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HEDGING STRATEGIES
HYBRID VESSELS
CREDIT LINES
FUEL ANALYSIS

# Pressure points

## LNG 'frontrunner' GTT reviews the development of its membrane technology and discusses the benefits of LNG transfer and onboard storage at low pressure

**Most large LNG carriers in operation are fitted with membrane technologies developed by GTT. These technologies offer a number of advantages: the integrated membrane tank fits closely with the form of the vessel's hull, and it also affords a lower lightship weight and greater flexibility in hull shape, thereby allowing improvements in vessel performance and reduced fuel consumption.**

The development of an extensive R&D department at GTT, together with more than 3,700 years of cumulated experience at sea, has allowed significant improvements in these technologies: for example, using a fully-equipped facility (see Figure 1) and numerical methods, GTT can compensate for the sloshing effects in cargo tanks and guarantees a boil-off rate (BOR) reaching 0.07% per day for the most efficient configurations.

Moving from large-capacity LNG carriers to smaller capacity ships and then to LNG bunkering vessels is a natural move for GTT. Given the fact that these vessels mainly operate in congested areas, GTT has, through a cooperation programme with Hamburg University, focused in particular on collision risks in order to assess the behaviour of the cargo containment system: the membrane system has been proven to be capable of withstanding considerable deformations which can occur during a collision, with no loss of tightness (see Figure 2).

GTT is also developing extensive models validated by feedback obtained from LNG carrier to FSRU transfers and by internal laboratory tests to assess the behaviour of LNG during bunkering operations (Figure 3).

However, at the time that LNG bunkering operations were initially developed, the context was slightly different. Originally, Type C technology was mainly applied to small capacity tanks and higher temperature fluids, such as ethylene and liquefied petroleum gas. It was upgraded to be applicable to LNG, and some shipyards not familiar with membrane technology were able to offer small capacity LNG vessels (feeders and/or LNG bunkering vessels). Of eight LNG bunkering vessels currently in service, one is fitted with a membrane tank (Figure 4).

GTT has since developed a network of outfitters able to build membrane tanks in non-membrane licensed shipyards.

The major reason for choosing the Type C tanks was that owners initially considered that the possibility of pressure build-up to about 4-5 barg was an advantage as compared with the membrane tank, which is limited to 700 mbarg[i].

So, in the case of an LNG bunkering vessel is 700 mbarg sufficient?

The primary purpose of an LNG bunkering vessel is to deliver LNG, and therefore the key question is what are

Figure 1

Figure 2
(Courtesy of Hamburg University)

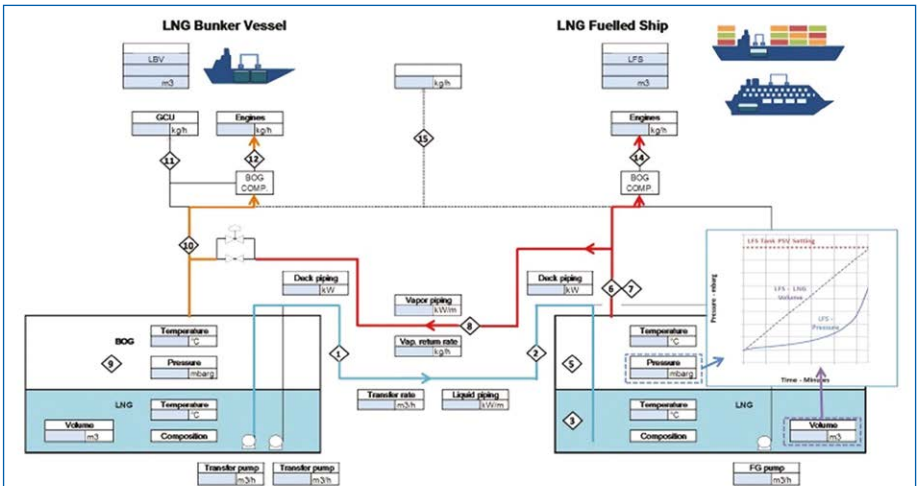


Figure 3 - assessing the behaviour of LNG during bunkering operations


Figure 4
(Courtesy of Conrad)

the consequences of delivering LNG to a client vessel at too high pressure?

According to common practice in the LNG industry, the pressure of an LNG receiving unit is set to about a few tens of mbarg above the pressure of the delivering unit in order to minimise boil-off gas (BOG) during the transfer. Of course, the initial conditions of the tanks and the composition of the LNG must first be considered, but once the transfer is at nominal flow rate, a configuration such as this is optimal.

In the case of an LNG bunkering transfer operation, the same philosophy applies. Therefore, if the LNG delivered to a client vessel fitted with Type B, Type C or membrane tanks is at a too high pressure, this means that either:

- the pressure 'reserve' of the client vessel after the bunkering operation will be significantly reduced if the BOG is not properly handled. This will impact the client vessel's BOG management during her voyage along with her tank pressure management flexibility,

or

- a large amount of BOG will be generated during the LNG bunkering transfer in order to achieve a lower pressure in the client vessel tank(s); the extra BOG generated has to be recovered by the LNG bunker vessel via a gas return line. The design of cargo handling equipment onboard the LNG bunkering vessel is therefore difficult to define as it depends on the quantity of gas return, its composition, etc. Generating a large amount of BOG will also lower the Methane Index of the LNG delivered and may impact the operation of the gas engines or gas generators, if any,

or

- the operation will take longer if the LNG transfer flow is reduced in order to ensure smooth handling of the BOG.

These simple observations demonstrate that according to the rules which have been in place in the LNG industry for decades, delivering LNG at low pressure (or at low temperature) minimises gas losses during transfer without penalising the client vessel.

Except for the delivery of small quantities (a few tens or hundreds of cubic metres) of LNG, where LNG tanks onboard client vessels are pressurised for fuel gas generation, many LNG fuel players (bunkering vessels or client vessels) are now considering that LNG bunkering vessels should deliver 'cold LNG', i.e. at a pressure that is as low as possible.

However, some other players are still considering that having a sufficient pressure reserve offers more flexibility. Two scenarios should be envisaged for the LNG bunkering vessel (assuming that the gas is used as fuel):

- most of the time, the LNG bunkering vessel is waiting at port between two deliveries; as discussed previously, greater BOG management flexibility via pressure build-up is a temporary solution which is of very little interest because all the BOG stored in the tank(s) as a result of the pressure rise will have to be released prior to LNG delivery to the next client vessel;
- the LNG bunkering vessel is also used as a feeder sailing from A to B: in this case the BOG will be consumed in the engines and the pressure will be kept low; 700 mbarg offers enough flexibility to manage the transient pressure fluctuations.

Another advantage of having an LNG bunkering vessel at low pressure (700 mbarg) as compared to a vessel pressurised to 4 barg is the loading limit of the tanks; according to the IGC Code, a low-pressure vessel allows storage of 5% more LNG than a pressurised vessel.

All the knowledge gained through its core business on large LNG carriers has enabled GTT to develop various areas of expertise in LNG cargo tank design and LNG handling systems, and to become recognised by the industry as an expert in LNG.

Detailed studies of LNG behaviour and the processing and management of the inherent BOG of LNG in tank(s) or during LNG transfer have shown that GTT membrane technologies are well-suited to LNG bunker vessels, offering owners or charterers definite advantages (more cargo, lower fuel consumption, etc.), and make sense for LNG bunkering applications. It is not surprising that some of them have recently chosen the membrane technology for bunker vessels.

i. For easier reading, a number of 'simplified terms' are used in this article. A pressure of xx barg means the maximum allowable pressure of the relief valves considered at liquid/vapour thermodynamic equilibrium. 'Cold LNG' means LNG at a low equilibrium temperature for a given pressure. The lower the LNG pressure, the lower its equilibrium temperature.

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