



Message from GTT Innovation Director

GTT is committed to providing the industry with high performance containment systems, especially in terms of thermal efficiency and reduced Boil-Off Rate. It is one of the key areas of focus of our innovation teams and this will be the focus of the 5th issue of GTT Inside.

Two initiatives are highlighted here. Both are intended to meet the two main expectations of our final customers. The first concerns the introduction of stringent quality standards for new generation polyurethane foams, so as to secure repeatable thermal conductivity and improved BOR. The second deals with the phenomena that drive boil-off gas generation in actual conditions. Here, our new modeling approaches will improve prediction accuracy and hence the operational performance of vessels at sea.

Innovative designs obviously remain a priority in order to offer enhanced performance. In this area, you will read here how we are entering the final development stages of the latest GTT technologies with the major Korean shipyards. Thanks to this close industrial cooperation, we are preparing the first releases of the new Mark V and NO96 MAX technologies.

Julien Burdeau, Innovation Director

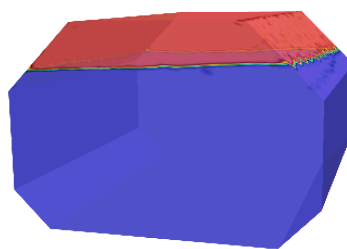
OPERATIONS / GTT develops state-of-the-art modelling to predict boil-off gas generated in operation

One of the most challenging issues with the sea transport of LNG is the prediction of boil-off gas (BOG) generated in operation. Indeed, BOG is a result of complex interactions between the cargo containment system, LNG and its vapor phase, the environment (sea conditions, air and sea water temperatures, and atmospheric pressure) as well as the actions of operators on the cargo (pumps, compressors, sprayers).

So far, most studies have focused on the assessment of the thermal performance of the insulating materials. These models calculate a design boil-off rate (BOR) that is valid under normative conditions, very different from those seen in actual operation. Existing methods are therefore not applicable to calculate and predict BOG during navigation.

With its unique knowledge of cargo containment systems (CCS) as well as its expertise in LNG, and the BOG phenomenon in particular, GTT has developed state-of-the-art models that enable the prediction of the BOG generated in operation. These models take into account complex phenomena such as heat transfer through the CCS, LNG thermodynamics, sloshing in the tanks and LNG aging. The effects of sea states are also modelled. Because these models aim at reproducing real operations, they have been tested and validated with operational data collected onboard LNGC.

These groundbreaking developments in the modelling of BOG will help us go much further in the understanding of BOG issues. This will allow us to offer unrivaled answers to questions often raised by charterers and operators regarding the reduction of LNG losses. More generally, they open the way to the optimization of the overall energy consumption of a LNGC or any LNG fueled vessel.



3D modeling of LNG evaporation under navigational conditions (blue=LNG; red=NG; green/yellow=mix)



TRAINING / Enhancements to G-Sim expand our training capabilities

G-Sim was installed in GTT's training center, enabling us to start our training activities in June 2014. One year later, the latest developments have further expanded training capabilities provided to our clients.

The original LNG Carrier simulation mode provided the capability for the instructor to select the type of containment system (MarkIII or NO96), and a single option for the vessel size (138,000m³) and propulsion system (steam). If it is typical for vessels build before 2005, it is not relevant for today. This issue has been addressed with the latest developments, which offer additional options of a 170,000m³ vessel and DFDE propulsion systems to be selected. Together with the original options, this evolution provides the possibility of 16 different ship configurations. These additions create the flexibility to adapt the ship model specifically to those actually operated by the client, thus making knowledge transfer and training more effective.

For the next stage of developments, options for a LNG barge and LNG as a Fuel should be available early 2016. ■

Save the date

GTT will be at **Gastech**,
Singapore,
27-30 October 2015

Please come and visit us
at **Hall 4, French Pavilion.**

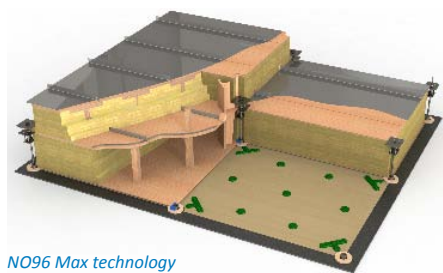
Gastech
Conference & Exhibition

INNOVATION / New Evolutions of the Mark and NO 96 containment systems

GTT has developed the NO96 Max system in order to improve the historical NO96 concept, enhance the performance and increase the system flexibility. Ship-owners and charterers are not only looking for low BOR, but also for increased CCS reinforcement to meet the strength requirements of new markets such as multi-gas carriers, offshore or LNG as a fuel.

To meet these requirements, GTT has developed a new efficient internal box structure based on pillars, combined with a high performance material already well known in the cryogenic industry: densified wood.

A "state-of-the-art" validation approach is used, based on a predictive numerical model correlated with dedicated test campaigns. From this model, it is relatively simple to optimize the pillar cross-section or number within the box, to meet low BOR or increased reinforcement specification. The

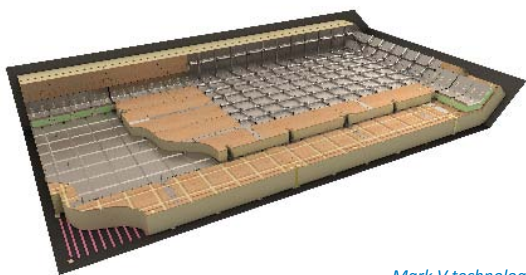


NO96 Max technology

bearing structure can be reduced by 80% compared to NO96, for the same strength, to reach a low BOR. In the meantime, bigger pillars can be used to reach similar strength as HD foam (Mark III solution). Even though the internal structure has been completely revised, it was decided to keep the external box dimensions identical to satisfy the current practice for integration on board. In addition, the anchoring to the hull, the membranes, the corners and special areas remain also the same as they have demonstrated their high level of reliability in NO96 equipped vessels.

GTT is now working with shipyards and suppliers to finalize the industrialization of the system through the adaption of existing manufacturing tools. The objective is to be ready for NO96 Max commercialization at the end of this year.

GTT has also developed a new Cargo Containment System: Mark V. This development has been conducted in the continuity of the Mark systems. The objective was to combine the advantages of the Mark systems and a new metallic secondary membrane with improved thermal performances (BOR equal to 0.075%/day). With small corrugations and an adapted low thermal coefficient material (Invar), the

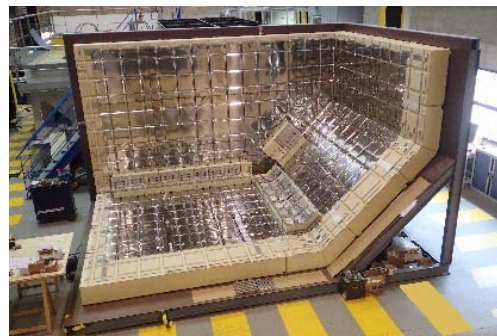


Mark V technology

integration of the new corrugated secondary membrane into the insulation panels is eased and has no impact on the global behavior of the insulation panels.

After several months of studies and development, the whole qualification plan, which includes numerical and experimental validation of all areas of the Mark V CCS - ie Flat Wall areas, Corner areas and Special areas - has been submitted to Classification Societies (DNV-GL and Lloyd's Register) with the objective to be granted with a General Approval during the summer.

In addition to this General Approval stage, the erection of an open mock-up is in progress in GTT laboratories in order to validate the erection procedures of the system. An identical



Open mock-up in GTT's laboratory

erection mock-up will be also erected by Hyundai Heavy Industries. Next, in order to assess the behavior of this new CCS under the worst conditions, a large mock-up, ballasted and cryogenic, is under construction in a Samsung Heavy Industries shipyard. Tests are planned in October 2015.

Moreover, to optimize the industrialization of Mark V, the appropriation of the design by Samsung Heavy Industries and Hyundai Heavy Industries is in progress in the framework of Mark V Joint Development Projects. This phase includes the development of a new welding machine for the secondary membrane by both shipyards and adaptation of specific tools.

The objective of all of these industrialization studies is to be ready for Mark V commercialization at the end of this year.

Focus

MATERIALS / New Foams for improved guaranteed daily BOR

Low BOR is a key requirement for ship-owners and charterers. GTT continues to innovate in this area.

In March of this year, GTT announced a new program to be introduced with Reinforced Polyurethane Foam (R-PUF) suppliers aimed at enhancing the product quality and also the production repeatability of the new high performance foams.

GTT now verifies the production of each new foam, and the foam manufacturer commits itself to a certain level of repeatability of the thermal performance of the foam. In this way the GTT guaranteed BOR for a typical 170.000 m³ LNG Carrier can be improved.

The first of these foams, tested, approved and "repeatable" is now available and other foams are under evaluation.

The GTT guaranteed daily BOR with this foam is now 0,085V/day for the Mark III Flex system. ■