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GTT in brief

An engineering company with more than 50 years of experience in the design of the Membrane Cargo Containment Systems

Independent company with strong shareholders

A 320 people company constantly working on on-going projects and new developments, aiming at proposing technologies for the development of the LNG market

- NO96 and MarkIII are the leading systems for LNGCs and offshore units
- GST system for on-shore tanks
- PLUTO II subsea cryogenic pipeline
LNG in Asia Pacific – Past, Present, Future

**Malaysia**

- One onshore LNG plant – Malaysia LNG, with a 9th train under consideration
- Petronas FLNG1 under construction
- FEED on-going for PFLNG2
- Lekas terminal
  - First regas terminal of Malaysia
  - Conversion of two MISC vessels into FSUs (Tenaga Satu and Tenaga empat)
- Pengerang LNG
  - For RAPID project
  - Large terminal planned
  - Small scale LNG & LNG Bunkering hub
- Lahad Datu project under consideration
LNG in Asia Pacific – Past, Present, Future

Indonesia

- Arun LNG, Bontang LNG, Tangguh LNG plants
- Donggi-Senoro LNG and Sengkang LNG are coming soon
- Regas terminals for power generation and/or industries
  - West Java FSRU
  - Lampung project
  - Central-East Java FSRU under consideration
- Eastern part of Indonesia
  - Projects of fuel switch for power generation
  - Very small demand in many islands
  - Interest in small-scale network
- FEED on-going for Abadi Masela FLNG
LNG in Asia Pacific – Past, Present, Future

Singapore

- SLNG to be commissioned soon
- Small-scale LNG hub under review
- LNG bunkering hub under review

Thailand

- One conventional size LNG terminal commissioned
- Extension under review
- Possibilities of small scale LNG

Philippines

- Declining domestic gas fields
- Limited gas distribution network
- LNG terminals coupled with gas pipelines and/or power plants
- First LNG import terminal under construction (Pagbilao LNG)
LNG in Asia Pacific – Past, Present, Future

Viet-Nam

- Huge gas reserves but reduced investments in E&P led the government to consider import projects
- Limited gas transport network
- Interest for mid/small-scale as well as conventional solutions
  - Mid scale terminal under consideration (Thi Vai)
  - Conventional terminal under consideration (Son My)
  - Small scale distribution along the coast, with Thi Vai, Son My terminals as loading ports

Papua New Guinea

- In addition to historical exporting countries, Papua New Guinea will offer a new supply source with PNG LNG project
- Other projects in the pipe
LNG in Asia Pacific – Past, Present, Future

China

- A growing demand for LNG
  - Regas terminals: 4 in-service, 7 under construction, more than a dozen planned
  - Huge peak-shaving storage sites

- Competition with domestic reserves of unconventional gas (rather mid-term than short-term)

- Competition with pipeline gas imports

- Strong wish to build at home the LNG carriers
  - GTT licensed several shipyards to expand LNGC shipbuilding in China
  - 1 experienced shipyard, Hudong Zhonghua is building its 6th LNGC, and received 4 orders from ExxonMobil / M.O.L.

- Great potential for river trade with its large streams (Yang Tse, ...)

GTT
50 years of membrane
Opportunities with other markets

Middle-East is able to supply both Europe and Asia areas
Size of Q-Flex and Q-Max vessels can be a limit, but more and more terminals are able to accommodate these vessels

Russian gas and arctic navigation
- Arctic routes could be opened for commercial use around 2018
- The North East passage is shorter than existing routes, stretching 13,000 kilometers along Russian shores to Asia compared to the 22,000 kilometer passage via the Suez Canal

Atlantic basin and new Panama Canal
- Current LNGCs are not transiting through the existing Panama Canal
- Current LNG ships are too big...
- But the new locks are opening new perspectives
Evolution of shipping habits

New International Rules and technological advances:
- Ballast water management
- Lower emissions (NOx, SOx...)
- DF-DE and ME-GI propulsion efficiency
- ECA areas are entailing interest for LNG Bunkering

The new range of “conventional” LNGCs is increasing, today around 155,000m³ to 170,000m³
- Only 8% of the current fleet
- But 85% of the current orders

Longer routes than previously observed

Demand for lower guaranteed BOR (0.1 – 0.125%V/day)
Evolution of shipping habits

Demand for improved flexibility in filling levels
- Shuttle vessels for Ship-to-Ship operations
- FSRU/FPSO under harsh environmental conditions

Reinforcements of the containment system allows for ship-to-ship operations:
- Mooring lines, fenders, wind, roll angle, tugs... will induce a ship disconnection before sloshing in the LNGC

In case of emergency disconnection while cargo transfer from FLNG to LNGC is not finished:
- Application of guidance issued by GTT for such situation
- Cargo transfer at sea (tank to tank transfer in the LNG Carrier) to come back within the authorized filing levels
Consequent requirements

- Safety
- Compactness
- All filling applications
- Low gas emissions
- Carbon footprint
- Local content
- Cost effectiveness
- Fast track solutions

GTT
50 years of membrane

Safety  Excellence  Innovation  Teamwork  Transparency
Evolving designs in LNG Containment Systems
- Towards stronger technical constraints
Low Boil-Off Rate / High Strength

MarkIII Flex system, a containment system which includes:
- An increase of insulation thickness to reduce BOR down to 0.1%Vol/day with standard density foam and cargo capacity
- An increase of foam density to strengthen insulation panels to withstand higher sloshing loads (increase of compressive strength by more than 100%)

NO96 containment system, developments are considering:
- Replacement of perlite by another insulating material to achieve a lower BOR (glass wool, low density PU foam...)
- Increased thickness of top cover plate and additional bulkhead to withstand higher loads

Full validation campaigns (strength and fatigue tests, FE Analysis...) have been performed. Technologies are granted by AiPs and GASAs

Current orders are already featuring these membrane developments
LNG-FPSOs with membrane

Membrane systems have been selected for Shell Prelude project and Petronas FLNG1 (among others)

Mainly new built units, LNG-FPSOs with membrane systems are featuring two-row arrangement

Two-row arrangement provides large benefits, without reducing standard membrane strong points:
- Flat deck
- Optimized hull occupation
- Support for topside modules
- All filling levels in open seas without reinforcements of the insulation
- Maximized storage availability during maintenance

On the maintenance side:
- Inspection can be performed on-site; procedures are already available
- Credibility of a proven system and of the related maintenance solutions
Two-row arrangement

Acceptable impacts on the ceiling and chamfers

No impacts even for harsh conditions

Acceptable impacts on the longitudinal walls and chamfers
Arctic routes

Several membrane LNG ships have already operated or are operating in arctic conditions:

- From the ’70s to the ’90s: SCF Polar and SCF Arctic
- Now: Provalys and Clean Energy (Snøhvit to Southern Europe), Ob River and Clean Force (Sakhalin II to Japan)

Many other membrane LNG carriers are ice-class or winterized

Studies with various partners, including the Krylov Institute, have demonstrated that membrane technologies can sustain the most stringent conditions (ice collision issues, vibrations, Arc7 Class ships)

MarkIII and NO96 systems have been approved by RMRS for arctic navigation
LNGC “OB RIVER”

Standard MarkIII system, Ice Class 1A, delivered to Dynagas by HHI in 2008
First LNGC to travel the Northern Sea Route from Hammerfest to Japan
Evolving designs in LNG Containment Systems - Towards design optimization
Panama Canal

Current locks of Panama Canal induces a Panamax design with a 100,000 m³ cargo capacity with membrane tanks

With the new locks, the increase of dimensions would allow the transit of:

- The existing 177,000 m³ LNGCs, with 4 Membrane tanks
- A new 185,000 m³ LNGCs, with 4 Membrane tanks
- A New-Panamax LNGC of 200,000+ m³, with 5 Membrane tanks
Design development LNGC 185,000 m³

MAIN CHARACTERISTICS

Hull
- Length overall: 300.00 m
- Length between perpendiculars: 292.00 m
- Moulded breadth: 47.00 m
- Depth to upper deck: 26.50 m
- Depth to trunk deck: 34.20 m

Power
- Total installed power: 40,950 kW
- Diesel-Electric Propulsion system: 3x12V50DF + 6L50DF
- Estimated speed at 90% MCR, design draught and 21% sea margin: 19.5 Knots
- Single screw, Fixed pitch
- Two electrical motors, total: 8.6m
- 31 MW

Tanks (Mark III Flex)
- Number of cargo tanks: 4
- Total insulation thickness (MkIII Flex): 0.400 m
- Insulation area (at primary barrier): 29,903 m²
- Gas density: 460 kg/m³
- Estimated boil-off: 0.10%

Departure Full Loaded: Design Conditions
- Displacement: 122,350 t
- Deadweight: 86,680 t
- Range (MDO only, reduced speed): 10,000 NM
- MDO capacities: 2700 t
- Design draught: 11.7 m

(All Data Preliminary)
Small Scale LNG chain

Conventional LNG shipping well established
LNG being a bulk cargo, an LNG chain becomes more and more efficient when dealing with large(r) capacities

Milk-run operations are the most efficient for small scale chains:
- Larger capacity
- Reduced number of vessels
- Easier to reconfigure when demand is increasing
- “Design one, build many”

But need for:
- Access to many harbours
- River trade
- High manoeuvrability
- Reduced tug support
- High cargo capacity
- Compact dimensions

Existing solutions are not optimized to fit the particular constraints of a small scale LNG chain
Shallow Draft LNG Carrier

Modularity of membrane systems for more flexible and optimized solutions

Tank shape customized to fit a particular hull

A design of a small scale LNG Carrier with a shallow draft (lower than 6m) is then possible, with a reasonable cargo capacity (16,500 m³):
- Regional waters to reach several islands
- Coastal and river trade
- Feeder for LNG bunkering

Cargo capacity reduces the number of vessels required for the small scale LNG chain (large cost savings in CAPEX and OPEX of the entire supply chain)
Shallow Draft Small-Scale LNG Carrier

**HULL:**
- $L_{bp} = 128m$
- $B = 28m$
- $D = 11.7m$
- $T_{des} = 4.7m$

**CARGO TANKS:**
- MarkIII CCS (400mm)
- Capacity = 16,500m$^3$
- Number of tanks = 3
- BOR (LNG) = 0.250%p.d.

**POWER:**
- DF-DE
- Speed = 12.5kts
- Power (MCR) = 7.830KW
Land storage tank: a long-term solution

Generalities on atmospheric storage tank technologies

**Single containment**
- Largest footprint
- Most economic design
- In case of failure, LNG is contained by a dike

**Double containment**
- In case of failure, LNG is contained by a bund wall

**9%Ni Full containment**
- Mostly used nowadays
- In case of failure, both LNG and NG are contained by the concrete walls (safest design)

**Membrane containment**
- Most compact design
- In case of failure, both LNG and NG are contained by the concrete walls (safest design)

Several configurations can be envisioned

Membrane tanks have the most flexible applications compared to 9%Ni FC
GTT land storage technology

GTT has optimized the design of the system since the first installation in 1981

33 membrane tanks using GTT technology have been constructed and are operational

Based on the same principles as LNG Carriers, the recognized advantages cover:

- Compactness of the design
- Easy design for large size tanks
- High prefabrication
- High local content
- Permanent monitoring of the membrane integrity
- Better adapted to harsh seismic conditions
- Better carbon footprint (-25% warming potential compared to 9%Ni tank technology)
- The fastest construction time
- The cost savings

Two tanks are under construction in South-East Asia
Evolving designs in LNG Containment Systems - Towards innovative solutions
Membrane Type Bunkering Solutions

Retrofit of a Container vessel

New section includes:

- a 5,000 m³ LNG tank
- a gas preparation room and additional 100 TEU

Newbuilding

Ropax vessel

- 1,700 m³ LNG tank
- Gas preparation room
Membrane Type Bunkering Solutions

4500 m³ LNG tank in front of Engine room

700 m³ selfstanding LNG tank on the main deck of a coastal bulk carrier
Membrane Type Bunkering Solutions

Offshore storage & bunker station

Ship-to-Ship transfer system
Conclusion

LNG market is Asia Pacific area is changing
- Historical importers remain on the top as being dependent from gas
- But large expansion of the network due to new countries able to supply LNG and countries increasing gas part of their energy mix

Technologies are available to offer several options to end-users to make projects economically viable and encourage LNG solutions

GTT membrane systems are adapting to any market and specific constraints
- Low boil-off rate
- All filling applications for LNG-FPSO, FSRU and shuttle carriers
- On-shore tanks
- Small scale and LNG Bunkering

Membrane systems are benefitting from the network of Licensed Shipbuilding Yards, Approved Repair Yards, Licensed EPC Companies, Approved Suppliers and GTT direct support to Owners and Operators
Thank You for your Attention

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