

# BONDING CRYOGENIC CONFINEMENTS

of **LNG**\* tankers

*\*Liquid Natural Gaz*



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**WHITE PAPER**

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# TABLE OF CONTENT

**INTRODUCTION.**

**3**

**LNG CARRIERS  
AND ONSHORE  
LNG STORAGE, AN  
ESSENTIAL LINK IN  
THE NEW GLOBAL  
ENERGY CHAINS.**

**4**

**MEMBRANE  
TECHNOLOGY  
DEVELOPPED BY  
GTT.**

**5**

**THE THREE  
STAGES OF BOX  
GLUING.**

**6-7**

**THE FOUR  
TECHNICAL  
CHALLENGES OF  
BONDING.**

**8-12**

**SAMES BONDING  
MACHINES FOR  
LNG TANKERS.**

**13-15**

# INTRODUCTION

## LNG carrier tanks: how to properly bond cryogenic containment ?

A modern LNG carrier consists of four 44,000 m<sup>3</sup> LNG tanks at -163 °C.

Their evaporation losses must not exceed 0.1% per day.

This is made possible by state-of-the-art cryogenic containment, with 27,000 bonded insulating caissons forming the first link in the thermal insulation barrier.

How can we ensure the efficiency of this bonding process which requires 120 tons of very expensive adhesives?

Is it possible to bond quickly and well?

How can we guarantee the availability of bonding machines on worksites operating in (3) 8-hour shifts or (3) 12-hour shifts?

In this white paper, Sames experts share the lessons learned from the construction of a hundred LNG carriers over 40 years.



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# LNG CARRIERS AND ONSHORE LNG STORAGE, AN ESSENTIAL LINK IN THE NEW GLOBAL ENERGY CHAINS

## Never before have shipyards around the world built so many LNG carriers.

In Asia, the world's leading powerhouse, 200 vessels were under construction at the beginning of 2023 at an average cost of \$250 million per unit. The world fleet totaled more than 640 vessels.

The United States, Australia and Qatar, the leading LNG-producing countries, are increasing their production significantly to compensate for declining supplies from Russia. By 2025, the global fleet of LNG carriers is set to outnumber that of supertankers.

This spectacular growth should not obscure the fact that it takes three to four years to build a single vessel. A LNG carrier is similar to a giant thermos,

400 meters long, in which four tanks hold a total of 176,000 m<sup>3</sup> of liquefied gas, i.e. cooled to -163 °C. The challenge is to insulate these tanks perfectly to limit evaporation losses to around 0.1% of volume per day.

The french company GTT, world leader in cryogenic containment, has been revolutionizing this market for 50 years with its membrane technology, which has been gaining ground over the last two decades at the expense of spherical tanks in favor of shapes adapted to ships' holds, and is now less costly to produce. This technology lowers the center of gravity of LNG carriers (resulting in higher cruising speed in heavy weather) and increases their LNG transport capacity by more than 50%.

## Sames and the construction of LNG carriers.

Sames works alongside GTT at shipyards all over the world for a unfamiliar but essential step: **gluing insulating caissons to the steel hulls of LNG carriers**. It is on these caissons that GTT's embossed stainless steel membranes are then attached, to form envelopes with exceptional insulating properties.



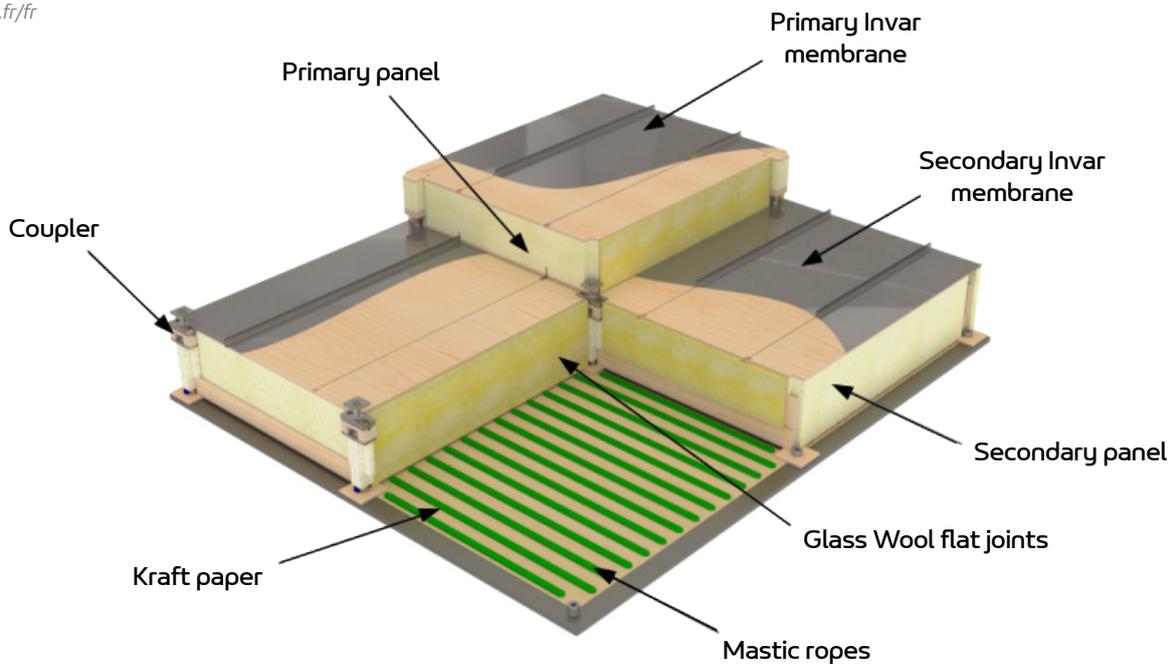
SINCE 1974, SAMES HAS BEEN INVOLVED IN THE CONSTRUCTION OF AROUND A HUNDRED LNG CARRIERS.

# MEMBRANE TECHNOLOGY DEVELOPED BY GTT

The NO and Mark membrane technology systems provide a reliable and safe solution for the bulk transportation and storage of LNG.

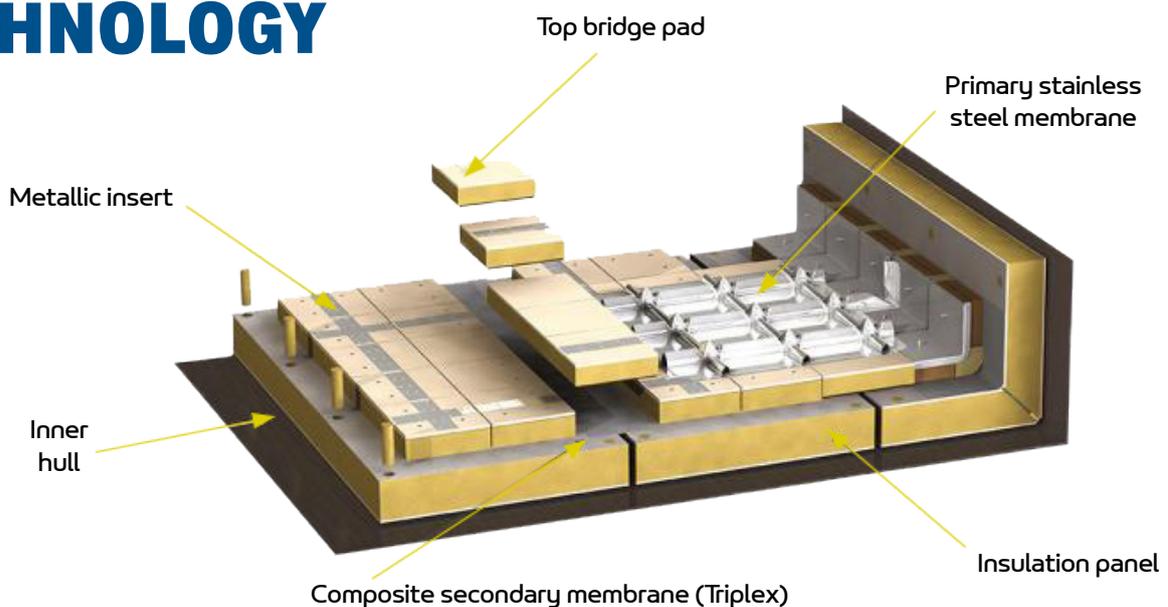
## N096 SYSTEM

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## MARK III TECHNOLOGY

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**BONDING CRYOGENIC CONFINEMENTS**  
of LNG tankers.



## THE THREE STAGES OF BOX GLUING

### STEP 1: Bonding the insulation boxes to the steel shell.

Several ribbons of epoxy glue are applied to each box by an automated resin applicator. The ribbons are pyramid-shaped. Their width is constant, but their height varies according to any deformations in the hull, previously measured by lasers. Therefore, the glue plays a dual role: fixing or wedging (depending on membrane technology) the steel and absorbing dimensional deviations.



### STEP 2: Bonding the composite membrane.

The composite membrane covers the joints between caissons to prevent thermal bridges and reinforce mechanical resistance to ship pitching and swell forces. It is fixed with a two-component adhesive (base and hardener), applied in wide, very thin strips.



### STEP 3: Bonding the top bridge pad.

The top bridge pad consists of insulating panels placed above the composite membrane. This ensures the continuity of the containment envelope. Three beads of a two-component adhesive are applied to the surface, with a thicker bead in the center. The operation should take less than 20 minutes after mixing to prevent the glue from hardening and no longer adhering with the same strength.



# KEY FIGURES

**27 000**  
caissons per ship.

**3m x 1m**  
average box size.

**300 kilos**  
average casing weight.

**500**  
different types of box.

**36 km**  
of secondary composite membrane.

**120 tons**  
of glue used for each vessel.

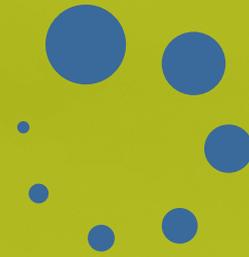
**5 to 25 €/kilo**  
average price of glues.

# THE FOUR TECHNICAL CHALLENGES OF BONDING



## CHALLENGE N°1

Can you control your glue consumption?



## CHALLENGE N°2

Can we glue even faster to reduce LNG carrier lead times?



## CHALLENGE N°3

How to guarantee effective, long-lasting bonding?



## CHALLENGE N°4

How to guarantee maximum availability of gluing machines?

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# CHALLENGE N°1

## Can you control your glue consumption ?

The insulating caissons of an LNG carrier require a total of 120 tons of highly technical, highly viscous adhesives. These have to be applied at a controlled temperature, around 30 °C for the bonding of the caissons to the hull, which sometimes requires air conditioning in the immediate environment.

Furthermore, they combine a base and a hardener in very strict proportions and must be applied within a short time to remain usable and fully effective.

### Best practices

- Pay careful attention to every detail of machine design to avoid dead volumes and product retention zones.
- Set up the machines for the first time before the worksite, and test them under real-life conditions for several days (temperature, humidity, speed, etc.).
- Check that glue bead widths and thicknesses are accurate to the nearest millimeter.
- It is requested to take ratio samples regularly during the day to guarantee the quality of the mixture throughout the LNG carrier's manufacturing process. No quality control can be carried out once the tank has been built."
- Train operators to manually adjust flow rates and visually inspect nozzles. A distorted nozzle deposits a bead of glue that does not comply with specifications and is often more abundant.

So there are several potential sources of waste:

Poor control of glue bead geometry (width, height). product loss due to insufficient or excessive tank temperatures. The optimum temperature of 22 °C is difficult to achieve due to the volume of the tanks. product losses due to delays in applying the caisson to the hull, which entails additional costs for removing the caisson, cleaning it, and applying new beads of glue.

All this on the scale of a bonding operation on 27,000 caissons and 36 kilometers of strings! An excess of just 1% of glue on an entire ship represents more than a ton of wasted product and significant additional costs.

# CHALLENGE N°2

## Can you glue well and work fast?

Even if the construction of an LNG carrier takes three to four years, each stage is completed under time constraints. After all, a dry dock has to be rented, and 30-meter-high scaffolding has to be erected at a cost of millions of euros.

As a result, crews work (3) 8-hour shifts or even (3) 12-hour shift. The shipowner and his inspectors make frequent site visits, as do the insurers. Every hour is precious, and all operations must run smoothly to avoid bottlenecks.

However, gluing the insulating caissons cannot be carried out in hidden time. It necessarily precedes the installation of GTT's stainless steel membranes, which is necessary to the manufacture of the LNG tanks.

How can you take account of these multiple pressures on lead times while guaranteeing consistently high bonding quality?

### Best practices

- Rely on proven technologies and machines resistant to the abrasiveness of the fillers contained in the adhesives (corundum), which have proven their worth on other LNG carrier construction sites.
- Check machine performance in terms of glue flow rates, pump power, application speed, rinsing, and cleaning cycle times.
- To quickly switch from one type of box to another (500 different types) opt for machines with automated gluing programs, activated by a barcode reader.
- Before starting work, test machines under real conditions for several days (temperature, humidity, speed, etc.) to limit on-site commissioning time.
- Have your operators been trained by experts from the machine supplier? Ask these experts for accompany the start-up for at least two to three weeks.
- Local assistance is needed to monitor the site during the resin-coating phase which lasts around 16 weeks per tank.



# CHALLENGE N°3

## How to guarantee effective, long-lasting bonding?

Reworking poorly bonded insulation caissons is every shipyard's nightmare. It causes cost overruns and delays, brings entire teams to a standstill, and casts doubt on the entire cryogenic containment of the LNG carrier... A scenario to avoid at all costs.

What's more, the bond must be durable. Otherwise, evaporation losses from the tanks will increase, and some of the loaded LNG will not reach its destination.

Although the adhesive is an invisible component of the LNG carrier, it plays a key role in the vessel's technical, economic and safe performance. Operators must constantly monitor two critical values: the base/hardener dosage ratio, and perfect product homogeneity at the static mixer outlet.

### Best practices

- Rely on tried-and-tested technologies and machinery proven on other LNG carrier construction sites.
- Before starting work, test the machines in real-life conditions for several days to check dosing ratios, casting quality, and correct bead laying.
- During construction, regularly check mix quality by means of crush tests.
- After each prolonged machine stoppage, repeat the dosing procedure. Adjust the base/hardener ratio according to ambient temperature which modifies the viscosities of both components.
- Perform daily platelet tests and submit them to a specialized laboratory.
- Ensure traceability of gluing operations: glue batch number, date and time, ambient temperature and name of operator, for each box.

# CHALLENGE N°4

## How to guarantee maximum availability gluing machines?

A high-performance gluing machine loses all interest if it has to stop frequently for rinsing, cleaning, maintenance, replacement of worn parts, or breakdowns.

Because around her, over forty operators find themselves out of business. There will be a delay in manufacturing the tank which may affect the overall construction schedule for the LNG carrier.

The gluing machine becomes the weak link in

an industrial process that is highly constrained in terms of deadlines and prices. And yet, the shipyards building LNG carriers are already fully booked for the next three years!

Therefore, they must increase their productivity to free up the dry docks which are the main bottleneck. For example, South Korea's largest shipyard has highly automated its process and can now manufacture an LNG carrier in 24 months. Fortunately, the hazards that threaten the availability of gluing machines can be anticipated.

### Best practices

- Rely on proven technologies and machinery which have demonstrated their high availability on previous LNG carrier construction sites.
- Check that the machine's design and choice of materials are compatible with the adhesives used. Example: abrasion-resistant metals for pump housings on caisson/shell gluing machines, as corundum is present in the glue.
- Perform preventive maintenance on all major wear parts identified as such before launching a manufacturing campaign.
- Ensure that the maintenance program is compatible with the team's work schedule.
- Check that there is a stock of spare parts and consumables in the country or nearby that can be available within a few hours.
- Verify the presence of repair technicians trained by the supplier and speaking a language widely used on the worksite, in or near the country.
- In the event of serious breakdowns, agree with the supplier on the timescale for intervention by its technical experts.



# SAMES BONDING MACHINES FOR LNG CARRIERS

**98%**  
average availability

## Laminator

Cartesian 3-axis gluing robot fed by a two-component machine:



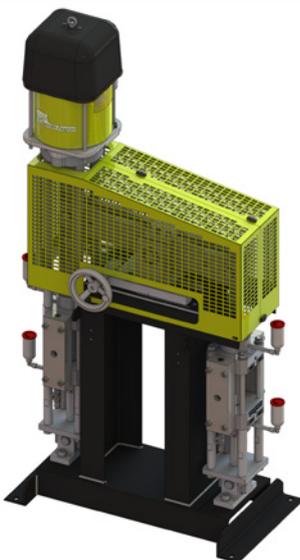
## Infinitec 2K solutions

High-pressure piston technology, with electronic variable dosage ratio.



## P85 solutions

High-pressure piston technology with mechanical variable dosage ratio.



## E60 triplex gluing machine

High-pressure piston technology with mechanical variable dosage ratio.



## Top Bridge Pad Machine

Triple comb sizing conveyor fed by a low-pressure gear machine with variable metering ratio.



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# DISCOVER SOME OF THE CONSTRUCTION SITES USING **SAMES** MACHINES



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of LNG tankers.

# TECHNICAL ADVICE

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**Sames** experts of LNG tank insulation bonding have been working on LNG tanker construction projects for 40 years, and can share the benefit of their experience in the field.

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## BOND • PROTECT • BEAUTIFY

With our manual guns, automatic and robotic applicators, supplied by our wide range of pumps & machines for fluid handling, dosing, mixing & dispensing Sames provides industrial solutions for production increase, quality improvement, material & cost savings.

We are designers and manufacturers of process equipment that is divided into 4 ranges:

### sames kremlin

Liquid paint application solutions



+



+



#### Airspray

Coating technology that guarantees the highest finish.

#### Airmix®

The perfect mix between finishing quality and productivity.

#### Airless®

Most productive application technology to protect surfaces.

### sames intec

### sames nanocoat

### sames inocoat



Sealant and adhesives application solutions



Liquid coating application solutions for rotating bells, with and without electrostatic



Powder coating application solutions