LNG as fuel and Bunkering

Disruptive innovations

GoLNG Conference
Stavanger Fjord1 – April 12th, 2018

Martial CLAUDEPIERRE
Bureau Veritas – Marine & Offshore

Agenda

GoLNG conference – StavangerFjord – 11th April 2018

01

introduction
- Why LNG as fuel ?
- Innovative breakthrough ULCS CMA CGM 20kTEU

02

Other innovative projects
- MSC World Class
- Ponant Polar Explorer

03

Technologies updates
- LNG fuel tanks
- Propulsion systems

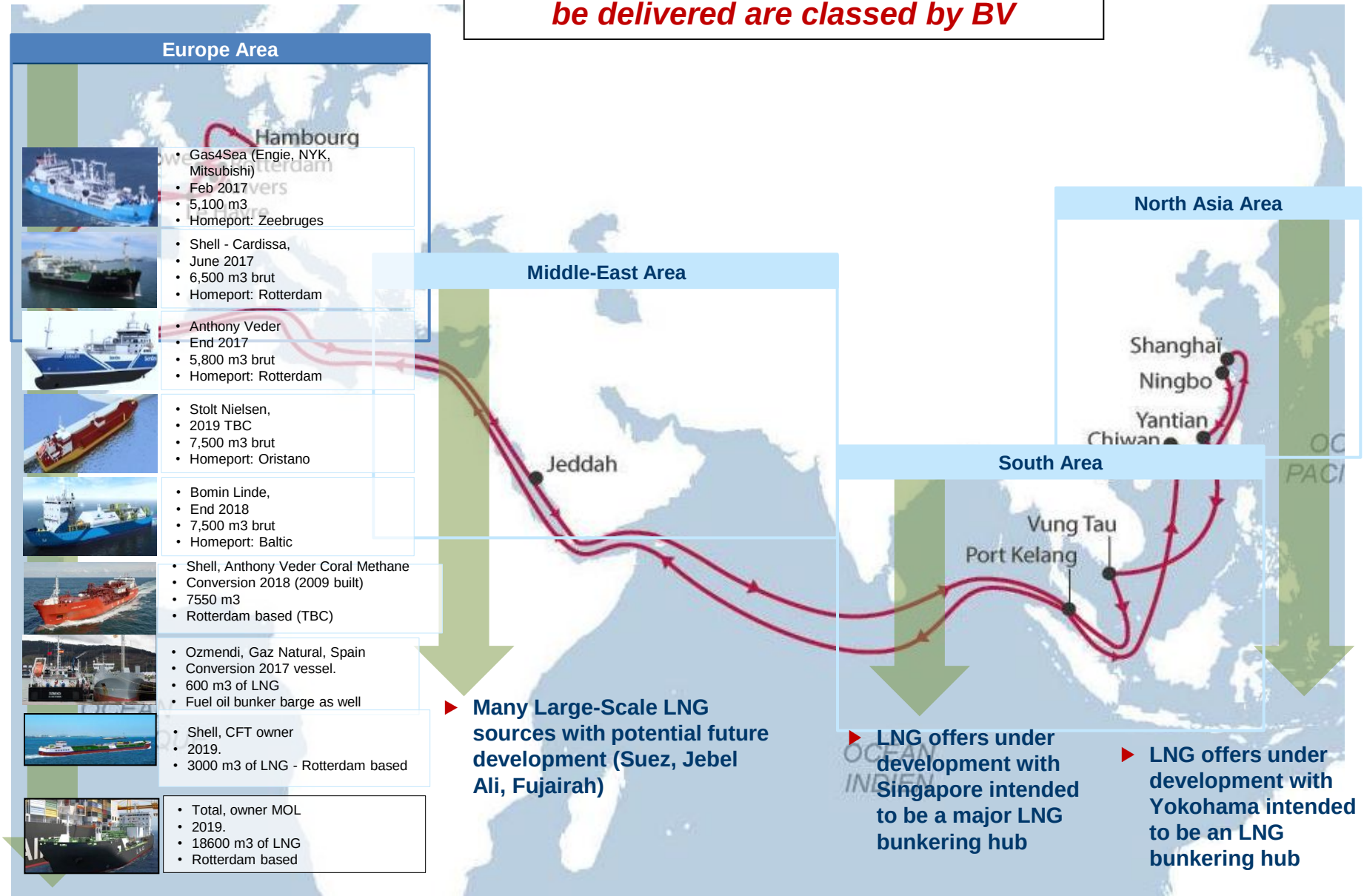
04

LNG bunkering challenges

01 Introduction

No more chiken and eggs discussion…

66% of LNG bunkerships in service or to be delivered are classed by BV



- Gas4Sea (Engie, NYK, Mitsubishi)
- Feb 2017
- 5,100 m3
- Homeport: Zeebruges

- Shell - Cardissa,
- June 2017
- 6,500 m3 brut
- Homeport: Rotterdam

- Anthony Veder
- End 2017
- 5,800 m3 brut
- Homeport: Rotterdam

- Stolt Nielsen,
- 2019 TBC
- 7,500 m3 brut
- Homeport: Oristano

- Bomin Linde,
- End 2018
- 7,500 m3 brut
- Homeport: Baltic

- Shell, Anthony Veder Coral Methane
- Conversion 2018 (2009 built)
- 7550 m3
- Rotterdam based (TBC)

- Ozmendi, Gaz Natural, Spain
- Conversion 2017 vessel.
- 600 m3 of LNG
- Fuel oil bunker barge as well

- Shell, CFT owner
- 2019.
- 3000 m3 of LNG - Rotterdam based

- Total, owner MOL
- 2019.
- 18600 m3 of LNG
- Rotterdam based

- **Many Large-Scale LNG sources with potential future development (Suez, Jebel Ali, Fujairah)**
- **LNG offers under development with Singapore intended to be a major LNG bunkering hub**
- **LNG offers under development with Yokohama intended to be an LNG bunkering hub**

LNG as fuel market in year 2017
The tipping point

Seatrade, 31st May 2017

MSC Cruises reveals novel look of its LNG World-class newbuilds

One year after they were first announced, MSC Cruises confirmed the order for up to four LNG-powered cruise ships of 200,000gt at STX France and released the first rendering of their novel design.

CMA CGM News, 7th November 2017

World Innovation: CMA CGM is the first shipping company to choose liquefied natural gas for its biggest ships

On the occasion of the COP23 in Bonn (Germany), the CMA CGM Group, a world leader in maritime transport, is pleased to announce its decision to equip its 9 future ships of 22,000 TEUs (Twenty-foot Equivalent Unit), delivered in 2020, with engines using liquefied natural gas.
CMA CGM is becoming the first shipping company in the world to equip giant containerships with this type of motorization, thus pursuing its firm commitment to the protection of the environment and to ocean conservation.

Gas fueled ships under BV class

DUX – Tug Boat

HONFLEUR – Brittany Ferries ferry to be built by Flensburger Shipyard

38 confirmed new orders BV class amongst 127 **27% market share**

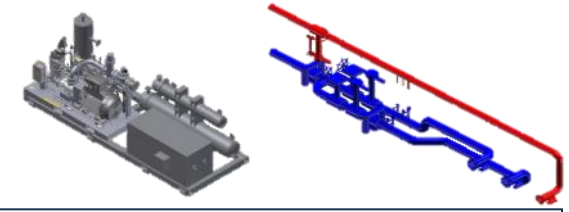
29 LNG fuel ships in operations BV class amongst 121 **24% market share**

02

LNG fueled innovative projects

ULCS Tank and fuel gas preparation system design

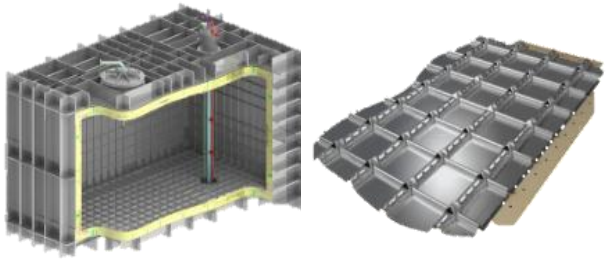
- Engineering for optimized Fuel Gas Handling System and Bunker Station



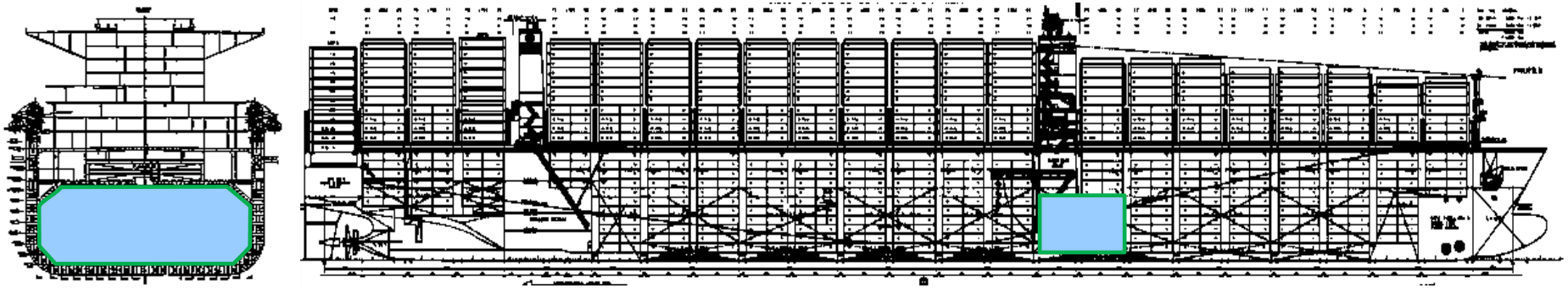
Fuel Gas Handling System and Bunker Station

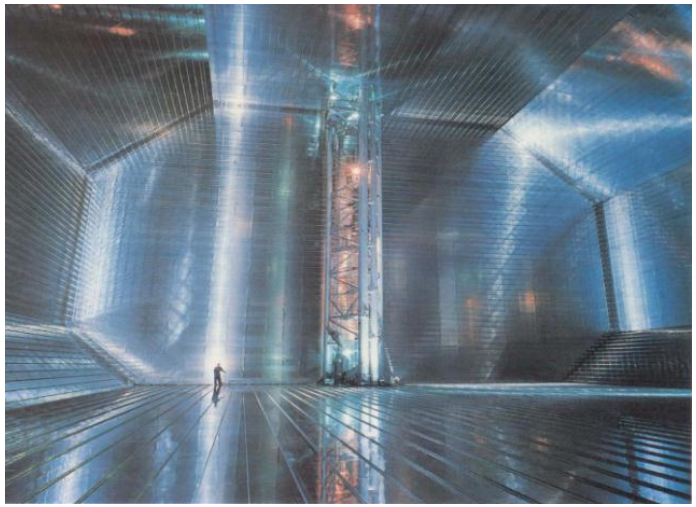
- Compact System thanks to hull-fitted Fuel Gas Tank
- 18 600 m^3 LNG

Fully Integrated and Compact LNG Fuel Tank



Membrane GTT Mark III LNG fuel tank

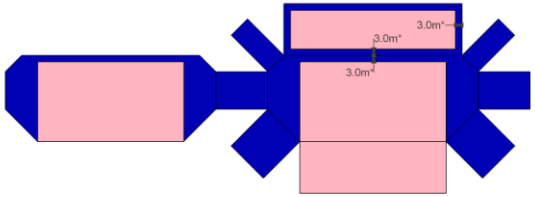




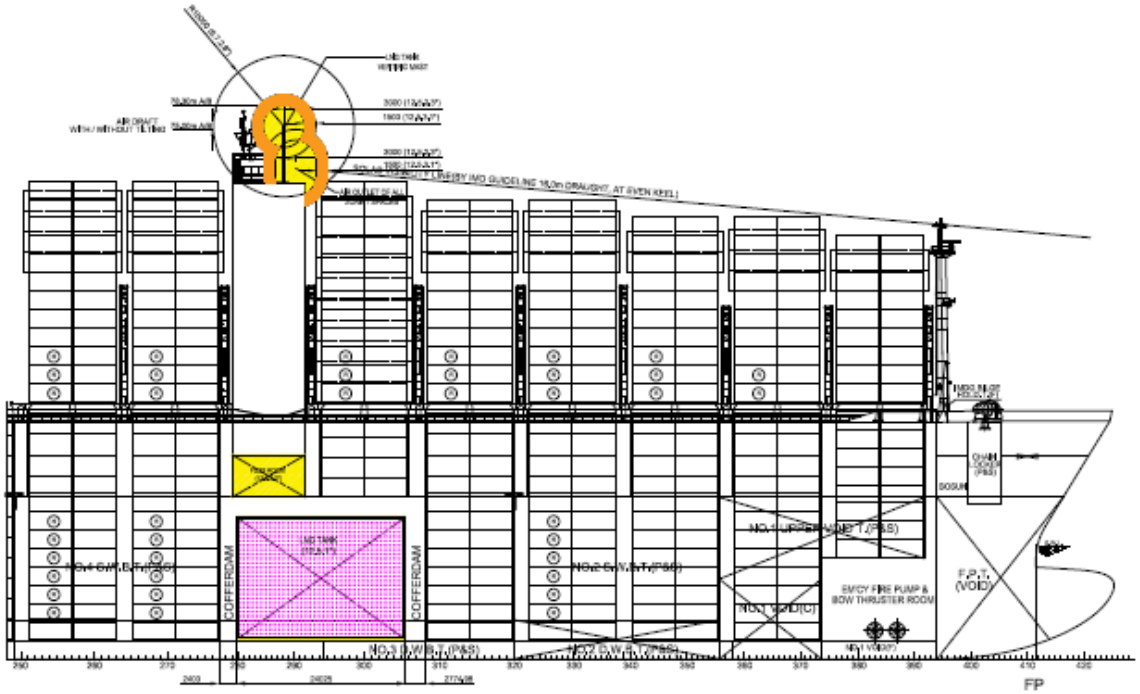
- Tank location under accommodations,
- Within one tank,
- Limited impact on cargo bays next to accommodations

Membrane Mark III LNG fuel tank from GTT

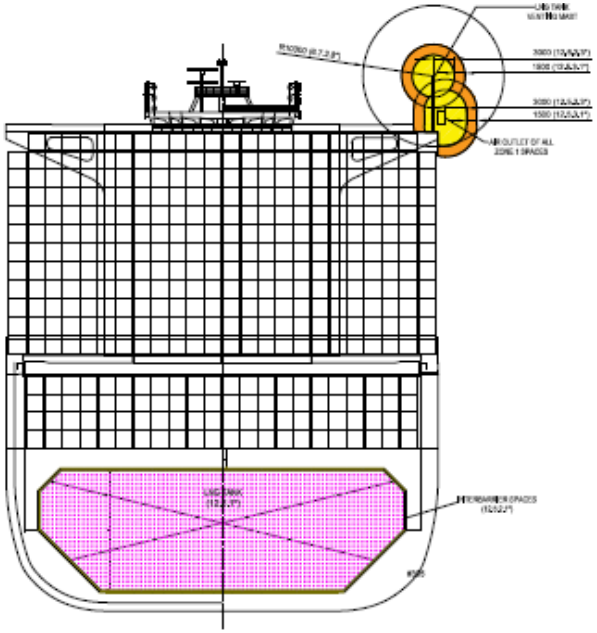
One LNG tank fitted with Mark III insulation – 270 mm thick
HD & Standard foam density (210 & 130 kg/m3)
Localization: below and forward accommodation block
LNG volume: 18 600 m3
Maximum tank pressure: 700 mbarg



210kg/m3 reduced mastic spacing
130kg/m3 reduced mastic spacing



PROFILE



LOOKING FORWARD

03 LNG fuel tank technologies

LNG Containment Systems

IMO Classification of LNG Carriers (IGC Code)

Independent tanks (separated from hull structure)

Type A

"simple" design

$P_0 \leq 0.7$ bar
Full secondary barrier

Type B

"refined" design

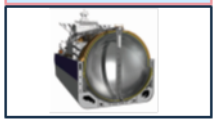
$P_0 \leq 0.7$ bar
Partial secondary barrier

Type C

$P_0 \geq 2$ bar
No secondary barrier

Cylinders

Spherical



Prismatic

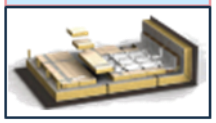
Integrated tanks (part of hull structure)

Membrane

$P_0 \leq 0.7$ bar
Full secondary barrier

GTT NO96

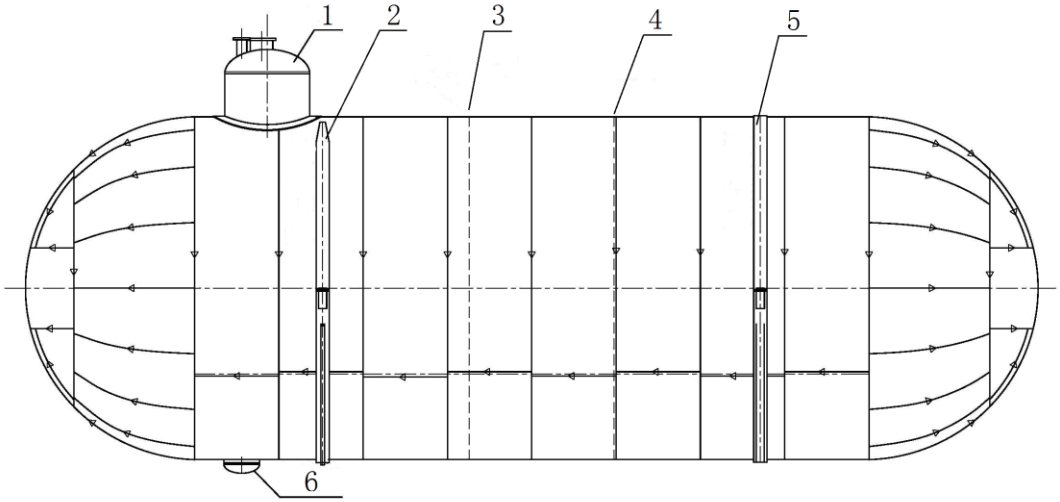
GTT Mark III

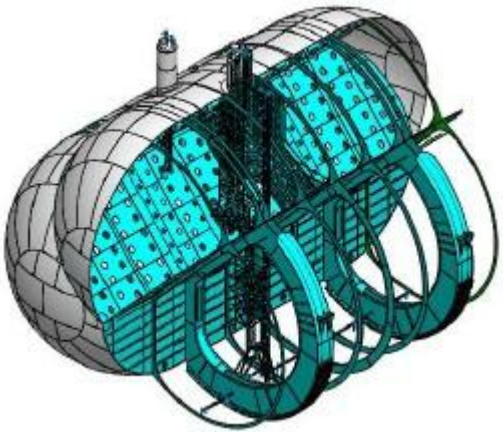


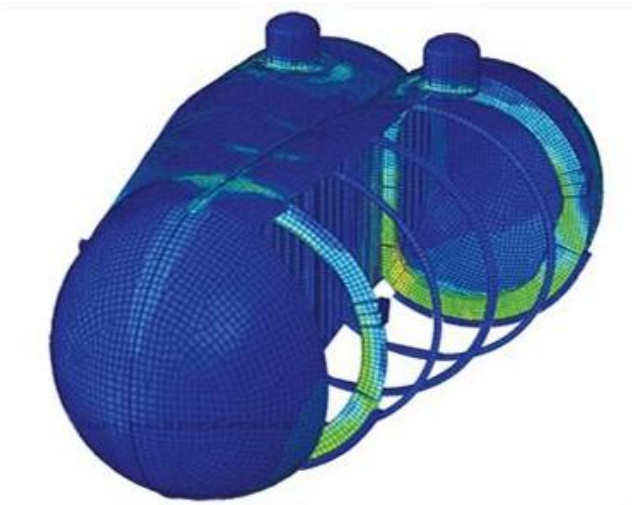
GTT CS1

Type C (pressurized tanks)

C-type tank, Cylindrical, Bilobe, Star-trilobe



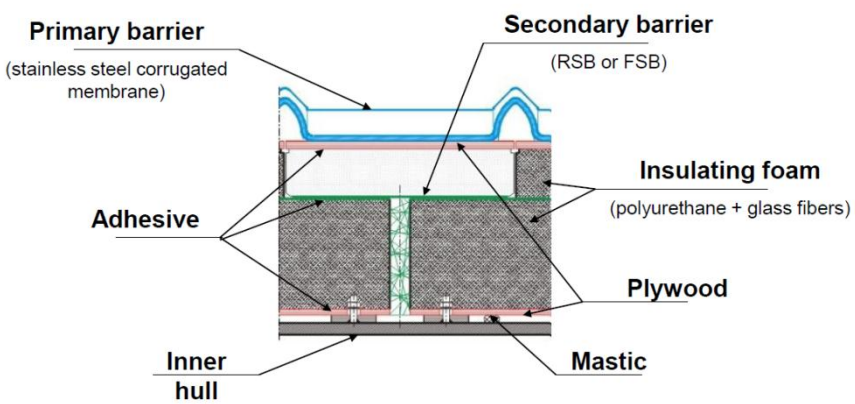




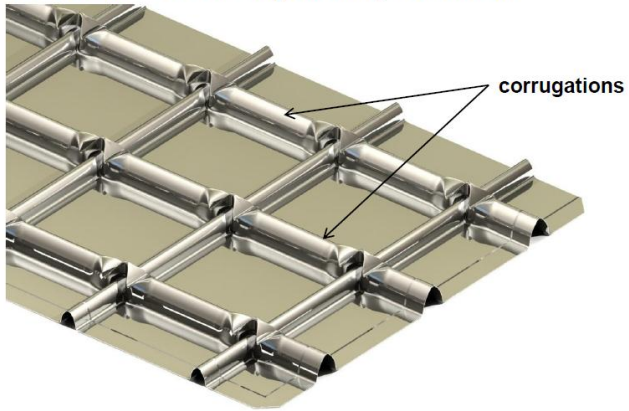
1-Dome
2-Fix support ring
3-Vacuum ring
4-Swash bulkhead
5-Slide support ring
6-Sump

GTT Mark III Flex containment system

Mark III is a proven technology



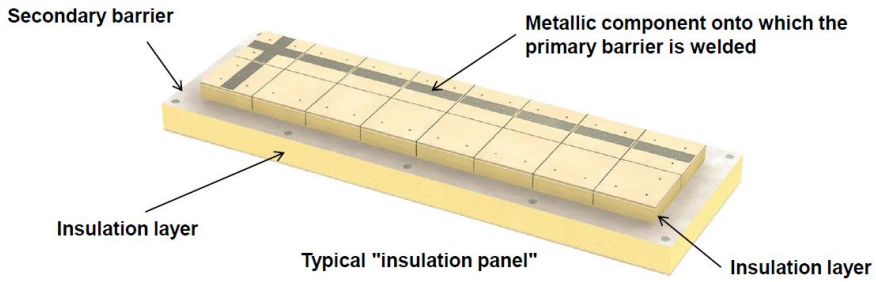
The corrugated stainless steel primary barrier:



- Thickness : 1.2mm
- Material : Stainless Steel 304L

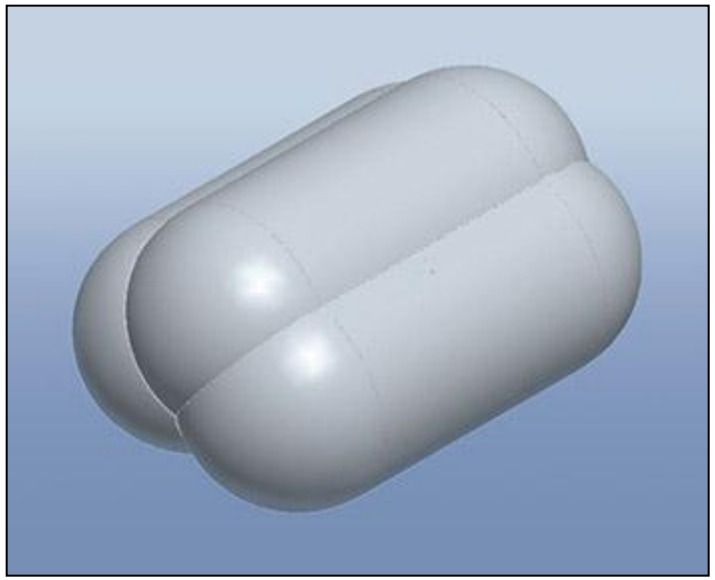
The insulation panel

- it is a prefabricated component integrating the two insulation layers and the secondary barrier and on top of which the primary barrier is welded.



Typical "insulation panel"

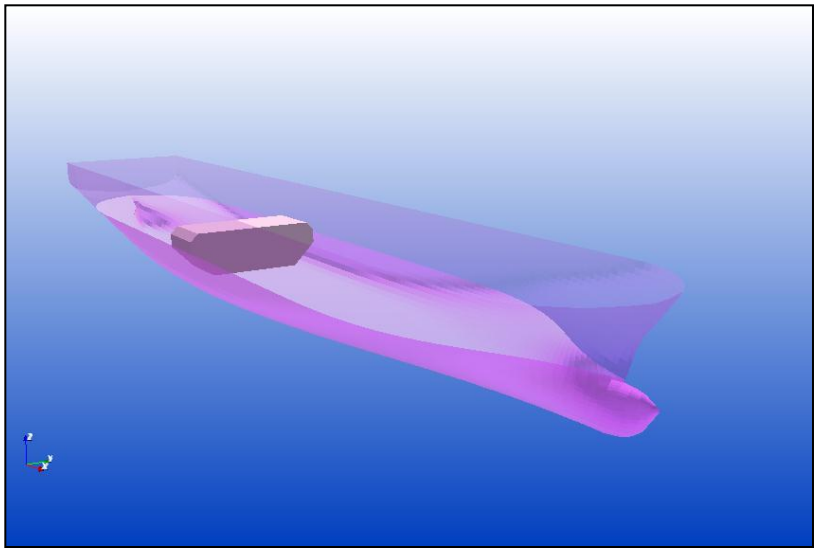
Multi lobe type C fuel tanks & volume ratio

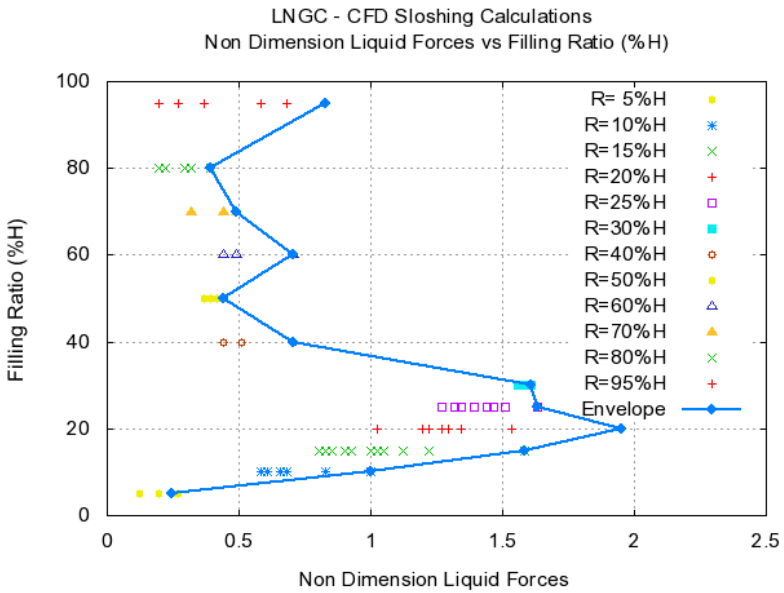


Tank type	Membrane	Type B	Type C single cylinders (x3)	Type C multi lobe (up to 5)
Volume useful for the LNG for a volume available of 2000 m3 in the tank hold space	1620 m3	1335 m3	970 m3	1230 m3
Volume ratio	**75%**	**63%**	**45%**	**62%**

Sloshing –
where BV experience makes a difference

3-step sloshing assessment and calculation process





1. Seakeeping analysis - to calculate the motions of the ship and, consequently, tank motions,

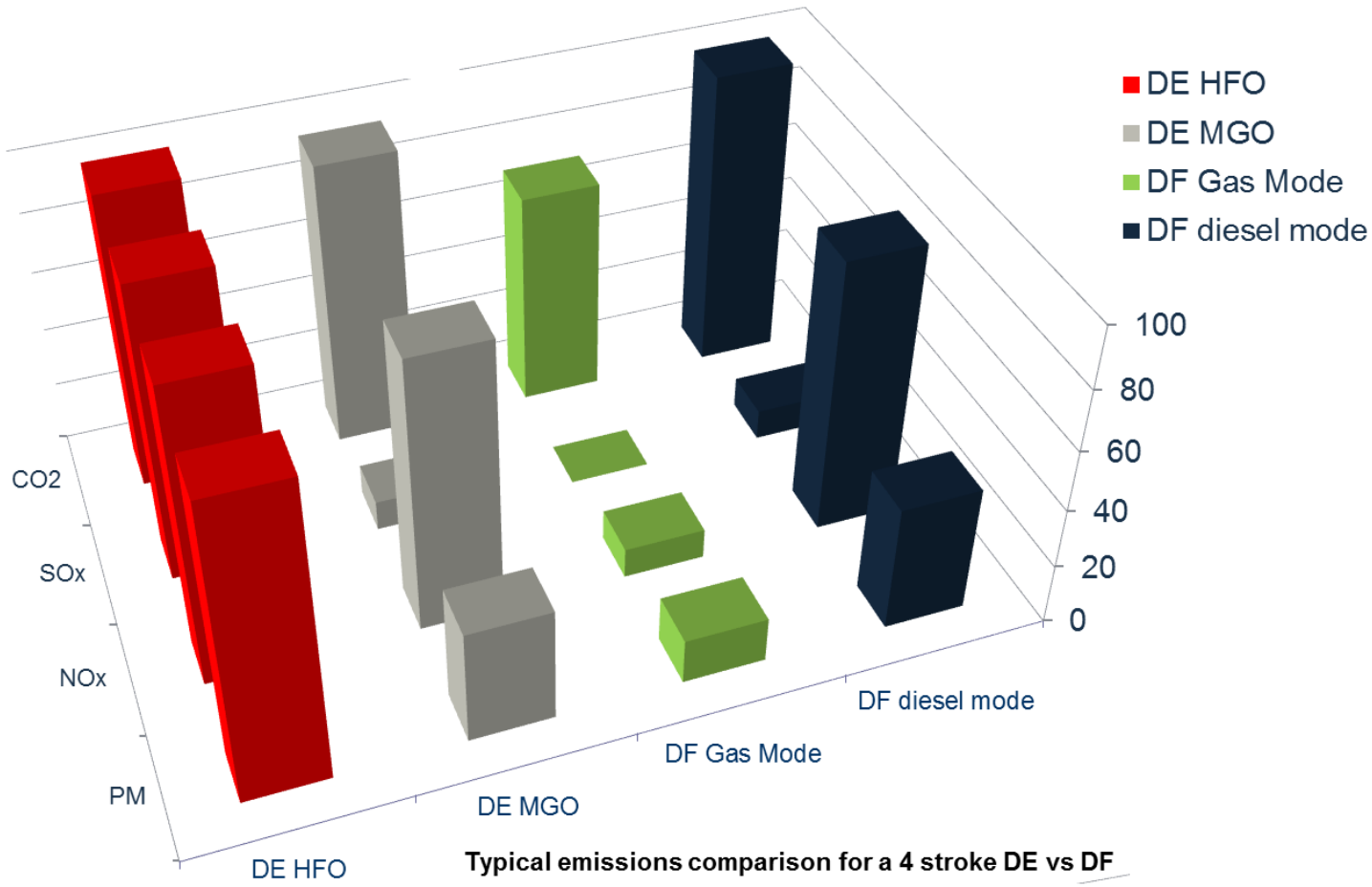
2. Sloshing model tests (carried out by the designer) and computational fluid dynamics (CFD) calculations (both using calculated tank motions) are carried out in order to determine sloshing loads,

3. Sloshing loads applied to entire containment system.

04 LNG propulsion designs

Emissions advantages / Gas Only and Dual Fuel Engines

LNG as fuel reduces significantly air emissions (SOx, NOx, CO2, PM)

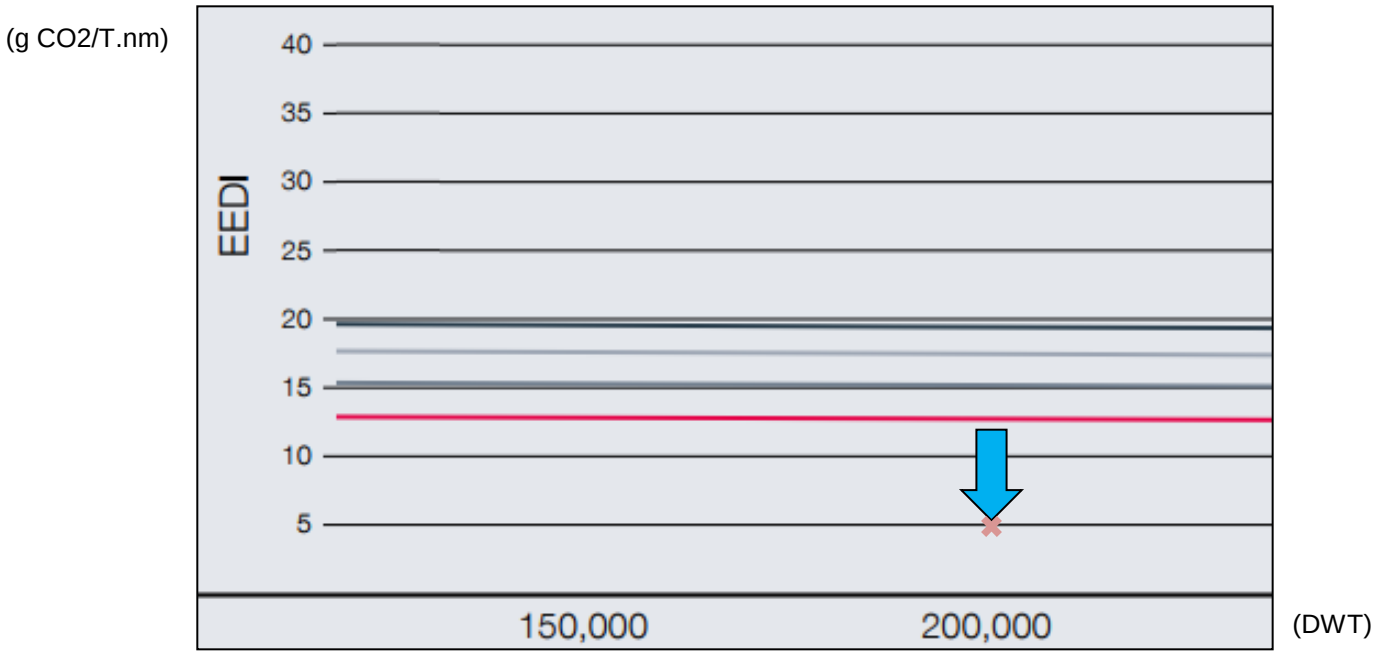


Typical emissions comparison for a 4 stroke DE vs DF

However some topics need to be addressed :

- methane slip which aggregate unburned methane specifically in Otto cycle and possible limited gas vent after engine stop should be taken into account as it might reduce significantly the CO2 reduction advantage.
- NOx Tier III compliance with high-pressure gas engines (needs EGR)
- Knocking & misfiring

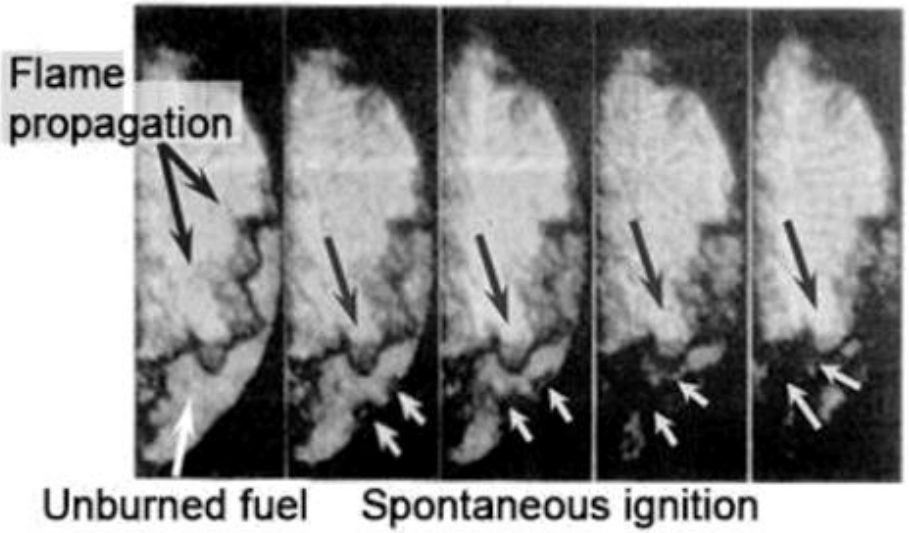
EEDI optimization with LNG as fuel

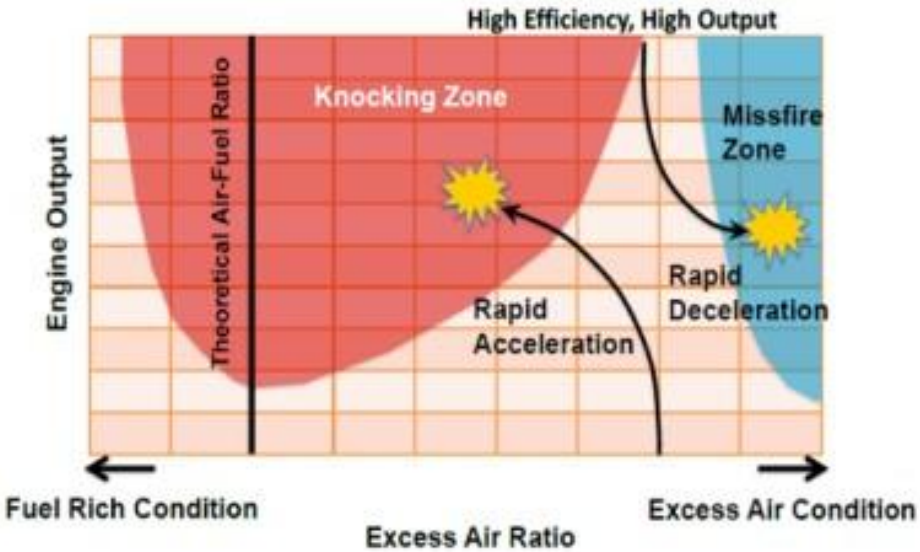


- EEDI is reduced by about 20% thanks to use of LNG, bringing attained value well below required value from 2025 (EEDI phase 3)
- From operational phase, the ships runs on LNG fuel 99% of the time thanks to low LNG fuel prices and broader range of running in LNG (except during manoeuvring)

DF internal combustion engines

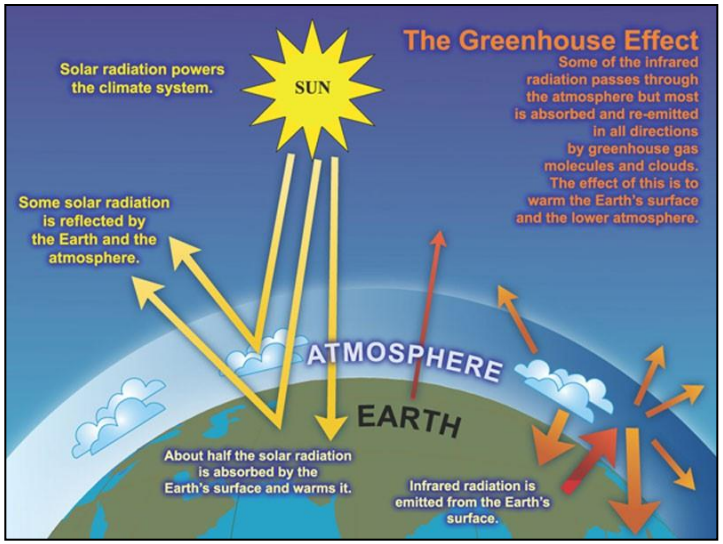
Knocking and misfiring



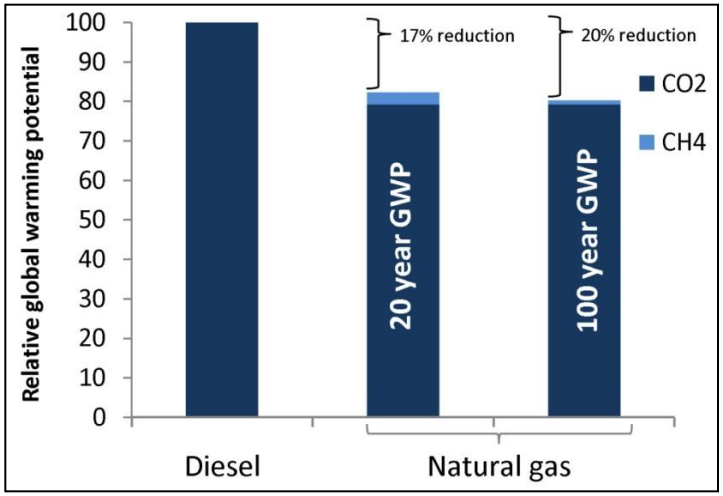


The way combustion should work in a gas engine is for the ignited flame to propagate through the unburned fuel mixture until combustion is complete. However, if the thermal load and combustion pressure in the cylinder increase for example due to an increase in load, the unburned fuel mixture may ignite spontaneously prior to being reached by the propagating flame. If spontaneous ignition sets off a chain reaction, this can result in serious damage to the engine due to severe pressure or temperature increases. This type of combustion is known as knocking, and it is something absolutely to be avoided in gas engines

The issue of methane slip



- The sources of methane releases in the atmosphere are:
  - Slip during gas combustion
  - Release when stopping gas operation
  - Tanks designs and operation



Methane slip & GWP for a 2-stroke ME-GI engine:

0.2 g/kWh (E3 cycle)

25-100% load

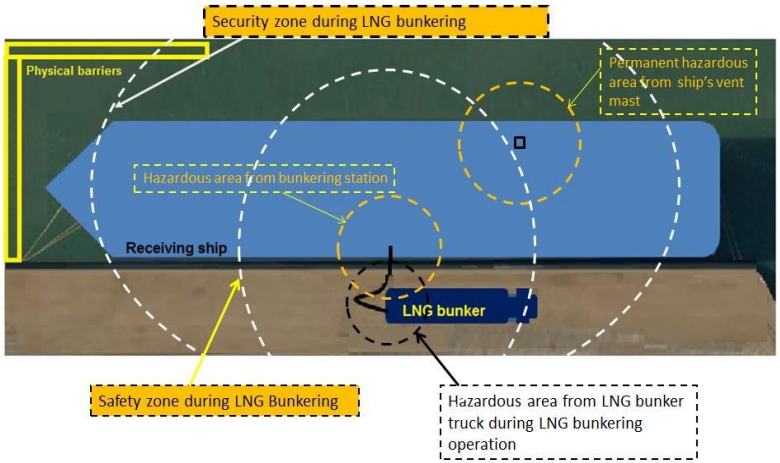
For a WinGD XDF : 2g/kWh.

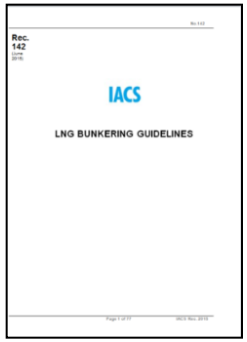
05 LNG bunkering

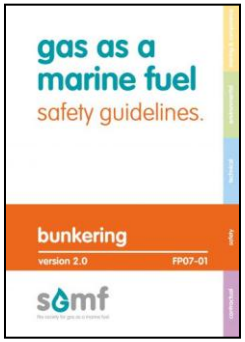
LNG Bunker vessels classed by BV

LNG bunkering
BV checks safe and efficient operations

General principle of safety zone







EMSA

USCG policy Letter & field notice on SIMOPS

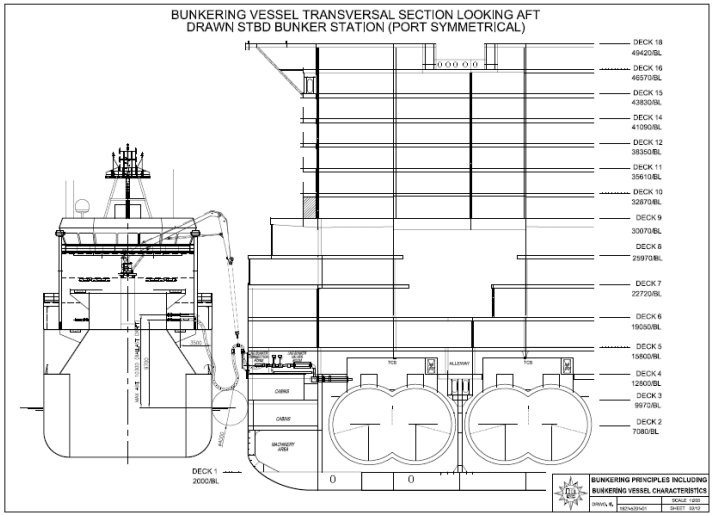
SIMOPS

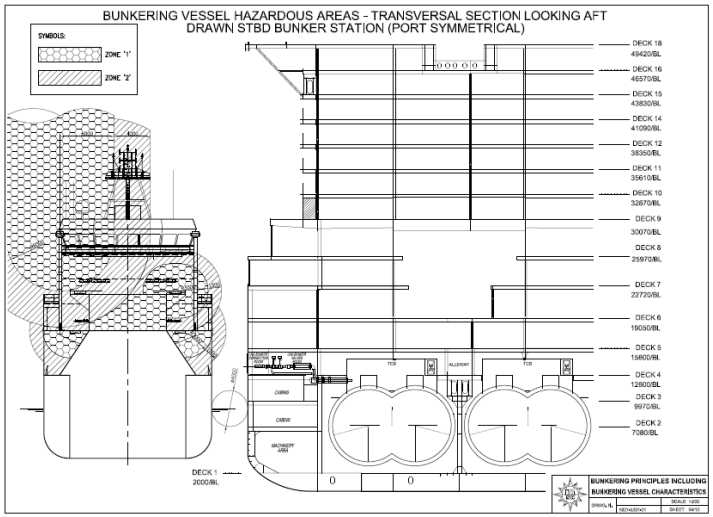
The main risk assessment is to be developed for the LNG operation *with* SIMOPS (commercial operation during bunkering).

LFL contour

Full bore release, Jet -X, Wind -Y

Compatibilty with receiving ships





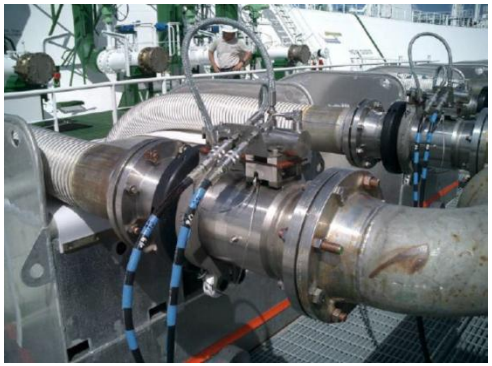
Connection, mooring

Physical connection

- Bunker / vapour
- Manifold heights
- ESD and communications
- Mooring
- Emergency systems (hoses and mooringn system)

Hazardous areas

- Overlap between bunker vessel / truck / shore facility and ship



Blue is the new Green!