CAUGHT IN THE MIDDLE

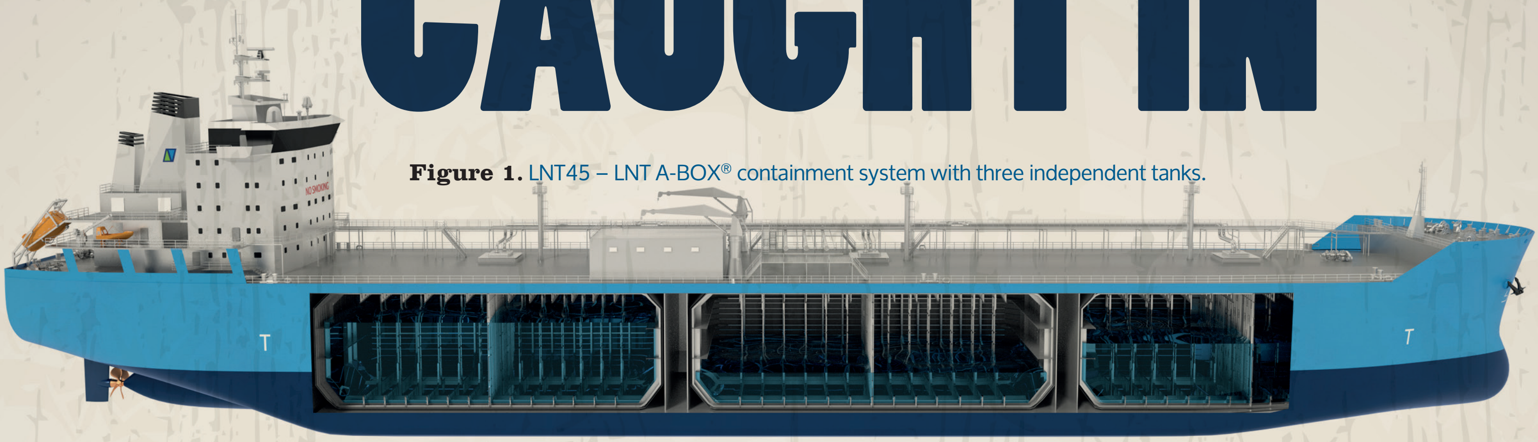

Figure 1. LNT45 – LNT A-BOX® containment system with three independent tanks.

Kjetil Sjølie Strand, LNG New Technologies, Norway, puts forward the case for a mid-sized LNG carrier fleet.

On 25 January 1959, the MV *Methane Pioneer* carried the world's first ocean cargo of LNG from Lake Charles, Louisiana, US, to Canvey Island, UK.

This prototype project was funded by the British Gas Council, whose involvement in the project came after the UK Parliament had passed the 1956 Clean Air Act, which came in the wake of the Great Smog that hit London in December 1952.

Methane Pioneer carried in total six trial shipments across the Atlantic, proving that the transoceanic transport of LNG was feasible. In November 1961, the UK government approved the British Gas Council's plan to commence LNG imports from Algeria.

Consequently, the foundation for the development of a new industry was laid.

Today, natural gas is one of the world's primary energy sources and LNG is transported across the world's oceans on massive LNG carriers of up to 266 000 m^3 cargo capacity. Total LNG trade in 2014 reached 239.2 million t, and the fleet stood at 421 LNG carriers, with another 163 on order at the end of the year. Challenges with coal consumption and air pollution are, however, still relevant in many places in the world. Efficient distribution of cleaner fuels, such as LNG, remains a challenge and is vital for economic and sustainable growth.

The development of LNG carriers

For the UK import scheme from Algeria, the first two commercial LNG carriers were built in 1964. They were the two sister ships *Methane Princess* and *Methane Progress*, built by the British shipyards Vickers Armstrong and Harland & Wolff, respectively. The cargo containment system was designed by Conch and based on the same principles as the *Methane Pioneer.* Each vessel had nine prismatic cargo tanks with a total capacity of 27 400 m^3. The tanks were insulated primarily with prefabricated balsa wood panels faced with plywood, and designed to act as a secondary barrier in the event of leakage from the primary aluminium tank. The cargo tanks were supported directly to the insulation system and the tanks were kept in position by aluminium keys in the centrelines. Even though the vessels were designed and built well before the IGC Code was written, the design would in principle meet the requirements of the code that was first adopted in 1983. Today, the containment system design would be designated as IMO type A. The two vessels operated successfully throughout their service life. They were easy to operate and reportedly popular among crews.

Figure 2. LNT45 – 45 000 m^3 LNG carrier.

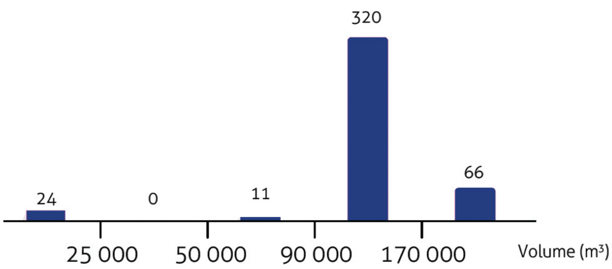

Figure 3. LNG fleet according to cargo capacity. Source: GIIGNL.

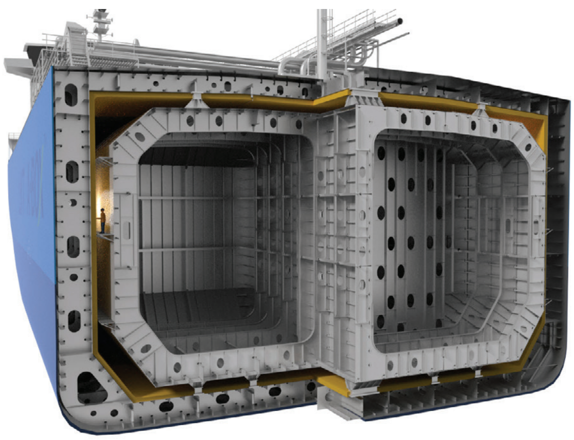

Figure 4. Tank section of the LNT A-BOX®.

In parallel, other technologies and prototypes were developed, especially in France, which was also planning LNG imports. The second prototype ship, the *Beauvais*, was undertaken by a group of French companies led by Gas de France in 1962. A third experimental ship, the *Phytagore*, was built in 1965 and used the Technigaz membrane cargo containment system. The *Jules Verne* was the first commercial project in France. It was a 25 840 m^3 LNG carrier, with a cylindrical cargo containment system built at the Ateliers et Chantiers de la Seine Maritime shipyard in France.

In the following years came the first membrane ships designed by French company Worms and Co., which later became known as the Gaztransport design. In 1970, Kværner Moss presented a design of an 88 000 m^3 LNG carrier with spherical cargo tanks, which resulted in the *Norman Lady*, which was delivered in 1973. In 1995, two new vessels were built for the Kenai LNG project by IHI Corp. in Japan. These were the first to be built with IHI's freestanding prismatic cargo tanks, the so-called SPB design.

Apart from IHI SPB, few new major innovations have reached the market since the first decades of the LNG history. Indeed, many of the technologies in use today are essentially the same as those used in the 1970s. However, the cargo carrying capacity for the ships has undergone considerable development.

LNG trade development

Driven by the economy of scale, the average size of LNG carriers has increased significantly over the years. The Q-Flex and Q-Max vessels built for Qatargas in the early 2000s are the largest to date. However, the standard size has continued to increase, and this now seems to be 170 000 m^3.

The main driver for economy of scale is the expected increase in distances over which LNG is anticipated to be transported. However, this may not actually be the case. There are now more LNG projects than ever around the world, and so trade distances are not getting longer, but rather are likely to become more regional.

The market developments and trends seem to argue in favour of the construction and use of medium size LNG carriers. Reasons for this development include the need to distribute LNG to smaller terminals planned around the world. Such terminals cannot accept larger vessels for reasons of storage capacity and draft limitations.

These smaller terminals represent an important trend in demand for LNG in Asia and elsewhere. The large Asian importers, such as Japan, South Korea and Taiwan, are slowing as growth markets and therefore suppliers are looking for new, smaller potential premium markets to be developed. Such smaller terminals will need to be served by smaller cargoes of LNG, which might come from reloads out of receiving terminals or directly from production facilities.

There are LNG terminals – planned and existing – that have an absolute need for medium sized LNG carriers to supply them. This situation is similar to what gave rise to the existing, but ageing, fleet of medium sized vessels in the fleet. These essentially came about from the existence of small terminals in the Mediterranean.

Essentially, the Qatari ships are the supertankers of the LNG industry. However, they mark the fact that the time has come to look carefully at specialisation and diversification within the LNG industry. This happened several years ago in the oil industry, with the development of vessel classes such as Suezmax, Panamax, etc. Both in tanker and dry trades, the main development over the last decades has been in ships for regional distribution to complement the development of large vessels for global distribution. This development has barely begun in LNG, however the demand is now becoming apparent and will need to be met.

Case study

Containment system

Based on the development of the LNG market, as well as knowledge and experience with different types of case carriers and how they came about, LNG New Technologies decided to develop a new containment system for LNG, which is particularly suitable for medium size LNG carriers.

The idea was to develop and commercialise a simple and efficient cargo containment system that could enable more shipyards, particularly in China, to build LNG carriers. Based on broad experience, knowledge of the IGC Code and its background, as well as in-depth studies of the existing containment systems (including those that failed), the team came up with the LNT A-BOX® design. The system is based on proven technologies, but in a new configuration and patent protected by LNG New Technologies.

The new design is based on an IMO independent tank type A as the primary barrier, a conventional cargo tank support system, and liquid tight thermal insulation attached to the hull compartment acting as a full secondary barrier.

For the first few projects, which are LNG applications, the cargo tank material will be 304L stainless steel. This could however, also be made from 9% nickel steel, and in case of ethane/ethylene applications, 5% nickel steel can be used as an alternative.

The cargo tank supports securing the tank position in the hull are made from laminated presswood, similar to that being used on other gas carriers with independent cargo tanks.

The insulation system is based on polyurethane foam panels fixed to the hull, with an inner surface of plywood covered with reinforced aluminium.

A special feature of the LNT A-BOX is the interbarrier space between the primary barrier and the insulation system, which enables access to both the primary and secondary barriers, as well as to supports for inspections and maintenance.

The technology has received an Approval in Principle (AIP) from DNV GL, Bureau Veritas, ABS and CCS. A thorough mock-up test was carried out and witnessed class in 2014.

Table 1. LNT45 carrier specifications

Shipowner	Landmark Capital
Class	ABS
Year of delivery	2017
Overall length	193.4 m
Length between perpendiculars	184.8 m
Beam	30 m
Depth	20 m
Draught (design)	9 m
Deadweight	29 500 t
Cargo capacity	45 000 m^3
Cargo	LNG
Tank design pressure	0.4 barg
Minimum cargo temperature	-165°C
Maximum cargo density	0.6 t/m^3
Boil-off rate	0.15%/d
Discharge capacity	3210 m^3/hr
Gas combustion unit	35 tpd
Propulsion system type	Mechanical propulsion controllable pitch (CP) propeller
Propulsion system output	11 700 kW
Service speed	16.5 knots
Main engine	Medium speed dual-fuel
Auxilliary engines	2500 kW dual-fuel
Bow thruster	1200 kW

45 000 m^3 LNG carrier

The LNT45 is designed as a medium size LNG carrier for worldwide trade, but with a particular emphasis on requirements for local and regional trades, as well as re-loading from large terminals. Landmark Capital has signed a contract for 1+1 vessel based on this design in China.

The ship design utilises the LNT A-BOX containment system and features three cargo tanks in three separate cargo holds. The cargo tanks are prismatic, and provide good volume utilisation, as well as freedom to design an efficient hull form.

The vessel is designed as a one grade carrier. Each cargo tank is fitted with two discharge pumps enabling the vessel to discharge a full cargo of LNG in approximately 15 hr without vapour return, with all cargo pumps operating simultaneously and using both liquid crossover. Similarly, the system is capable of loading a full cargo of LNG with a vapour return line in approximately 15 hr.

In order to be able to load at conventional, large scale LNG terminals, the ship is equipped with an additional elevated loading platform with a set of vapour and liquid manifolds to meet the working envelope of the LNG loading arms on the terminal's jetty.

In order to allow for loading of slightly warmer cargoes, which may be relevant for re-loading from large import terminals, the cargo tank design pressure has been set at 0.4 barg.

During normal service, boil-off gas will be used as fuel in the main and auxiliary engines to maintain the cargo tank pressures below tank relief safety valve set pressures. The design boil-off rate is less than the main engine consumption at normal service speed, and a system for forced evaporation and to ensure sufficient fuel gas to consumers at all times will be installed. A gas combustion unit designed for redundant boil-off handling will be installed.

The ship's propulsion system consists of a medium speed dual-fuel engine, with power output of 11 700 kW, which is connected to a reduction gearbox and controllable pitch propeller. The design is also provided with two dual-fuel auxiliary engines and a shaft generator. The shaft generator has a power take-in (PTI) mode to enable its use as a 'take-me-home' motor, powered by the auxiliary generator sets.

The service speed is 16.5 knots and the trading range is approximately 13 000 nautical miles. The vessel is provided with a bow thruster and flap rudder to ensure a high degree of vessel manoeuvrability.

Conclusion

The existing mid-size fleet is small and ageing, while the average LNG carrier size has increased to 145 000 m^3. Emerging LNG importers and a portion of existing smaller import terminals can no longer receive cargoes from an average-sized carrier. There is a strong demand for a fleet of cost-efficient LNG carriers for coastal and regional distribution, where large scale LNG infrastructure is not feasible. LNT45 has been designed to meet this demand. Reloading from large terminals as well as ship-to-ship operations, short voyages and frequent port calls in shallow waters have been kept in mind during the design phase.

The LNT45 design is considered suitable for local and regional trades and is a potential enabler for the more widespread use of LNG in regions without access to pipeline networks. **LNG**