Cryogenic Tanks for LNG

EASISchool 2 – 2019/10/01

Benoît MOREL

Safety | Excellence | Innovation | Teamwork | Transparency

GTT at a glance

A French **technology and engineering** company with **more than 50 years of experience** in the design of the Membrane Cargo Containment Systems.

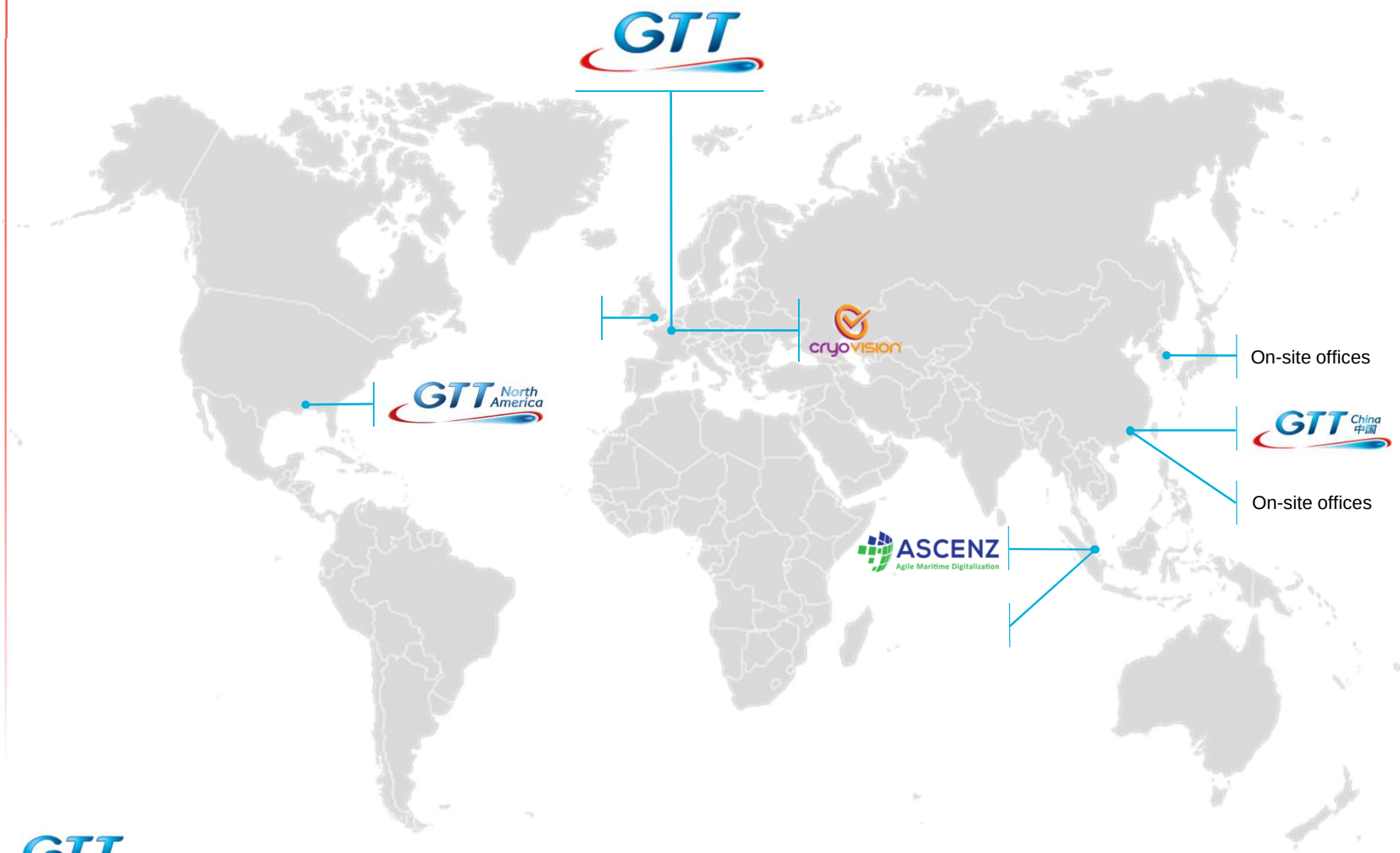
Expert in liquefied gas containment systems

GTT is a public company listed on the Euronext Stock Exchange (Paris)

428 highly qualified people(1), present worldwide

(1) As at June 2019 - GTT SA / Excluding interns and apprentices

A worldwide group

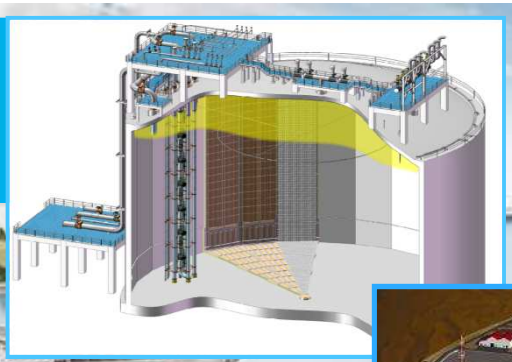


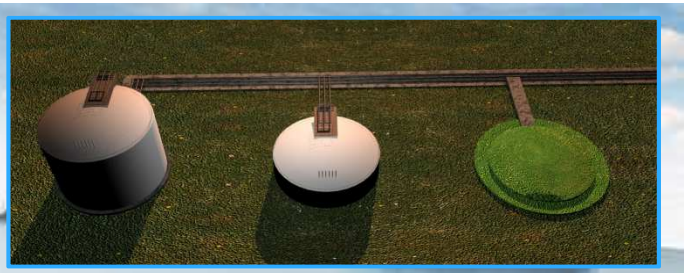
Cryogenic liquefied gases

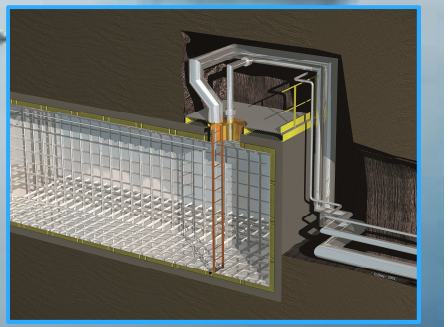
Liquids	Composition	Temperature of Liquefaction	Density (kg/m^3)
LH_2	H_2	20K	70
LN_2	N_2	77K	807
Liquid Argon	Ar	87K	1397
LNG	**CH_4 (70%-99,8%), C_2H_6 (0,1%-15%), C_3H_8 (0-10%), …**	**110-112K**	**430-470**
Liquid Ethane	C_2H_6	184K	544
GPLs	$C_3H_8 – C_4H_{10}$	231 – 272K	581 - 602

LNG Tank : Transport & storage

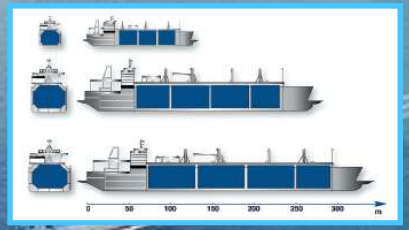
- Land storage
  - Liquefaction
  - re-gasification
  - 60 000 à 300 000 m^3







- LNG tanker
  - 20 000 à 260 000 m^3



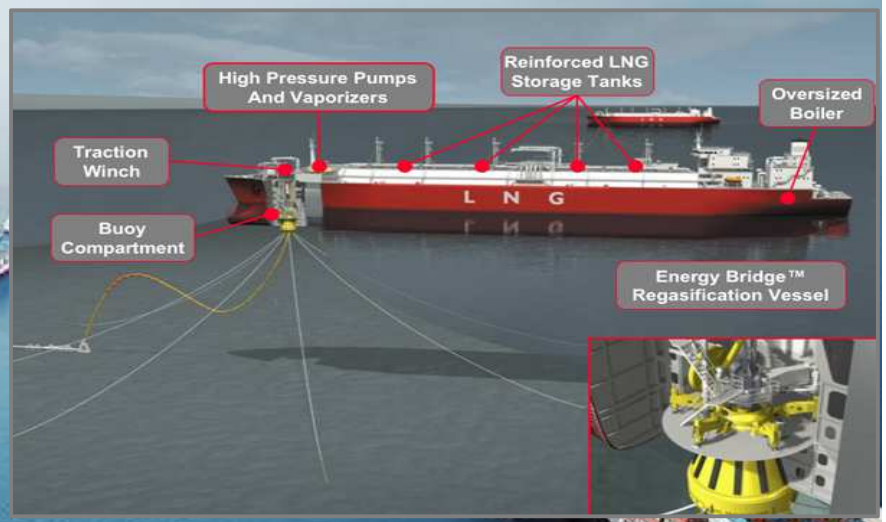
LNG Tank : Production « Floating LNG »

Dimensions

- Length 488m
- Width 74m
- Draught 17-20m
- Weight 600,00 ton fully ballasted; 260 000 ton dead weight

FPSO : Floating LNG Production, Storage and Offloading unit

- Floating LNG « FLNG »
  - FPSO
  - FSRU
  - 100 000 à 200 000 m^3



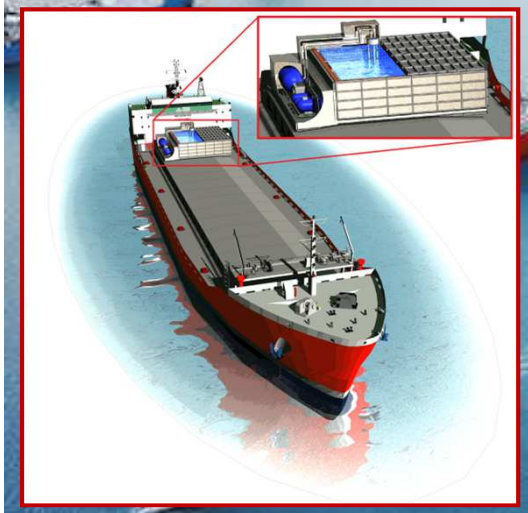
FSRU : Floating storage & regasefication Unit

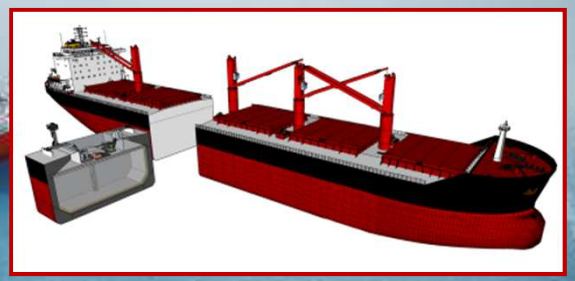
SRV : Sail & Regas Vessel

LNG Tank: LNG as a Fuel

- RoRo/Cruise
  - 600 to 4000 m^3

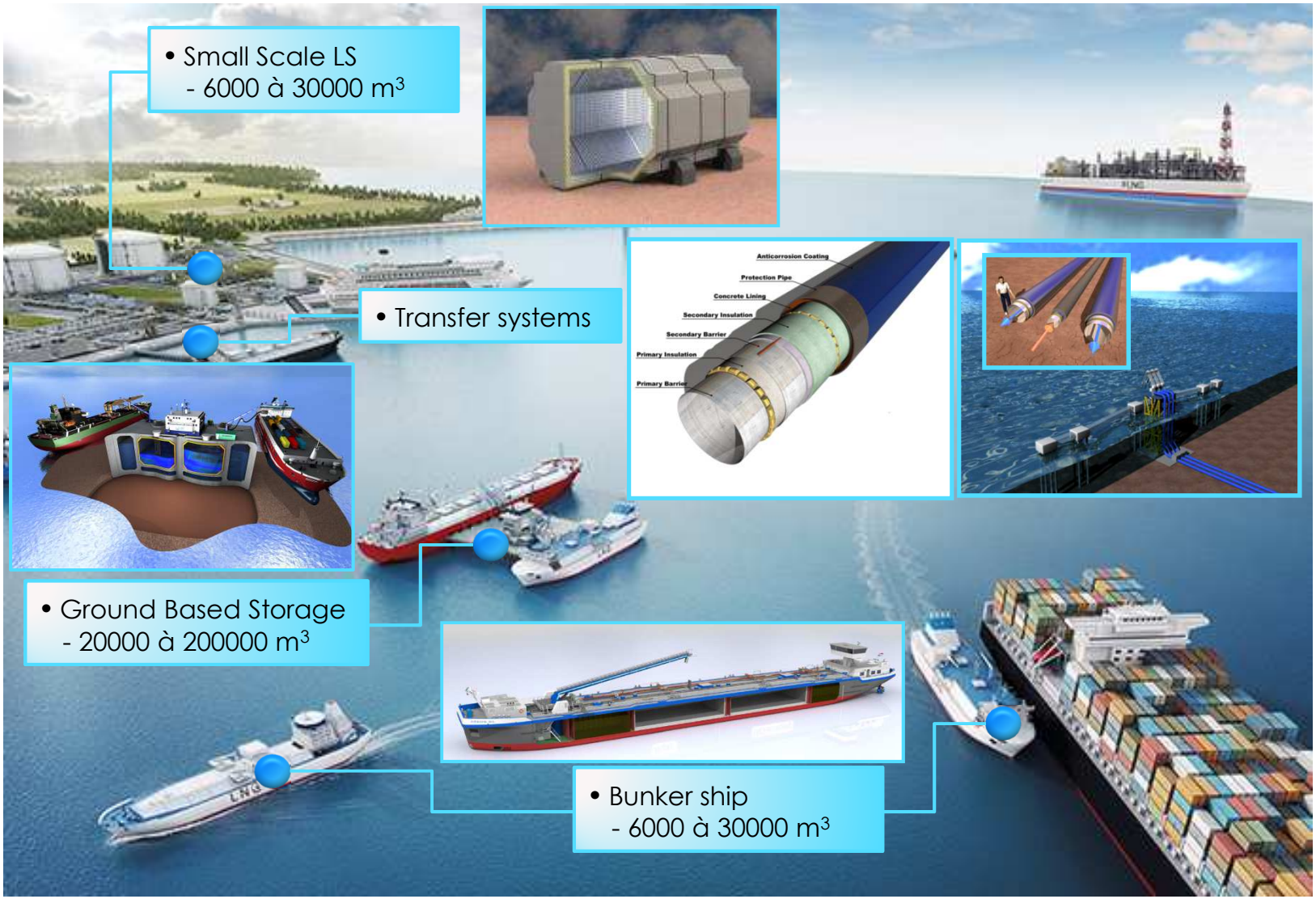
- Tanker/ Bulk carrier
  - 2000 to 6000 m^3





- Containers
  - 10000 to 30000 m^3

LNG Tank : local distribution networks



Cryogenic Cargo Tanks

Generalities

- Classification of CCS

IMO Classification of LNG Carriers

Independent tanks

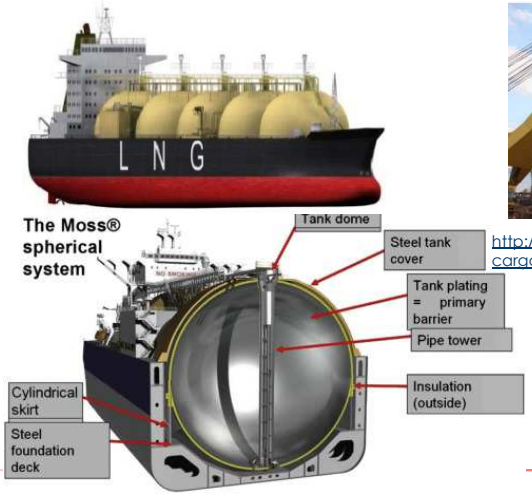
Type A
P0 ≤700mbar
Full secondary barrier

Type B
Po≤ 700mbar
Partial secondary barrier

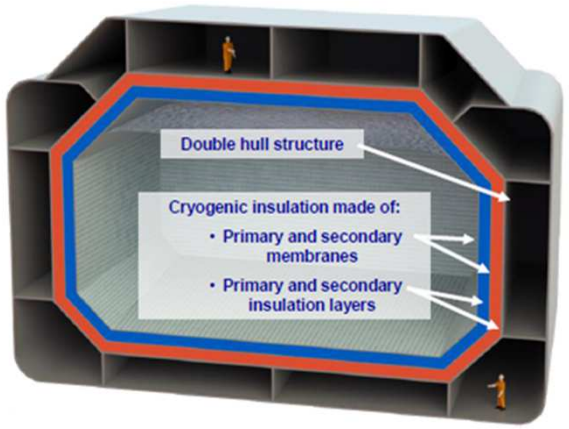
Type C
P0 ≥ 2000mbar
No secondary barrier

Integrated tanks

Membranes
P0 ≤700mbar
Full secondary barrier



http://www.liquefiedgascarrier.com/cargo-containment-systems.html



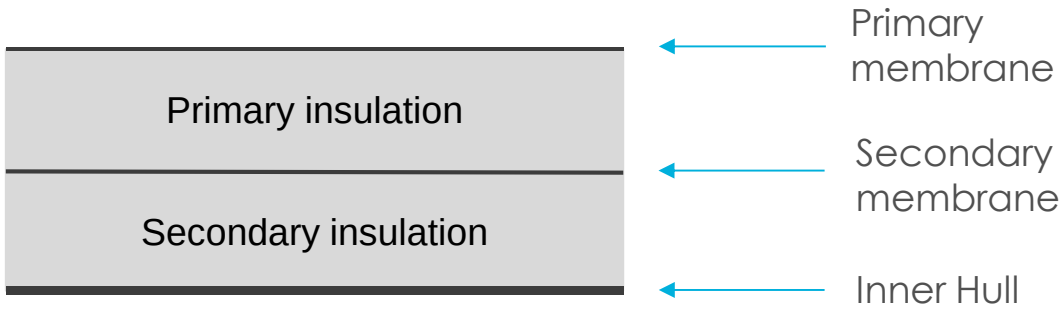
Generalities

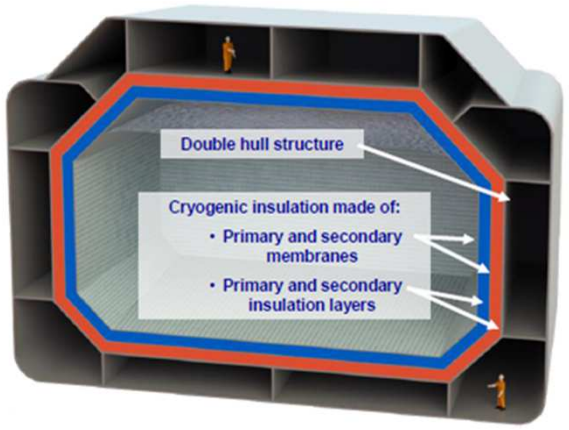
Classification of CCS

IMO Classification of LNG Carriers

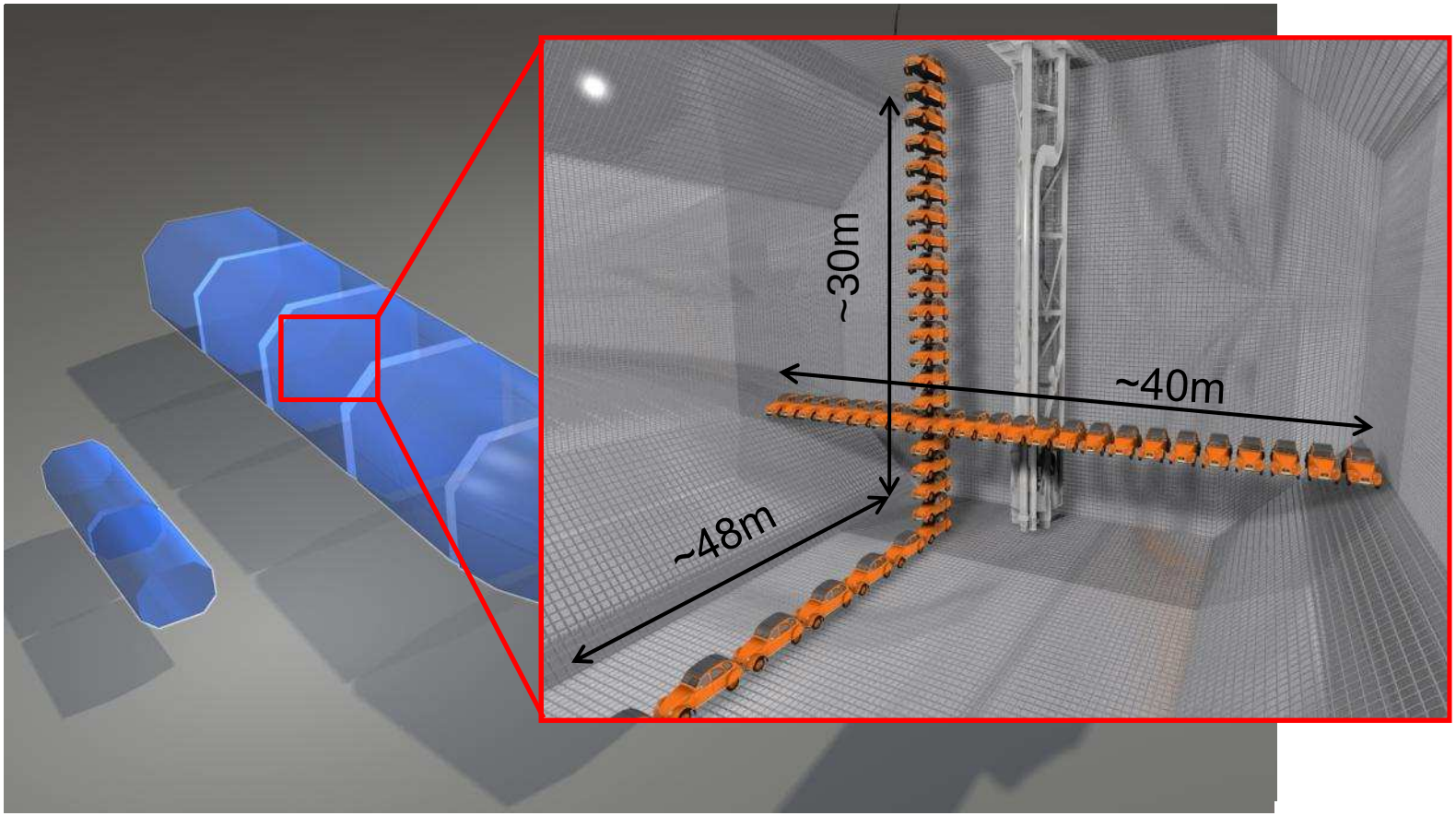
- **Independent tanks**
  - **Type A**
    P0 ≤700mbar
    Full secondary barrier
  - **Type B**
    P0 ≤ 700mbar
    Partial secondary barrier
  - **Type C**
    P0 ≥ 2000mbar
    No secondary barrier
- **Integrated tanks**
  - **Membranes**
    P0 ≤700mbar
    Full secondary barrier

Principles of GTT membrane systems





LNG carriers: some size key figures



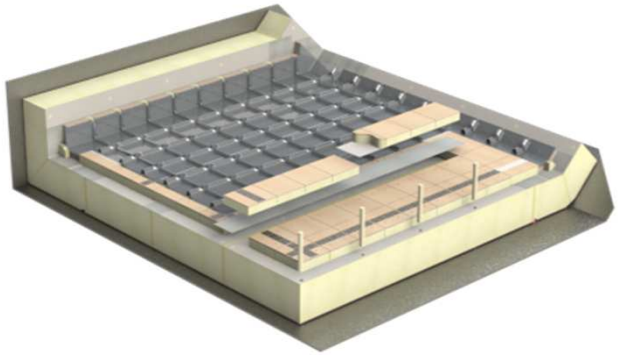
- ~ 5000 à 13000 m^3 of insulation
- ~ 10 à 25 km of welding per tank

Common Characteristics of membrane

- Complete double hull vessels (bottom, sides, deck)
- Containment system anchored to the inner hull
- Two membranes (second able to hold LNG for at least a fortnight as per Int. Gas Carrier Code)
- Two layers of insulations (secondary able by itself to keep temperature above design parameters of steel grades in worst conditions)
- Insulations spaces inerted with Nitrogen

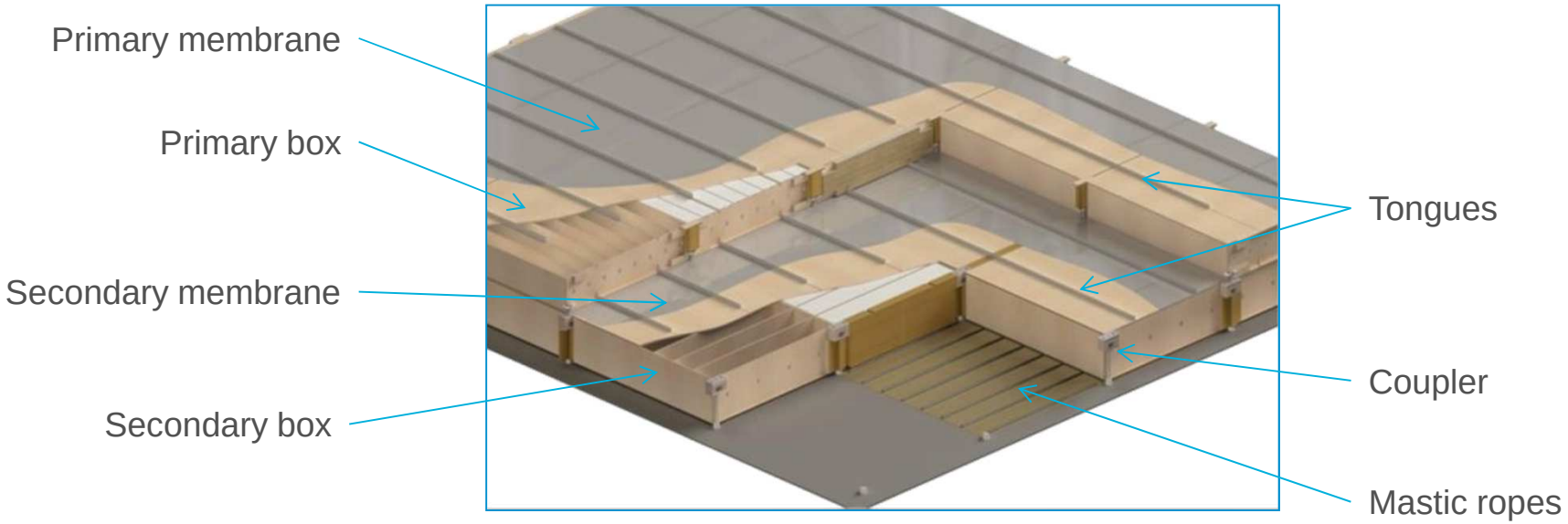
NO96 system

Mark III system

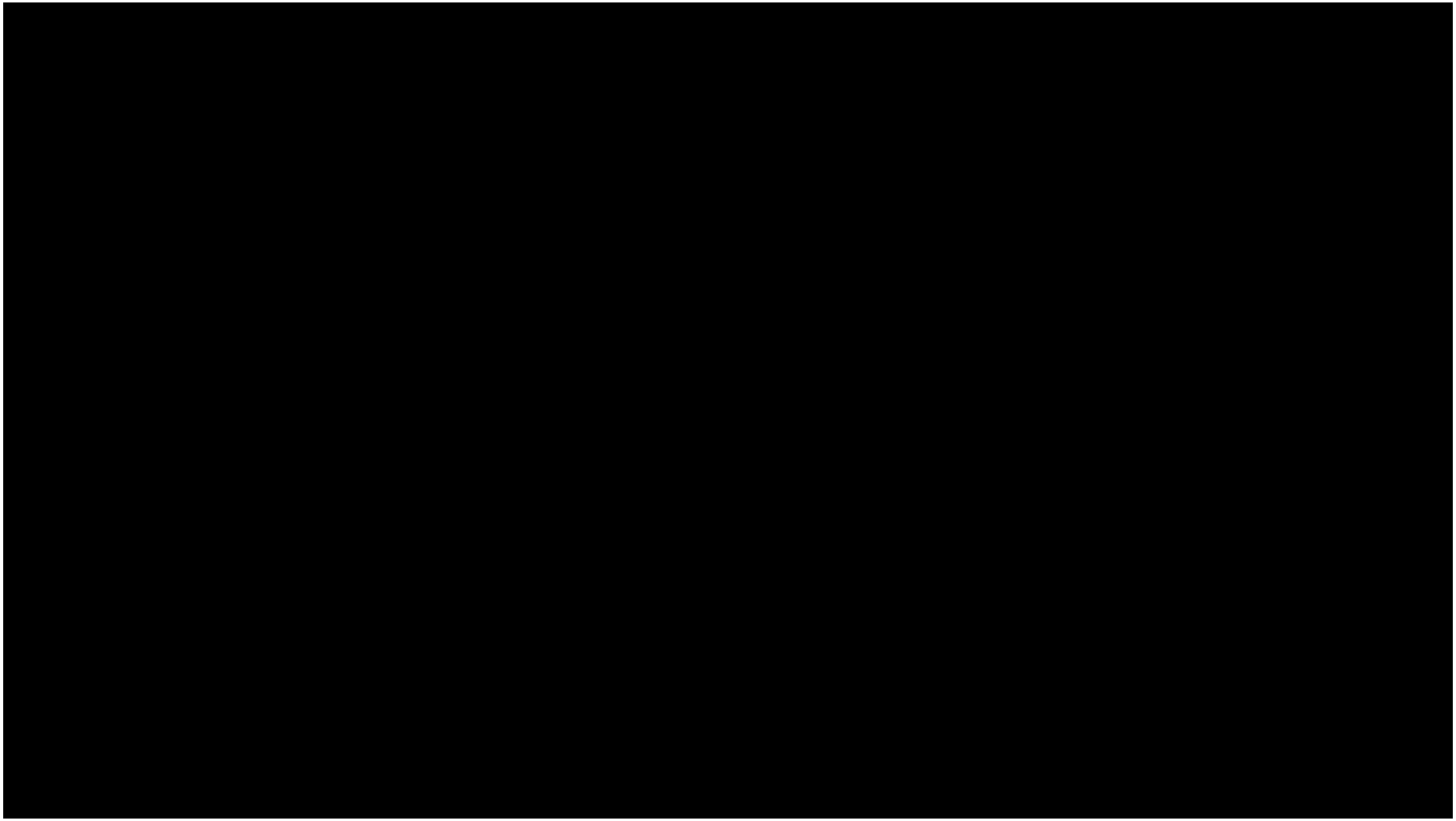


NO 96 CCS: Description

- Boxes made of birch plywood
- Perlite as insulation material (or Glass Wool in NO96GW)
- Primary and secondary membranes made of 36% Nickel-Steel alloy



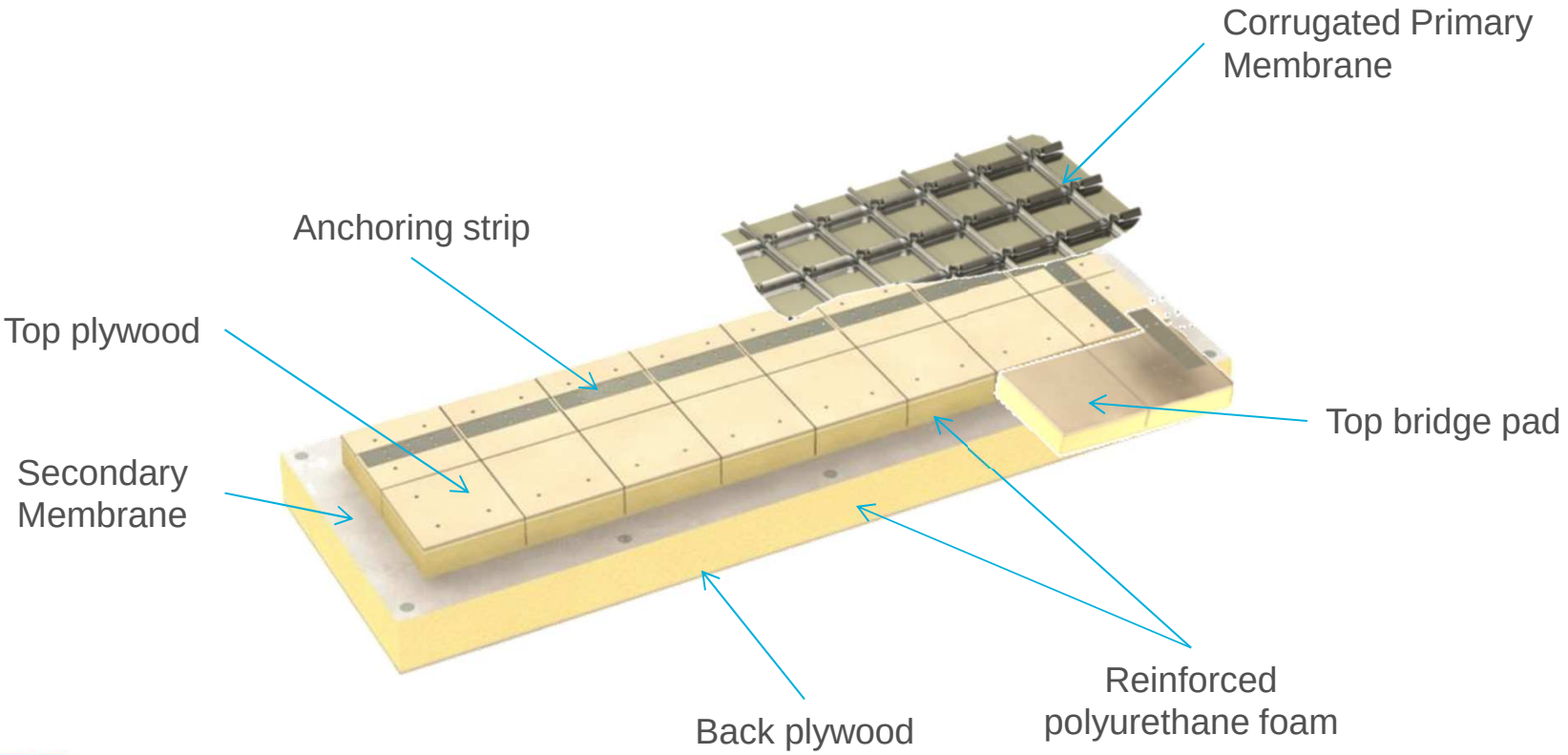
NO 96 GW system



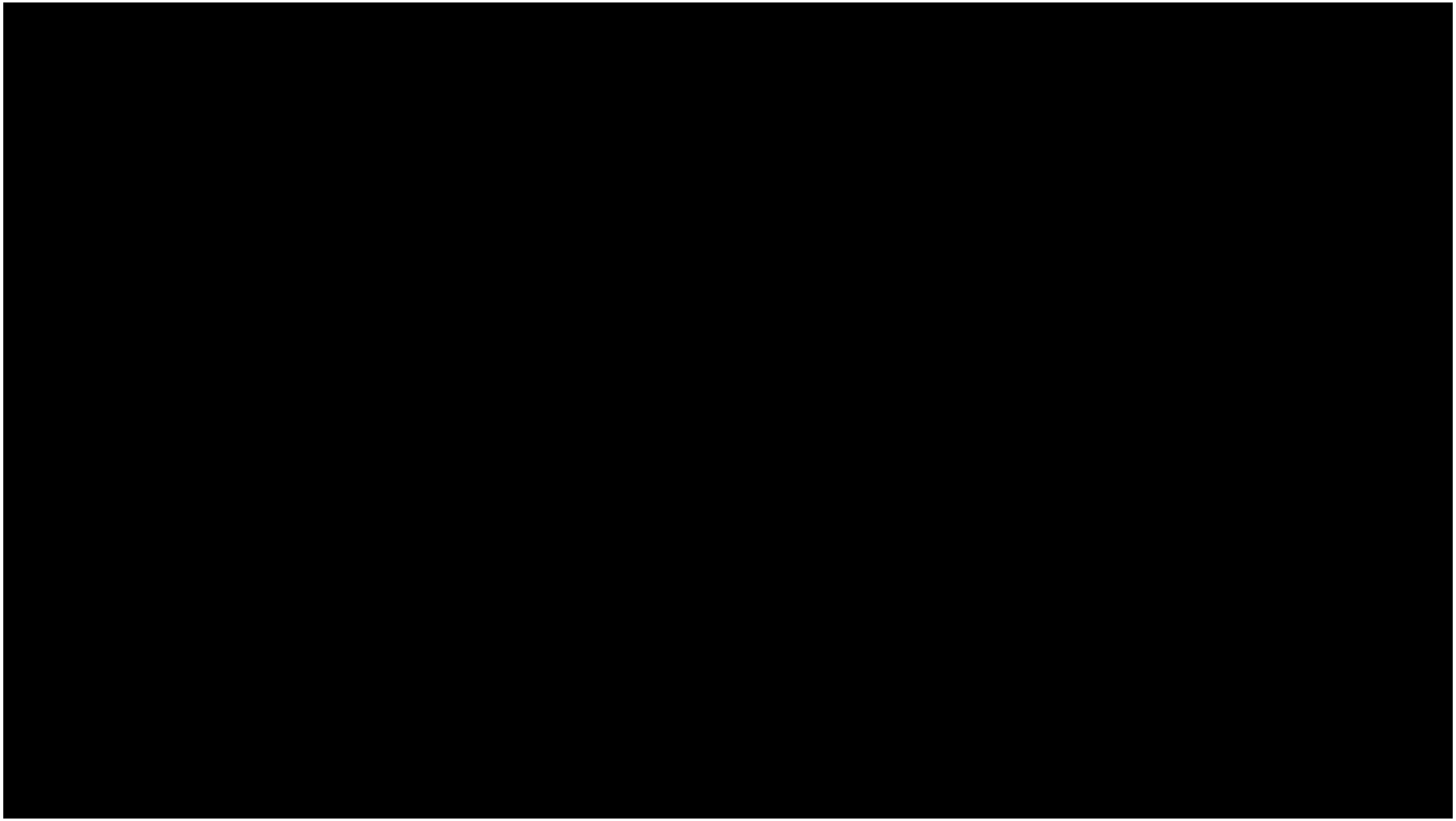
NO 96 GW system

Mark III CCS: Description

- Insulating panel made of reinforced PU foam
- Corrugated primary membrane made of SUS304L
- Secondary membrane made of aluminium foil between two glass cloths



Mark III system



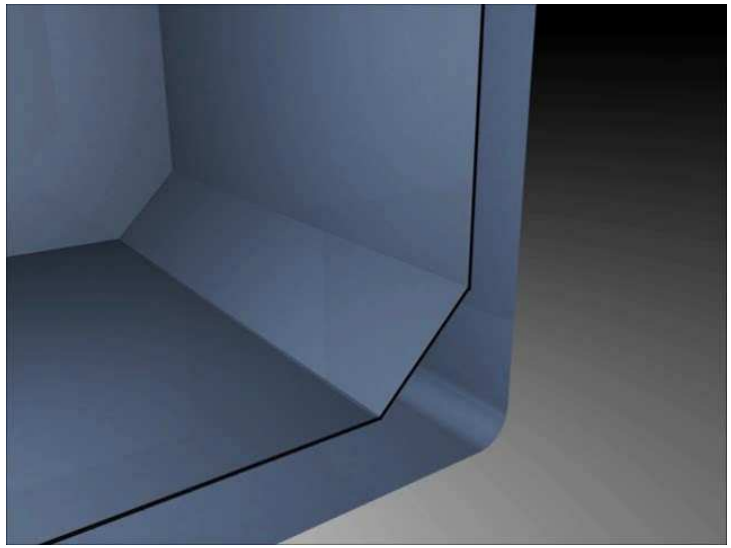
Mark III system

LNG carriers: mechanical stresses

- Structure : double hull deformation

Flexion

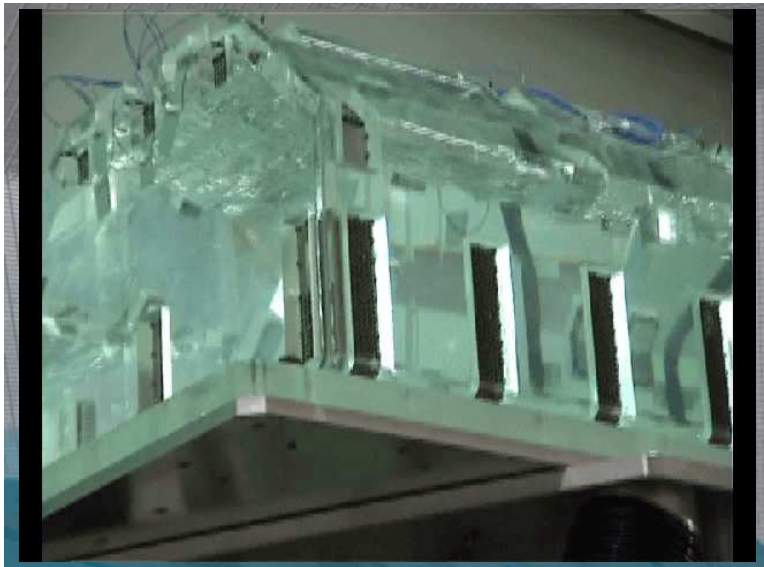
Ballast Pressure

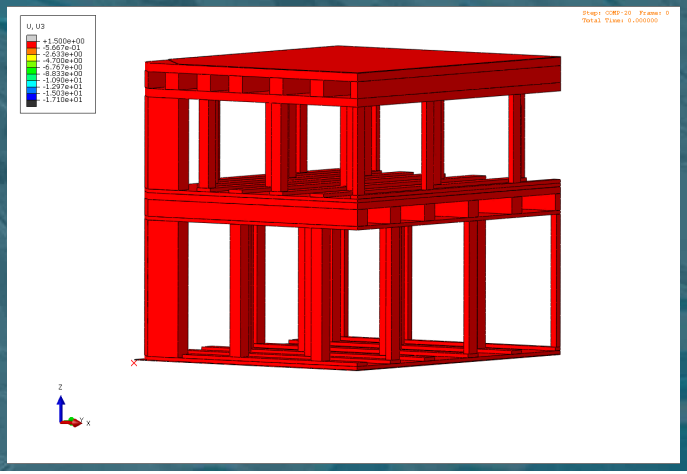


Torsion

LNG carriers : mechanical stresses

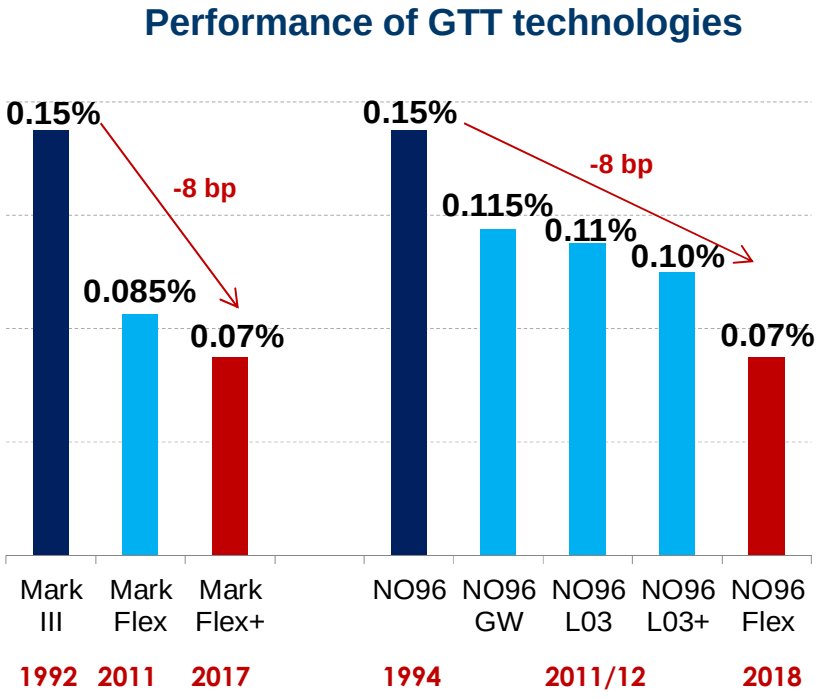
- Fluid : cargo sloshing

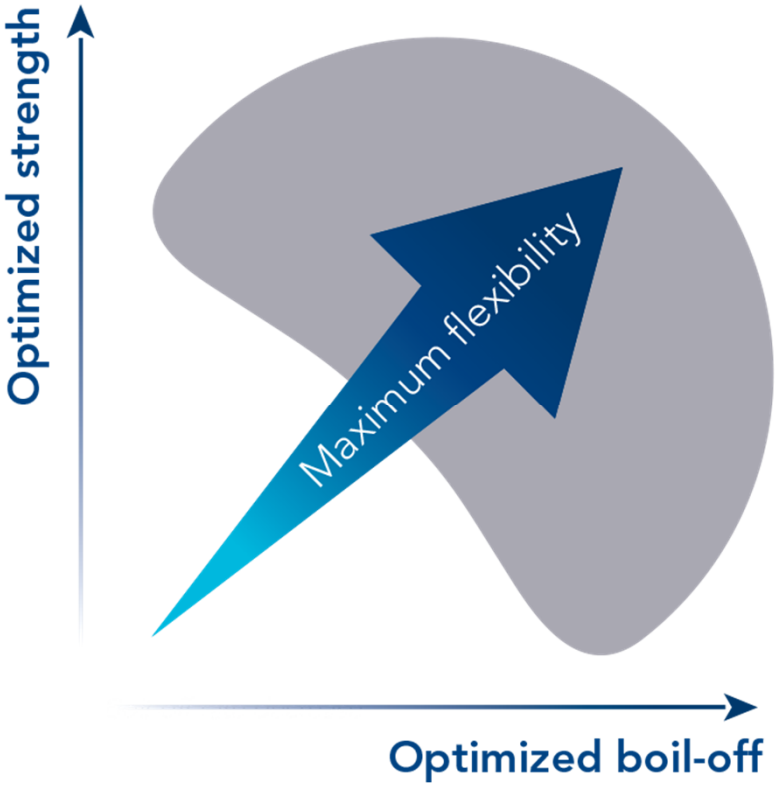




Innovation is key

GTT containment systems are **constantly evolving** to **meet market requirements** in terms of **strength** and **thermal efficiency**





On the materials side

Overview of some used materials and some of theirs destinations

Functions / Requirements

Functions

Insulation
Adhesion
Enchoring
Thightness
Inner hull flatness correction
Compression, tension, peeling and/or shearing resistance

Application requirements

LNG compatibility
Sea water compatibility
Environmental resistance
Inter material compatibility
Ageing up to 40 years

Manufacturing requirements

Raw materials volumes market supply
Industrial processability

Materials

Organic/Polymer

Plywood
Mastics/Glues
Coatings/Paints
Foams
Fibers
Composites
…

Mineral

Fibers
Wools
Powders
…

Metals and alloys

36% Nickel-Steel alloy
Steanless steel
Aluminium
…

Typical parameters to assess…

… down to -170° C

CTE
Compressive, tensile, peel and shear strentghs
.
Thermal conductivity
Gas composition (closed cells foams)
Gases permeabilities
.
Corrosivity
.
Chemical reactivities and kinetics of polymerisation
.
…

Exemples of bench used by GTT to assess material performances

Insulation

Guarded Hot plates (thermal conductivity)
Temperature range: -160°C ⇔ +70°C sample size (mm) : 300x300x25

Calorimeter (Heat capacity)
Temperature range: -150°C ⇔ +40°C

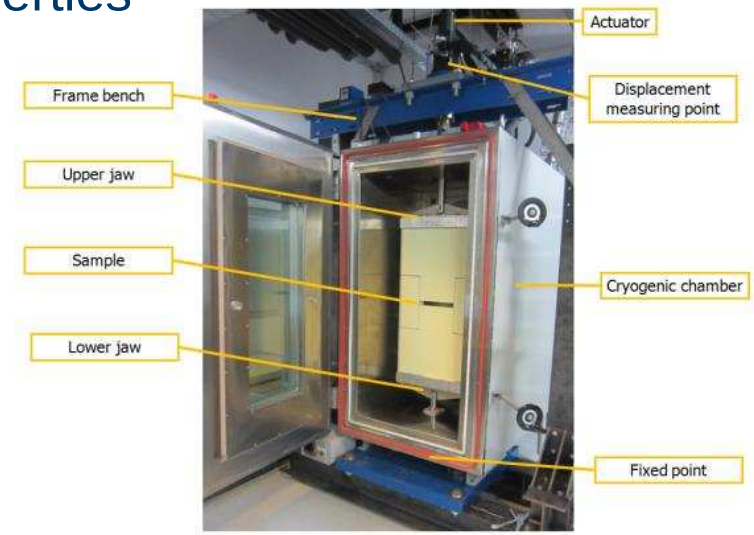
Heat Flow Meters (thermal conductivity)
Temperature range: -160°C ⇔ +40°C sample size (mm) : 300x300x25 (200x200x20)

GC-MS (PUF gas analysis)

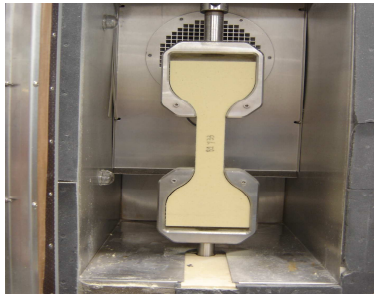
Exemples of bench used by GTT to assess material performencies

- Mechanical properties

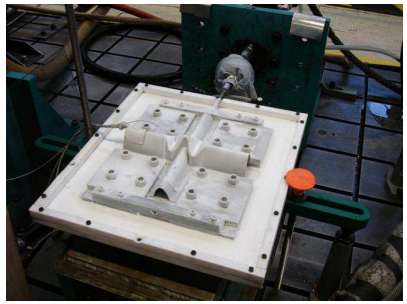
Rheometer -DMA
Temperature range: -150°C ⇔ +70°C



Mechanical test benches
Temperature range: -170°C ⇔ +40°C
Mechanical ranges : 1 ⇔ 250 kN



R-PUF tensile strength test



MARK III Primary Membrane fatigue test

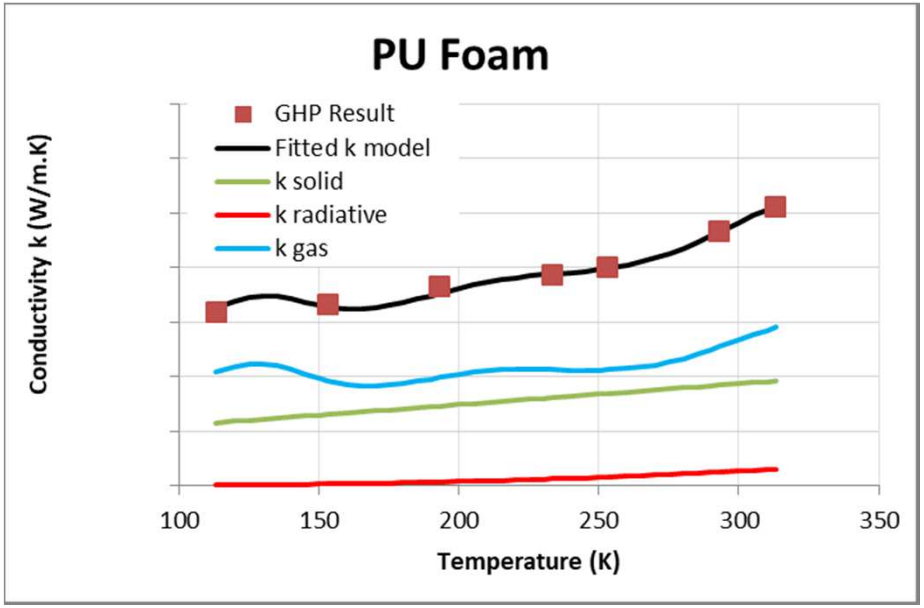
Dilatometer (CTE)
Temperature range: -150°C ⇔ +40°C
sample size (mm) : 3*3*30

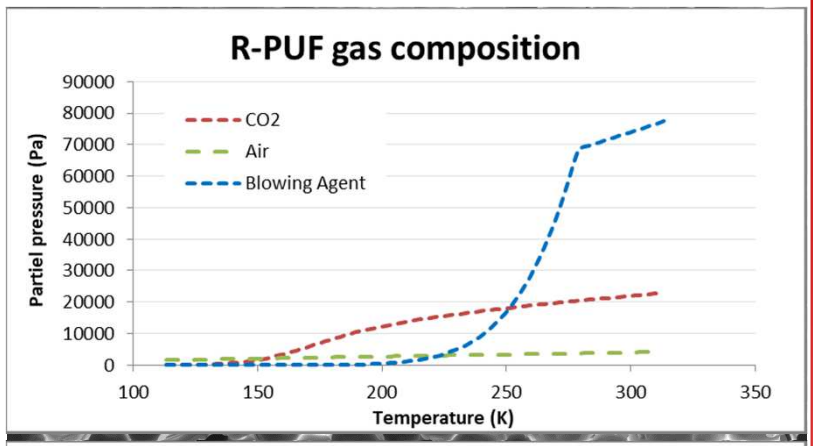
LN_2 Immersion dilatometer (CTE)
Temperature range: -196/23°C
Sample size (mm) : 50x50x300

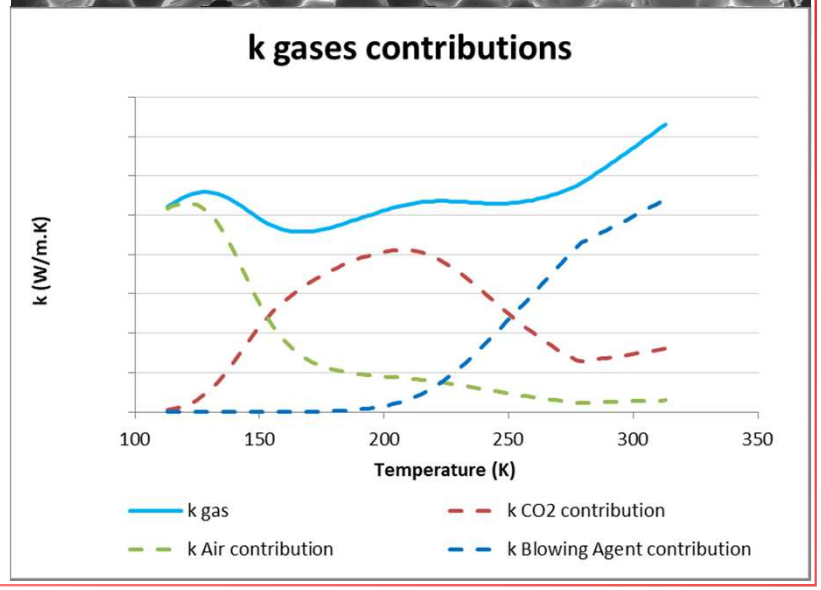
GTT R&D Material activities

- Exemple : PU Foam optimisation by thermal conductivity modelisation
  - Gas composition
  - Ageing prediction

    (coupling gaz diffusivity)



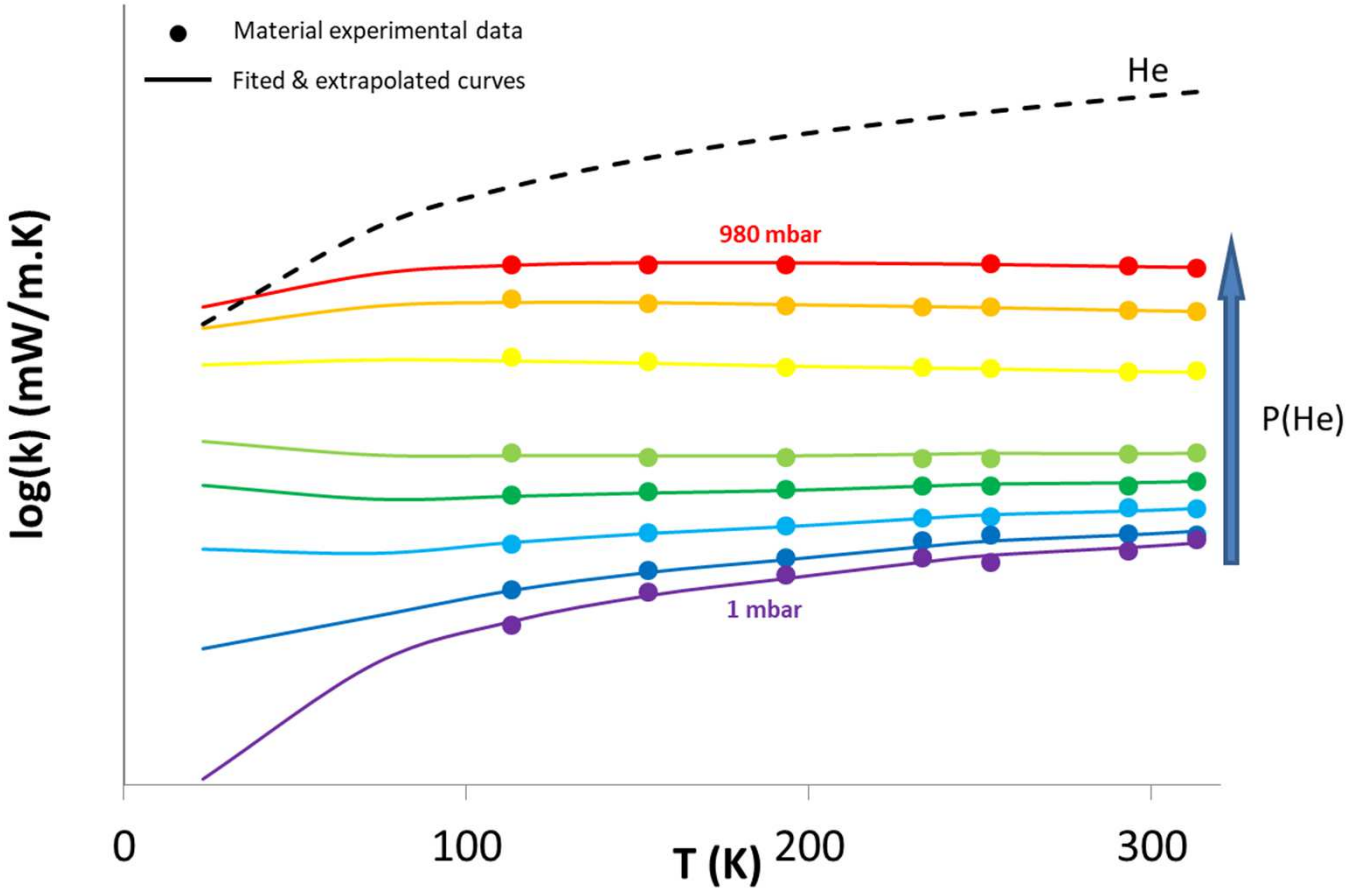




GTT R&D Material activities

- Exemple : Vacuum conductivity assessment of nanostructured materials (aerogel like)

k_{He}(293K) = 153 mW/m.K






To conclude

The details make the perfection and the perfection is not a detail.

Leonardo Da Vinci






Image courtesy of STX, Engie, Excelerate, Reliance, SCF Group, Shell, CMA CGM, Matthieu Pesquet, Conrad




Thank you for your attention



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