# GII Inside

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# NOTE FROM THE CEO

## Philippe Berterottière

Chairman & CEO of GTT Group



Innovation is at the very heart of GTT's mission, and this new edition of GTT Inside offers a perfect illustration of how our teams relentlessly push the boundaries of technology to support the maritime energy transition.

From the launch of GTT CUBIQ $^{\text{TM}}$ , a chamfer-free LNG fuel tank concept designed to simplify construction and optimise performance, to our advanced pipe stress analysis methods ensuring the highest safety standards on LNG carriers, we are proud to showcase solutions that combine technical excellence with practical value for shipyards and ship-owners.

We also highlight our progress in 1 barg tank design pressure for LNG bunker vessels, a breakthrough concept that enhances operational flexibility while ensuring uncompromised safety. Beyond LNG, GTT continues to play a decisive role in shaping the future of ethane transportation, supporting the growing fleet of Very Large and Ultra Large Ethane Carriers with membrane technologies, which improve efficiency, reduce costs, and open new opportunities for our customers.

These achievements are the result of a strong commitment: listening to our partners, anticipating regulatory changes, and translating operational feedback into ever more reliable, efficient, and sustainable solutions.

Enjoy your read.

Philippe Berterottière





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### **TECH IN FOCUS**

# GTT CUBIQ<sup>TM</sup>, A CHAMFER-FREE MEMBRANE LNG FUEL TANK: SIMPLER DESIGN, GREATER VALUE

GTT has developed a new LNG tank concept, GTT CUBIQ<sup>™</sup>, specifically designed for merchant vessels, with a focus on LNG-fuelled container ships. Drawing on several years of operational feedback from in-service vessels, the concept combines lessons learned at sea with advances in sloshing methodology, tank engineering refinements, and a close alignment with evolving regulations.

#### A Major Design Evolution

By eliminating the traditional chamfer in fuel tank geometry, GTT engineers have reduced corner areas and simplified construction, unlocking a range of operational and economic benefits for shipbuilders and ship-owners.

This geometry delivers clear benefits for shipowners in three key areas:

- Design efficiency: The optimised geometry offers better enhanced volumetric efficiency, more usable space and lower construction cost per cubic meter.
- Ease of construction: Thanks to standardised geometry, scaffoldings are simplified, installation time is shortened, and complexity reduced, making the construction process faster and more efficient.
- Improved Business Case/Total Cost of Ownership: a lower boil-off rate (BOR) allows downsizing of the fuel gas system, reducing operating costs and freeing up additional cargo space.



Figure: GTT CUBIQ<sup>™</sup> LNG fuel tank -Optimising space while allowing more TEUs in a smoother LNG tank erection process

# TECH IN FOCUS - GTT CUBIQ™, A CHAMFER-FREE MEMBRANE LNG FUEL TANK: SIMPLER DESIGN, GREATER VALUE

#### **Designed for Real-World Operations**

The GTT CUBIQ<sup>™</sup> concept is suitable for LNG-fuelled tanks up to 25 meters wide and 14,000 m³ in capacity exceeding the requirements of long distance operations such as Europe to South-East Asia routes. It supports different insulation options, including standard foam or hybrid foams, achieving an optimised boil-off rate (BOR). Testing campaigns confirmed the necessary reinforcement levels required, enabling a lighter containment system at 1 barg design pressure, affording compliance with cold ironing regulations.

#### **Behind the Innovation: Three Main Drivers**

#### 1. Operational feedback

The first generation of membrane fuel tank designs focused on maximising fuel autonomy, as LNG was initially harder to bunker. Increasing onboard LNG volume reduced the risks linked to frequent bunkering and enabled the owner to bunker at the cheapest port. Today, smaller tank capacities are increasingly possible.

#### 2. Refinement of Sloshing Methodology

Additional model tests and sloshing simulations have significantly improved GTT's post-processing statistical analysis and refined its analytical models. These advances make it possible to design more precise reinforcement arrangements and to use lower-density materials in selected areas. The result is a lighter containment system with improved thermal performance, bringing benefits to both yards and ship-owners/charterers.

#### 3. Regulatory Developments

The release of IACS (International Association of Classification Societies) recommendation No. 34 has introduced more realistic environmental conditions based on decades of buoy and satellite data. Therefrom, additional simplifications have been possible, confirmed by advanced simulations and model testing, aligned with sea state conditions likely to be encountered by LNG-fuelled vessels.

# TECH IN FOCUS - GTT CUBIQ™, A CHAMFER-FREE MEMBRANE LNG FUEL TANK: SIMPLER DESIGN, GREATER VALUE

By redefining LNG fuel tank geometry, GTT CUBIQ $^{\text{TM}}$  delivers a simpler, more efficient and cost-effective solution, helping shipyards and ship-owners improve construction schedule and vessel performance while reducing operating costs, as summarised below.

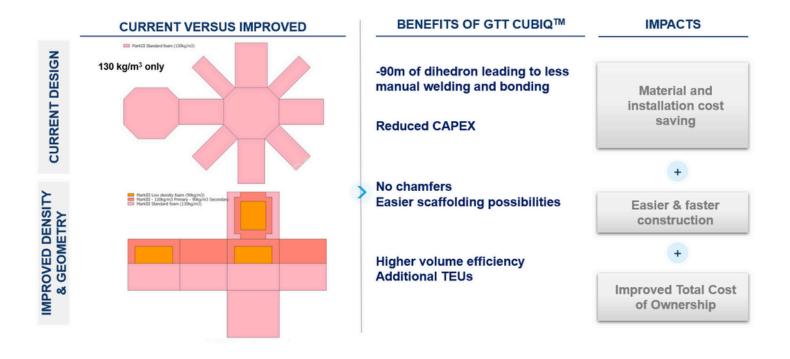


Figure: GTT CUBIQ™ LNG fuel tank – Summary of benefits

## **TECH IN FOCUS**

# KEEPING LNG CARRIERS SAFE: THE IMPORTANCE OF PIPE STRESS ANALYSIS

At GTT, ensuring the integrity of cryogenic pipe networks is a core part of our contribution to LNG carrier design. These systems, which carry LNG at extremely low temperatures, present unique engineering challenges. Among them, pipe stress analysis is essential - not only because it is required by the IGC Code, but also because it helps prevent leaks, ruptures, and other failures that could affect the vessel, its crew, the environment, and the cargo.

Several factors contribute to the complexity of stress analysis for cryogenic pipe, making it significantly more demanding than for networks operating at room temperature:

1. Extreme Temperature Variations
Cryogenic fluids such as Liquid Nitrogen
(-196°C) and LNG (-165°C) cause large
temperature differences compared with
ambient conditions. This leads to significant
thermal contraction of the pipe and, if not
properly pre-cooled, bowing effects as the pipe
bends under uneven temperatures.

Rapid cool-down and warm-up cycles can induce thermal shock, creating high stresses that may cause cracking, deformation of pipe anchorages and supports, or loss of tightness in joints and flanges.

Anchor

Because these variations are far greater than conventional systems, stress analysis is essential to ensure materials and supports can safely withstand them.

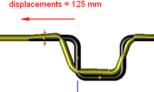
#### 2. Complex Loading Conditions

Cryogenic pipe systems on an LNG Carrier are subject to various loading conditions:

- Weight Loads: The weight due to permanent loads (pipe, insulation, fluid, ...) and the weight due to temporary loads (snow, ice, ...) have to be considered during the pipe stress analysis.
- Thermal Loads: As described above. thermal expansion and contraction are contributors stress to during operation. For instance, the thermal shrinkage of a Stainless Steel line operating at -165°C is around 2.5 mm/m, which means that a straight pipe of 50 meters - anchored at one side - will shrink about 125 mm.

In addition, the pipe stress analyst must consider all operating modes and ensure that all of them will be ASME B31.3 code compliant.

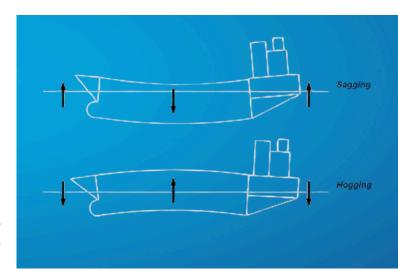
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displacements = 125 mm

#### TECH IN FOCUS - THE IMPORTANCE OF PIPE STRESS ANALYSIS

- **Pressure Loads:** The internal pressure of the cryogenic fluid exerts hoop stress on the pipe thickness that must be considered in conjunction with other loads. The pressure will have an important impact on the lines where Axial Expansion Joints are provided; the generated pressure thrust will have to be handled by supporting structures. For example, the pressure thrust to be withstood by the adjacent structure of an Axial Expansion Bellow installed on a 24" diameter pipe (wall thickness 6.35 mm) with a pressure of 10 bar will be around 280 kN (= 28 tons, to be compared with the weight of a pump tower which is around 40 tons).
- Inertial Acceleration: LNG Carriers are subject to accelerations due to waves and sea conditions. For example, applying an acceleration equal to 0.3g leads to an increase in the pipe weight and all connected items by 30% and generate additional horizontal loads on pipe supports equal to 30% of the pipe weight.
- Hull Deformation: The hull of an LNG Carrier can deform under various loading conditions, such as cargo weight (depending on tank and ballast levels) and wave action Acting like a beam, the vessel bends and imposes displacements on pipe supports. Two main types are considered: hogging (bending upward at midship) and sagging (bending downward at midship). Combined with thermal effects, these deformations increase stresses in the pipes as well as the reaction forces on supports and equipment.



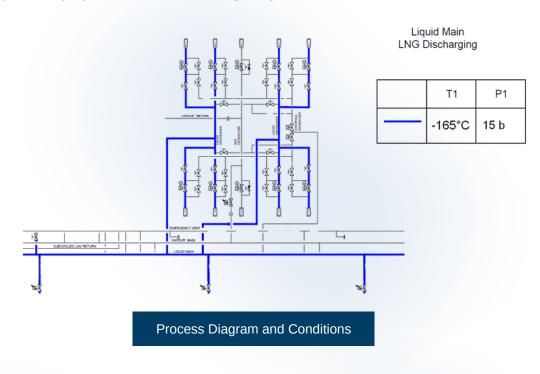
- Dynamic Loads: These are loads that will fluctuate rapidly over time, such as Pressure Relief Valve opening, Slug Flow and Water Hammer. Slug flow is a phenomenon that occurs under special circumstances of two-phase gas-liquid flow and is the most serious scenario in a two-phase flow as it involves a moving liquid mass pushed by gases in between. Water Hammer refers to rapid and often large pressure and flow fluctuations resulting from transient flow conditions (ex: gradual or sudden valve closure, pump trip, etc.). These events generate reaction forces at any change in flow direction (elbows, tee, etc.).
- Connection Loads at the manifolds as per SIGTTO (Society of International Gas Tanker and Terminal Operators) recommendations shall be considered during the analysis to ensure the design of the manifold supports. Those loads, applied on the manifold, are applied during cargo transfer when Marine Loading Arms are connected to the ship manifold.
- **Vibration Loads:** Pipe lines are subject to vibrations on an LNG Carrier. The two most likely sources of excitation are the engine and the propeller.

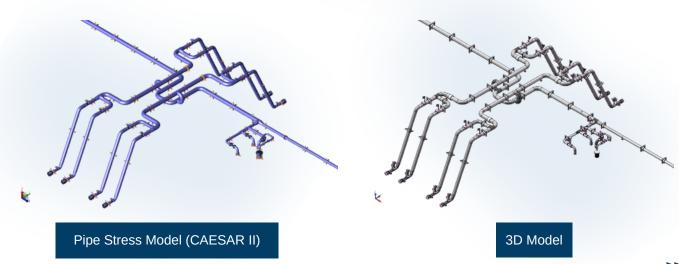
#### TECH IN FOCUS - THE IMPORTANCE OF PIPE STRESS ANALYSIS

- **3. Support & Restraint Loads:** The pipe support configuration (location & function) will significantly influence the stress distribution in the system. The pipe stress analyst must select and model these supports accurately to ensure the correct behaviour of the lines by checking that the pipe system will be able to withstand any expected loads without excessive stress.
- **4. Safety & Environmental Concerns:** The consequences of a leak or rupture in a cryogenic cargo line can be severe. Release of cryogenic fluids can lead to frostbite and cryogenic burns, material embrittlement, and environmental damage.

#### **How Pipe Stress Analysis Mitigates Risks**

By using different inputs as the Process Diagram, Process conditions and 3D models, the pipi stress analysis will play a crucial role in mitigating these risks.

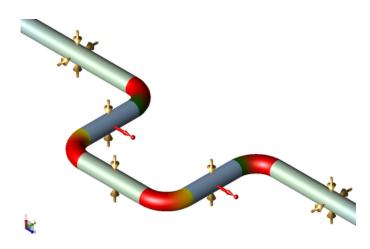




#### TECH IN FOCUS - THE IMPORTANCE OF PIPE STRESS ANALYSIS

Identifying High-Stress Areas: The pipe stress analyst will highlight locations where stresses exceed allowable limits (for example elbows from pipe expansion loop, small branch connections, etc.) and proposes modifications in conjunction with the pipe designer.

**Optimising Support Configuration:** The analyst will define the pipe support configuration (location and functions) based on



the pipe layout in order to minimise stress concentrations and control thermal expansion.

**Selecting Appropriate Materials:** The analyst will recommend the selection of fittings that will have sufficient strength to withstand stresses.

**Designing Expansion Joints & Pipe Loops:** The pipe stress analyst will define expansion loops sizes and locations and define expansion joint characteristics to absorb thermal expansion and prevent excessive stresses.

**Validating Design Adequacy:** The analyst will ensure that the pipe system meets all applicable codes and standards requirements and check:

- The calculated stresses within code allowable levels (example: ASME B31.3),
- The loads on pipe supports as per recommended values,
- The loads on equipment nozzles as per Vendor requirements or recognised standards (example NEMA SM23, API 610, etc.),
- The displacements of the lines as per recommended values (example: limited pipe deflection in sustained case, etc.),
- The first natural frequencies of the pipe arrangement as per recommended values the limitation of pipe displacements as described above will allow to provide stiffer network and therefore increase the first natural frequency.

Pipe stress analysis translates complex operating conditions into practical design rules, ensuring that cargo lines remain safe, reliable, and compliant. It is an essential step in delivering robust LNG carrier systems.

By overseeing stress analysis for the most critical pipe networks on membrane LNG carriers, GTT brings essential expertise that contributes directly to the safe and reliable design of these vessels.

## ADVANCING LNG BUNKER VESSEL DESIGN: THE 1 BARG TANK DESIGN PRESSURE UPGRADE

As the LNG bunkering ecosystem evolves, with new supply chain dynamics, stricter regulations, and greater competition among suppliers - designers of LNG cargo systems must adapt their solutions. In this context, GTT has introduced the 1 barg tank design pressure solution, providing LNG bunker vessels with greater flexibility, regulatory compliance, and cost efficiency.

#### Why 1 barg?

The 1 barg design pressure for LNG bunker vessels has received multiple Approvals in Principle (AiPs) from leading Classification Societies, following comprehensive risk assessments. This configuration offer several advantages:

• Operational Flexibility: The ability to load LNG at higher temperatures, up to -153°C, ensures compatibility with a broader range of LNG supply sources, including regasification terminals, as illustrated in the table below.

**Assumption:** LNG composition is defined according to the IGF Code. The possible temperature range becomes wider when LNG contains little nitrogen, providing greater flexibility.

In addition, the amount of natural gas that can be stored in the vapor space increases by approximately 4,500 kg (for an 18,600 m³ LNG bunker vessel at 50% LNG volume) compared to 0.7 barg. This offers more operational flexibility during LNG bunkering, particularly when return gas is limited.

Pressure Safety Valve Pressure setting	0.7 barg	0.8 barg	0.9 barg	1 barg
Max loading temperature of LNG	-155.6 °C	-154.8 °C	-154 °C	-153.3 °C
Extra mass of gas compared to 0.7 barg	Reference	+ 1,500 kg	+ 3,000 kg	+ 4,500 kg

However, it is important to recall the benefits of maintaining the vapor space at the lowest possible pressure at all times in order to preserve a comfortable safety margin.

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#### PIONEERING PROGRESS - THE 1 BARG TANK DESIGN PRESSURE UPGRADE

- Energy efficiency: Reduced reliance on subcoolers during standby or idling phases lowers electrical consumption and optimises energy use.
- Regulatory readiness: Extended holding times support compliance with emerging environmental standards, such as AFNOR recommendations on cold ironing.

#### A Decade of Development

GTT's work on elevated pressure LNG containment systems spans over a decade, in close collaboration with Classification Societies:

Cruise Vessel Fuel Tanks: Alternative design approved for 2,600 m³ tanks at 2.0 barg, used during bunkering and emergency scenarios. *Reference Vessel:* Commandant Charcot (IMO 9846249) ordered to GTT in 2018 with close to 5 years of operation in LNG.

**LNG Brick™ Tanks & Bunker Vessels:** AiPs for 2,000 m³ tanks at 2 barg and 4,000 m³ tanks at 1 barg under the IGC Code.

Ultra Large Container Vessel (ULCV): Recent AiPs for 1 barg tanks under the IGF Code, granted by BV, ABS, and DNV.

#### **Technical Implementation**

For shipyards, adopting the 1 barg configuration requires limited adjustments across few areas, despite containment system main components remaining completely unchanged:

#### 1. Containment System Design

- Reinforcements limited to the dome cover (thickness, stiffeners, crossing pieces, welds, and bolts).
- Additional non-destructive testing (NDT).
- Pump tower optimised thanks to adapted dome dimensions.

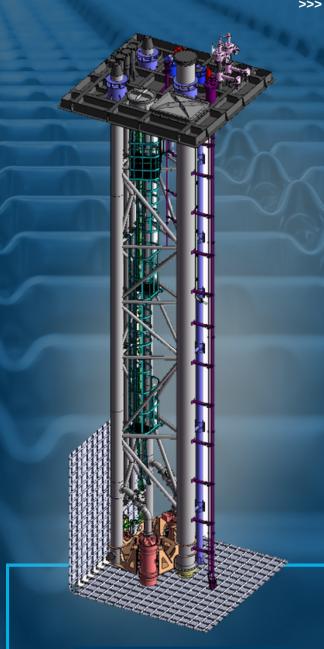


Figure: Combined Dome and 1 barg Configuration for Membrane Tanks

#### PIONEERING PROGRESS - THE 1 BARG TANK DESIGN PRESSURE UPGRADE

#### 2. Inner Hull Reinforcements

Minor structural upgrades to cofferdam bulkheads, tank tops, dome seats and double bottoms are necessary to accommodate increased pressure.

#### 3. FGHS Equipment Adjustments

- Pressure Safety Valves (PSVs) with dual settings (1.0 barg for normal operation and 0.7 barg for alternative containment scenarios).
- Updated high-pressure alarms and expanded sensor ranges.
- Compressors and heaters adapted to wider inlet pressure ranges.

#### **Operational Savings**

Following chart shows how savings on subcooler power consumption are increased when idling duration and/or tank design pressure is increased. Idling varies from 1 to 5 days and design pressure of 0,7 barg and 1 barg are shown.

# Excess Subcooler Consumption (kW) - 700 mbarg Subcooler Consumption (kW) - 1 barg 3500 3000 2500 2000 1500 1000 1 2 3 4 5 Idle duration (days)

#### Power Consumption comparison between 1 barg and 0.7 barg

To illustrate, 490 kW of electrical power are saved for 1-day idling, figure increased to 980 kW for 3 days, from design pressure upgrade.

#### **Key Assumptions:**

- Subcooler is TBF 700 or equivalent.
- Since operating LNG bunker vessel at high pressure is not recommended due to off-LNG specification risks, LNG temperature is to be brought down to customer LNG temperature requirement at end of idle.

The 1 barg design pressure is now a certified by many Class societies while becoming a practical upgrade for LNG bunker vessels. Besides offering huge operational flexibility and operating costs savings to Shipowners and Charterers, Shipyards are now in position to upgrade their standard offer for bunker vessels.

# GTT MEMBRANE TECHNOLOGY DRIVING THE NEXT GENERATION OF ETHANE CARRIERS

Since the launch of Ethane Crystal, the first 87,000 m³ membrane-type Very Large Ethane Carrier (VLECs), GTT has established itself as a key player in the ethane carrier market. Today, membrane ethane carriers are an integral part of the industry, with the first units already completing their initial special surveys.

As of August 2025, the global fleet of membrane-type VLECs includes 18 vessels in service, with a further 23 on order, among them eight Ultra Large Ethane Carriers (ULECs). The standard VLEC size equipped with GTT technology has now exceeded the 100,000 m³ threshold, while GTT has also successfully introduced the 150,000 m³ ULEC size to the market.

This growth reflects strong demand from leading owners such as EPS, IINO, MISC, MOL, Purus, and Reliance. It is also supported by the close cooperation between GTT and major shipyards, such as China Merchants Heavy Industries-Jiangsu, Dalian Shipbuilding, Hanwha Ocean, Hudong-Zhonghua, Hyundai Heavy Industries, Jiangnan, and Samsung Heavy Industries, as well as ship designers like Deltamarin and MARIC.

In addition to their standard multi-cargo capability, carrying ethane, ethylene, butane, propane, propylene and any LPG mix, membrane ethane carriers can also be offered with an "LNG Cargo Ready Notation."

When equipped with the Mark III technology, they may even be adapted for ammonia (NH₃) transportation.

GTT's membrane containment systems provide superior thermal performance compared with other independent tank systems. They are designed in line with industry practice, where vessels typically operate either fully loaded or empty. To reflect this, the system includes authorised filling limits: from 0% to 10% in the bottom part of the tank, and from 60% to 100% in the upper part. This arrangement makes possible to use low-density polyurethane thermal foam. reducing conduction and thereby lowering the boil off rate. By combining different filling levels across four cargo tanks, the system can safely accommodate all capacities from 0 to 100,000  $m^3$ .

The containment and cargo handling systems on membrane ethane carriers also allow the simultaneous transport of two different cargoes, for example ethane in cargo tanks 1 + 3, and propane in cargo tanks 2 + 4, with segregation systems designed in full compliance with industry rules.

The combination of GTT's membrane technology, which guarantees a low boil-off rate (BOR), with a lightweight containment system, delivers clear operational advantages.

#### PIONEERING PROGRESS - GTT TECHNOLOGY DRIVING THE NEXT GEN OF ETHANE CARRIERS

#### These include:

- At least 500 mm lower draft, enabling reduced fuel consumption.
- Limited thermal shock and shrinkage effects, allowing greater cargo volume by 500 m<sup>3</sup>.
- "Heel-Out" capability, increasing discharge volume at each voyage by more than 1,000 m<sup>3</sup>.
- Reduced cooling power requirements (by approximately half) during all phases of the voyage, such as ballast, laden and discharging, translating in lower fuel oil consumption (by more than 800 tons of Marine Diesel Oil yearly).
- Higher average speed of +0.8 knots based on Automatic Identification System data over five years voyages.
- Faster loading by 20% enabling shorter time in port and greater cargo volume on yearly basis.

Altogether, these factors result in approximately +5% more cargo carried per voyage and about 4% more voyages per year.

#### **Constant Innovation to Support Our Clients**

GTT continues to develop its technologies to deliver higher performance and lower costs for shipyards and ship-owners.

Recently, GTT introduced "SLIM™" versions of both Mark III and NO96 systems, which have received Approvals-in-Principle (AiPs) from major classification societies. These variants increase cargo capacities while reducing procurement costs.

- For VLECs, Mark III Slim<sup>™</sup> adds about 1,300 m³ of cargo capacity and reduces deadweight to 200 tons.
- For ULECs, the gain is around 1,800 m<sup>3</sup> with a weight saving 250 tons.

The new systems also support higher design pressures, up to 0,4 or even 0,7 barg in harbour and ballast conditions, reducing the operating time of the reliquefaction plant.

In addition, Ship-to-Ship (STS) transfer operations with membrane-type ethane carriers have been successfully demonstrated under standard marine conditions.

At the occasion of Gastech 2025 in Milan, GTT and its partners announced the launch of a new three-cargo tank VLEC design.

## **MEET GTT**

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





elogen

16 Oct. 2025

People Tech Marine, Greece 21-22 Oct. 2025

LNG Shipping & Terminals, UK

21-23 Oct. 2025

Hydrogen Technology World Expo. Germany







21-24 Oct. 2025

Kormarine, Korea

12-13 Nov. 2025

SMF Fest, Spain

25-27 Nov. 2025

Propulsion & Future Fuels, Germany











26-27 Nov. 2025

Ship Energy Efficiency Summit, Greece 02-04 Dec. 2025

Argus Clean Ammonia, The Netherlands 02-05 Dec. 2025

World LNG Summit, Istanbul, Türkiye

11-12 Dec. 2025

OSJ Conference Middle East, Dubai

## LEARNING & DEVELOPMENT

Stay up to date with our industry-focused training sessions

<u>Use of Ammonia, LNG, Methanol and Hydrogen as a Marine Fuel</u>
16-18 December

**GTT Membrane Technologies Course** 

16-18 December

**LNG Cargo Operations (Online)** 

<u>SIGTTO course:</u> 17-21 November <u>Refresher course:</u> 14-16 October

**FSRU Systems and STS Operations course** 

18-20 November

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

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