CONTAINER
SHIPPING & TRADE

How LNGC systems are adapted for bunker duty in cargo ships

20 Jul 2020

by M Kalyanaraman

https://www.rivieramm.com/news-content-hub/how-lngc-systems-are-adapted-for-bunker-duty-in-cargo-ships-60299

Tank types, vapour return and other equipment that serve bunkering operations must be adapted to meet the specific requirements of cargo vessels

Barge with GTT membrane tank

The tank types as well as the gas-handling systems and operating procedures of liquified natural gas carriers (LNGC) are reference points for LNG-fueled cargo ships. But bunkering requirements are often not the same as cargo operations and the systems of the LNGCs need to be adapted for the LNG-fueled ships. Choice of tank type, requirements on vapour return, additional equipment that would be needed during bunkering on the receiving vessel, as well as the bunker supply ship need to be decided, selected and integrated.

Further, historically, the LNG cargo trade has been characterised by dedicated routes, ships and terminals so the ship-terminal-ship interface did not change much during the life of the ship. Each LNG train, from end-to-end, incorporated unique features and serve only those dedicated routes and terminals. But in recent times a spot market has developed for LNG trade. In the future, LNG bunkering too will likely expand, requiring greater standardisation to accommodate a range of players across the globe. In fuel oil bunkering, for instance, the technologies and procedures are so standard that they allow for a large spot market.

Applying membrane tanks

GTT’s LNG fuel directorate Abdoulaye Diouf says the business case for LNG has been validated in terms of low fuel cost, availability and environmental perspectives, but bunkering time and safety have become factors to be considered. Quality of LNG, the containment system and the bunkering operation have caught the attention of operators, shipowners and charterers.

Historically, LNG bunkering operations started out in specific areas, sometimes in stranded locations involving small volumes. The containment system was mostly Type C tanks, with pressure up to 10 barg and volumes at 500 m3 or less. LNG temperature is not a key issue for Type C as the containment systems have enough flexibility to overcome any poor containment system insulation or LNG quality, says Mr Diouf.

Operational requirements have changed, he says. Mr Diouf sees a segregation emerging between the high-volume LNG market (higher than 2,000 m3) and the low-volume market.

Mr Diouf cites the case of cruise ships where owners want to maintain operational pressure as low as possible to render unlikely any gas venting scenario (which are safety issues). In these cases, containers or Type C tanks of several hundred cubic meters start to show limitations. Other ship operators also want pressures low all the time in their vessels, including during bunkering operations. This would mean fewer bunkering personnel, a faster process and less time spent in bunkering.

“It is like how a balloon releases air faster as nothing disrupts its relief hole: high pressure downstream will hinder the LNG pump in the bunker vessel from delivering at its full flowrate,” says Mr Diouf. “This blockage will prolong bunkering, unless the receiving tank is maintained at low pressure,” he notes.

From passenger ships to container vessels, ship-owners and operators are favouring containment systems with lower pressures, in his opinion. “Lower pressures are safer and favour the business by cutting bunkering time,” says Mr Diouf.

Regardless of which containment system is chosen, two requirements are emerging: cold incoming LNG (low pressure); and vapour return facility during bunkering (gas generated from the receiving ships is routed back to the feeder).

Mr Diouf says GTT, a leading supplier of membrane tanks to LNGCs, has thoroughly studied pressure evolution in a receiver during LNG transfer operation, under time or gas treatment constraints. “Several test benches have been carried out that have helped us understand LNG behavior in various operational profiles, including LNG transfer operation and idling,” he says.

Mr Diouf says GTT performs compatibility analyses that involves proper selection of the bunker vessel, confirms the feasibility of LNG transfer operations with existing bunkering vessels, and addresses future changes such as the need for partial bunkering or bunkering at various locations with specific LNG conditions. Key equipment and lines involved in bunkering are selected, an emergency response plan, such as during blackouts, is evolved, and the operating procedure is optimised.

Coralius Aurora with TGE Marine Type C tank

Handling high pressures

TGE Marine Gas Engineering's sales engineer Johannes Dziuba sees the problem of boil-off gas (BOG) during bunkering as a key determining factor in choosing containment systems and equipment.

TGE Marine Gas Engineering has delivered the cargo tanks and the gas-handling systems for four of the first six LNG bunker vessels in operation in Europe, as well as multiple fuel gas systems for various kinds of LNG-fuelled vessels on the receiving side.

Boil-off gas build-up is a consequence of several operating scenarios, as well as the equipment and tank containment systems used. In Mr Dziuba's view, as the tanks get larger for greater volume, the top of the empty tanks becomes quite warm which could lead to greater production of flash gas from incoming LNG.

"If the owner has analysed the operational profile and ensures the vessel conforms to that operational profile, they will have great success"

An onboard Gas Combustion Unit (GCU) or chiller system to treat the vapour, or a system to return the vapour back to the bunker vessel, would help. Having the capacity to keep the BOG inside the tank would also be highly beneficial, says Mr Dziuba. With integral tanks, such as membrane tanks with a maximum rating of 0.7 barg, this would be difficult to accomplish, unlike a Type C tank that can hold pressure of up to 4.5 barg (8 barg and higher is possible).

Mr Dziuba says among the studies TGE Marine has done is a simulation of various bunkering scenarios: Type C tank delivering to membrane tank; membrane tank delivering to membrane; and so on. A membrane tank delivering to a membrane would be highly challenging because neither side can handle high pressures, due to BOG production, he adds.

TGE Marine did a simulation of three cases using membrane tanks on the receiving side and Type C on the bunker vessel: Case 1 was free flow of BOG from receiving ship to bunker vessel; Case 2 was the use of a BOG compressor at 150 mbarg (starting tank pressure on both sides) for vapour return; Case 3 was vapour return with BOG compressor at 300 mbarg (difficult case). In Case 3, the starting pressures were higher, with the bunker tank pressure at 300 mbarg and vessel tank pressure at 400 mbarg

The BOG production conditions were: bunker tank of 18,000 m3 capacity; bunkering rate 1,600 m3/h; BOG displacement out of vessel tank at ~ 3,100 kg/h; and vessel tank flash gas production at ~ 490 kg/h.

In Case 1, the vessel tank pressure crossed the 0.7 barg typical of membrane tank design pressure and crossed 1.2 barg towards the end. Bunker tank pressure too crossed 0.7 barg. In Case 2, the bunker supply tank pressure almost touched 2 barg, while the receiving vessel tank pressure stayed below 0.5 barg. In Case 3, the supplying tank pressure almost touched 3 barg, while receiving tank pressure was well under limits.

Mr Dziuba says the BOG compressor can be placed on bunker supply vessels or on the receiver vessel: "Other means of BOG handling could be used, such as a reliquefaction unit or a GCU. Reliquefaction results in high space requirements and power consumption. A GCU requires a large amount of space and increases opex due to burning of gas."

Furthermore, TGE has developed a special Type C bunker tank for larger container vessels, which can be placed exactly in a 40 ft container bay, maximising space efficiency and providing the advantages of a Type C tank at the same time.

Making trade-offs

The differences between the operational requirements of an LNGC and LNG-fueled cargo ships, such as a container vessel, play key roles when adapting cargo tank designs for bunkering purposes. ABS Group manager for LNG services Robert Kamb says: "The Type C tank is attractive when the ship owner does not want to install additional equipment. This is the case when power demand is low and when the BOG rate is slightly higher. In an integral tank type, the trade off is larger tank capacity. Long voyages are possible without needing bunkering. Additional equipment, such as GCU may be required, and I have to manage the LNG as cargo," he adds.

On loading limits, Mr Kamb asks, how much LNG can possibly be loaded into the tank at the given temperature and pressure, so that the filling limit that specifies the limit at the reference temperature is not breached? For a Type C tank, the loading limit is lower than membrane tanks (around 85% for Type C and 98% or more for membrane) but pressure accumulation capability is higher. Further, the Type C tank occupies typically four times more space than the conventional tank.

On the topic of operating conditions, Mr Kamb says owners often underestimate the idle time of a ship. This means power demand is typically lesser than anticipated, which is critical for an LNG-fueled ship. If the propulsion system is not being put to use to match the BOG production rate, then it could lead to higher pressure and temperature. Also, LNG bunkers coming in are often warmer and that leads to higher BOG production rates. "If the owner has analysed well the operational profile and ensures that the vessel conforms to that operational profile they will have great success. If the operational profile does not quite match, then they may want to consider investing in a reliquefaction plant," he says.

Mr Kamb says the IGF code does not require vapour return, although the IGC code requires it, which means bunker vessels need it.

The challenge with vapour return is that in the future it will have to be satisfactorily accounted for, he says. "In LNG cargo operations, there is a third-party surveyor, since large volumes and millions of dollars are involved. Variable factors have to be accounted for. Most of the currently operating LNG bunker vessels have maybe one or two customers, so everything is accounted for and disputes do not arise. But the ubiquity of LNG bunkering is increasing. Soon, the commercial aspect of vapour return will have to be accounted for, such as in spot markets that may develop for LNG bunkering, just as in fuel oil bunkering. The reality, however, is that even gas-fueled ships with vapour return do not need to use it. If LNG is cooled down, then the tanks can be kept cool enough," he adds.

The ideal case for bunkering is having cold LNG in the tank that is practically empty and cold LNG comes in the bunker barge. "But that is always not the case. During the design phase, accurate inputs are required as to power consumption, fuel, geographical location, quality of supply, transport equipment, parameters of bunker barges, expected operational profile of the shipand so on," he says, adding that all these have to be considered while selecting the bunker tank type.

Further, while a membrane tank may have a lower boil-off rate than a Type C tank, in the smaller versions typical for LNG marine fuel installations, a higher aspect ratio can increase BOG rates. "Additionally, in the integral (membrane) tank, the inter-barrier space pressure, exterior pressure, nitrogen system, as well as the gas detection in that space add to the complexity," says Mr Kamb.