



Marine Cryogenic Insulation Provider

since 2001

General Introduction



GTI-Group is a group of companies doing engineering , material science and contracting specialized in Marine Cryogenic insulation field of Marine Cargo Tanks & Pipelines of Liquefied gas LPG/LEG/LNG carriers. We provide professional cryogenic cost effective insulation solution's, class approved materials as well as design, insulation repair & maintenance.

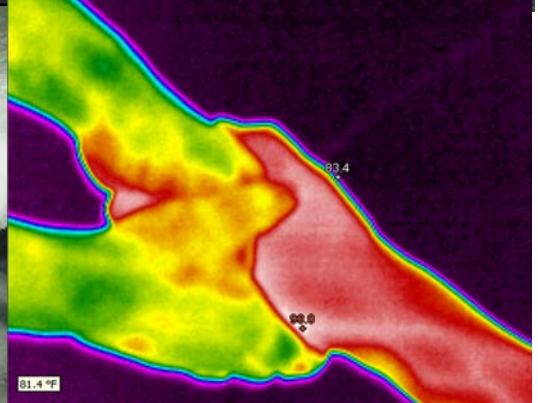
GTI group's predecessor was in 2001 as AAGARD consulting and our group members have over 25 years experience from the field. With the experience in cryogenic insulation, our technology and services can meet the requirements of customers around the world. We can supply all from class approved raw materials to apply turn key class approved solutions on vessels.

We have created more than 30 innovative patents of new insulation products and procedures and obtained the general customers consistent approval and praise. Our focus is to be in the front with technology and based on experience make best products that suits your needs



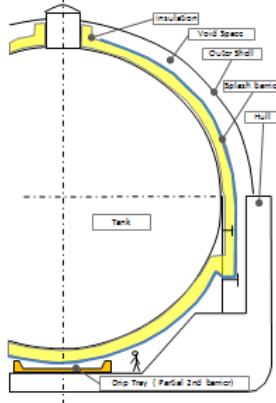
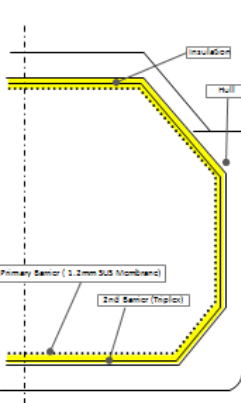
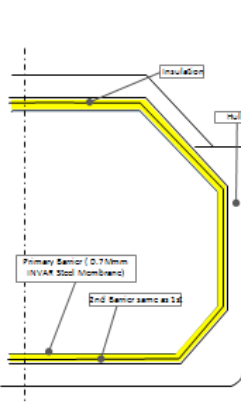
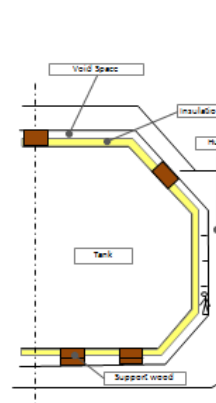
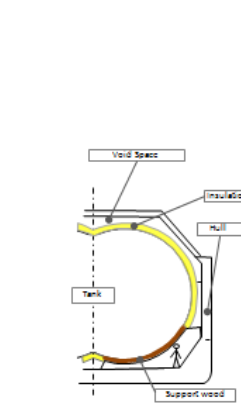
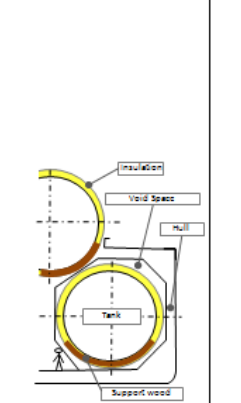
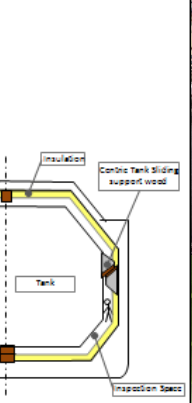
Marine Insulation Design Challenges

- Extreme weather conditions
- Tanks thermal cycling contraction / expansion
- Mechanical protection
- LNG spillage resistance
- Maintenance free
- Fire Protection
- Low Space requirements
- Ageing
- Cost



Main Cargo tank systems

OVERVIEW OF TYPICAL LNG/LEG/LPG CARGO CONTAINMENT SYSTEMS

	Spherical Tank with thermal brake (Moss Rosenberg)	Prismatic Membrane Tank (Insulation function as tank inside hull structure)		Prismatic Tank Supported with paralll wood supports (fixed & sliding types)	Bilobe tank Supported by paralll wood supports (fixed & sliding types)	Cylindrical Tank supported by paralll wood supports (fixed & sliding types)	Prismatic (& Cylindrical) tank supported by parralell & tank centric sliding wood supports
		Gaz Tranzport system (Mark III)	Techingaz system (no96)				
Typical CARGO	LNG (-163C)	LNG (-163C)	LNG (-163C)	LPG(-45C), LNG (-163)	LEG (-105C), LPG(-45C)	LNG (-163C) ,LEG (-105C), LPG(-45C)	LNG (-163C)
Typical Volume /vessel	LNG 80.000 – 150.000 m3	100.00– 250.000m3	100.00– 250.000m3	< 90.000m3	<40.000m3	< 60.000m3	
Tank Section							
Tank Material	Aluminium alloy or 9% nickel steel Typ. Thickness : 20 - 60mm (IMO Independant tank B Code)	Stainléss Steel Grade 304 L Typical Thickness 1.2mm (IMO Membrane tank Code)	36% nickel steel (INVAR) Typ. Thickness : 0.7mm (IMO Membrane tank Code)	Low temperature Carbon steel/SUS Typical thickness 15 - 35mm , Aluminium tank/ SUS (IMO Independant tank A/B Code)	Low temperature Carbon steel/SUS Typical thickness 15 - 35mm (IMO Independant tank C Code)	Low temperature Carbon steel/SUS Typical thickness 15 - 50mm (IMO Independant tank C Code)	Stainléss steel/ Aluminium , IMO Independant tank A code
Tank Secondary barrier (in case of tank rupture)	Tank insulation to be able to transport leaking cargo to Drip tray that function as secondary tank barrier.	Insulation designed with internal secondary barrer (Triplex)	Insulation designed with internal secondary barrer (Invar membrane)	For IMO B tank, insulation designed to transport leaked cargo to sump point as partial barrier. For IMO A-Tank LPG , not required	IMO C tank - Not required	IMO C tank - Not required	Insulation on hull side act as secondary barrier for leaked cargo up to 15 days
Insulation measures for thermal Contraction and Expansion	Insulation material deisgned with slots on cold side and flexible material/pattern on warm side. Crack barrier to stop potensional cracks to penetrate full insulation thickness	SUS membrane designed with buckling to absorb thermal contraction. Flexible Insulation joints between rigid Polyurethane panels	Insulation material properties with very low thermal contration coeffisient (Invar Steel, Plywood)	Insulation material deisgned to follow tanks movement. Sometimes with Crack barrier and crack barrier	Insulation material deisgned to follow tanks movement. Sometimes with Crack barrier	Insulation material deisgned to follow tanks movement. Sometimes with Crack barrier	Insulation material with flexible joints/ slotted cold sides covered with buckling outer surface
Insulation thickness	220- 300mm, 0.15% Daily boiloff rate, BOR	220 - 260mm, 0.15% BOR	500- 530mm , 0.15% BOR	120 - 400mm	120 - 200mm	120 - 350mm	200- 350mm
Typical Main Insulation Material	Fire retardant Plastic Foam/Polyurethanes & Mineral wools	Fire retardant Polyurethanes	Non combustible Perlite	Fire retardant Plastic Foam/Polyurethanes & Mineral wools	Fire retardant Plastic Foam/Polyurethanes & Mineral wools	Fire retardant Plastic Foam/Polyurethanes & Mineral wools	Fire retardant Polyurethane Panels

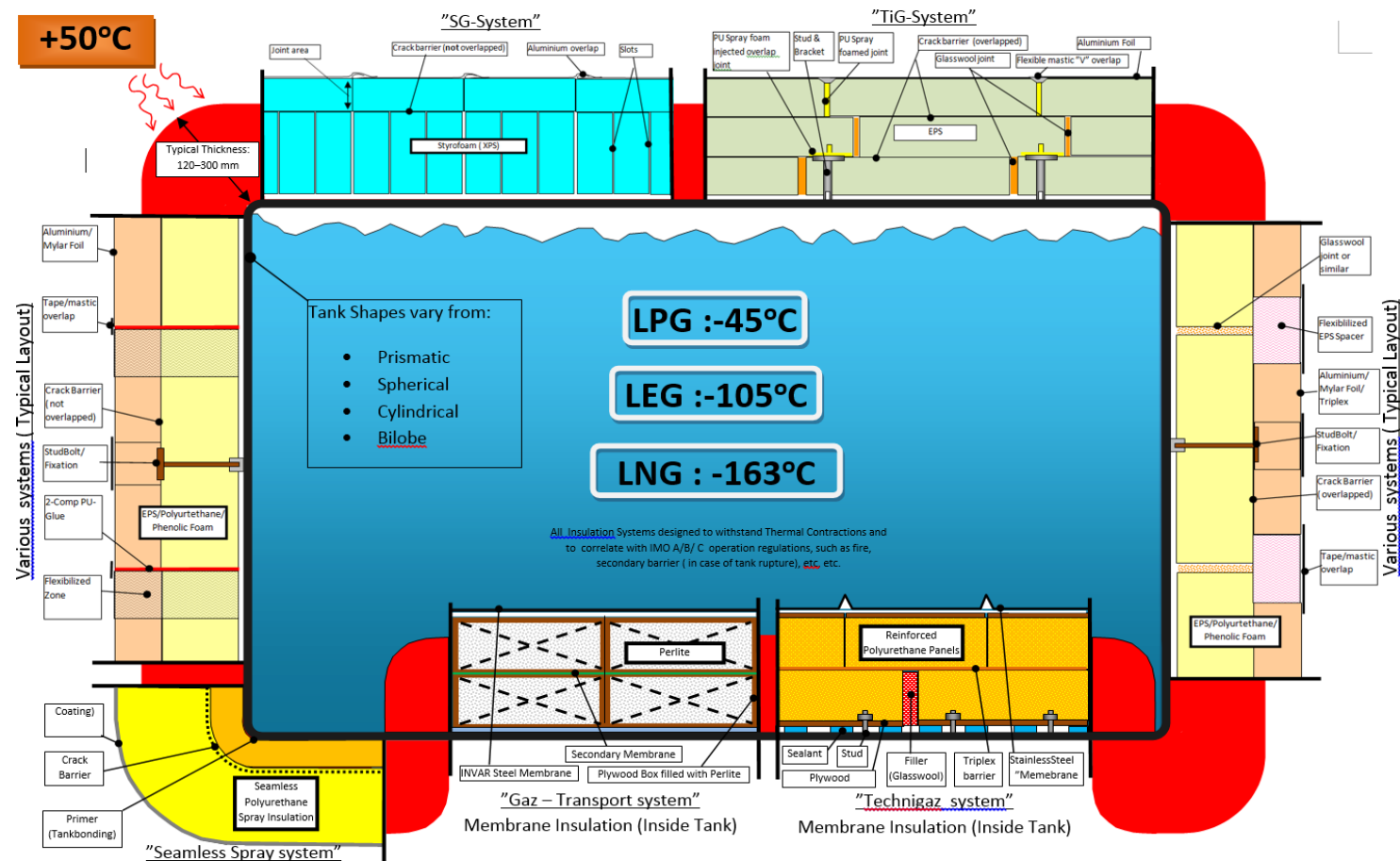
Main Cargo tank insulation systems

Choosing the right materials

Extensive trials and testing in order to obtain the necessary approvals for new materials and systems are often slow and expensive. Commercialization is also a challenging process due to general skepticism to new solutions in a conservative market, unlike the conventional insulation systems seen on vessels operating today, which are proven and have long service track records and references.

Panels or bonded insulation systems?

Prefabricated insulation panel systems were one of the first successfully commercialized insulation systems approved for installation on cargo tanks. Their main advantage is that the quality and end result of the panels are easily controlled during the prefabrication process. (fig 1) However, with a panel based system, a lot of effort and technical expertise is required to design, produce, assemble and install these panels – each individual panel must be fitted on the tank manually, requiring a lengthy installation period which also results in many joints. A leak in one of these joints due to human error and poor quality control can affect the insulation system in its entirety, with water and vapour ingress penetrating in through the layers and diminishing its insulation properties. This is a significant disadvantage, which is further exacerbated by the thermal cycles of expansion and contraction experienced during operation – loading, unloading of cargo, which places stress on these joints.



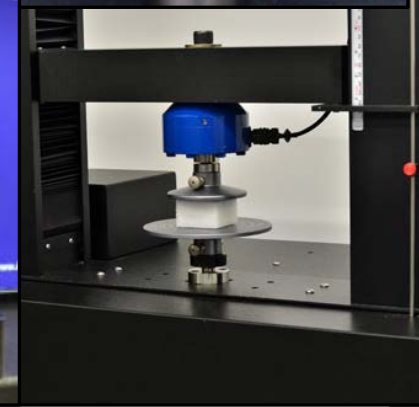
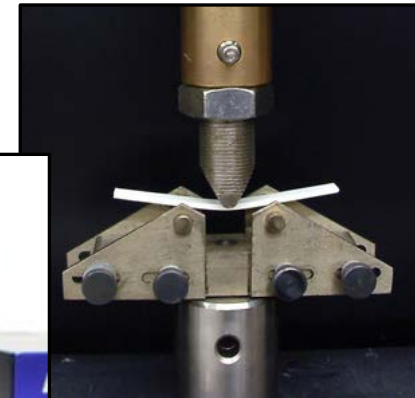
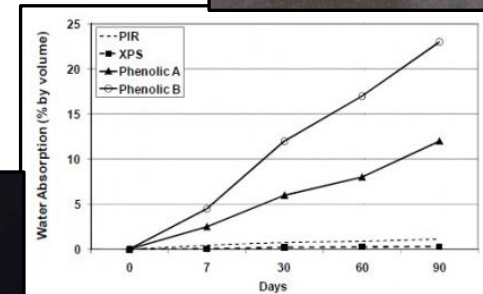
Cryogenic Insulation material requirements

Material Test items from IMO – IGF code

6.4.13.3.2 Thermal insulation and other materials used in liquefied gas fuel containment systems shall have the following properties, as applicable, to ensure that they are adequate for the intended service:

- compatibility with the liquefied gas fuels
- solubility in the liquefied gas fuel
- absorption of the liquefied gas fuel
- shrinkage
- ageing
- closed cell content
- density
- mechanical properties, to the extent that they are subjected to liquefied gas fuel and other loading effects, thermal expansion and contraction
- abrasion
- cohesion
- thermal conductivity
- resistance to vibrations
- resistance to fire and flame spread
- resistance to fatigue failure and crack propagation

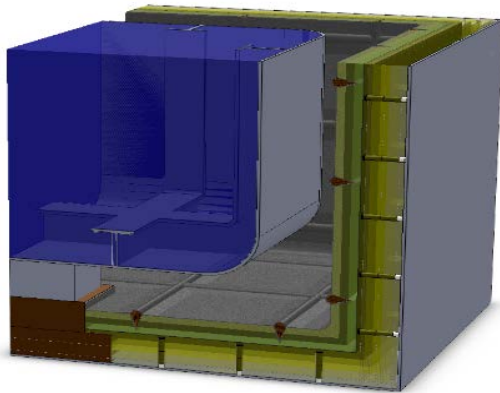
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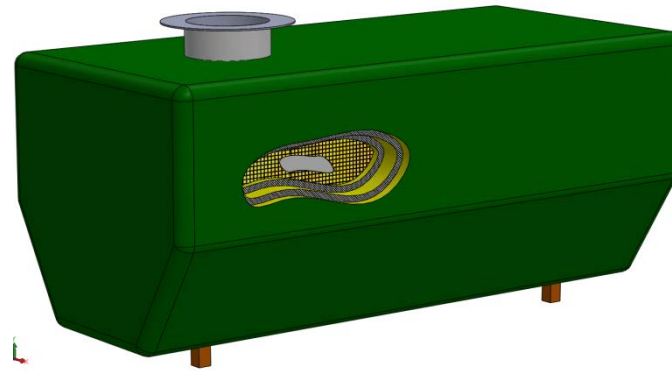
Tank Insulation by fully Reinforced Polyurethane spray foam Insulation system

Our fully reinforced and bonded PU spray insulation system can be applied on all IMO classed tanks. Our patented flexible and highly abrasive fire protecting LEM "Light engineering material" Polymeric coating is finally sprayed/ reinforced on the foam surface as outer protection.

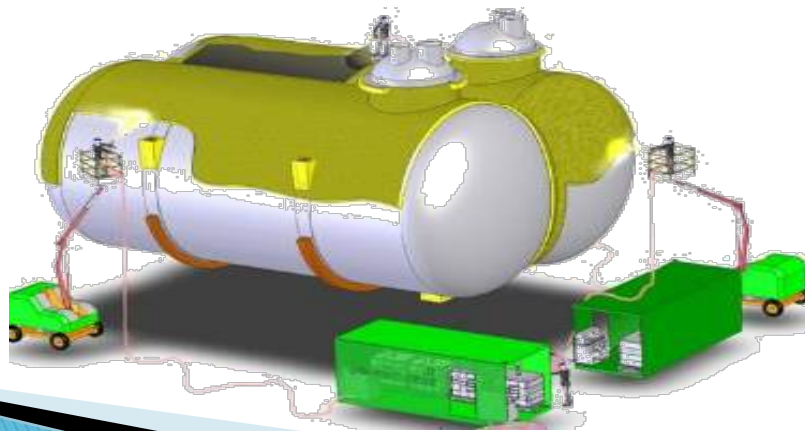
IMO LNG Type A tank



IMO LNG Type B tank



IMO LNG Type C tank



ADVANTAGES

- Fully seamless bonded & with non corrosive outer protection
- No joints or voids
- Less thickness required than panels
- Less storage area on site
- Easier transportation
- Cost effective and fast application
- Seamless solution for zero hour service

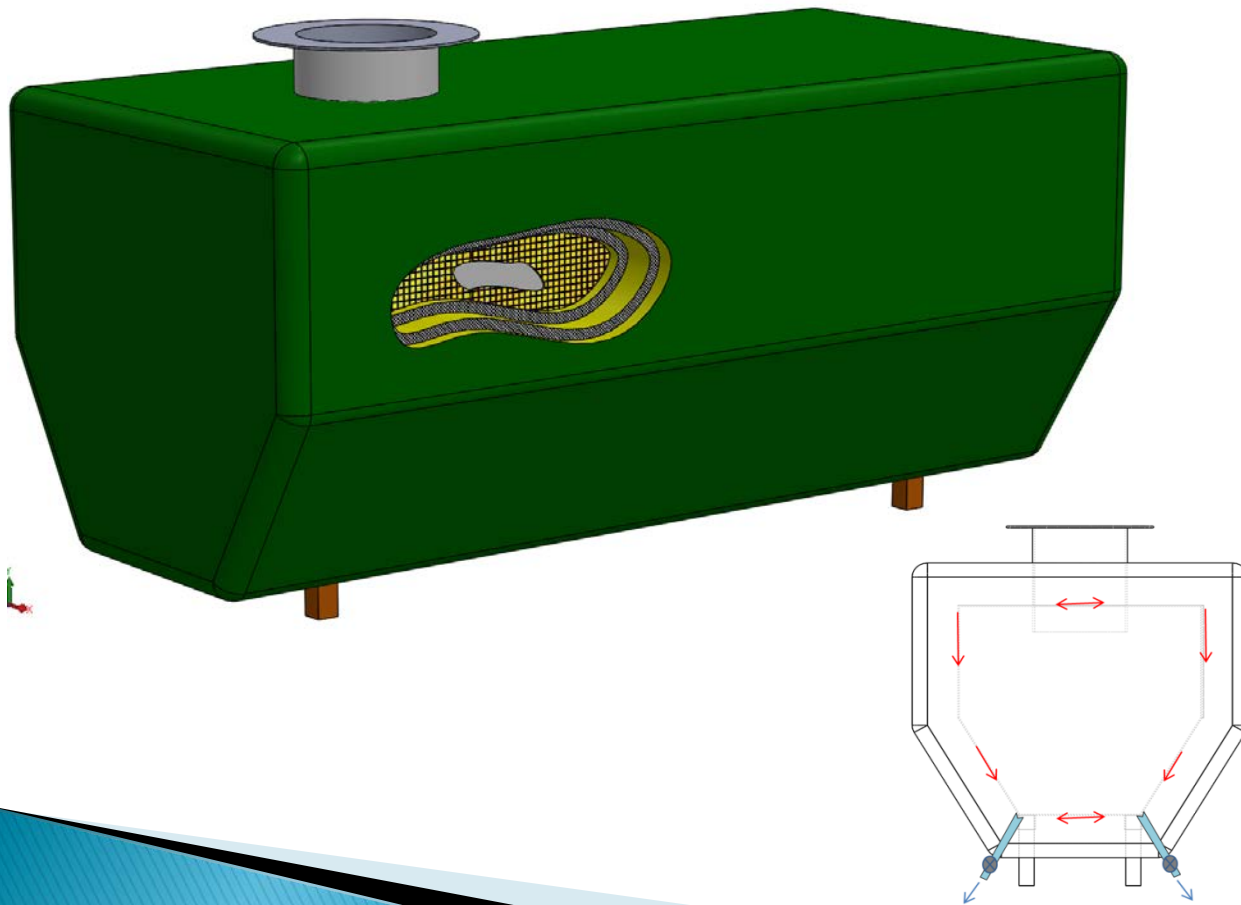
CONCERNS

- Can not be applied in humid / cold weather
(>94% RH, <5C)

IMO Type B tank / GTI Spray Foam Insulation solution

GTI developed & patented the Spray foam insulation solution on IMO Type B tank.

Spray foam insulation on B tank

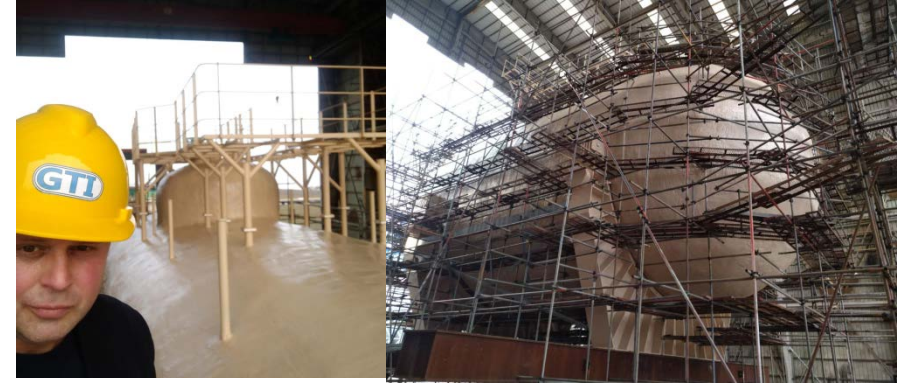
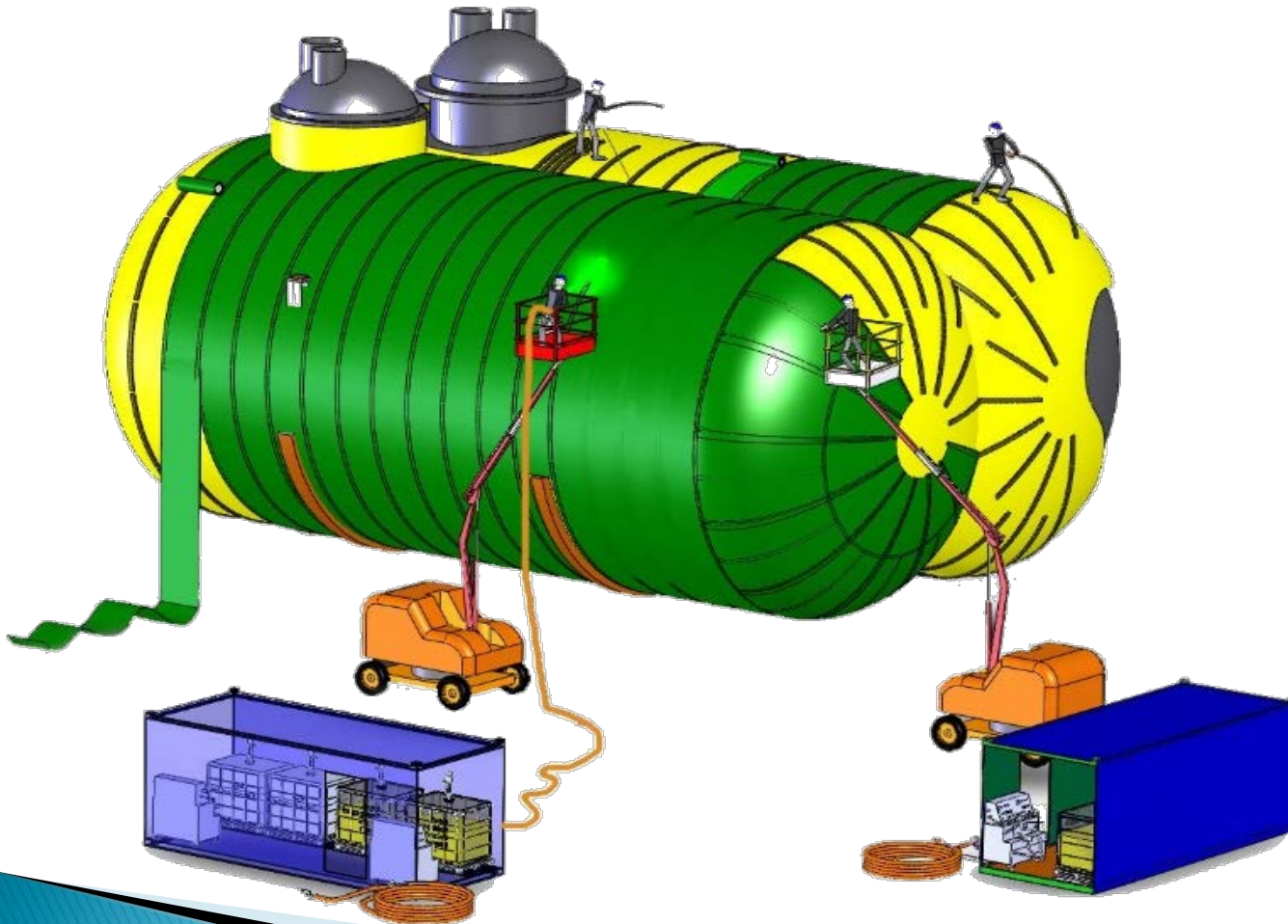


Main principles

- Efficient material Handling and less workforce requirement
- Seamless system without joints
- No stud bolts on tank
- Special vapor barrier and integrated small leakage drainage and detection system
- Homogeneous and seamless application eliminating risk for cold spots and cracking for the lifespan of the ship
- No Maintenance
- Cost effective, Low BOR

IMO type C tank for LNG Deck Tank Insulation

Fully reinforced seamless insulation system for deck tanks



Advantage

- Improved smoother prefabricated surface with no pinholes
- Improved Fire retardant properties
- Reinforcement system to prevent cracks and delamination
- Durable surface mechanical property

Pipe insulation Challenges

- * Instant cooling/contraction of pipe lines to -163C
- * Rough weather/work conditions on deck
- * Cryogenic (-163C) resistance of materials
- * Insulation properties/ageing
- * Maintenance/Visual
- * Fire resistance
- * Vapour tight
- * Vibrations
- * Support
- * Iceing
- * Cost efficient



Lack of Contraction joints and poor GRP jointing results in cracks– Water Ingress to insulation layers
 Lack of contraction joints of pipe insulation causes cracks in outer insulation layer as insulation will not be flexible enough to follow pipes natural thermal contraction. Besides of salt water and rain water, humid air from deck will be "sucked in" to the insulation.



Water in insulation layers becomes ice and crushes Insulation cell material
 Locations where water accumulates in insulation layers will crush insulation cells and create worse and worse situation for each cool down.

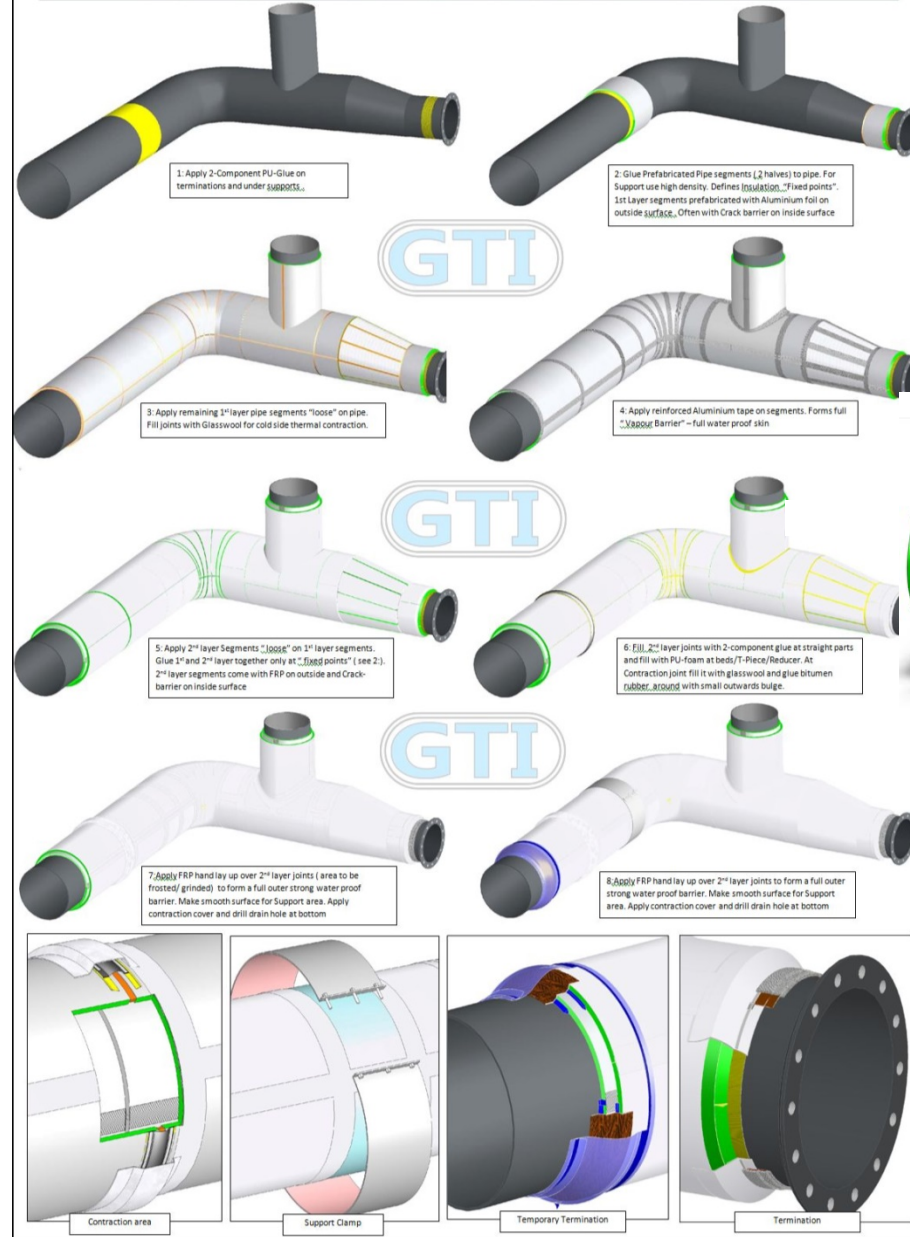


Crushed insulation material result in failure of Pipe support area
 Support Insulation areas are part of the pipes structural support. Ice Crushed insulation at those locations can cause very dangerous situations for pipe rupture caused by vibrations and friction to ships structure

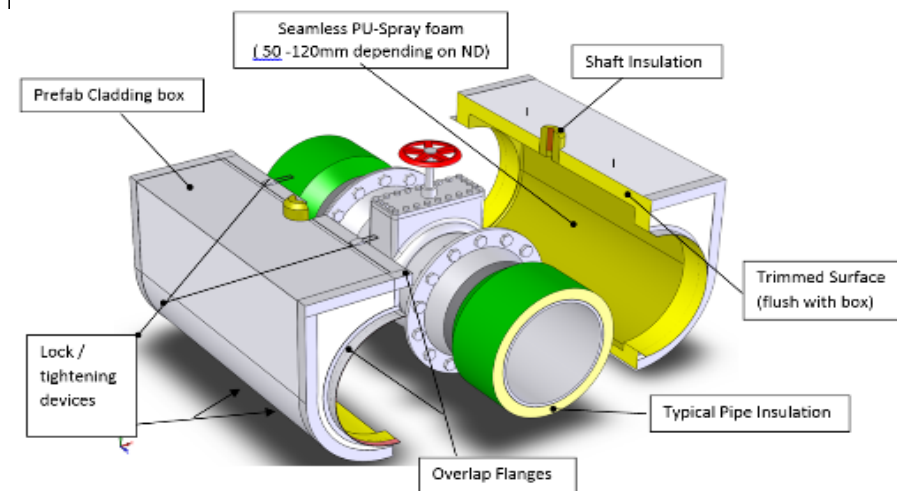
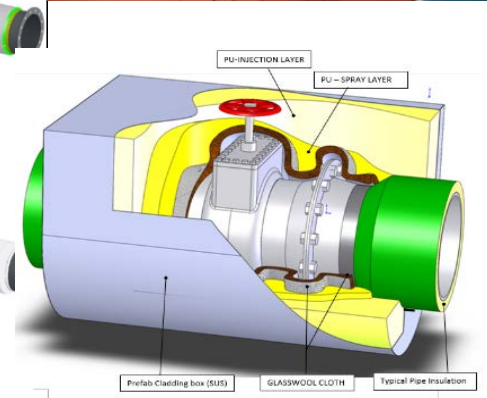
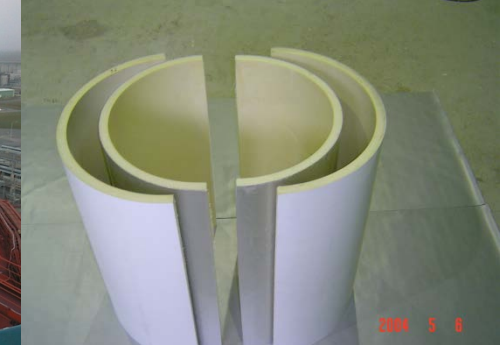


Pipe Insulation Prefabricated pipe segment solution

- ✓ Multilayer system
- ✓ Vapor barrier on first layer
- ✓ Contraction flexible buffer required
- ✓ Glass fibre mesh as crack barrier
- ✓ Glue joint
- ✓ GRP/Al/SS protection



Multilayer insulation



Valve insulation

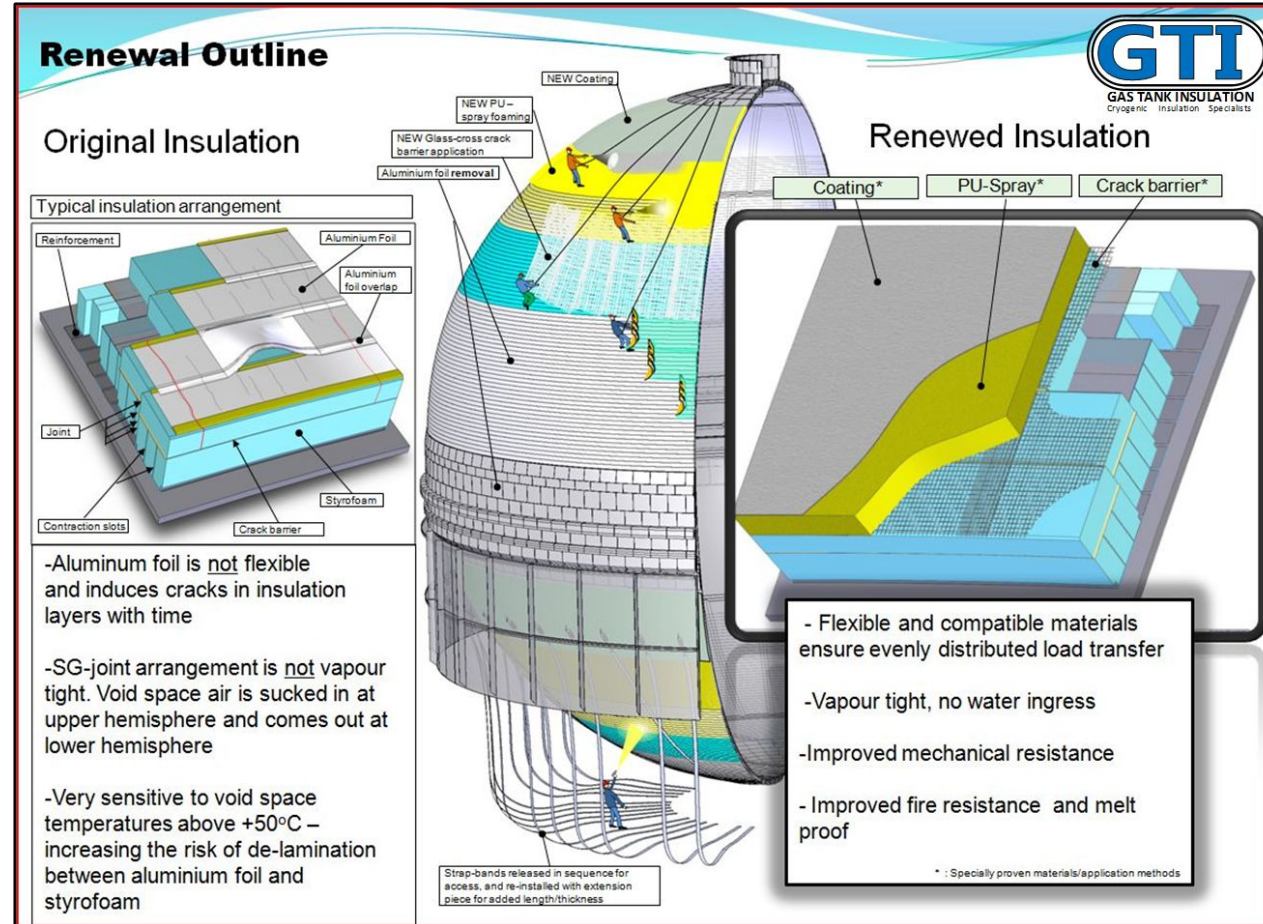
Typical Insulation Failures – LNG PIPE/TANK insulation



Repair solutions for MOSS tank Panel / SG-Systems

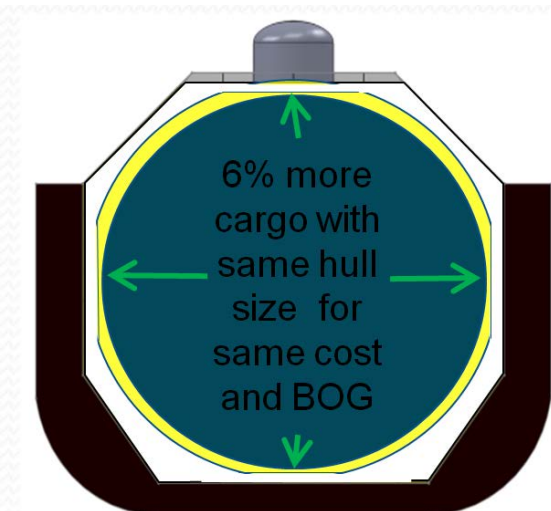
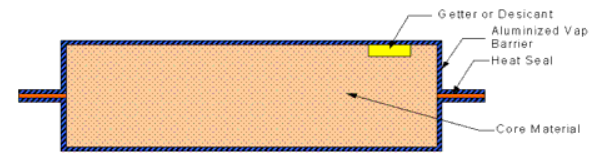
- Reduced Boil Off %
(from 0.025 to 0.015 or 0.015 – 0.008)
- Renewed Insulation System
- No removal of original insulation layers
- 100% Vapour tight system. Small leak shield rectification
- Reduced Inert Gas Consumption, 100% tight seamless and reinforced outer barrier
- Improved fire retardant
- Efficient Application
- Proven method & materials

GTI have experience for repair and full upgrade of 6 moss tankers since 2001



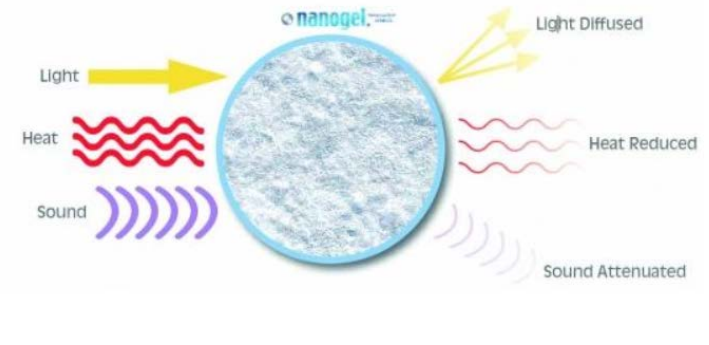
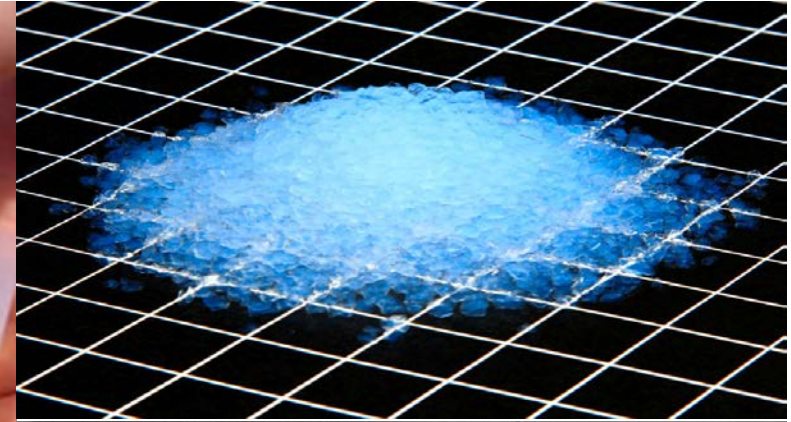
VACCUME panel insulation (VIP) for cryogenic LNG fuel tanks

- LOWEST K-VALUE OF ANY MATERIAL ON EARTH (initially 8 – 10 times better than PU-Foam)
- EASY TO COMBINE AND INSTALL WITH SPRAY FOAM
- NON COMBUSTIBLE MATERIAL
- VAPOUR TIGHT
- REFLECTIVE BARRIER
- ~50% REDUCTION IN WEIGHT/PU FOAM INSULATION PROPERTIES



Aerogels

Often referred to as 'frozen smoke', Aerogels are ultra light-weight nano-porous materials consisting of gas particles replacing liquid to make up their molecular structure. The result is a solid, light weight material (the lightest known man-made material that has very low thermal conductivity and fantastic insulation properties. It can also be made hydrophobic - disallowing water to enter its nano-porous structure - and generally environmentally friendly. However, more research is required to produce it economically for commercial use. In the near future, one might find it commonplace on cryogenic insulation systems.



Thank you

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