Technical Conference

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Developing large scale IMO type A tank system in aluminum to carry LNG

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LNT

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Introduction

The Development Project

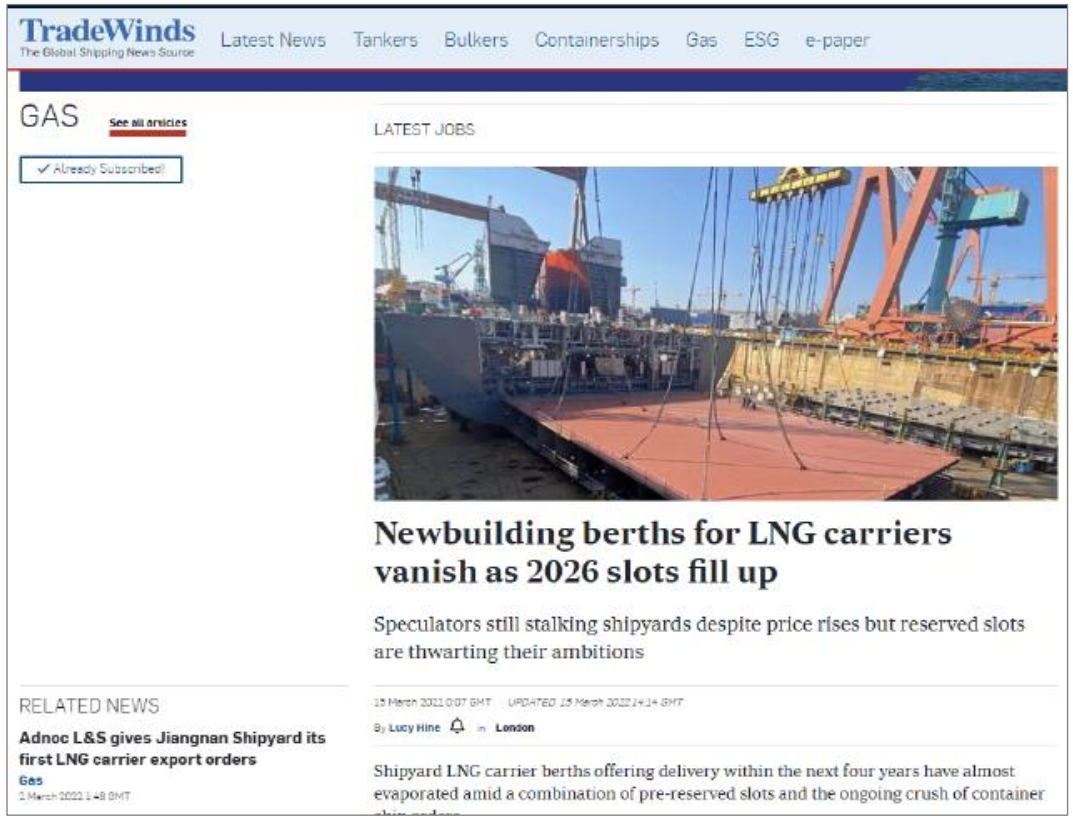
Objectives
of the development project

Enable more yards & create competition

Unlock new markets

Develop & optimize designs

Create more competition
– Increase availability and flexibility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Newbuilding berths for LNG carriers vanish as 2026 slots fill up

Speculators still stalking shipyards despite price rises but reserved slots are thwarting their ambitions

15 March 2022 0:07 GMT UPDATED 15 March 2022 14:14 GMT

By Lucy Hine in London

Shipyard LNG carrier berths offering delivery within the next four years have almost evaporated amid a combination of pre-reserved slots and the ongoing crush of container

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Adnoc L&S gives Jiangnan Shipyard its first LNG carrier export orders

Gas

2 March 2022 1:48 GMT

High demand, limited supply

The market for design, development and construction of **large-scale LNG carriers** is dominated by membrane technologies and a few major Korean shipyards.

In order to facilitate **more competition and flexibility** in this field there is a desire to develop a simple and robust design that can be **built by many shipyards** and at the same time meet the demands of future LNG shipping.

The market need more flexibility

The development of the global LNG trade points towards more **flexible shipping** whereas partial discharge to smaller terminals or Ship to Ship Transfer (STS) to smaller feeder ships will be required. Consequently, technical solutions that can **mitigate sloshing** and **enable partial loading** is desired.

Mid-scale carriers
- To unlock new markets

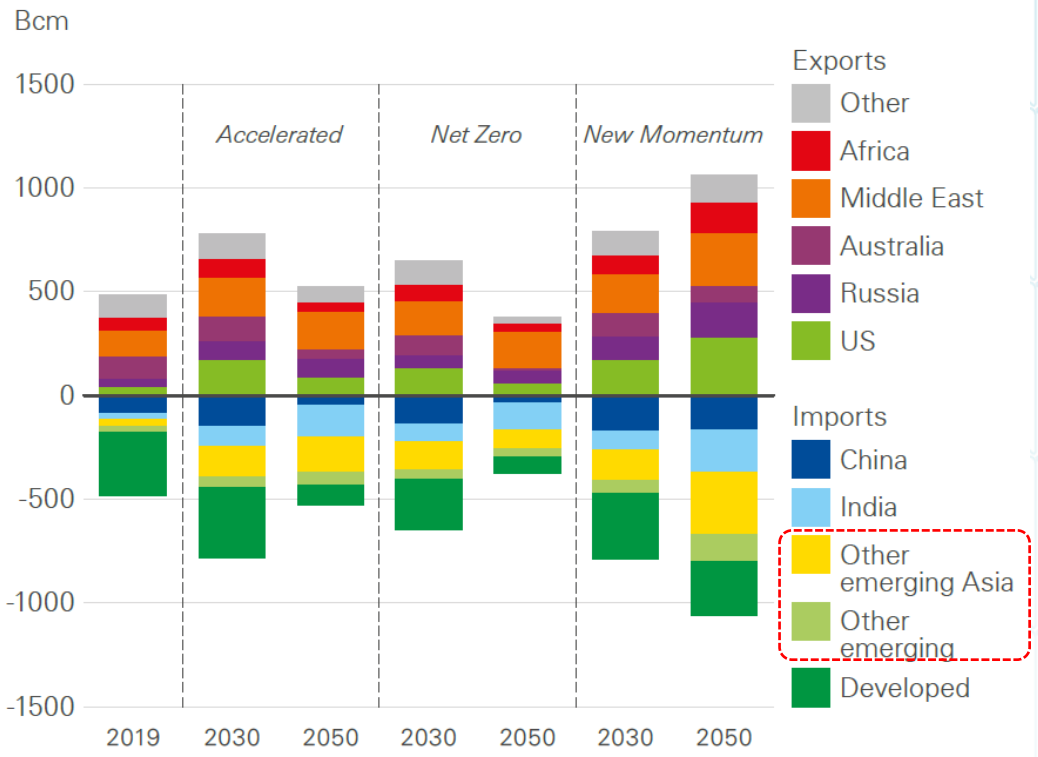
Population growth and urbanization are driving energy demand in emerging markets.

Much of the anticipated growth within the LNG sector is expected to come from smaller import nations and emerging markets.

These markets are however lacking large-scale infrastructure for LNG imports, and often located in geographical regions with shallow waters.

In order to reach and unlock these markets, low cost and right-sized ships and terminals are needed.

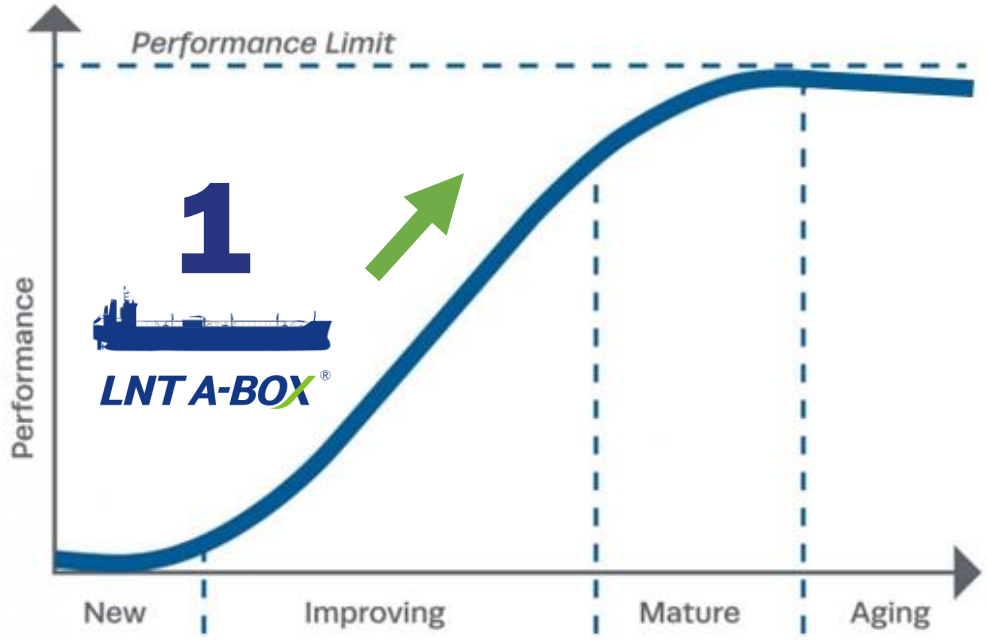
✓ ***Mid-scale carriers and floaters can play a vital role to enable this development.***



Source: BP Energy Outlook 2022

Optimize design
- Readiness to build and streamline the production

- The project seek to optimize and commercialize new LNG carrier designs to meet these needs of the industry.
- This involves cooperation with ship designers, selected shipyards and selected owners.



Background

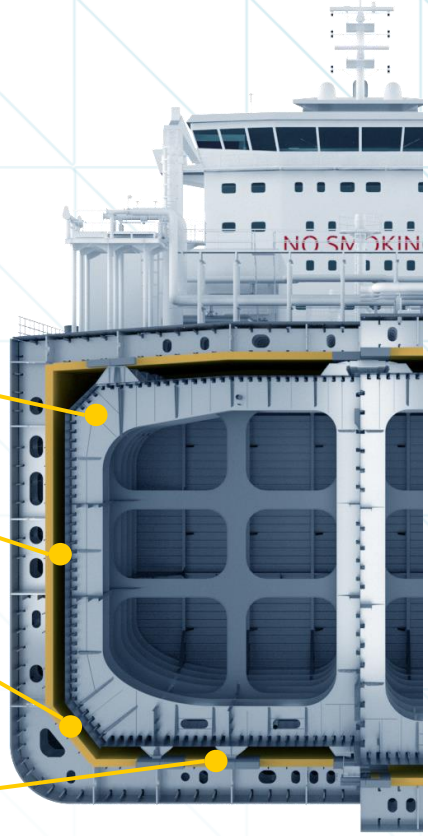
LNT A-BOX® containment system

LNT A-BOX®
- A containment system based on IMO type A tanks

The LNT A-BOX® is a construction-friendly and efficient containment system for LNG, enabling more shipyards to build LNG carriers and floaters at a reasonable cost.

- The technology is based on a robust and prismatic IMO independent tank type A and proven principles.
- The insulation system consists of pre-manufactured PU panels fixed to the compartment plating and with an inner surface designed as a full secondary barrier.
- In between the tank and the insulation, there is an accessible interbarrier space inerted with dry nitrogen.

LNT A-BOX®
Flexible | Efficient | Robust



Primary barrier
Self supporting IMO independent tank type A.

Interbarrier space
Accessible space between tank and insulation.

Secondary barrier
Liquid tight thermal insulation.

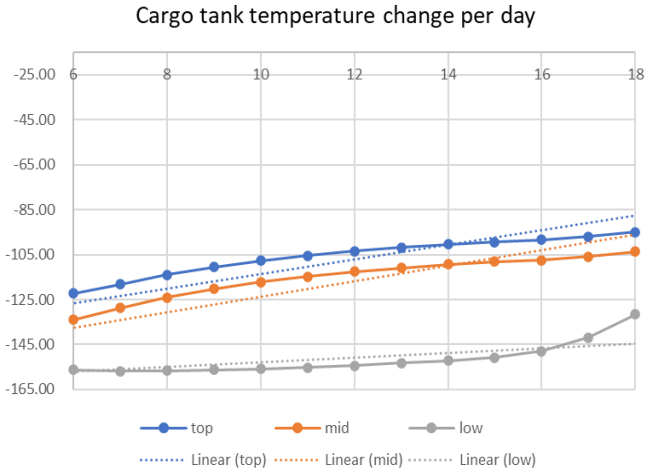
Cargo tank support
Conventional cargo tank support system.

"An independent tank type A without insulation, inside an insulated hold space"

45,000m3 LNGC Saga Dawn - Proof of concept

- The first LNT A-BOX® type LNG carrier, the 45,000m3 Saga Dawn, was delivered in 2020 and has traded successfully in Southeast Asia since then.
- She has frequented 6 different terminals, including large-scale LNG liquefaction plants, re-export hubs and medium-scale import terminals.
- The vessel also carried part-cargos at around 50% loading and received cargos via ship-to-ship transfer from a conventional-size carrier.
- The cargo system has proven its flexibility and operated without any issues. Feedback from owners, charterers and crew has been very positive.

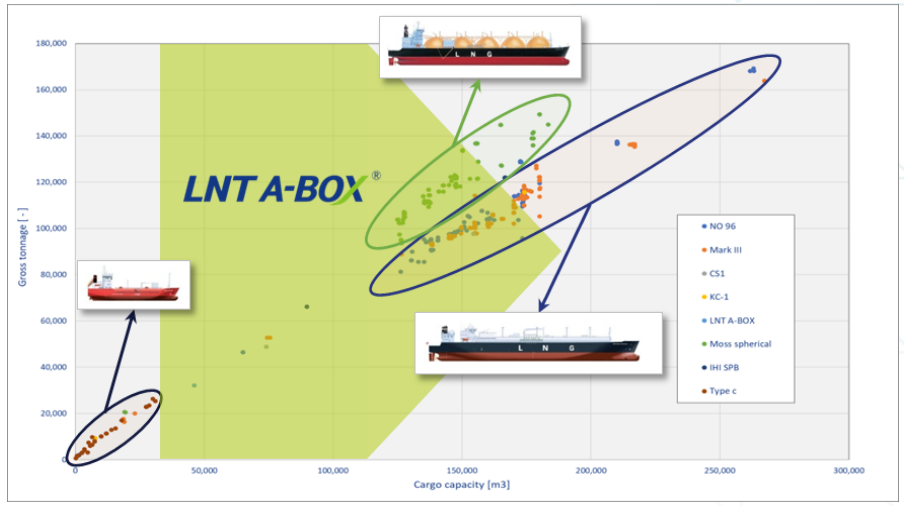
Saga Dawn
- Operational experience & performance



- **No issues related to the containment system reported**
  - No abnormalities observed
  - No cold spots found
- **Loading performance as per specification**
  - The temperature stability has proven better than specification with the containment system in cold condition.
  - Loading rate faster than specification.
  - Tank design pressure (MARVS) of 0.4 bar g reduce challenges related to loading pressure peaks and instability of cargo after loading.
  - BOG compressors handle all return gas.
- **Smooth cargo operation cycles**
  - The system proves stable in the operation phase with respect to temperatures and is rapidly ready for loading.
- **Stable operation of the containment system**
  - The N2 filled protection spaces around the tanks and the secondary barrier operates with even pressure.

Proven in the mid-scale segment - What does it take to scale up?

What does it take to scale-up?

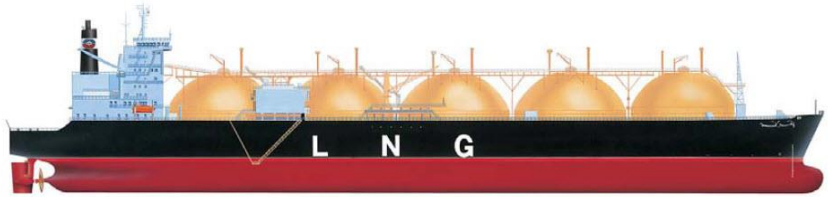


Large-scale LNGCs

Industry standards and LNT A-BOX®

Large-scale LNG carriers
- What is the relevant benchmark?

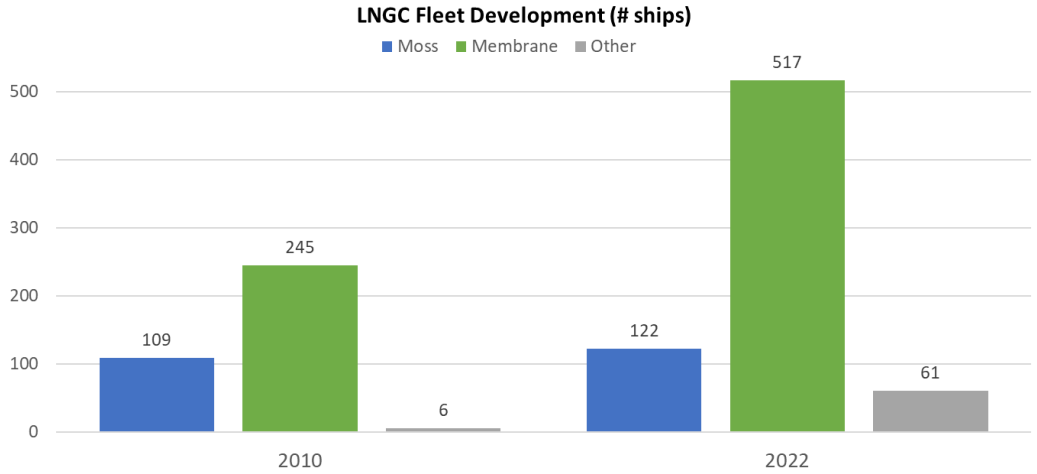
Spherical independent type B tanks



The Moss type LNG carriers used to dominate the traditional large scale LNG segment. Excellent technical performance, but disadvantage on tonnage.

Membrane systems

The market has however been taken over by membrane systems which today dominate the market for large scale LNG carriers.



Membrane type LNG carriers of approximately 174,000m3 is the current industry standard.

Different yards prefer different membrane systems, but the principle is essentially the same in terms of IMO IGC and requirements.

Large-scale LNG carriers
- Key performance indicators and cost drivers

CAPEX

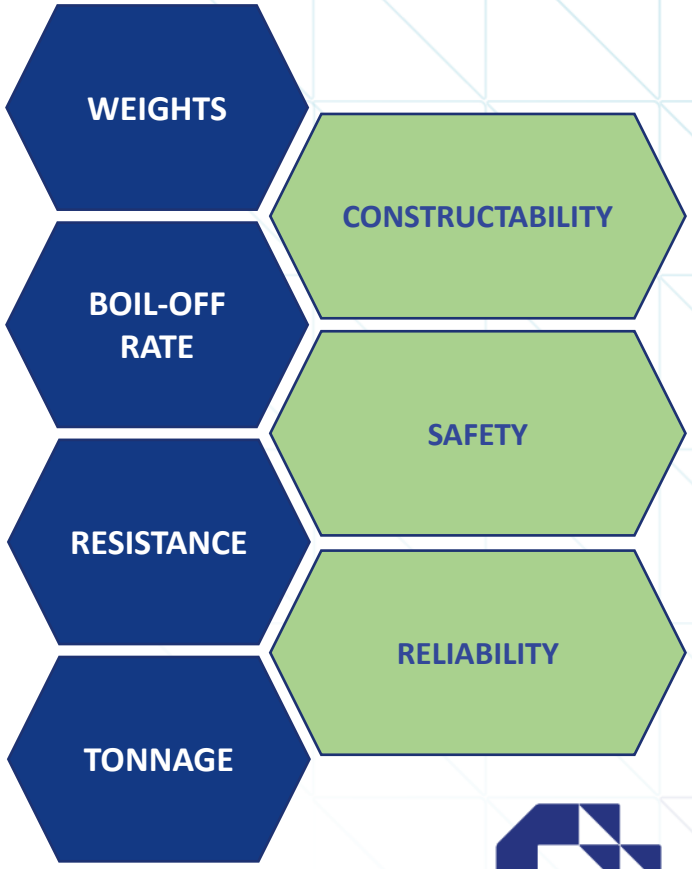
- Complexity and constructability
- Lightweight and tank weight
- Specifications and outfitting

OPEX

- Simplicity and robustness
- Reliability and maintenance
- BOG handling

VOYAGE

- Hull shape efficiency
- BOR and energy efficiency
- Volume utilization and tonnage



175,000m3 LNG carrier
- Based on LNT A-BOX® containment system

CSSC 上海船舶研究设计院

Main Dimensions

Loa	294.80 m
Lpp	290.00 m
Beam	45.80 m
Depth	26.50 m
Design draught	11.50 m
Scantling draught	12.50 m
DWT	80,500 ton
Gross tonnage	112,433 -

Speed, Consumption & Machinery

Service speed:	19.5 knot
Corresponding power:	abt. 2 x 10,830 kW
Endurance:	16,000 nm
Dual fuel main engine:	2 x 13,000 kW
Auxiliary engines:	2 x 3,680 / 2 x 2,770 kW
Crew:	36 pers

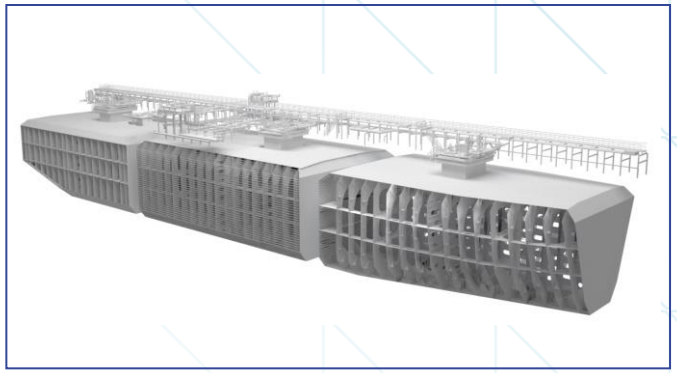
Cargo System

Containment system:	LNT A-BOX®
No. of cargo tanks:	4 -
Total capacity:	174,000 m3
MARVS:	0.25/0.40 bar g
Design density:	0.5 ton/m3
Min.temp.:	-163 °C
BOR:	0.07 %/day

Cargo tank weight
- Important for costs and performance

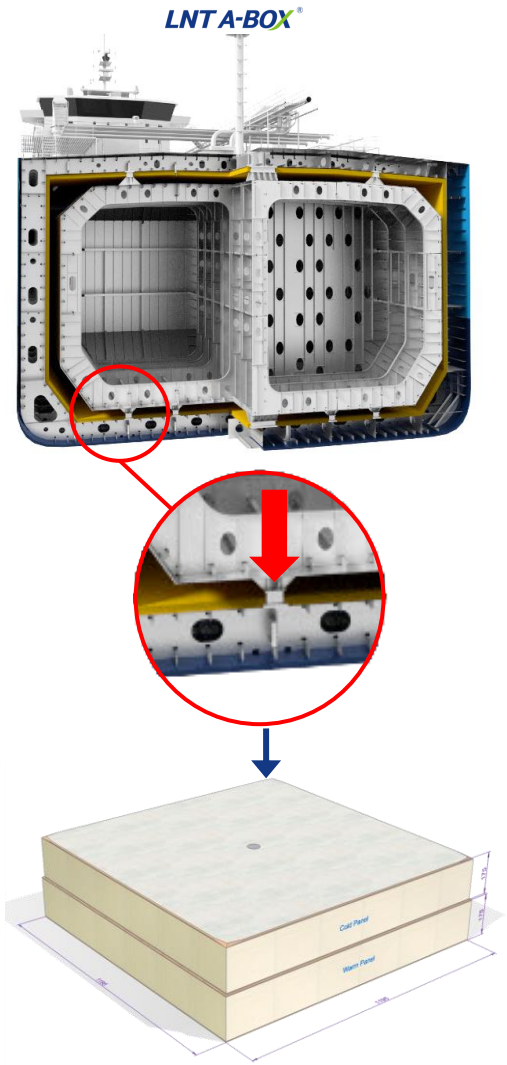
WEIGHTS

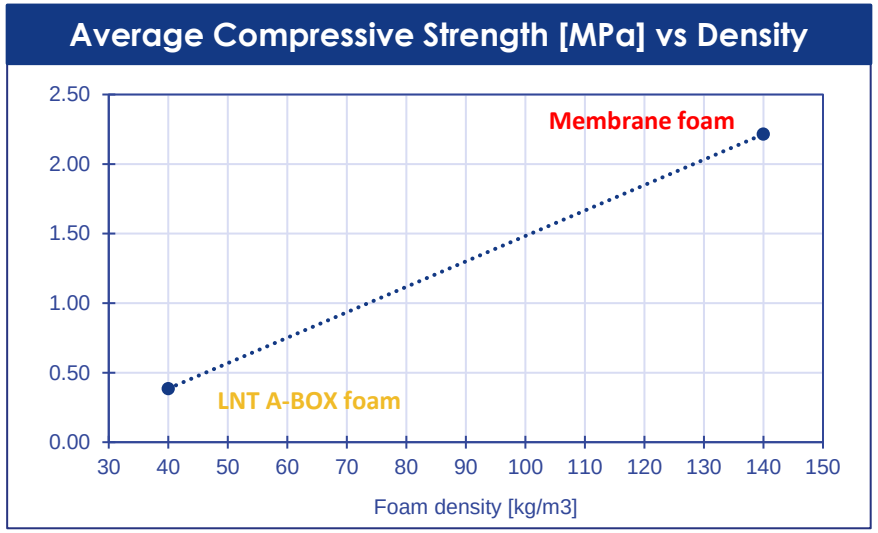
- The hull and general ship systems will be more or less the same between different containment systems,
- Any self-supporting independent tank will however weigh more than a thin membrane. Consequently, the weight of the cargo tanks will be higher for an LNT A-BOX type carrier than for a membrane vessel.
- Therefore, weight optimization is an important part of the development.
- Aluminum has the potential to reduce the tank weight significantly, and I will get more back to that in the last part of the presentation.

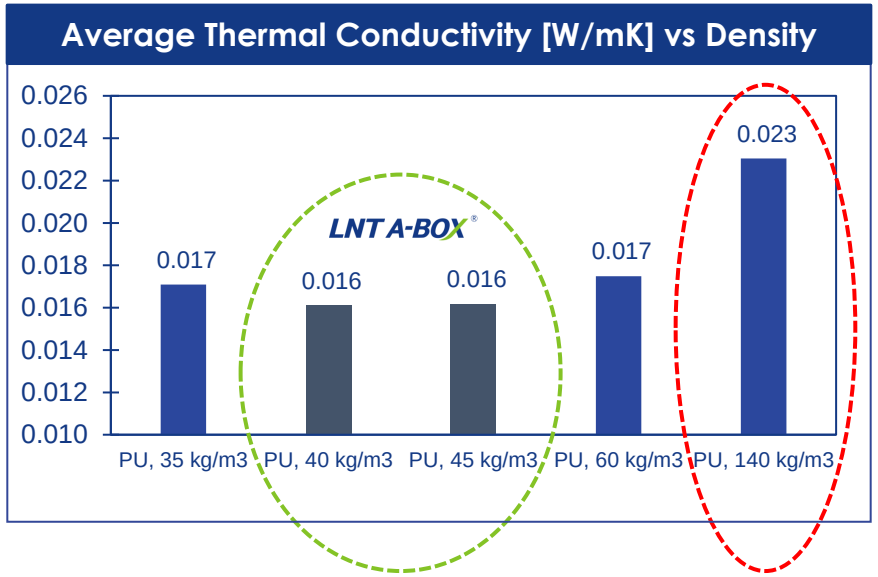


Insulation optimized for thermal performance gives low Boil-Off Rate (BOR)

BOIL-OFF RATE







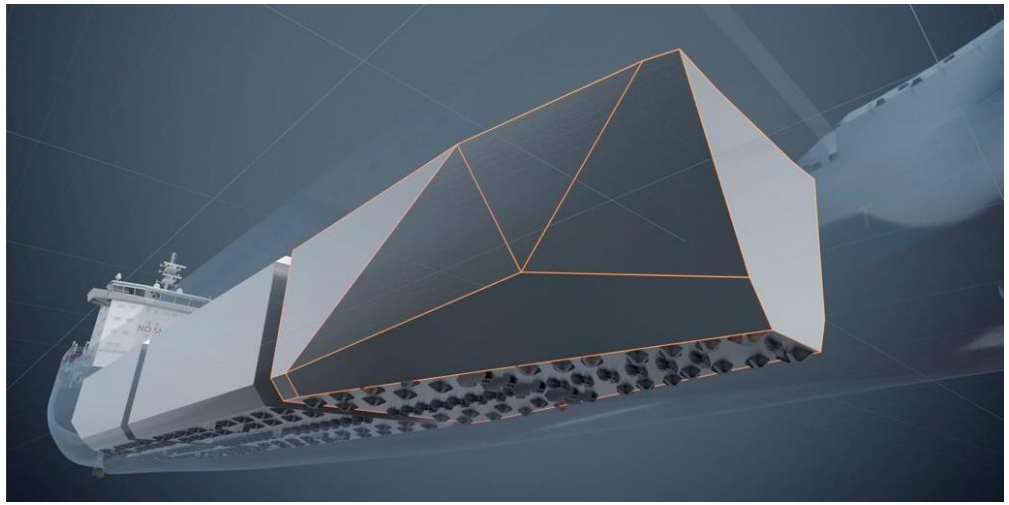
- The insulation is not exposed to static and dynamic loads from the cargo.
- Therefore, we can select low density foam and optimize for best possible thermal performance.

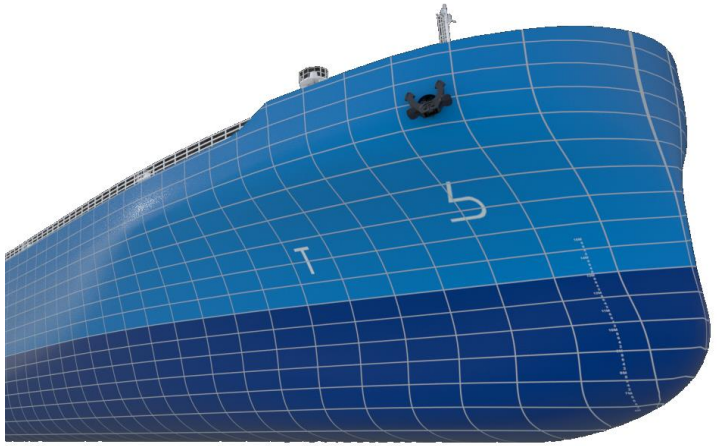
✓ *LNT A-BOX offers superior thermal performance – i.e. lowest possible BOR.*

✓ *The insulation system is lighter, and counter some of the difference in primary barrier weight.*

Geometrical flexibility of the containment - Gives hydrodynamic efficiency

RESISTANCE





- Geometrical flexibility of the containment system gives the ship designer freedom to design an efficient hull form.
- Parametric model combined with rich experience of SDARI and CFD evaluations to optimize for best possible performance.
- Preliminary resistance predictions points towards fuel savings compared to other modern large scale LNG carriers, despite slightly higher weight.

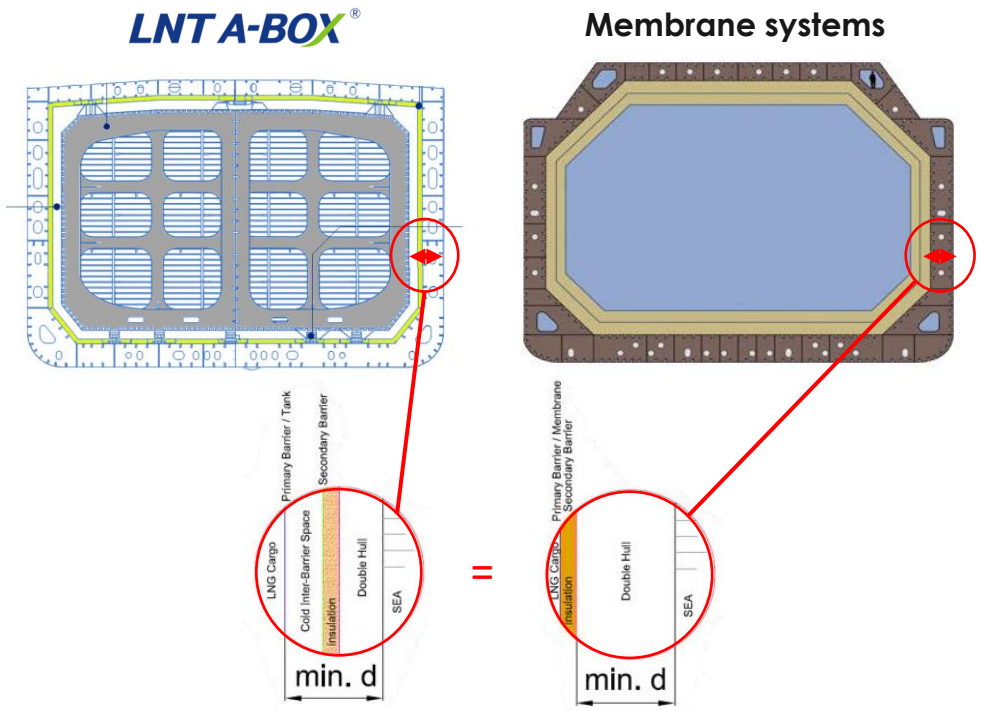
Tank geometry and rule requirements offers market leading volume efficiency and tonnage

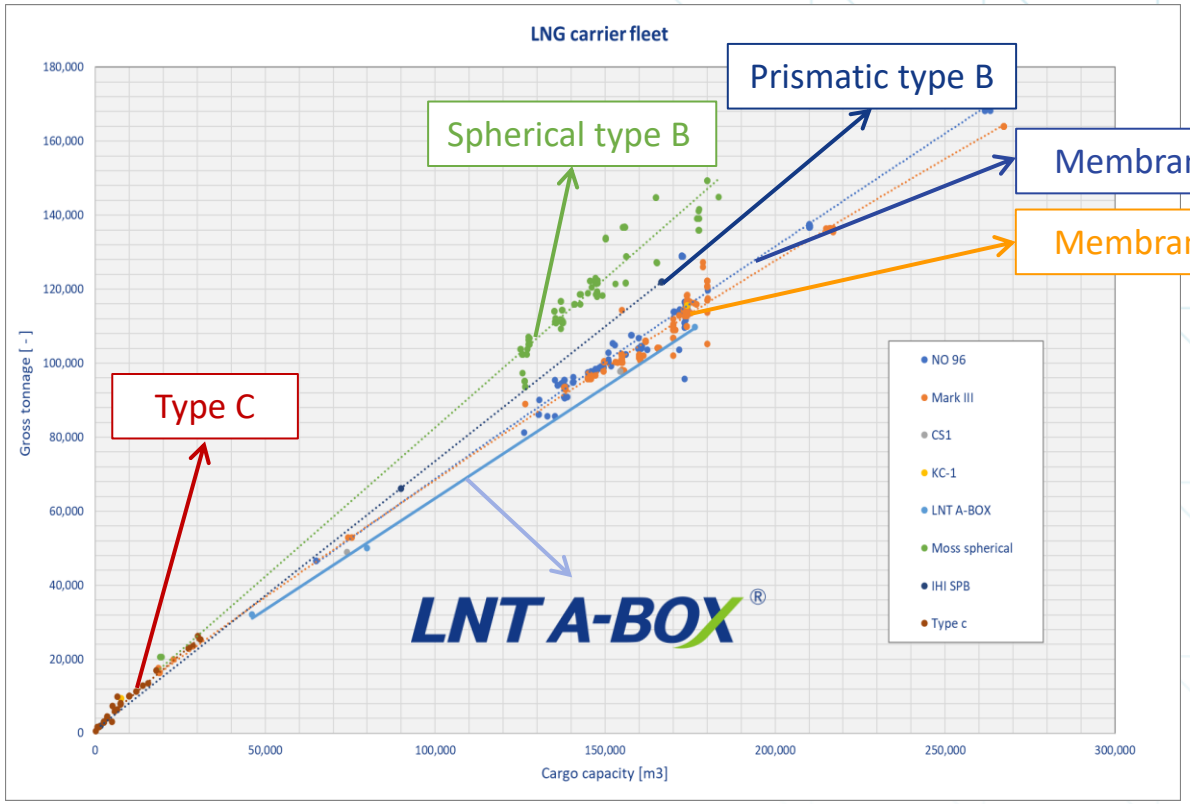
TONNAGE

Geometrical flexibility of the LNT A-BOX® containment system secure high utilization of the ship hull lines.

IMO IGC requirement: Distance to outer shell, β, whichever is less of: d, B/15 or 2 m

- *For independent tank types to the tank primary barrier*
- *For membrane systems to the hold space*





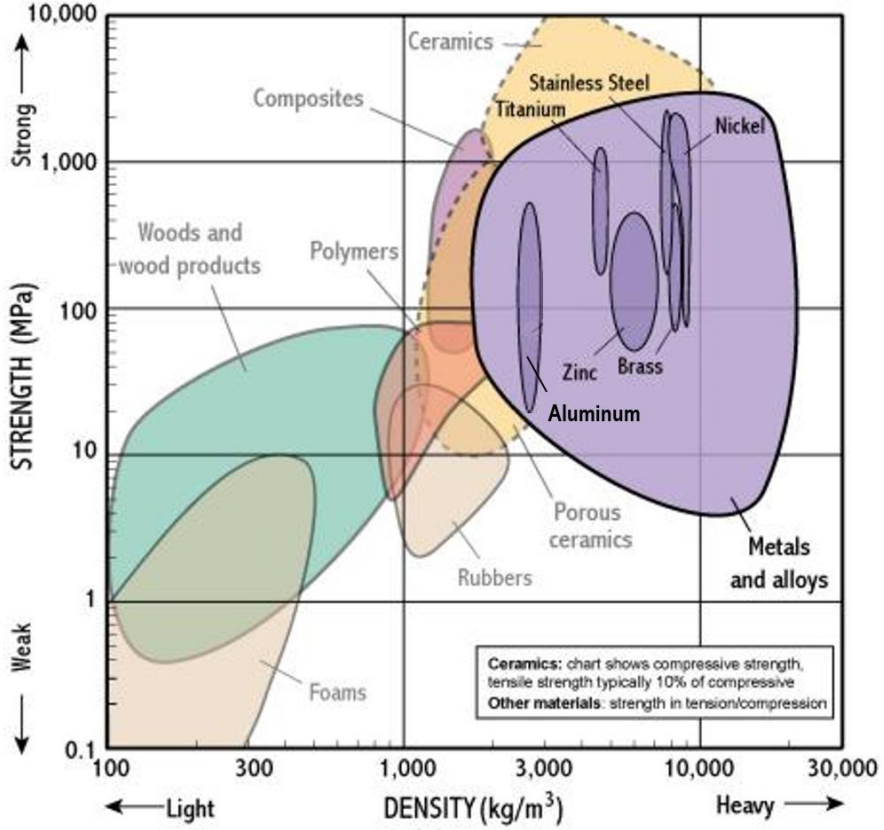
Aluminum tanks

IMO independent tank type A

Tank material options
- and design considerations

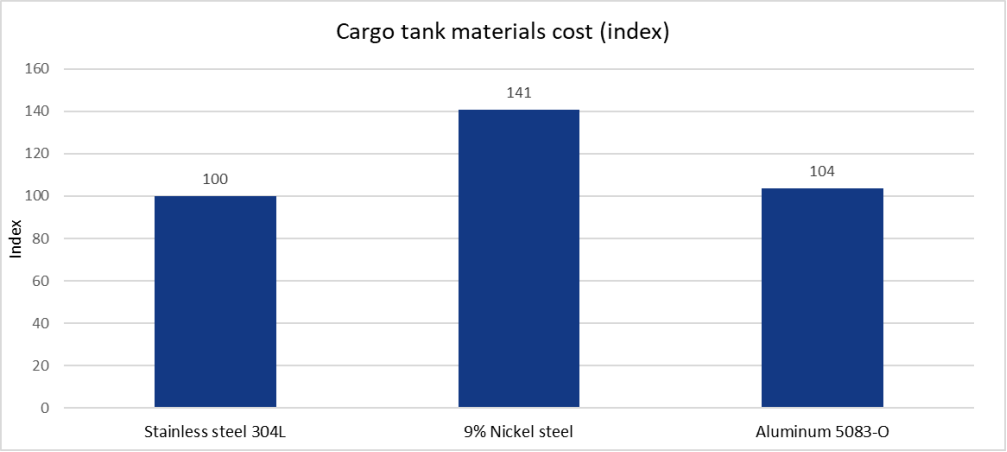
- In the case of LNG at -163°C, the options are stainless steels, nickel-alloys or aluminum.
- These materials have different properties and different pros and cons. Important parameters for selection are:
    - *Material density*
    - *Strength parameters*
    - *Weldability*
    - *Thermal expansion coefficient*
    - *Cost*

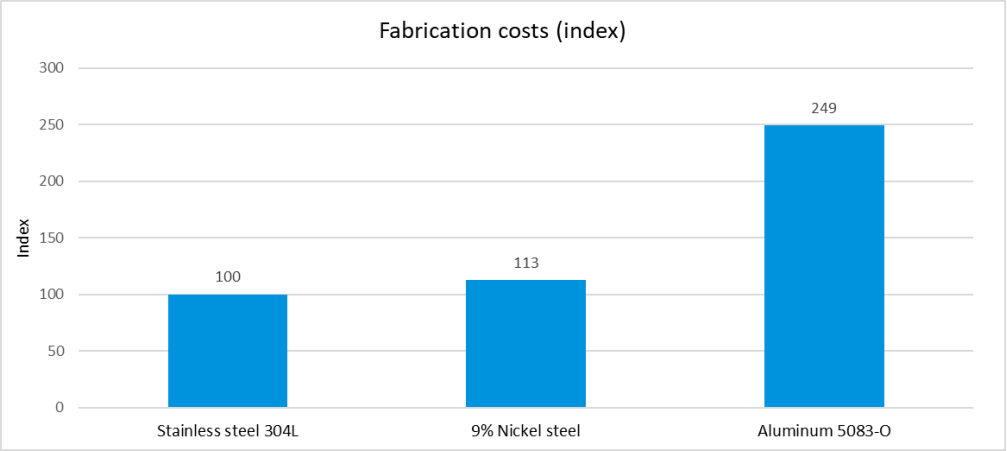
Tank Material	Standard	Density	Yield	Tensile
		[ton/m3]	*[Mpa]*	*[Mpa]*
Stainless steel, 304L S30403	EN10028-4	7.85	170	485
9% nickel steel, X7Ni9	ASTM A240	7.85	585	680
Aluminum, A5083-O	ASTM B209M	2.67	125	275

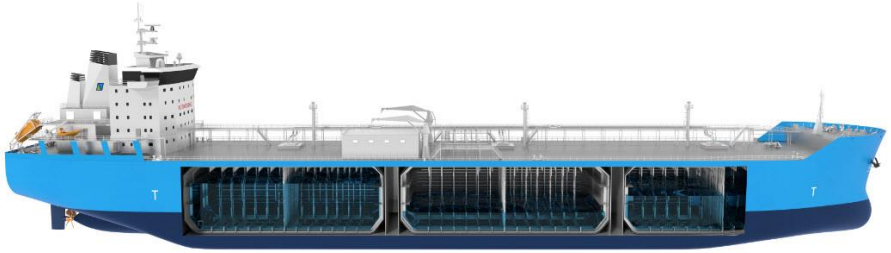


Source: www-materials.eng.cam.ac.uk

Tank materials selection
- Material costs, fabrication capability and size segment

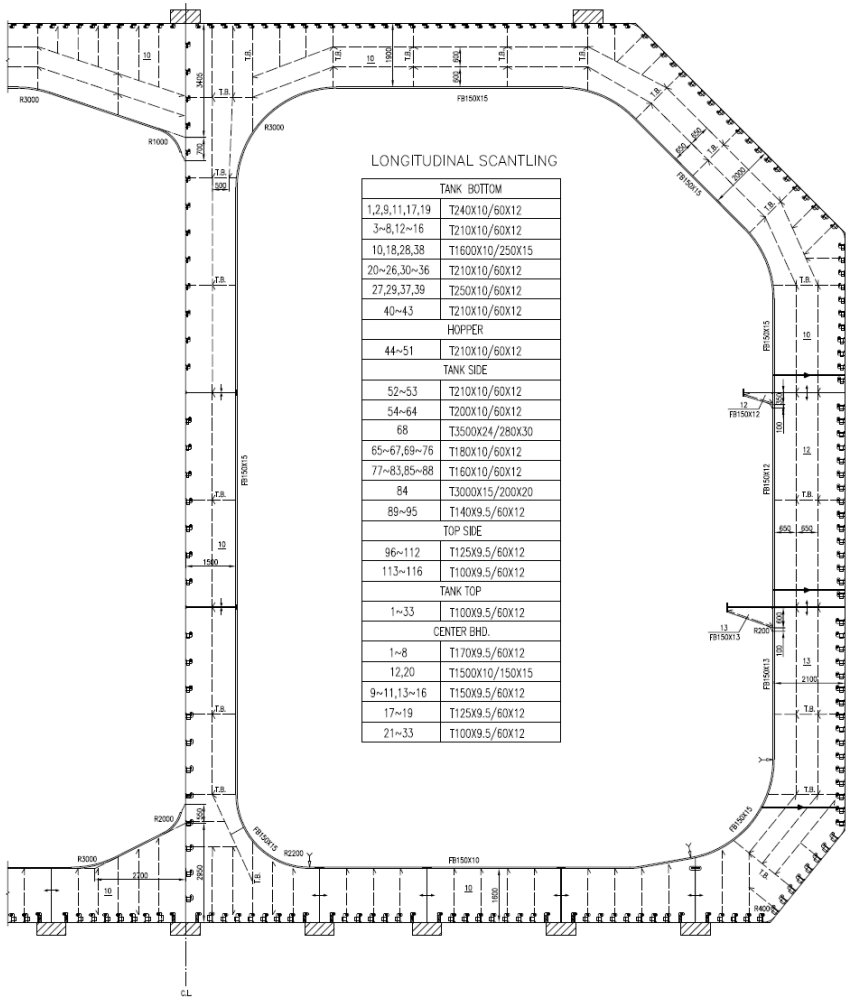






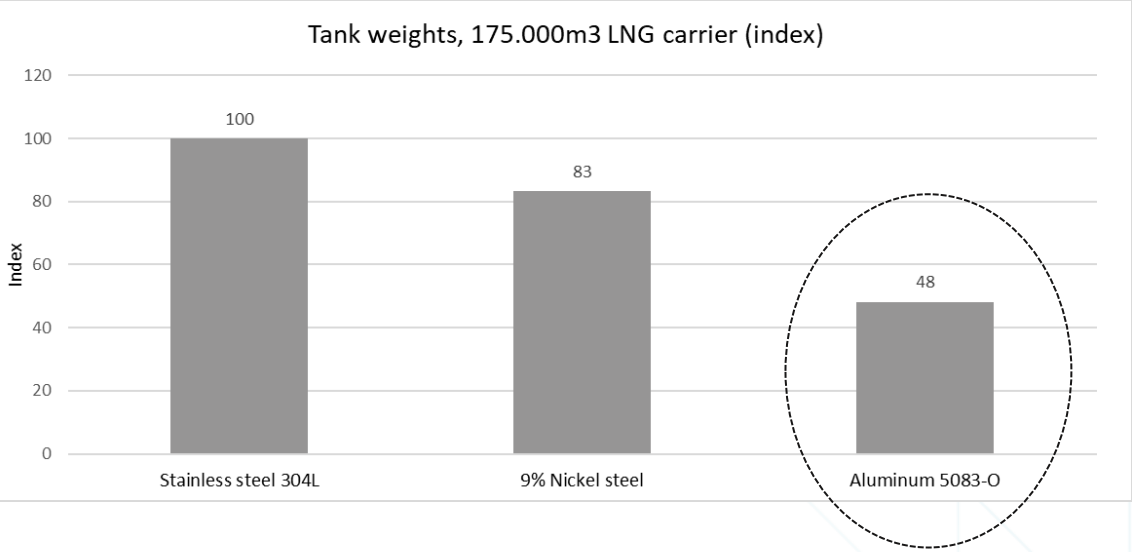
- For mid-scale vessels, weight is somewhat less critical as we are often competing with type C pressure vessels. And in addition, minimum plate thickness requirements will absorb some of the theoretical weight savings between different materials.
- Ease of fabrication and availability of qualified yards and welders will typically be more important for smaller sizes. Consequently, stainless steel and 9% nickel steel are considered suitable for this segment. This was the main reason for the choice for the 45,000m3 Saga Dawn, where stainless steel 304L was used.
- For larger sizes the different material properties can be utilized more and will have more significance for the weight.

Large-scale tanks
- Aluminum gives a significant weight saving



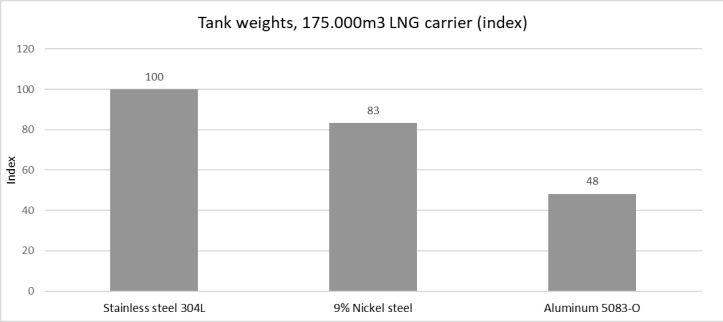
LONGITUDINAL SCANTLING

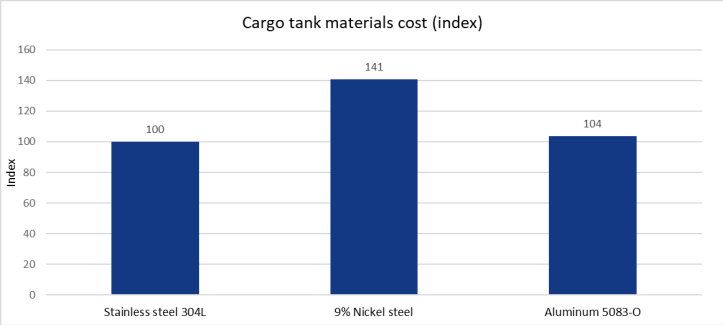
TANK BOTTOM	
1,2,9,11,17,19	T240X10/60X12
3~8,12~16	T210X10/60X12
10,18,28,38	T1600X10/250X15
20~26,30~36	T210X10/60X12
27,29,37,39	T250X10/60X12
40~43	T210X10/60X12
HOPPER	
44~51	T210X10/60X12
TANK SIDE	
52~53	T210X10/60X12
54~64	T200X10/60X12
68	T3500X24/280X30
65~67,69~76	T180X10/60X12
77~83,85~88	T160X10/60X12
84	T3000X15/200X20
89~95	T140X9.5/60X12
TOP SIDE	
96~112	T125X9.5/60X12
113~116	T100X9.5/60X12
TANK TOP	
1~33	T100X9.5/60X12
CENTER BHD.	
1~8	T170X9.5/60X12
12,20	T1500X10/150X15
9~11,13~16	T150X9.5/60X12
17~19	T125X9.5/60X12
21~33	T100X9.5/60X12

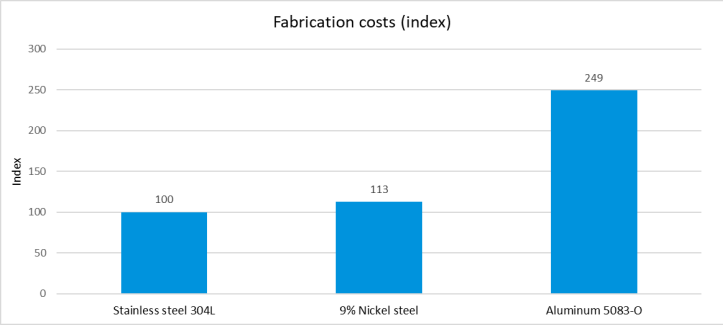


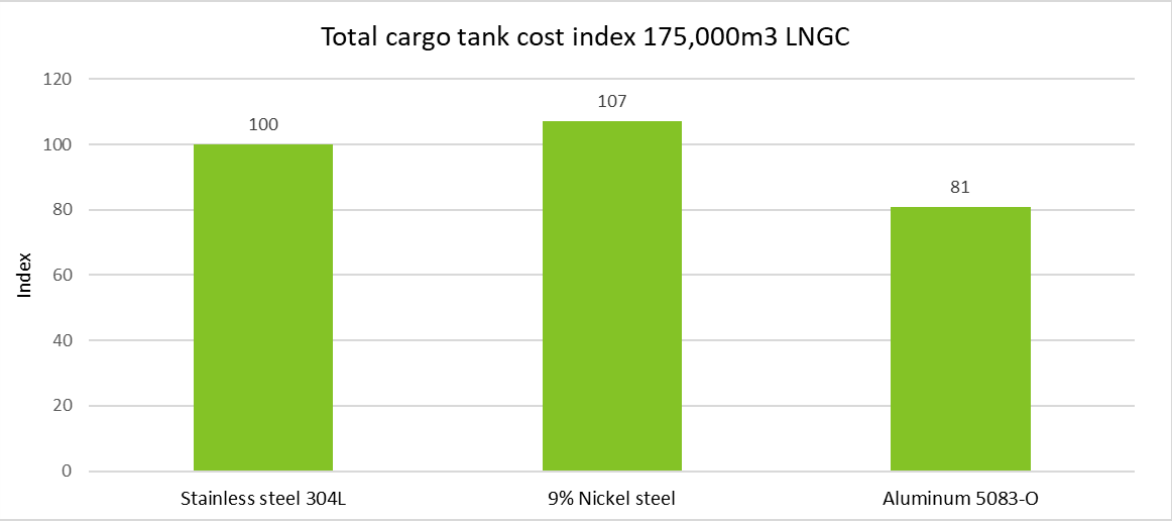
- Preliminary design indicates a weight reduction of more than 50% when comparing with stainless steel as the baseline.
- As such, this has a significant impact not only on the cargo tank material cost, but also on the lightweight and displacement of the ship.

Cargo tank cost
- Aluminum is the most attractive material for large-scale





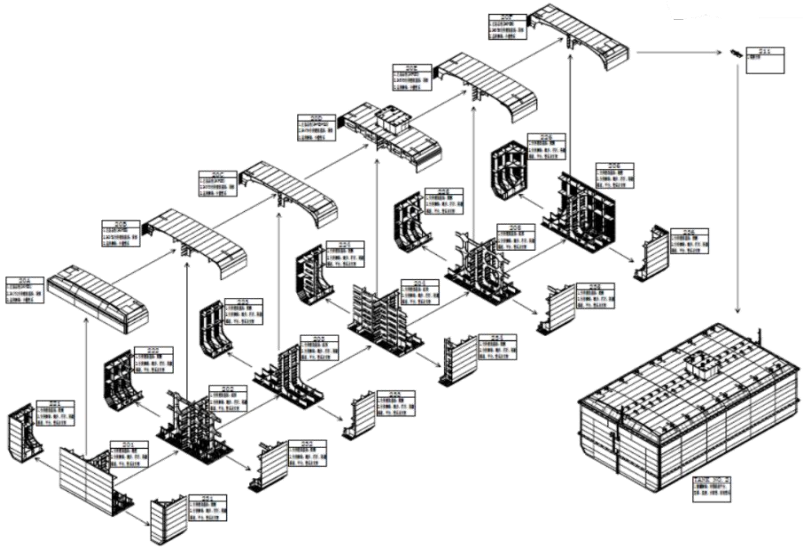


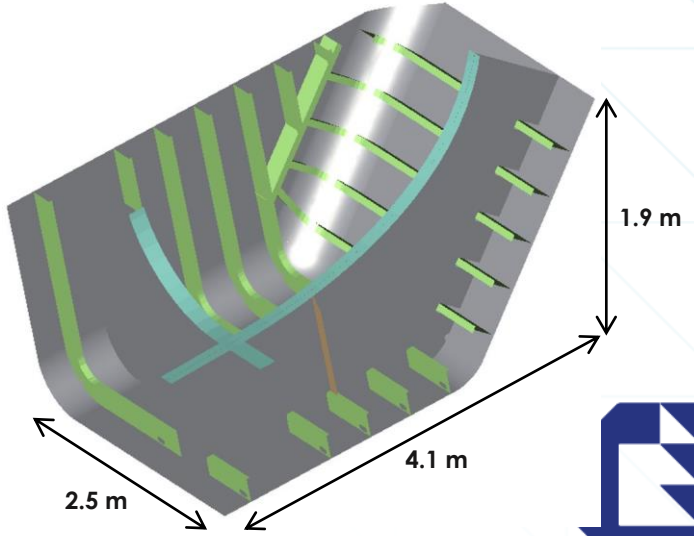


Conventional design and fusion weld fabrication - Mock-up to verify design principles and fabrication process

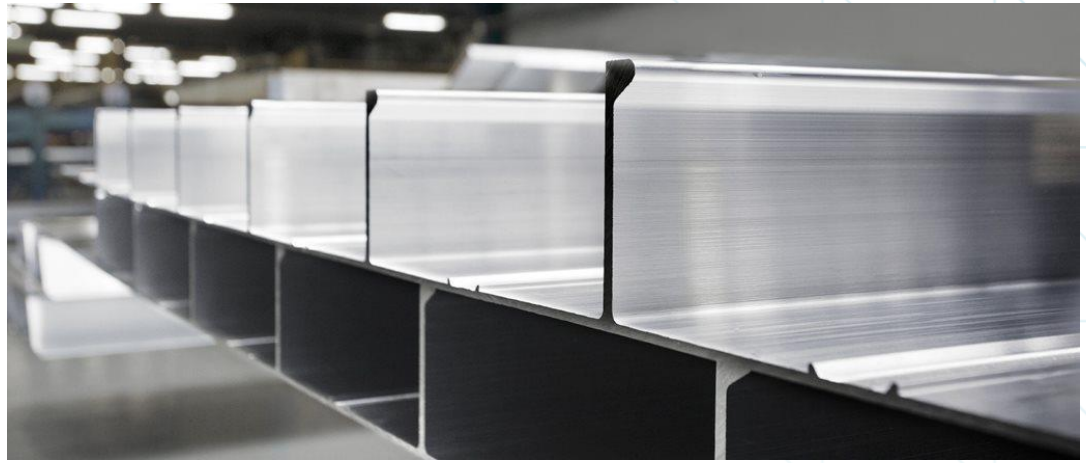
- First step of the development is based on a conventional design and fabrication process based on welded A5083-O. This means that allowances must be made for reduced-as-welded strength and ductility, compared to the un-welded metal.

- Mock-up unit with representative structural details and welds to verify principles to be used for a full-scale tank. Construction details including shell plate corners, web/girder crossing with details and brackets – all in dimensions similar to that expected for a large-scale tank.



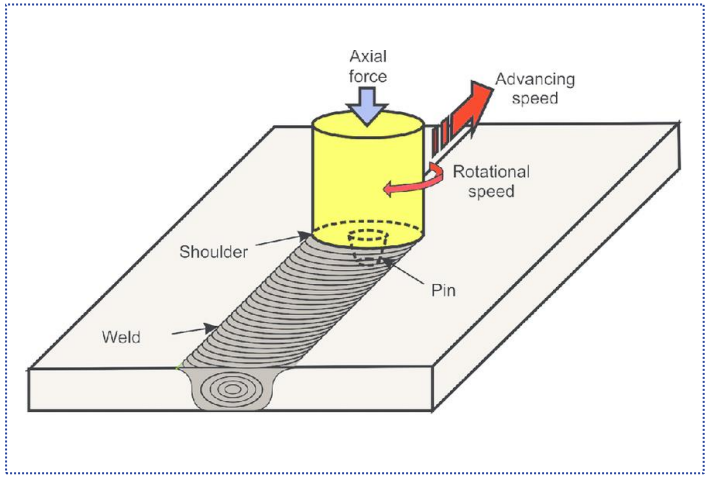


Next steps
- Extrusions and friction stir welding (FSW)



- There is a potential to optimize the production process and further reduce weight by utilizing extrusions and automated friction stir welding (FSW).
- Extrusion of aluminum profiles is a procedure where the material is heated to near-melting temperature and pressed through a tool, which gives the aluminum the desired shape. These profiles are lined up and welded together to a large construction which is similar to a typical panel used in tank production
- This gives the opportunity to produce large panels sections from extruded profiles by the aluminum manufacturer. Typical panel sizes could be in the range of 16 x 2.5 meter and basically limited by the restrictions for transportation.

Extrusions and friction stir welding (FSW) - Optimizing fabrication and weight



- FSW is an automated welding technique comprising a rotating tool guided between the profiles. The method is very fast and does not require filler materials nor gas shield. In addition, the FSW does not reduce the strength of the material.

- A design and construction process based on extrusions and FSW can give significant advantages:

  - ✓ *Overall reduction of welding – as stiffeners are integrated as part of the extruded profiles.*

  - ✓ *Reduction of on-site welding – as complete panels can be supplied by manufacturers.*

  - ✓ *Reduced weight – since the strength of the FSW is equal to the strength of solid material*

  - ✓ *Optimized material usage – as waste is eliminated*

Summary

Concluding remarks

Large-scale LNG carriers with IMO type A tanks in aluminum has the potential to reduce costs and shorten the lead time

- WEIGHTS
- CONSTRUCTABILITY
- BOIL-OFF RATE
- SAFETY
- RESISTANCE
- RELIABILITY
- TONNAGE

Thank you

Questions?

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