ensure extra long holding time up to 80 days
  - Dry coupling system with break-away device to avoid LNG leakage

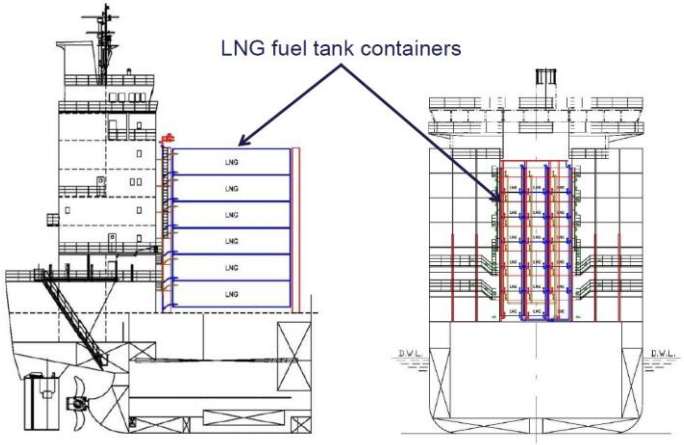
LNG FOR CONTAINER VESSELS

Marine Service GmbH

40‘ ISO LNG Tank Container developed by Marine Service for external loading with LNG within a safe environment.

LNG as Fuel

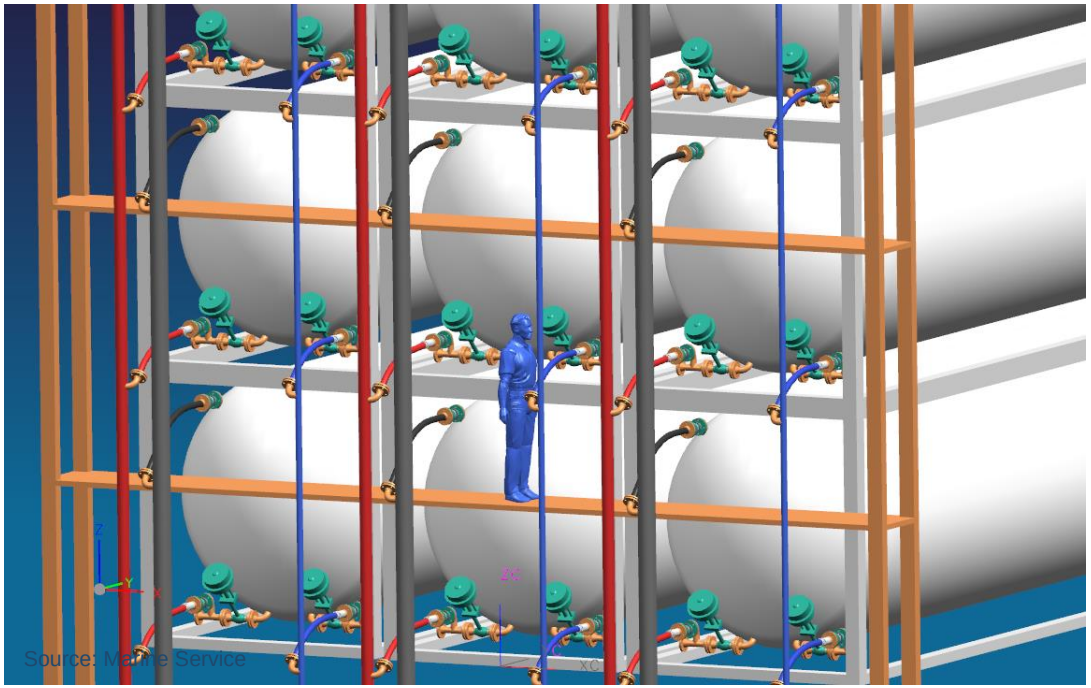
with the Marine Service LNG Tank Container onboard a feeder ship

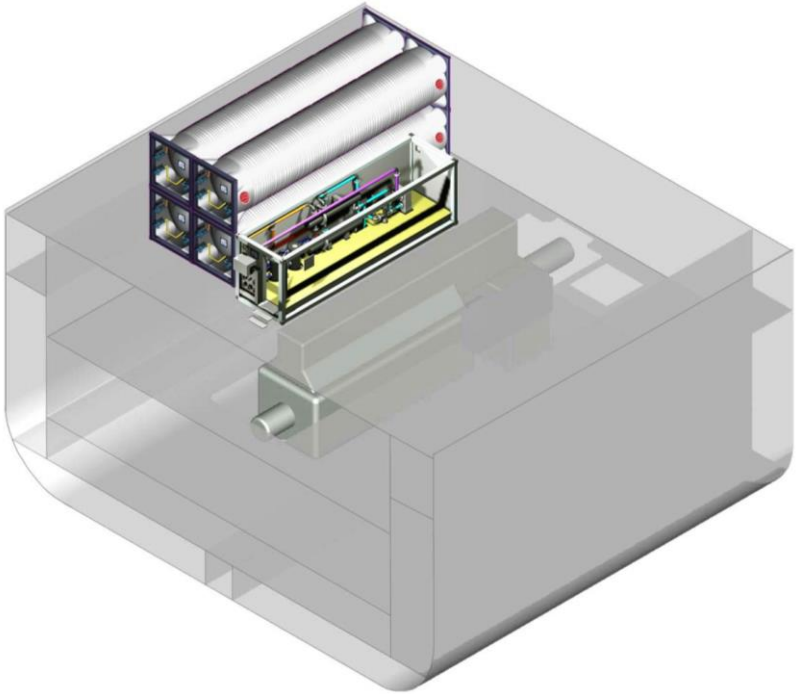


CONTAINER IN CELL GUIDES

Marine Service GmbH

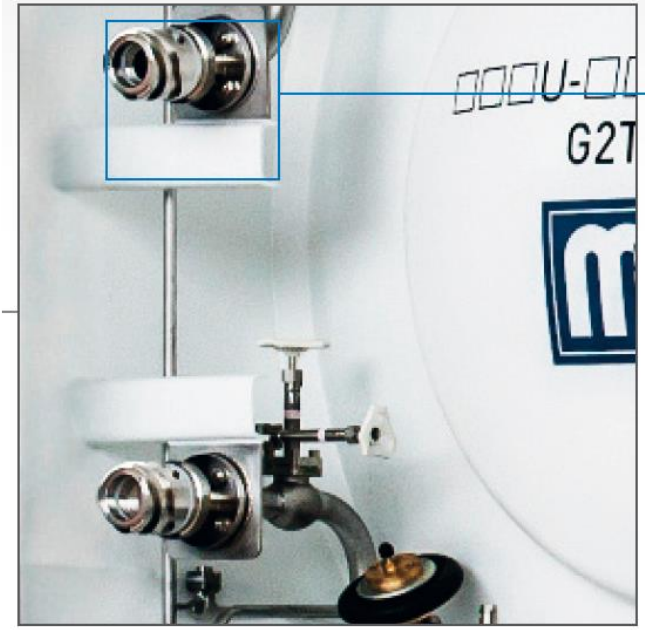
- Up to 6 LNG fuel tank containers in one stack
- LNG container hose connections in cell guides





LNG DRY COUPLING

Marine Service GmbH



TCC couplings connect the tank container with the LNG pipe.

The TCC series offers maximum safety and performance from -200°C to +60°C

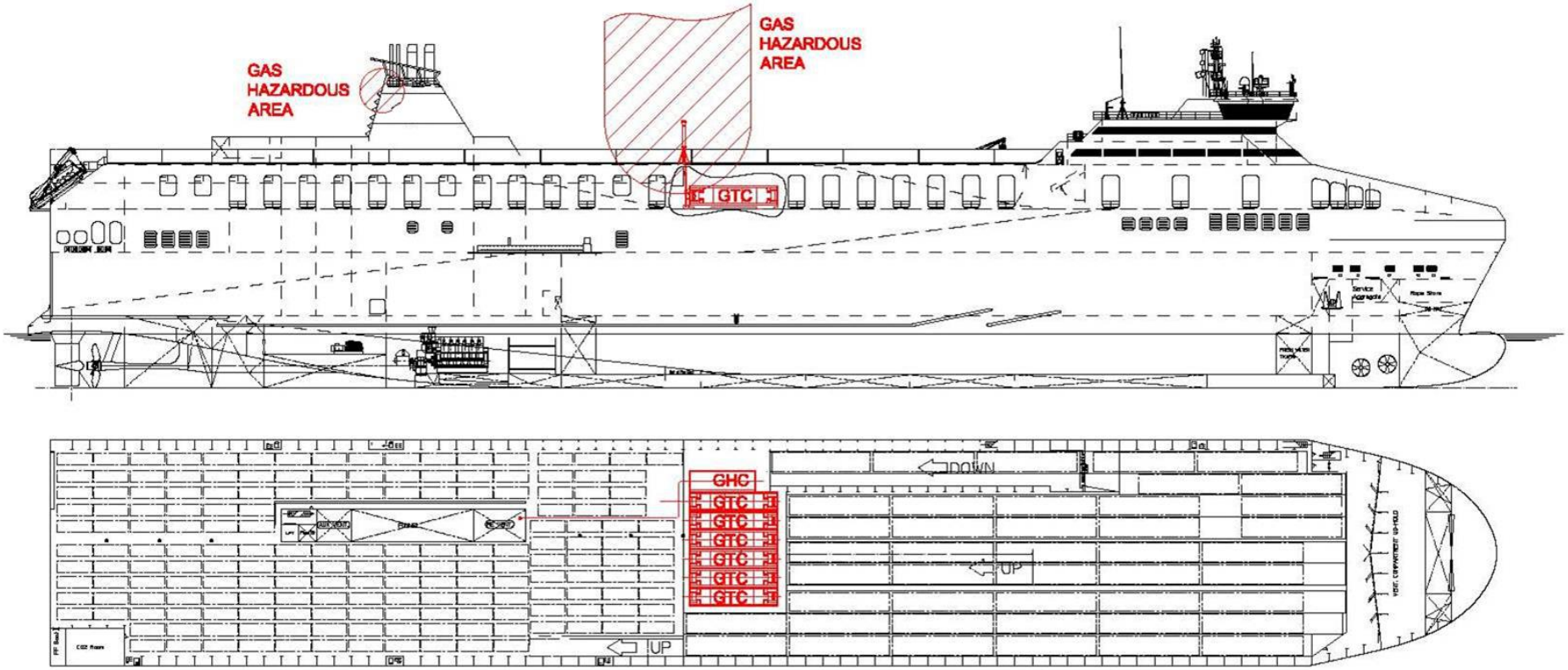
The dry coupling developed by Marine Service has a break-away device and is TÜV certified with more than 1000 trial couplings with nearly no leakage (10^{-5} mbar * l / sek) .

LNG DRY COUPLING

Marine Service GmbH

LNG RORO PROJECT

Marine Service GmbH



LNG PROJECT: PERMANENTLY INSTALLED TANKS

Marine Service GmbH

Installation of permanent tanks with vertical layout
for a project on the Great Lakes

LNG GVU HOUSING

Marine Service GmbH

A GVU (Gas Valve Unit) is used for a retrofit installation of an LNG propulsion. Additional explosion protection equipment in the engine room is therefore not needed, which would be very expensive and difficult to install.

LNG TANK SYSTEMS: FSRU

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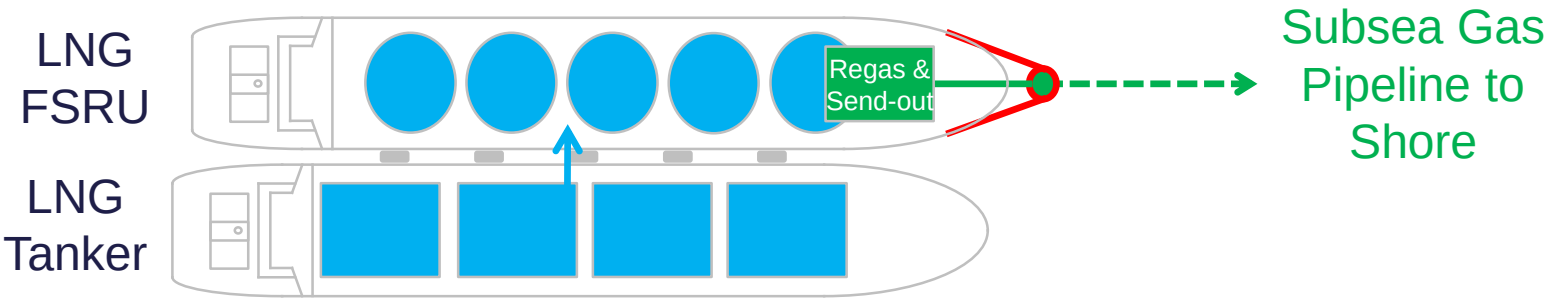


OLT – LNG FSRU “Golar Frost” (2003)
Offshore Livorno, Italy

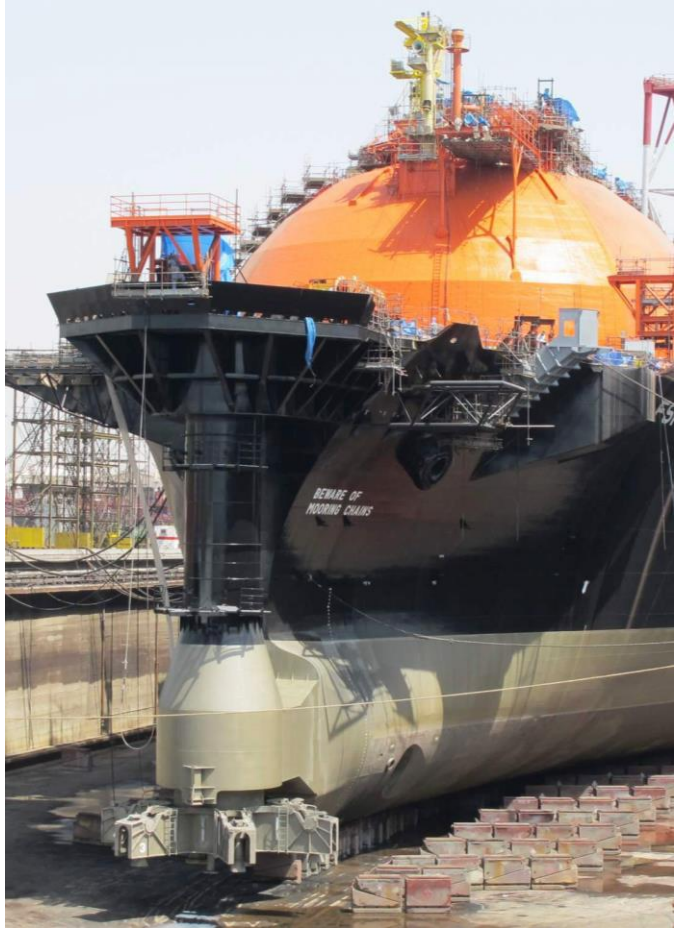
LNG FSRU “FSRU TOSCANA”
Source: Marine Service

FSRU MOORING SYSTEM

Marine Service GmbH

Turret and Swivel
Source: LMC

LNG FSRU “FSRU TOSCANA”
Source: Marine Service



LNG DISTRIBUTION IN HAMBURG

Marine Service GmbH

LNG BUNKER POSSIBILITIES

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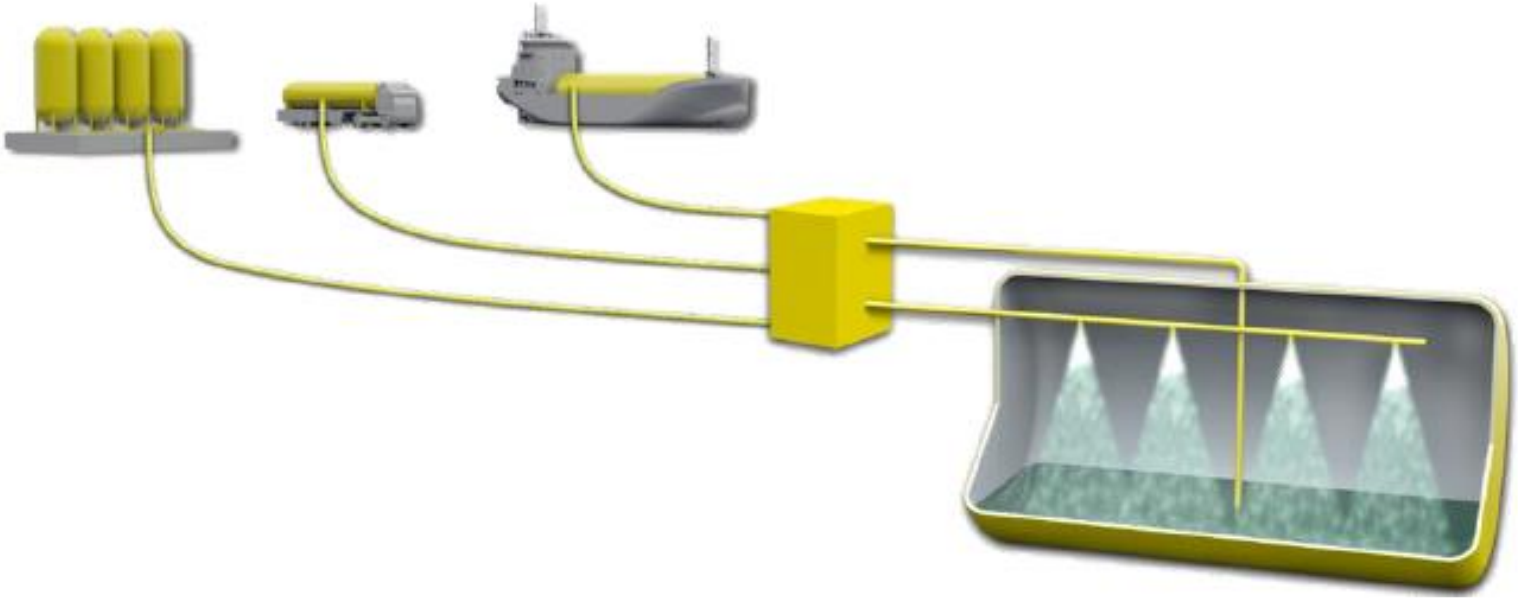
- **Truck-to-ship**
- **Shore-to-ship**
- **Ship-to-ship**
  - Barge
  - LNG carrier



LNG BUNKER SAFETY

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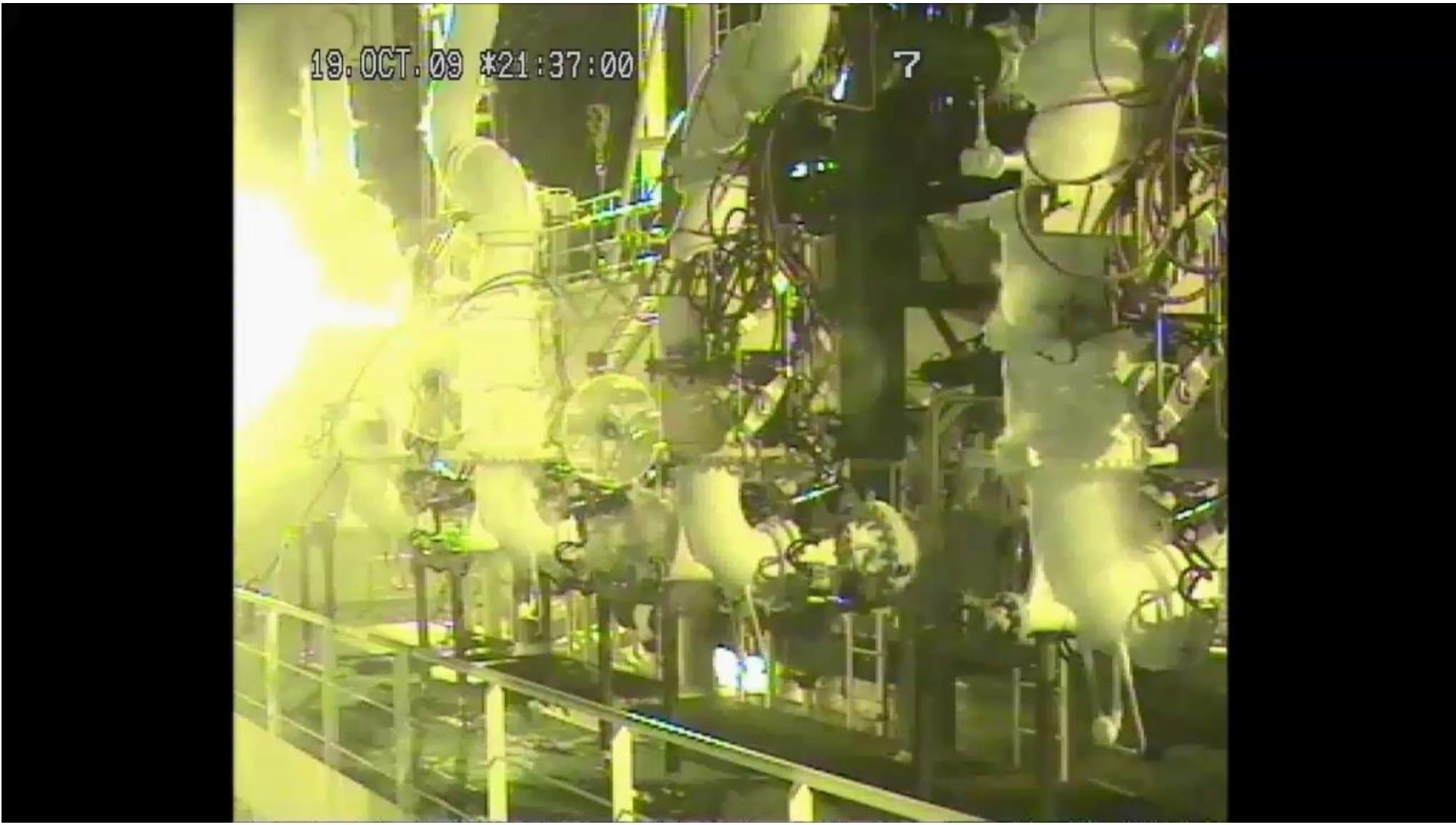

LNG TRUCK TO SHIP

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High flexibility: Trucks can drive to the jetty of the vessel to be supplied
Limited amount of fuel: The amount of LNG which can be delivered by trucks is very limited or many trucks have to be used.

.

MS “Viking Grace” in Finland

Risky security chain
e.g. emergency stop

Security zone: barrier

LNG SHORE TO SHIP

Marine Service GmbH

The infrastructure onshore has been prepared, however, not all vessels are equipped with loading arms.

Many terminals are only laid out as import terminals where no fueling can be done.

LNG SHIP TO SHIP

Marine Service GmbH

LNG bunker vessels have a relatively large capacity and are flexible with regard to the bunker location.

Bunker procedure is similar to today‘s oil / diesel procedures.

Regulations are currently not yet applied uniformly.

LNG MOORING SHIP TO SHIP

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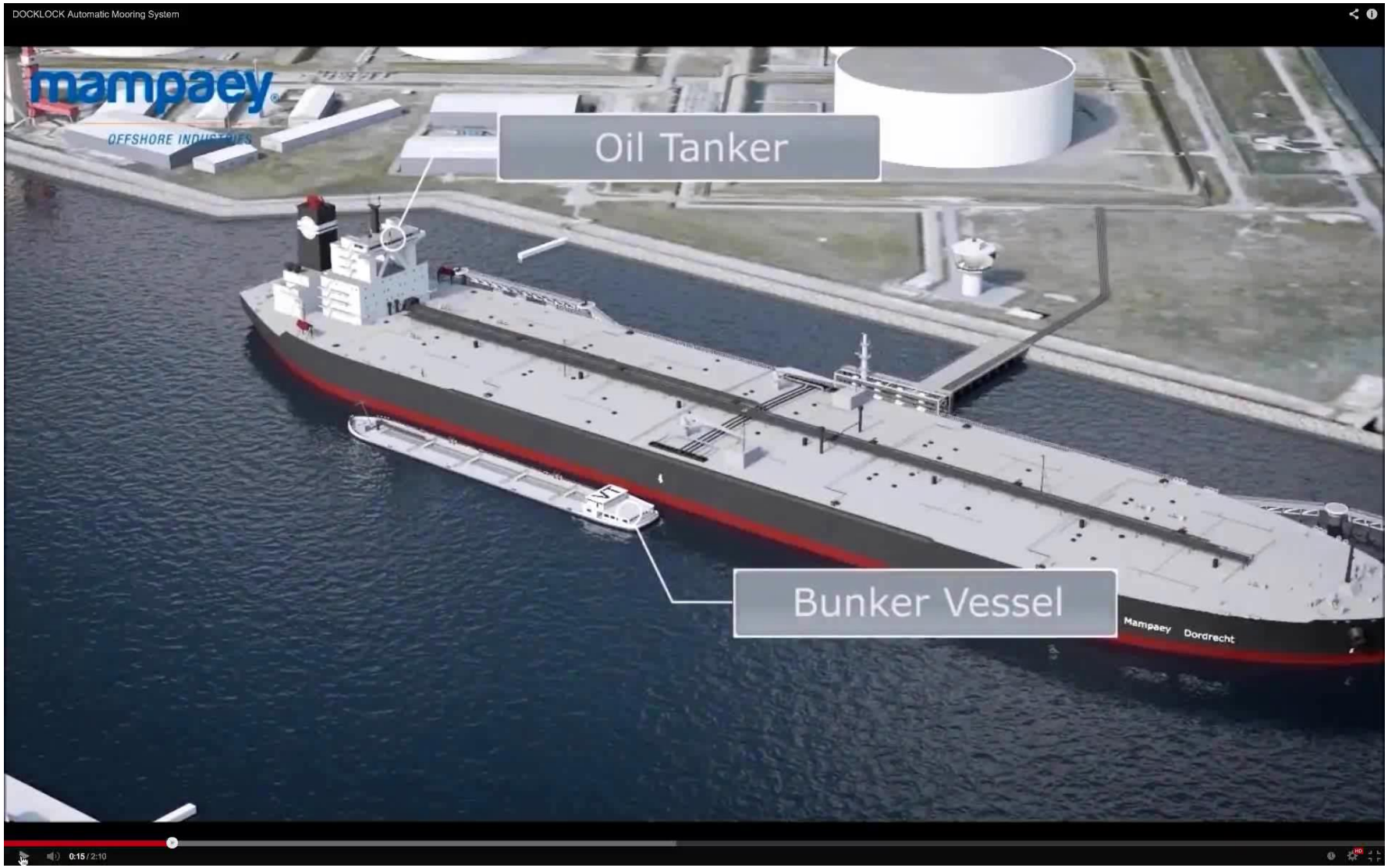

Soot Cloud over Hamburg, 4 October 2014

Foto: News Art

Marine Service GmbH

Thank you for your kind attention

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