LNG Fuel system for Perfect project

Perfect project workshop - 7th December 2017
Who is GTT?

- Inventor of the membrane containment system 50 years ago
- GTT provides the containment systems technology to the main shipyards building LNG Carriers
- **400 LNG Carriers** equipped with GTT systems
- **350 people** dedicated to the development, engineering and industrialization

Polar Alaska: Yokohama in 1969

174,000 m³ LNG Carrier tank
Large Scale – Years of experience benefits in LNG transportation

The whole chain is equipped with GTT Systems

Floating LNG Production:
- Shell Prelude
- Petronas PFNLG
- ENI Choral

LNG Carriers:
- 318 in operation
- 73 in order

Floating Storage and Regasification Unit:
- 20 in operation
- 10 in order

A new market rising

First large LNG Fuelled Ship
Design of LNG fuel membrane tank
Challenges when using LNG as a fuel

- Cargo capacity is driven by:
  - Available space
  - Lightship weight

- LNG needs 79% extra volume to store the same energy as HFO

- LNG needs dedicated storage system

- Hence, LNG containment system has to be the lightest and the most space efficient

Save cargo capacity through integrated tank
Membrane tank for LNG as a fuel application

**Membrane tank, what does it mean?**

- **Non-self-supporting tank** that consists of a thin liquid and gas tight layer (membrane) supported through insulation by the adjacent hull structure. (IGF § 2.2.29)
  - Fully integrated tank inside ship structure
- **Atmospheric** tank of 0.7 barg
  - Low pressure solution
- **Two** liquid tight barriers
  - High reliability
Membrane solution for LNG fuel storage

- **LNG volume of 17 300 m³**
  - Two bunkering operations per round trip in Port Kelang

- **Two integrated membrane LNG tanks**
  - Designed as a pure LNG fuel ship

- **Mark III Flex technology for the fuel storage system**
  - Sea proven technology
  - Guaranteed Boil Off Gas
  - 400 mm thickness, set to achieve requested thermal performance
  - Boil Off Rate: 0.17% pd

- **Maximal pressure: 700 mbarg**
  - Flexibility to handle and store boil off gas
Mark III Technology

- Primary stainless steel membrane
- Corner panel
- Hard wood key
- Top bridge pad
- Metallic insert
- Top plywood
- Primary insulation layer (RPUF)
- Composite secondary membrane (Triplex)
- Secondary insulation layer (RPUF)
- Back Plywood
- Inner hull
- Insulation panel
- Resin ropes
- Corner panel
- Hard wood key
LNG tanks integration

- Membrane tank as an integrated solution offers:
  - High space occupation
  - Reduced additional weight
  - Reduced impact on Cargo Capacity

- Tank location based on probabilistic approach
  \[ F_{CN} = 0.016 < 0.04 \]
LNG fuel membrane tank - safety
LNG Fuel Handling System

- **Two main functions:**
  - Feeding the gas consumers
    - Gas turbines
    - DF engines
    - DF Boiler
  - Manage the tanks pressure
    - Keep the tank pressure under design value

30 bar
6 bar
0.7 bar
1. Feeding Consumers

2. BoG Management

- Warm NG
- Cold NG
- LNG vaporizer
- BOG compressors
- LNG tanks
- Fuel gas pumps
- TCS
- DFDE & boiler
- Turbines
Boil off gas handling

- **Rules approach**
  - Pressure to be maintained during **15 days** under idle mode (IGF Code)
  - Need to handle excess BOG
  - Four possible options:
    - Thermal oxidations (GCU, boiler, among other)
    - Pressure rise
    - Reliquefaction plant
    - LNG sub-cooling
  - Selected solution: dual fuel boiler as BOG management system

- **Operational approach**
  - Boil off gas to be consumed by both turbines and engines
  - During idle phase, excess boil off to be stored inside the tank
Boil off gas handling

- **Aim:** improve energy consumption by no gas waste
- **Why?**
  - Boil off gas is continually produced
  - Significant variation of ship’s energy consumption
- **Operational profile**
  - Most of the time, needed power is greater than boil off
  - For period up to 40 hours, excess BOG is foreseen
Boil off gas handling in idle phase

**Idle phase**
- Small gas consumption ~ 400 kg/hr
- Excess BOG to be stored in the tanks
- Pressure increase of ~ 16 mbar/hr
- Enough to stand idle phases up to 26 hours

![Pressure rise in tanks graph](image_url)
Conclusion

- Due to the compactness of membrane solution, LNG storage impact on cargo capacity is reduced.

- Design of reliable and simple Fuel Gas Handling System has been developed and is ready for applications.
Thank you for your attention