GTT Inside

The GTT newsletter - November 2020 - n° 19

# Message from Philippe Berterottière, Chairman & CEO, GTT

Welcome to this latest issue of GTT Inside.

First of all, GTT would like to share a matter of concern with you.

The Korea Fair Trade Commission has recently issued a decision in which it requests GTT to allow the licensed shipyards, at their request, to perform the technical assistance services, currently included in our technology license.

We consider that providing technical assistance has been since the very beginning the most efficient way to ensure the quality and the proper implementation of our technologies, which, as you know, are very complex. These services are three-fold: (i) design and engineering services, (ii) on-site assistance during construction and (iii) approval of components' suppliers.

We are convinced that the technical assistance we offer, which incorporates the largest state-of-the-art and return of experience from vessels in service, is unrivaled. The hundreds of deliverables we provide, from the liquid motion studies to the detailed design of the tank, from the structural computation of the pump mast to the optimum sizing of the equipment, from the validation of the materials to the on-site assistance, are very much required and represent an essential and integral part to guarantee safe, reliable and high-performance LNG tanks.

We strongly believe that our current offer complies with Korean fair trade laws and have therefore decided to appeal the KFTC decision.

In the meantime, we will continue to work in close partnership with the shipyards in order to fulfill pending and upcoming orders, providing our partners with ever more innovative, safe and efficient technologies, for the benefit of the entire industry.

Back to GTT Inside:

You will discover in this issue the SLING R&D program aimed at further digging into the phenomena of liquid motion. Such R&D programs are very helpful in the validation of our designs, such as the recently obtained A.I.P. from BV for the NO96 system for fuel tanks on container vessels. You will also discover that we have proposed an improved design for the nitrogen circuit on NO96 vessels. Last but not least, Cryovision can now offer SBTT tests during vessel operation.

GTT continues to work to improve the design, constructability and efficiency of our membrane containment systems.

Philippe Berterottière

## AiP for GTT NO96 technology for ULCV

Bureau Veritas has awarded an Approval in Principle (AiP) for the application of GTT NO96 technology for a LNG fuel tank of an ultra large container vessel.

This adaptation of the NO96 technology, already used in over 200 LNGc, represents a reliable and competitive solution for ULCV fuel tanks. It gives to the historical licensed shipyards, already specialised in NO96 technology, the opportunity to propose the optimal membrane system according to the requirements of the ship-owners.

The challenge of this study was to validate the adequacy of the GTT NO96 technology to the specific structural solicitations of the Container Vessel. Thanks to these results, GTT can now offer to the ship-owners the choice between the two membrane technologies; Mark III and NO96.

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# TECHNOLOGIES

## New nitrogen pressurization system

After two years of development by the Cargo Handling System design team, GTT can now present the **new nitrogen pressurization system Evolution 3 for the NO96 membrane containment systems**. Extensive work involving GTT Process & Instrumentation and Stress Piping specialists has been conducted leading to the **full acceptance by Daewoo Shipbuilding and Marine Engineering shipyard**. Application of the new nitrogen pressurization system on future LNG units equipped with GTT NO96 membrane containment systems such as LNG Carriers, but also FSU/FSRUs and offshore FLNGs can now go forward.

This evolution of the NO96 nitrogen pressurization system was inspired by the Mark **III** system, a nitrogen pressurization solution that has **proved its reliability and efficiency** over the years.

Development studies including **functional analysis of the system, process flow and PID diagrams** have demonstrated the full compliance of Evolution 3 with the IGC code. Piping optimisation has been performed to remove the requirement for cryogenic nitrogen pipes and also to save space on the vessel deck. Detailed complementary studies such as the definition of equipment list and associated specifications, and piping flexibility calculation (see Figure 1) have been conducted to **fully validate this new nitrogen pressurization system**.

In case of gas pollution in one insulation space, the independence offered by the system allows an **easier and more efficient maintenance of the polluted insulation space** while the others tank insulation spaces remain normally regulated, and remain **without any risk of being contaminated by any pollution**.

It should also be noted that Evolution 3 is **fully compatible with all the evolutions of NO96 CCS** (perlite, glass wool, L03/L03+) **without any modification of the insulation.**

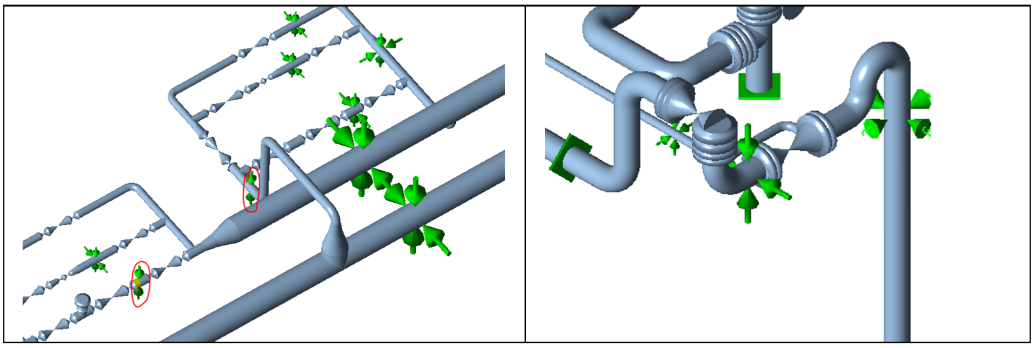

*Figure 1 - 3D model for piping flexibility calculations*

These significant improvements brought by Evolution 3 offer to the NO96 containment systems **additional operational flexibility and enhance the safety of its insulation spaces.**

Cargo tanks equipped with NO96 containment system **respond now much more to operators' expectations for FSU/FRSU, FLNG and even LNG fuelled applications** when tank segregation is required.

**GTT has obtained an Approval in Principle from the Bureau Veritas, the American Bureau of Shipping and the Lloyd's Register, for the new NO96 pressurization system Evolution 3.**

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# STUDIES

## Sloshing of LIquefied Natural Gas

For many years, GTT has been at the forefront of **research into the fundamental behavior of liquid motion** (sloshing) of LNG. Besides GTT's extensive laboratory of sloshing assessment equipment, GTT has been involved in a number of industry research projects. The reader may well remember the Sloshel project, where a very large water flume was used to simulate full-scale sloshing on tank walls.

Now, GTT has t**eamed up with MARIN and others partners** for a new research program; "SLING".

### Overview of the research programme SLING

SLING stands for Sloshing of Liquefied Natural Gas (LNG). This major international cooperative research programme began in 2016 at the instigation of MARIN and GTT. SLING is supported by NWO-TTW, the Dutch Technology Foundation. The remainder of the consortium comprises four top Dutch universities, representatives from the LNG shipping and shipbuilding industry, engineering companies, and research institutes (Figure 1). Through advanced experiments, numerical simulations, and theoretical modelling, SLING **aims to plug the gaps in the knowledge of wave impact loads induced by sloshing in LNG tanks.**

*Figure 1 - SLING consortium*

### Objectives

Natural gas is in liquid form at -162°C and atmospheric pressure. Vessels which transport LNG (LNG carriers, LNG bunker vessels or LNG feeders), floating units that produce or re-gasify LNG (respectively FLNG and FSRU), and vessels which use LNG as a fuel (LFS), all need to be equipped with dedicated tanks to hold the LNG and minimize the heat transfer. **Membrane LNG tanks** designed by GTT are widely used because, with their prismatic shapes and with no structure inside the tank except a pump tower, they use the hull space most efficiently. However, **sloshing impact loads are the dominant design factor of these containment systems.**

The current state-of-the-art methodology to assess sloshing impact loads relies on sloshing model tests. **A model tank at scale 1/40** is filled with water and a heavy gas. It is **placed on the platform of a hexapod that simulates the real ship motions**. The ullage gas within the model tank is a mixture of nitrogen and Sulphur hexafluoride tuned so that the gas-to-liquid density ratio is the same as within a LNG membrane tank. **The ship motions are calculated at scale 1 and down-scaled according to the Froude similarity.** The model tank is equipped with 300 piezo-electric pressure sensors located in the relevant areas where liquid impacts occur.

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However, despite the Froude similarity for the imposed motions and the density ratio similarity, these tests do not fully represent the reality. Some physical phenomena that occur during LNG impacts and influence the impact loads are not present during the small-scale tests (for instance phase change or hydro-elasticity). Some other phenomena involving compressibility and viscosity of the fluids, or surface tension at the interface, are biased because there is no fluid that can fulfil the relevant similarity laws. Nevertheless, dedicated measurements on-board an LNG carrier have shown that t**he long-term statistics of the impact loads as obtained by GTT sloshing assessment methodology are conservative.** The conservatism on the mechanical strength of the containment system is always to the detriment of its thermal capacity. Therefore, **GTT's ambition is to be able to optimize the containment system design**, especially for LFS, in order to find, for any project, the r**ight balance between mechanical strength and thermal efficiency.** This will enable the **operation of partially filled tanks with more flexibility**, or to design new tank shapes f**urther maximizing the use of the vessel's capacity,** and obviously to minimize the amount of boil-off gas.

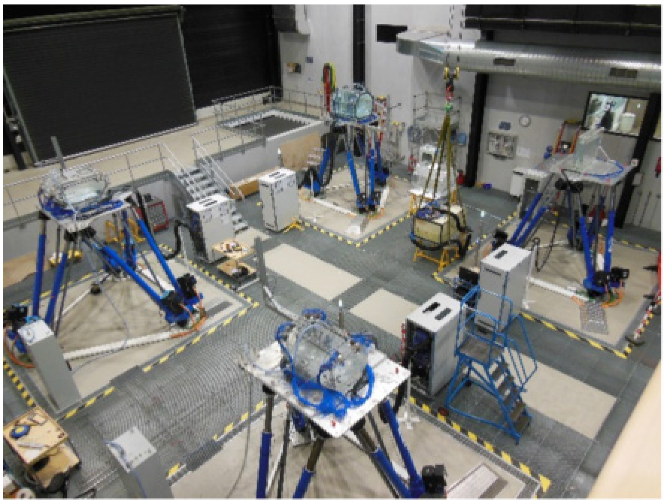

*Figure 2 - GTT Liquid Motion Laboratory*

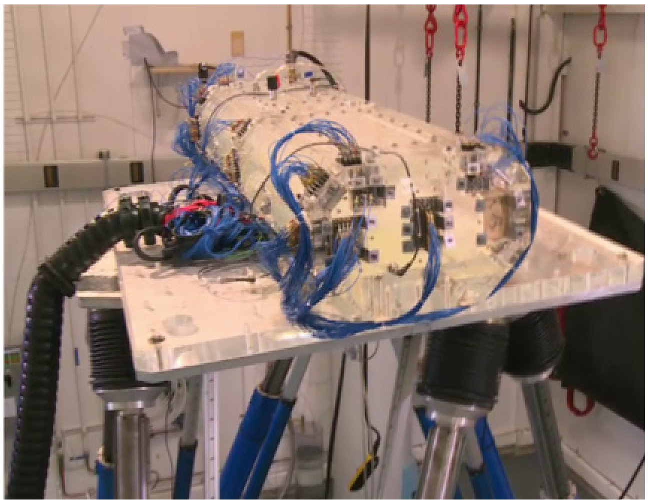

*Figure 3 - Sloshing Model Tests*

This requires a better knowledge of physics of the sloshing impact which lead us to explore the last frontiers of this complex domain: **the multiphase dynamics, the variability of sloshing loads and the structural response to very sharp space and time pressure distributions.** The objective of SLING is to **disentangle this complex physics in order to better master the scaling of the pressure measurements from sloshing model tests to full scale.**

## Scope of Work

SLING consists of **five projects**: three thematic research projects, an engineering project, and a physical integrative project.

The **three thematic projects** respectively study the multiphase dynamics, the variability of the wave impact loads and the structural response through experiments and numerical simulations. Wave impact tests, performed within a new facility designed and built through the engineering project, have been especially designed to ascertain the influence of each phenomenon independently. Moreover, several kinds of numerical simulations contribute to this knowledge acquisition by extending the physics implemented in the numerical models.

The **engineering project** led to the design and construction of a first-of-its-kind test facility, named The Atmosphere. This facility consists of a wave canal that is operated within an autoclave. The Atmosphere has officially been inaugurated in MARIN on October 19th 2020.

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Figure 4 - The Atmosphere


Figure 5 - The Wave Canal within the Autoclave

Finally, t**he integrative project** gathers the knowledge gained by the different experiments and numerical simulations in order to develop new theoretical models for liquid impacts. The models are implemented into a software framework, named the Liquid Impact Simulator (LIS). The LIS enables to generate in only a few seconds a space and time distribution of a wave impact load on a wall. The inputs are simply the wave geometry and kinematics that can be derived from either a test, a numerical simulation or even a simple drawing. The LIS calculation can integrate different levels of complexity for the wave impact physics including phenomena inducing variability of impact pressures.

### Current status

The new facility The Atmosphere is operational since early 2020. A few test campaigns have already been performed to master the generation of the waves, to study the influence of the ullage pressure and of phase change on the global and local wave shapes. **SLING will run until the end of 2021**. Many test campaigns are scheduled. No test results have been published yet.

By its complete involvement in SLING research programme which accompanies the development of LNG as a fuel in the shipping industry, GTT is fully in line with the new baseline included in its logo: *Technology for a Sustainable World.*

# SERVICES

## Cryovision innovates for its services for Vacuum Testing

Since 2012, the operators of Cryovision (GTT's first subsidiary) **have sailed on more than 150 LNG vessels around the world,** thus transforming their position of pioneers into a position of leader for the t**hermographic control of tanks equipped with membrane technologies.**

Today, in order to be able to provide a complete offer to its customers, Cryovision has carried out the qualification process to provide **SBTT, PBGT, Helium Test and Vacuum Box test services, all known as "vacuum tests".**

With their in-depth knowledge of GTT technologies, Cryovision operators are now working to **provide these services, at sea, at repair shipyards or at new construction shipyards.**

True to its DNA (inherited from GTT), Cryovision has developed innovative tools and procedures to improve or accelerate these «classic» services.

A good illustration of these innovative procedures is the new SBTT (Secondary Barrier Tightness Test) performed at sea (in gassed up conditions).

The test is made by establishing a **pressure difference between primary (inter barrier space) and secondary spaces (insulation space between secondary barrier and double hull)** and then by recording the variation of the pressure difference in relation to time.

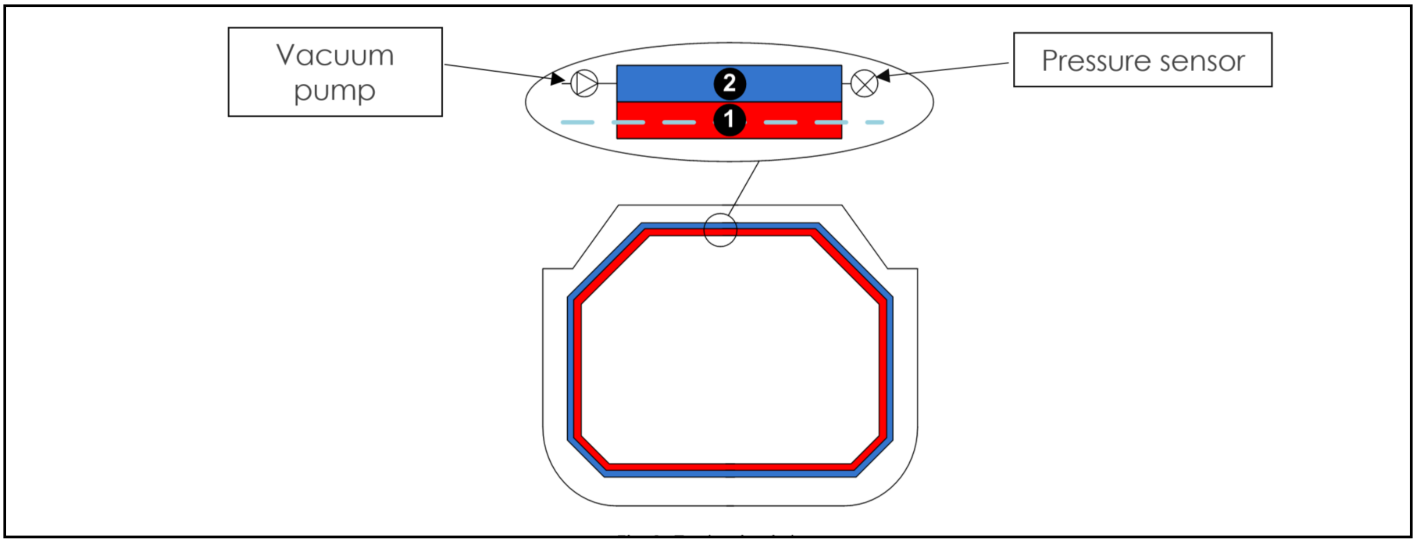


*Figure 1 - Test Principle*

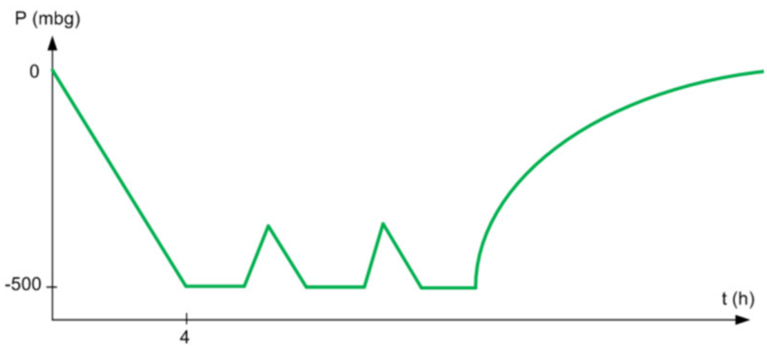


*Figure 2 - Pulling vacuum in IS (secondary space)*

In order to compare test results with reference values obtained previously during ship's operational life, the test conditions should be close to the standardized conditions of a dry dock.

Tank stripping and warming-up before the test is therefore required although the tanks may be kept in Natural Gas conditions.

Even if the test could be performed in navigation conditions, it is recommended to perform it in calm sea conditions so that any hull deformations (due to ballast acceleration or wave bending moments) remain low and the test conditions remain comparable with the standard test.

Thanks to this more complicated but **well-structured and innovative procedure**, **the Classifications Societies recognize that the SBTT "at sea" is an equal to the SBTT in the shipyard**, even though the test is perform with tanks under Natural Gas conditions.

With Cryovision's experience in on-board testing, a choice of light, autonomous and explosion proof equipment has been made to **optimise the logistics.**

*Figure 3 - Example of Autonomous Pressure Sensors*

This test is a **real alternative to the classic process which consists in waiting for the dry-dock** to perform the SBTT.

With this “at sea” procedure, the condition of the secondary barrier may be known prior to dry dock. In case of adverse results, mitigation actions (such as TAMI inspection) could be taken in due time or dry-dock mobilization plan could be modified accordingly.

This is a new opportunity in term of predictability and optimization of Special Survey

With this new opportunity, **Cryovision can now support its customers throughout all the validation / revalidation process of tanks using membrane technologies.**

 