

GTT Inside

FEBRUARY 2026 | N°35

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NOTE FROM THE CEO

Since taking up my role as Chief Executive Officer of GTT on 5 January, I have spent my first weeks meeting many of you, our clients and partners across the LNG value chain. These exchanges have been both energising and instructive. They reaffirm my conviction that beyond technology, our industry is built on trust and long-term relationships.

They have also taken place at a time when, despite geopolitical uncertainty, LNG fundamentals remain strong. Record investment decisions for new liquefaction projects provide greater visibility for our industry and reinforcing sustained momentum.

In this context, I am pleased to introduce this new edition of GTT Inside, highlighting the latest innovations in our membrane containment technologies. These developments reflect our ambition to push technological boundaries, simplify shipyard operations, and support ship-owners throughout the lifecycle of their vessels.

I look forward to engaging with you in the coming months to address the challenges ahead. Through close collaboration and shared commitment, we will continue to advance our industry and shape a more sustainable future together.



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FRANÇOIS MICHEL

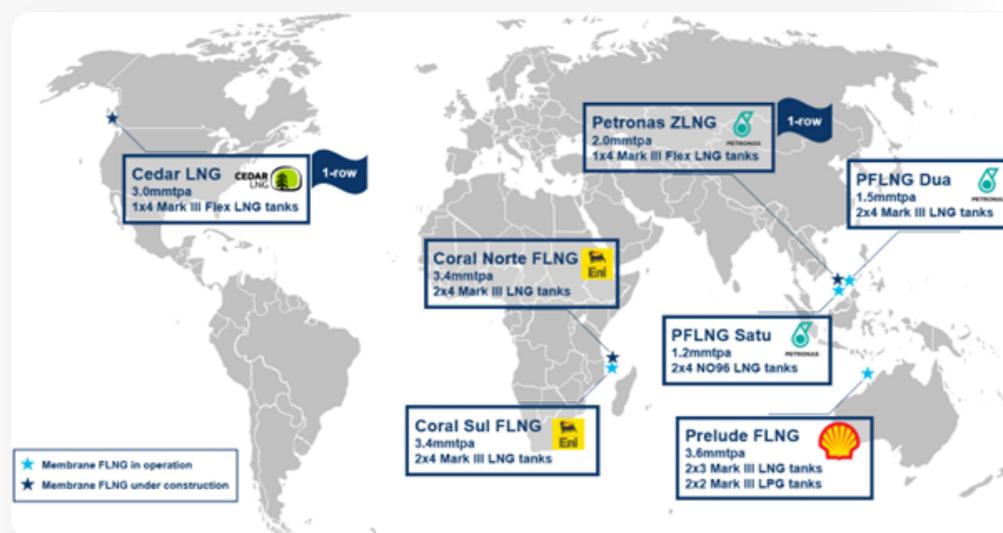
CEO of GTT

PIONEERING PROGRESS

EXPANDING THE APPLICABILITY OF MEMBRANE FLNG DESIGNS THROUGH CONTINUOUS INNOVATION

TOPIC 1

The global energy market is increasingly demanding flexible, robust, and cost-efficient LNG¹ infrastructure. Thanks to decades of continuous R&D, GTT's membrane technologies have become the benchmark for the most efficient and reliable containment solutions for FLNG² applications. To date, four FLNG units equipped with GTT technologies are in operation worldwide, with three additional units currently under construction, including two featuring a 1-row architecture, demonstrating the maturity and strong industrial track record of these solutions.



FLNG units equipped with GTT membrane technology

Recent design improvements further strengthen the leading position of GTT-equipped FLNGs across the full spectrum of metocean conditions, from nearshore to offshore.

¹ Liquefied Natural Gas

² Floating Liquefied Natural Gas

One-Row Design: Now Applicable to a Broader Range of Projects

The transition from a traditional two-row configuration to a one-row concept delivers **substantial structural and weight efficiencies**, including savings of more than **10,000 m²** of containment system surface area and approximately **200 tonnes** of stainless steel associated with pump tower structures.

Historically, the one-row FLNG concept with **four tanks** was primarily suited for nearshore sites with mild sea states, typically below **1.5 metres** of significant wave height. This limitation was primarily driven by increased sloshing loads at intermediate filling levels, combined with the large transverse breadth of tanks in one-row configurations, which can **amplify the impact pressures** on the containment system.

Leveraging higher levels of local reinforcements and adjusted tank dimensions with **5 metre** lower chamfers, GTT has significantly **enhanced the robustness of the tanks** without filling limits.

This design evolution is also supported by extensive service feedback from more than **30 membrane-type FSRUs³** operating with large tank breadths at all filling levels and exposed to a wide range of sea states, providing valuable full-scale validation of sloshing behaviour and long-term structural performance.

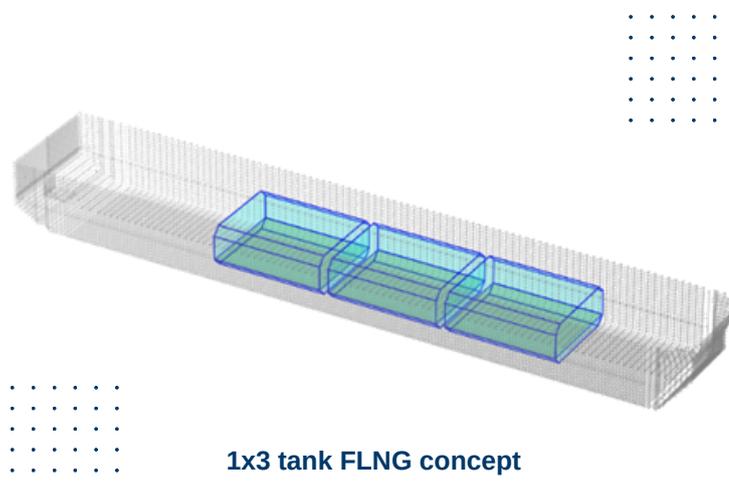
As a result, the **one-row FLNG design now offers expanded applicability** and can be deployed on offshore sites with significant wave heights of up to **4 metres**, providing a fully validated operating envelope. Beyond this range, the concept remains applicable, with site-specific assessments enabling optimised solutions tailored to more demanding metocean conditions.

For many projects, this opens the door to a highly competitive solution delivering an optimal balance between cost efficiency, operational flexibility, and technical performance.

³ Floating Storage and Regasification Units

Introducing the 1×3 Tank FLNG Concept: Reduced CAPEX with Full Storage Capacity

Building on the advantages of the one-row architecture, GTT has studied a new concept featuring only three elongated membrane tanks arranged in a single row. This 1×3 configuration maintains the same total storage capacity thanks to tanks up to **60-metre -long** while offering additional value to stakeholders.



Removing one tank - and its associated equipment and systems - directly subtracts an additional **2,000 m²** of containment system and **50 tonnes** of stainless steel. The project schedule will also benefit from **shorter construction time**, especially considering that topside integration can proceed in parallel with membrane tank erection.

This concept is particularly suited for projects operating under **mild metocean conditions**, combining compactness, simplified arrangements, and reduced construction risks.

A Comprehensive Portfolio of Solutions for All FLNG Projects

Whether for **LNG or LPG storage**, and whether the project is located nearshore or offshore, GTT's membrane technologies (**NO96 and Mark III**) offer a complete range of solutions adaptable to all metocean conditions.

By continuously advancing the design of membrane-based FLNGs, GTT ensures that owners, operators, and shipyards benefit from **the most efficient, most flexible, and most competitive containment systems**, tailored to the specific requirements of each project.

SUSTAINABILITY CORNER

REDUCING GHG EMISSIONS IN LNG CONTAINMENT SYSTEMS

TOPIC 2

As regulations tighten to protect the stratospheric ozone layer and reduce greenhouse gas (GHG) emissions from maritime transport, GTT focuses on **enhancing the environmental performance of LNG cryogenic containment systems** while maintaining the highest technological and safety standards.

By far, the primary source of GHG emissions associated with LNG cryogenic containment systems is excess boil-off gas (BOG). GTT's advanced containment technologies and associated services are specifically **designed to minimise BOG generation** and facilitate its efficient capture and reliquefaction, thereby supporting the Group's commitment to bringing to market solutions that reduce carbon footprint.

Materials used in membrane containment systems constitute the second major source of emissions. Within this category, the blowing agent currently used to expand insulating foams represents a significant share of material-related emissions, owing to the high Global Warming Potential (GWP) of hydrofluorocarbons (HFCs).

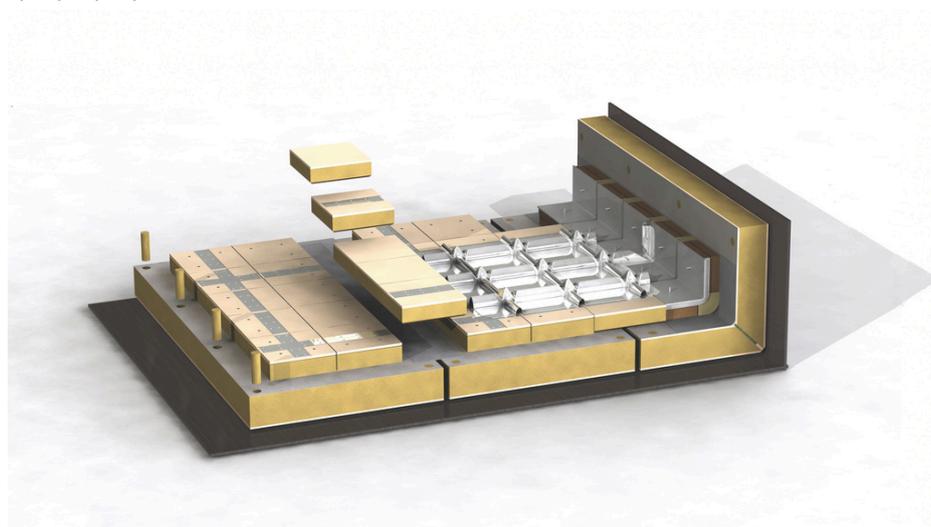
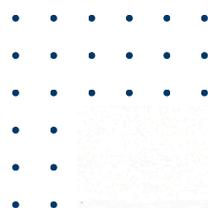
To address this issue, GTT decided in 2023 to discontinue the approval of Reinforced Polyurethane Foam (R-PUF) using HFCs and **to move towards blowing agents with very low global warming potential** (see GTT Inside [N°30](#), published in March 2024).

GTT has identified HydroFluoro-Olefins (HFOs) as a relevant alternative. Their environmental performance is significantly better with a GWP of **3.88** for HFO-1233zd, compared with **962** for HFC-245fa¹. For a standard LNG carrier of **174,000 m³**, this represents an estimated reduction of around **65,000 tonnes** of CO₂ equivalent.

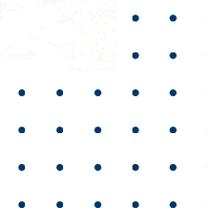
¹ According to the AR6 report of the Intergovernmental Panel on Climate Change (IPCC)

SUSTAINABILITY CORNER: REDUCING GHG EMISSIONS IN LNG CONTAINMENT SYSTEMS

Beyond their environmental benefits, HFOs offer **similar thermal conductivity levels and comparable boil-off rate (BOR) performance** to HFC-based foams in LNG carriers. The additional cost associated with the use of HFOs compared with HFCs remains very limited, resulting in a highly competitive CO₂ abatement cost of around **USD 2 per tonne** of CO₂. In practical terms, switching to HFO-based foams **can save the equivalent of one to two years of LNG carrier operational GHG emissions** for a standard LNG carrier equipped with GTT membrane technologies, depending on the operating profile and the containment system type.



Mark III technology



In 2025, GTT teams worked closely with their partners to ensure a smooth transition towards HFO-based foams. Today, these foams are available for both Mark III and NO96 technologies. The GTT Group remains fully committed to extending this transition to additional applications.

TECH IN FOCUS

DESIGN IMPROVEMENTS ON LNG CARRIER CARGO HANDLING SYSTEMS: RELIABILITY, SAFETY, AND OPERATIONAL FLEXIBILITY BY DESIGN

TOPIC 3

At GTT, incremental engineering refinements are a catalyst for tangible value at sea. Building on operational feedback from vessels in service, we have developed a series of **improvements to LNG Carrier (LNGC) cargo handling systems** that strengthen reliability, safety and operational flexibility, without altering the overall architecture.

Three optimisations are now available to shipyards and ship-owners: an optimised pump tower design with tubular cable way; a top filling pipe designed to limit stratification and rollover risk; and rupture disks offering passive protection against accidental insulation-space overpressure.

Optimised Pump Tower & Tubular Cable Ways: Robust Structure and Targeted Membrane Protection

The pump tower is subject to cryogenic temperatures, ship motions, cargo motions and dynamic loads. Its **mechanical integrity remains central** to safe cargo handling. In this latest evolution, GTT has simplified the tower by removing five strut stages, and increasing the pitch between stages from **1,840 mm** to **3,000 mm**. This optimisation reduces static and dynamic loads while maintaining the required strength and stiffness.



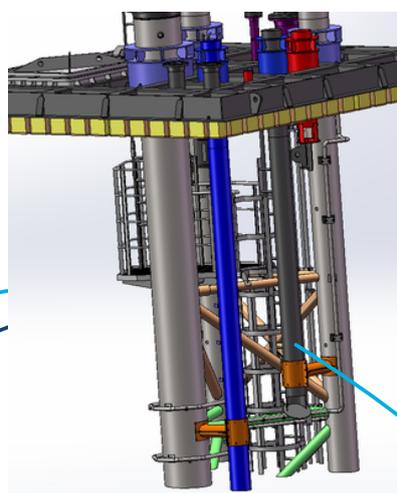
Optimised pump tower with tubular cable ways

In parallel, GTT has replaced traditional bolted cable trays with tubular cableways, removing hundreds of bolts on each pump tower and reducing the risk of falling objects.

The purpose of this change is essential: to **reduce the risk of damaging the membrane** at the bottom of the tank due to dropped objects when the ship is at sea. This approach has already been implemented on container vessels and LNGCs equipped with membrane tanks.

Top Filling Pipe: Expanding the Operational Envelope

The top filling pipe introduces an additional top entry line, allowing operators to fill the tanks from the top when loading a new cargo which is heavier than the liquid heel remaining onboard. This capability is designed to **save time during commercial operations** at the loading terminal, while managing stratification and rollover risks, avoiding sudden boil-off surges. The top filling line is typically needed in **one or two cargo tanks** and is widely used on FSRUs¹, FLNGs² and container vessels. With new commercial trends on the LNG shipping market, more and more partial loading and unloading operations are performed, which means that the top filling line now also makes sense on new LNGC designs.



In dark grey, the top filling line

Rupture Disks: Passive Safety for Insulation Spaces

Membrane damage from accidental overpressure in insulation spaces is rare, but can be severe. Such a dramatic event can only occur during the tank secondary barrier tightness test performed every **five years**, as safety valves are blanked during such a test. Overpressure is not supposed to occur, and yet it has been experienced in the history of the LNGC industry. When it happens, consequences are severe as it typically takes several months to repair the damaged membrane. GTT therefore decided to look for a **fail-safe solution**, to make sure this can never happen again.

¹ Floating Storage and Regasification Units

² Floating Liquefied Natural Gas

TECH IN FOCUS: DESIGN IMPROVEMENTS ON LNG CARRIER CARGO HANDLING SYSTEMS:
RELIABILITY, SAFETY, AND OPERATIONAL FLEXIBILITY BY DESIGN

GTT's solution involves **two rupture disks** per cargo tank (one per membrane). The disks remain perfectly tight during normal operations and **will not break** when the safety valves are in service. The rupture disks do not replace the safety valves. Instead, they should be considered as complementary to the safety valves. Indeed, when the ship is in service, the insulation spaces **will still be protected** by these valves, as before, as they would open at a lower pressure compared to the rupture disks. Rupture disks can only break when safety valves are blanked, that is to say during the tank maintenance, and this is when accidents can occur.



A rupture disk

Together, these improvements deliver more robust designs, safer maintenance, and more flexible and faster commercial operations. They embody GTT's philosophy of practical innovation: **careful engineering fed by operational feedback** and targeted to real operational requirements.

ACROSS THE LIFECYCLE

ENSURING SAFETY AND PERFORMANCE OF LIQUEFIED GAS UNITS

TOPIC 4

With more than **60 years** of field experience, **GTT's expertise extends well beyond engineering and design**. It also encompasses highly specialised know-how that supports clients and stakeholders during one of the most critical phases in a vessel's lifecycle: initial LNG operations.

During this stage, all equipment, including compressors, heaters and insulation, are tested **under real conditions**, through the full spectrum of operations the vessel will perform throughout its service life: insulation cool-down, tank loading and unloading, and cargo transfers between tanks. At this stage, design assumptions are confronted with operational reality, and experience proves decisive.

Over the years, GTT has built an unrivalled operational track record with more than **14,000** cumulated tank-years for Mark III and over **12,900** for NO96. GTT has attended more than **1,400** refits dedicated to cargo tank inspection and has supported the commissioning of over **250** units since 2013. This experience concerns LNGCs¹, FSRUs², FLNGs³, VLECs⁴ as well as container vessels, cruise ships, bunker vessels and onshore storage tanks. Notably, every FLNG equipped with GTT membrane systems has benefited from GTT's presence at start-up.

Operational expertise at the heart of commissioning

GTT relies on **a dedicated in-house gas commissioning team** composed of former seafarers with extensive experience in gas operations, including gas engineers and chief officers. These specialists work **in close coordination with shipyards** from cargo tank closing through to vessel delivery, ensuring that GTT systems are tested and operated in strict accordance with design specifications, technical documentation and procedural requirements established during the engineering phase.

¹ Liquefied Natural Gas Carriers

² Floating Storage and Regasification Units

³ Floating Liquefied Natural Gas

⁴ Very Large Ethane Carriers

ACROSS THE LIFECYCLE: ENSURING SAFETY AND PERFORMANCE OF LIQUEFIED GAS UNITS

Given the highly sophisticated nature of this technology, commissioning and testing activities may occasionally bring to light unforeseen operational challenges. The most critical areas of attention typically include:

- **Pressure management in cargo tanks and insulation spaces:** deviations identified during tightness tests, such as improper return to atmospheric pressure following vacuum conditions or inadequate safeguards during tracer gas injection, as well as incorrect settings of the integrated automation system during operations, may result in overpressure scenarios with potential technical and schedule implications.
- **Inerting and preservation of cargo tanks and insulation spaces:** inadequate atmospheric control may result in damage to the cargo containment system, thereby necessitating further investigation and the implementation of corrective measures.

To support on-board teams, GTT's gas commissioning specialists deployed on board are supported by engineering experts based at GTT's head office. Each decision is underpinned by dedicated studies, including comparison with data from the fleet, simulations and risk assessments aimed at defining acceptable operating thresholds and evaluating the potential consequences of any defect or improper operation.

Securing commissioning from preparation to start-up

GTT's commissioning assistance covers all critical phases: preparation of commissioning, commissioning, and start-up with gas.

During the preparation phase, before any fluids are introduced inside the cargo tank and insulation spaces, GTT works closely with shipyards and stakeholders to secure future operations. This includes:

- **Reviewing all the testing procedures** related to the cargo tanks, cryogenic piping and insulation spaces such as cold tests of the cryogenic piping, insulation space commissioning, tank preservation after closing, gas trials, etc.
- **Verifying the line-up** and setting of the equipment and automation as per design documents.
- **Checking P&IDs**, alarms and safety logic as per cause-and-effect diagram
- **Controlling the equipment readiness** thanks to regular patrols

ACROSS THE LIFECYCLE: ENSURING SAFETY AND PERFORMANCE OF LIQUEFIED GAS UNITS

All observations identified during patrol activities are systematically documented and promptly communicated to the shipyard via the Daily Patrol Report (DPR).

Regular coordination meetings with shipyard commissioning teams ensure that corrective action plans are implemented to confirm the expected configuration.

GTT		Report		NCR	Week	1
Owner		Ship name		Page	1 / 1	
GTT Representative		Romain Sirgue		Class		
Techno	MKIII			Date		
N°	05					
Subject	IBS/IS Nitrogen supply		Location	Buffer Tank IBS/IS header		
GTT Observations						
Please note that NSV6 has been operated in Manual (opening 20%) in continuously. They justified this manual operation by a regulation issue on NSV6, which create an over pressure in buffer tank. Then need to depressurize and to acknowledge alarm to restart system. Please note safety risk to damage Fuel tank membrane due to overpressurise IBS/IS. Safety issue: - Buffer tank PSV isolated and PSV sealing removed - PG and PT-00501 out of range - No Value for PT-00501 on control computer						
						
Recommendations						
Action from SY: Perform buffer tank PSV calibration, Line up PSV, keep NVS6 in auto mode, calibrate PT-00501						
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Daily Patrol Report issued by GTT gas commissioning officers

As a result of this structured methodology and sustained technical oversight, commissioning activities are meticulously prepared, ensuring that gas trials are conducted under strictly controlled and safe conditions.

Supporting critical operations during gas trials

As already mentioned, the commissioning and start-up are critical project phases during which key decisions must be taken quickly to preserve operational safety and avoid schedule delays due to cargo operation mishandling.

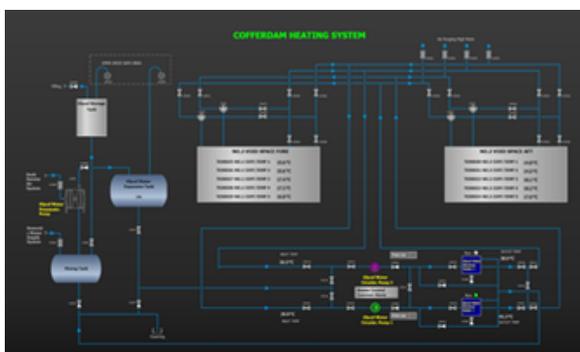
ACROSS THE LIFECYCLE: ENSURING SAFETY AND PERFORMANCE OF LIQUEFIED GAS UNITS

GTT provides **24/7 support to shipyard and ship-owners** from inerting and introduction of the first LNG (gassing-up, cool-down, submerged pump testing, etc.) to steady-state operations and decommissioning. During the operations, our gas commissioning officers regularly control the cargo tank parameters and conditions, the appropriate pressure management, the situation of instrumentation, and the compliance of operations with testing procedures.

Our gas commissioning officers are also supporting the shipyard and ship-owner teams **when non-nominal operations are encountered** or deviation from the initial testing procedures arise. For example, our teams have supported critical operational aspects such as cofferdam heating system performance and insulation space pressure management.

During gas trials, it has been observed, for example, that the maximum temperature of the glycol heating system did not exceed **+55°C**, whereas the design operating setpoint was **+90°C**. Our assistance was requested to resolve the issue. All possible causes (pump and heater capacities, piping installation and length, system set points, alarms and safety) were listed, tested and properly investigated. A detailed due diligence review identified excessive pump flow and an incorrect regulation set point.

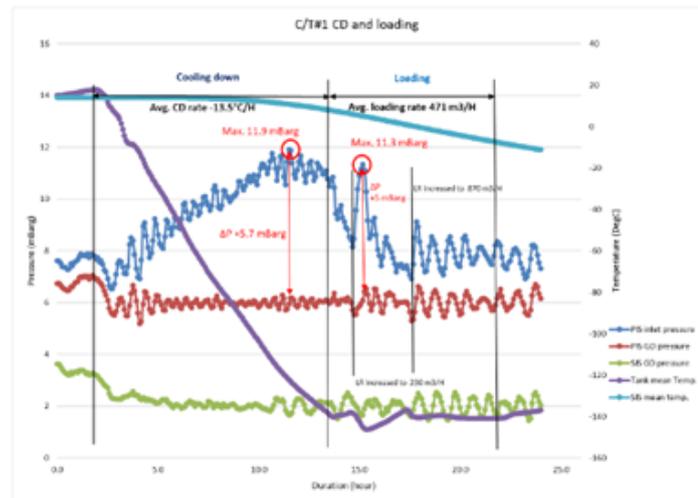
Close cooperation then enabled proper system configuration, resulting in performance in line with expectations. This assistance is essential **to secure the timeline of the gas trials** and to **ensure safe operations** knowing that the cofferdam heating system is essential to maintain an acceptable temperature range of the hull steel structure as per IGC requirements.



Example of assistance to fix glycol heating system performance

ACROSS THE LIFECYCLE: ENSURING SAFETY AND PERFORMANCE OF LIQUEFIED GAS UNITS

Appropriate pressure management is key for membrane technologies. Our gas commissioning officers are regularly asked to fix nitrogen header and insulation space pressure regulation so that it returns to the acceptable operating range.



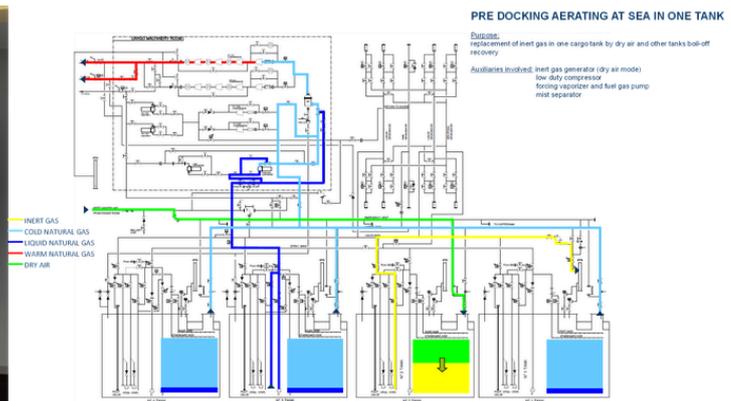
Example of assistance to fix an insulation space pressure management issue

Sharing knowledge to build long-term performance

Beyond technical assistance, GTT's commissioning teams actively **share latest state-of-the-art in GTT technologies** and LNG operations with shipyard personnel and ship crews. Training sessions and on-the-job guidance cover key areas such as cargo handling system, gas operations, safety practices and environmental performance.



Regular training is possible for shipyard and crew



By integrating advanced engineering capabilities, extensive operational know-how and close partnerships with shipyards and shipowners, GTT ensures that liquefied gas units are delivered **in full compliance with the highest standards** of reliability, safety and performance. From preparation to start-up, GTT's commissioning support not only secures immediate performance but also establishes the foundations for long-term operational excellence across the liquefied gas fleet.

MEET GTT

EVENTS

The GTT group will be taking part in these forthcoming conferences and exhibitions:



9/10 Mar. 2026
LNGCON,
Barcelona




12 Mar. 2026
Webinar "Voyage Optimisation
for WASP vessels": [Inscription](#)



16/18 Mar. 2026
WMF Conference,
Copenhagen



12/16 Apr. 2026
Seatrade Cruise Global,
Miami



20/21 Apr. 2026
7th American LNG Forum,
Houston



22/24 Apr. 2026
Sea Japan,
Tokyo



28/29 Apr. 2026
8th Global LNG Forum,
Barcelona



5/7 May 2026
LNG Bunkering,
Amsterdam

LEARNING & DEVELOPMENT

Stay up to date with our industry-focused training sessions

[Use of Ammonia, LNG, Methanol and Hydrogen as a Marine Fuel](#)

21st-23rd April

[GTT Membrane Technologies Course](#)

24th-27th March

[FSRU Systems and STS Operations Course](#)

28th-30th April

[LNG Cargo Operations \(SIGTTO\)](#)

16th-20th March

[LNG Cargo Operations \(Refresher\)](#)

14th-16th April

More information:
www.gtt-training.co.uk

About GTT Inside

Any question?

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Department at
communication@gtt.fr

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