LNG as Fuel – Bunkering, storage and processing

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1 Introduction

Today there is no doubt that improvement of ship's emissions is urgently required, even if shipping is supposed to be the most eco-friendly means of transportation. There are different ways to cut NO_x, SO_x, particulate matters and CO_2 emissions, but only one solution provides "all in one" reduction of all mentioned emissions: LNG as a ship's fuel will reduce NO_x to clearly below Tier III level (for four stroke engines), SO_x to zero, particulate matters to about zero and CO_2 by about 20 % without any after treatment of combustion gases or exhaust gas recirculation.

Using LNG as a fuel is common technology for decades on LNG carriers. There is an excellent safety record for loading/unloading of those vessels as well as for operation of propulsion systems based on burning boil-off gas. Further there is about ten years of experience mainly in Norway on small ships with LNG propulsion, e. g. ferries and offshore supply vessels.

2 Small LNG Carriers

Even though an established worldwide infrastructure for LNG exists, that does not fit the needs for LNG bunkering. There is a significant gap between the large scale LNG terminals served by large carriers of 140,000 cbm upwards in order to supply millions of tons of natural gas to the gas grids and the small installations for LNG as bunker fuel. To close this gap, small LNG carriers being large enough to call at the major terminals for loading, but also being small enough to serve the bunker infrastructure are required. First steps are done with "Coral Methane", a 7,500 cbm combined LNG/Ethylene/LPG carrier designed by TGE and operating since 2009 for Anthony Veder Group/NL. This ship loaded several LNG cargoes at large European import terminals like Zeebrugge. A next generation ship is under construction at Meyer Werft in Germany – a 15,600 LNG carrier for Anthony Veder Group with gas handling system from TGE. Both ships have dual fuel propulsion systems to control the tank pressure as well as to reduce emissions.

Based on IMO type C tanks LNG carriers of 40,000 cbm or even more are feasible, maximum 10,000 cbm per cylindrical or 20,000 cbm per bilobe tank have been studied. The major advantages of this very reliable tank type are the flexibility in pressure management (BOG) and the fact, that no secondary barrier is required.

3 LNG bunkering

LNG bunkering will have to be as close as possible to the traditional bunkering, if it shall be accepted by the majority of the shipping industry; that is more or less consensus. However, there are few details in place about how to bunker large amounts of LNG to a ship while it is alongside at the terminal for cargo operations. Bunker volumes and required bunkering rates will exceed by far the current Norwegian practice, and bunker vessels or barges will be required to cover the needs. The safe handling of heavy equipment like dry break emergency release couplings and double wall hoses or pipes of relevant diameters will ask for mechanically or hydraulically supported installations. Technical solutions do not seem to be the major issue, as ship-to-ship transfer of large amounts is current practice in LNG business. The main challenges are the procedures and the global and local regulations that still need to be developed.

The bunker interface would require better standardization than for current fuel oil bunkering, as the use of quite a number of reducers cannot be accepted for LNG. Each flange connection is a hazard for spillage and leakage, therefore a reduction to the minimum is mandatory. Further data connection between the ships including ESD (emergency shutdown) function has to be in place for safe bunkering. Vapour return connection is not a must; however, it will clearly ease bunkering at high loading rates and avoid accidental gas emission via safety relief valves during bunkering.

4 LNG fuel tanks

One basic disadvantage of LNG is its low density: For the same energy content LNG takes roughly twice the volume of liquid fuels. There are several types of containment systems for LNG available, but some are not feasible for the given conditions on ships using LNG as fuel following current designs. E. g. most of the membrane tank systems as used on the very large LNG carriers are sensitive to sloshing and could therefore not carry partial loads – thus any use as fuel tank is not possible. IMO type A (self-supporting tanks designed like ship structures) and type B (self supporting prismatic or spherical) tanks are generally feasible for fuel gas tanks, but their requirement for pressure maintenance and secondary barrier rise difficult problems that are not yet solved in a technically and commercially sound way. This will be a future solution for ships carrying large amounts of LNG as fuel.

So IMO type C tanks (pressure vessels based on crack propagation design) turn out to be the preferred solution for today. Those tanks are very safe and reliable, their high design pressures allow for high loading rates and pressure increase due to boil-off; finally they are easy to fabricate and install. The major disadvantage is the space consumption of this tank type that is restricted to cylindrical, conical and bilobe shape. In addition to the unfavorable LNG density these tank shapes lead to a total factor of 3 to 4 times the oil bunker tank volume to carry the same energy in LNG. On top of that, high design pressures reduce the allowable maximum filling limits, if following today’s status of regulation.

Tank insulation is required in order to reduce heat ingress and to protect the ship structures against the cryogenic temperatures of LNG. This may be done by vacuum or foam insulation depending on the operational and tank shape requirements. Vacuum tanks have an excellent insulation performance; however, they are restricted to cylindrical shape, limited in size and usually do not have a manhole for inspection or mounting of in-tank equipment. Foam insulated single shell IMO type “C” tanks are feasible in cylindrical, conical or bilobe shape in order to better fit to the available space. Either foam panels are glued to the tank and protected by vapour barrier and steel sheets, or foam is directly sprayed to the tank surface and covered by a polymeric layer. Both has been done for small LNG carriers with type C tanks. Even with special high-capacity panels the heat ingress is clearly higher than for vacuum insulated tanks.

5 LNG fuel gas systems

Basically the process system is intended to bring the LNG to the pressure and temperature level as required by the engines. Pressurizing may be either done by small vaporizers keeping the entire tank on high operation pressure, by pumps serving the vaporizers or by compressors. All versions are feasible, the plant capacities and operational requirements will dictate the right solution tailor-made for each situation.

A lot of projects in the market are based on dual-fuel engines, that are able to run on liquid fuels (HFO, MDO, MGO) as well as on gas (using small amount of MDO/MGO as pilot fuel). These systems combine inherent redundancy with fuel flexibility. Redundancy of gas-driven propulsion systems is required by the Code and these engines will just switch over to liquid fuel without interruption, if gas systems fail. Further the operator may choose the fuel that is more easily available or cheaper on short notice.

Also 2-stroke engines will be available as dual-fuel engines quite soon. They require a different process system due to high injection pressure of 300 bar g. On LNG carriers this can be done by BOG compressors, possibly combined with reliquefaction system. But for other ships high pressure pumps and high pressure heater are the preferred alternative to achieve the required pressure level. Tanks will usually be equipped with in-tank pumps to feed the high pressure system as well as the low pressure fuel gas supply to auxiliary engines.

6 Conclusion

Technical solutions for distribution of LNG as bunker fuel as well as safe operation of LNG fuel gas systems are available. Emission control and rather low LNG prices should be the main drivers to develop LNG as fuel. Currently the missing of the related bunker infrastructure as well as the regulatory framework for such operations is the main challenge that needs to be addressed soon in order to make LNG a reliable option for the Owners in their decision about future ships. With the relevant dates for ECA & SECA legislation coming closer the pressure will rise for everybody to find a solution to cover the challenges resulting from it.

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