Bunkering is key for deepsea ships

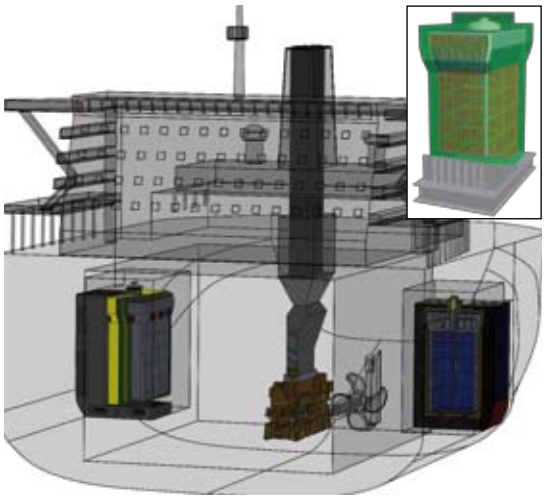
As industry races to design LNG fuel systems for deepsea vessels, Syd Harris looks at an innovative bunker tank solution from Scandinavia

All LNG-fuelled vessels currently in service are relatively small and engaged on shorthaul routes. They are in operation in Norway, either in the North Sea, across fjords or in coastal waters, and include ferries, offshore supply ships and coastguard cutters. In addition a Yangtze River tug has recently been trialled on an LNG/diesel oil mix following an engine retrofit. All these vessels can be easily refuelled from local shore and river bases and, as a consequence, do not require a large LNG storage capacity on board.

In all these pioneering vessels, and there are now just over 20 of them, LNG is stored below deck in horizontally mounted, vacuum-insulated, cylindrical pressure vessel tanks with dished ends. The first gas-powered ferry, *Glutra*, has two 32m^3 LNG tanks sized for fuel delivery by road tanker. *Bergensfjord*, the first of five LNG-fuelled, double-ended ferries owned by Fjord 1 and operated along the E13 route in western Norway, has two 125m^3 fuel tanks. Both the Norwegian coast guard cutter *Barentshav* and supply ship *Viking Energy* have a single 234m^3 LNG fuel tank. Each of the three ferries in the Tidekongen series, which provides a passenger and bicycles service for Oslo commuters, has a single 29m^3 tank.

More recently, proposals have been unveiled for larger LNG-powered ships on deepsea routes, as more shipowners seek to benefit from the environmental and potential cost-saving advantages of clean-burning gas. In contrast to the LNG-fuelled vessels in service the LNG fuel tank storage capacity for deepsea ships would need to be in excess of 500m^3. This is a size which is not considered economical or feasible for vacuum-insulated tanks, not least because of the large amount of underdeck space occupied by a horizontal, cylindrical pressure vessel tank and any associated containment/insulation arrangements.

To find a solution for the larger LNG bunker tanks that will be required by deepsea vessels three Scandinavian companies have formed an alliance to develop a complete LNG fuel bunkering, storage tank and gas delivery system. Two of the partners, Marine Gas Insulation AS (MGI) and Torgy Mek Industri AS, are near neighbours in Tønsberg in Norway. The third partner, LR Marine AS, is based in the Danish port of Frederikshavn.



Artist's impression of two Type A LNG fuel tanks on each side of the engineroom of an oceangoing ship; inset, a JG/Rolls-Royce-designed 450m^3 Type A LNG fuel tank

As with all means of carrying LNG by sea, the arrangement for supporting an LNG bunker tank must be able to withstand tank movements arising from both temperature changes and the flexing of the hull structure due to ship rolling, pitching and heaving. This requirement has been taken into account by the alliance trio in their proposed LNG storage system, which consists of a tank resting within an insulated ship compartment. The system is being developed for both IMO Type A prismatic and Type C cylindrical tanks. The IMO Type C cylindrical tank would be vertically mounted.

The IMO Type A tank offers the most compact installation and the best utilisation of space. For this containment system the tank would be the primary barrier and a liner in the insulation would provide a fully integrated secondary barrier.

The supporting arrangement for the Type A tank is a totally new approach and is described as being similar to a crib able to accommodate expected in-service tank thermal contraction and expansion cycles. At this stage the solution is patent pending and no technical details

have been released, but it can be seen that a key element of this still secret design approach is the arrangement of the tank support surfaces in a certain direction in relation to the bottom sliding supports of the tank.

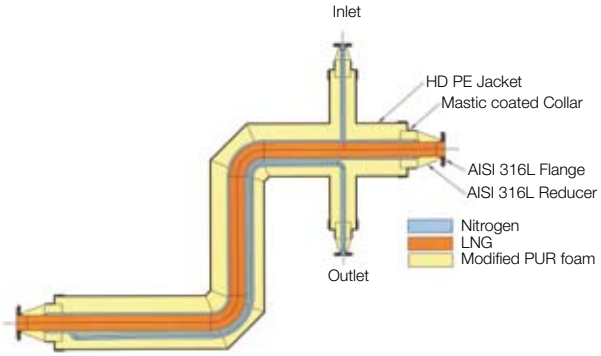
To complement the fuel tank development a fully insulated LNG bunker pipeline delivery system has been proposed. This system, which has been designed in close cooperation with LR Marine, consists of double-wall, insulated piping and a nitrogen generator unit to cool and maintain the bunker pipe at cryogenic temperature prior to filling. The approach is designed to prevent the generation of flash gases and thus enable filling without restriction.

In January 2009 Jahre Group AS (JG), a small Norwegian marine service and gas technology company, also from Tønsberg, initiated a three-year LNG fuel tank research and development project. Funding was provided from the Norwegian Research Council-backed MAROFF project and JG LNG Fuel AS was formed to promote the IMO Type A fuel tank concept developed by the MGI/Torgy/LR Marine alliance.

In a further step, JG has agreed with Rolls-Royce Marine AS in Norway to work together on the design of prismatic LNG fuel tanks for all types of ship. Rolls-Royce has become a major player in supplying both gas engines and azimuth thrusters in Norway. Rolls-Royce systems are fitted on the Bergensfjord series, for example, as well as the latest double-ended ferry ordered by Fjord1. Being built by the Fiskerstrand BLRT yard in Norway, the latter vessel will be the largest LNG-fuelled, double-ended ferry on completion.

The pair of shortsea roro/multipurpose cargo ships that Sea-Cargo ordered at the Bharati shipyard in India two years ago represent a key step in the evolution of LNG-fuelled deepsea ships. Each of the LNG-powered Sea-Cargo vessels, which are scheduled for delivery in 2011, is to be provided with a Rolls-Royce/Bergen gas engine. When they commence operations, the ships will provide a 10-day, round-trip service, with calls at Baltic, Norwegian and UK ports, and will refuel at the new Risavika LNG terminal now being commissioned by Nordic LNG on the outskirts of Stavanger.

Both Sea-Cargo ships are to be provided with two vacuum-insulated, horizontal, cylindrical bunker tanks, of 240m^3 each, forward of the engine room. The tanks will take up a considerable amount of underdeck space, which, in turn, compromises the vessels' cargo-carrying capacity to a certain extent. Rolls-Royce and JG appreciate that the Sea-Cargo ships are approaching the limit as regards the viability of horizontal Type C tanks, and for larger oceangoing vessels they are promoting



The fully integrated, double-wall bunker pipe is an integral part of the system

the cost-saving advantages offered by Type A prismatic LNG bunker tanks.

Prior to filing a patent application, JG presented its Type A tank concept to Det Norske Veritas (DNV) for review. Acknowledging that the concept's tank support system solution is intended for LNG marine storage and the transport of LNG in general, the class society highlighted certain critical aspects of the overall design which have formed the basis for further development. In June 2010 the insulation system developed by MGI for the concept was granted "approval in principle" status by DNV.

Mock-up testing facilities have been made available under the auspices of the MAROFF project. As part of the programme a test model of the Type A bunker tank has been prepared, complete with support structure. The tank has been insulated with polyurethane foam and combined crack and leak barriers have been integrated in the foam as per the MGI design.

In the tests the insulation was gradually cooled and then submerged in liquid nitrogen. Extensive temperature measurements were made inside the insulation layers during the eight-day test period. A further test was carried out in which the mock-up of the tank was quickly submerged in liquid nitrogen.

Following the initial tests it was concluded that more research on stress patterns in the foam will be required and further testing is planned.

Looking to the future, the question arises as to whether this new Type A concept could conceivably become more than just an LNG bunker tank design and go on to pose a challenge to the established LNG carrier cargo containment systems. The new insulation, with its integrated secondary barrier, and the robust prismatic cargo tanks appear to offer the shipowner undoubted advantages, not least a neat, compact ship, a flat main deck and no requirement for the hull structure enclosing the cargo tanks to serve as a means of LNG containment. *LNG*