

Message from the CEO

In this issue of GTT Inside, we are very pleased to keep you abreast of one of the major development programmes currently being carried out by GTT, the new Mark V containment system. Three mock-ups, in three different places, have been constructed which allows us to address specific development and industrialization items on each of them. In fact, this programme is going at full speed! We are also very excited about briefing you on LNG Advisor, a system aimed at supplying the main parameters of boil-off to the crew in real time, thereby allowing them to manage it better. This system is going to be marketed by Cryometrics.

We also give details of an evolution of the testing method of the primary membrane at time of erection. This, once again, highlights the fact that we are constantly working to reduce the time for building and testing our systems. Enjoy your reading!

Philippe Berterottière, CEO

LNG AS FUEL SOLUTIONS / AIPs for 4,000 m³ Bunkering Ship concept with a cargo vapour pressure of up to 2 barg

GTT has recently received an Approval in Principle (AIP) from Bureau Veritas and Lloyd's Register for its 4,000 m³ Bunkering Ship concept, using Mark III Flex Cargo Containment system in tanks which can be operated with a vapour pressure of up to 2 barg. Increasing the upper limit on the pressure value to 2 barg gives more operational flexibility.



Indeed, the BOG management during loading and bunkering operations is made more flexible thanks to this larger operational range of vapour pressure. Vapour can be buffered and condensed in the tanks to help the Fuelled Ship or feeding facility handle the excess vapour. When needed, condensation is performed by spraying LNG into the vapour phase. In addition, the duration of bunkering operations is optimized by increasing loading flow rates.

Finally, during voyage and stand-by mode, the time before gas pressure reaches the upper limit is longer. This improves the holding time when there is no BOG consumption and reduces the use of any possible reliquification plant, thereby diminishing costs.

This development will contribute to the current development of LNG as a fuel market. Further studies are carried out with NO96 technology and also for bunker tanks for LNG Fuelled Vessels.



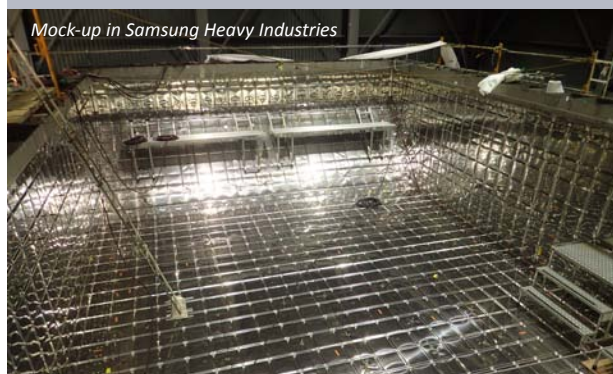
General Approval for Mark V

Based on current components of Mark III CCS (same 304L corrugated primary membrane and R-PUF insulation), Mark V proposes a new Fe-36%Ni corrugated secondary membrane and an increased insulation thickness. The aim of these improvements is to propose a BOR lower than 0,075%/day with two metallic membranes.

In September, DNV-GL and Lloyds Register have granted their General Approval for this new technology. It was followed by Bureau Veritas in late October. Based on around 100 documents including numerical and experimental analyses, GTT has developed all the areas of the tanks and all reports have been submitted to Class (Standards areas and special areas – liquid dome, gas dome, pump tower support). These General Approvals are important milestones in the commercialization of this new system.

In parallel to this validation, various mock-ups (in GTT, in Samsung Heavy Industries yard and in Hyundai Heavy Industries yard) have been assembled to check the erectability of the CCS. A campaign of tests (ballast tests and cryogenic tests) is under progress in a large scale mock-up. These tests will demonstrate the satisfactory behavior of this Mark V CCS under in-service conditions. ■

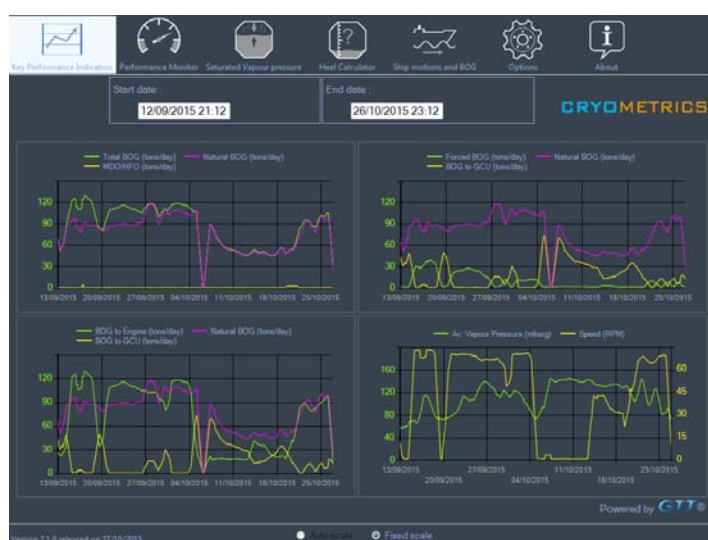
Mock-up in Samsung Heavy Industries



INNOVATION / GTT and Cryometrics have jointly developed LNG Advisor, a boil-off gas monitoring system specifically designed for LNGCs

Boil-off gas (BOG) is the second largest cost for an LNG charterer, representing one third of the total shipping costs. Monitoring this phenomenon is therefore a key issue for the LNG shipping industry.

Consequently, GTT and Cryometrics have developed LNG Advisor, a system that automatically monitors the performance of an LNG carrier in real-time, both on board and on shore. LNG Advisor is commercialized by Cryometrics, a new subsidiary fully owned by GTT and being currently incorporated. Cryometrics will specialize in the operational efficiency of LNGCs, LNG fuelled-ships and any ships carrying liquefied gases.



LNG Advisor will track the BOG consumption of the engines, the BOG burnt in the gas combustion unit, the natural and the forced BOG and also key parameters influencing the overall consumption of the ship such as the tank vapour pressure as well as the ship motions. LNG Advisor will also monitor the MDO (marine diesel oil) and HFO (heavy fuel oil) consumptions.

In addition to the monitoring of KPIs, LNG Advisor will automatically detect in real time any deviation of the performance of the LNG carrier and allow crews to comment ON any overconsumption; underperformances are identified and documented.

Thanks to an online data portal, LNG Advisor will offer shipowners a real time monitoring service on board and on shore, therefore allowing onshore teams to track the performance of their LNGCs with higher precision and improved reactivity.

LNG Advisor also features an LNG saturated vapour pressure calculator, allowing analysis of the real thermodynamic state of the cargo. This will help crews anticipate the boil-off rate, therefore giving them more confidence and flexibility to use the tanks as buffers when the engine energy demand is low.

An LNG heel calculator is also included to help crews estimate the LNG required for the ballast voyage. The aim is to reduce unnecessary margins and maximize the cargo sold at the discharging terminal.

Installation of LNG Advisor is straightforward and can be made at new-build, drydock and also during navigation. The system is compatible with all LNGCs fitted with GTT membrane technologies and with all propulsion systems.

OPERATIONS / NH3 test: numerical optimization

The Mark III system primary membrane is made of stainless steel sheets welded together. The welds have to be thoroughly checked to ensure a good tightness of the system.

This can be done by covering the welds with a sensitive paint that reacts when in contact with ammonia, and injecting Nitrogen-Ammonia mixture in the primary insulation space, through several injection keys supplying spraying pipes.

Deficient welds will make yellow paint turn blue-violet. Presence of ammonia in all areas of the insulation space is ensured by reference leak points located all around the tank, which react when in contact with ammonia.

In order to reduce test duration, and the cost of the test, GTT has made some developments.

During tightness tests, statistically, some reference leaks were almost always the last to react, showing that in those areas, ammonia sweeping was less effective.

Firstly, a test simulation in the insulation space has been performed with P-Gaz (GTT software), which is a finite-volume method algorithm simulating gaseous flows in insulation spaces. The simulation has pointed out the same less effective sweeping areas than in real tests, validating the simulation method and hypotheses (Figure 1).

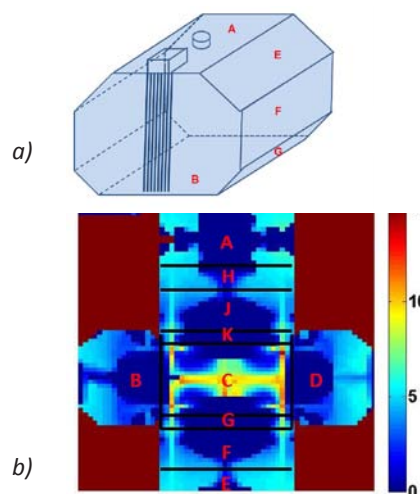


Figure 1 : (a) 3D-representation of a Mark III LNG carrier tank primary space (b) Unfolded representation in 2D of a primary space ammonia concentration during a tightness test injection simulation (volumic %)

In order to homogenize the sweeping and reduce the test duration, numerous P-Gaz simulations have been performed varying injection keys number and locations as well as the mixture injection flow-rate. Two effective modifications have been retained: the addition of two injection keys and the doubling of the mixture injection flow-rate.

Several tightness tests on LNG carrier tanks have been carried out using one or both improvements. Statistics have been made on their reference leaks reaction time and have confirmed simulation results. The better configuration found was the combination of the two modifications, resulting in reduction of the mixture injection duration of 40% (up to two days saved) and a more homogeneous sweeping. These injection improvements were then applied on the Mark III LNG carrier tanks.