A POLAR ADVENTURE

Alexandre Tocatlian and Eric Minaux, GTT, France, provide detailed insight into how the company helped make the first polar exploration vessel powered by LNG possible.

Exploring the poles and the areas surrounding the Earth's southernmost continent while offering sustainable, environmentally-friendly tourism was what luxury cruise company Ponant had in mind when it began designing its polar exploration vessel *Le Commandant-Charcot*.

Sailing under the French flag, with a capacity of 270 passengers and a crew of 180, *Le Commandant-Charcot* will start sailing in the Arctic Circle and Antarctica from the summer of 2021. Thanks to its innovative hull design, the 150 m vessel will be able to operate safely and with complete autonomy, unassisted, in extreme ice conditions on cruises of up to three weeks long.

Protecting the oceans, their ecosystems and the environment in general is a priority for the shipowner Ponant. This important consideration was incorporated right from the design phase. To this end, Ponant chose cutting-edge technology to guarantee it would have a minimal impact on the environment and outperform even the most restrictive standards. The shipowner studied the various maritime propulsion system solutions available, and selected a hybrid propulsion system, combining LNG and batteries.

A joint achievement

In July 2017, Ponant contacted Gaztransport & Technigaz (GTT), a technology and engineering firm specialised in membrane containment systems for transporting and storing liquefied gas, especially LNG. GTT proposed an innovative solution, offering freedom from the usual constraints of bunkering in very remote areas, by substantially increasing fuel storage capacity. Later that year, Ponant took the decision

Figure 1. *Le Commandant-Charcot* : polar exploration vessel.

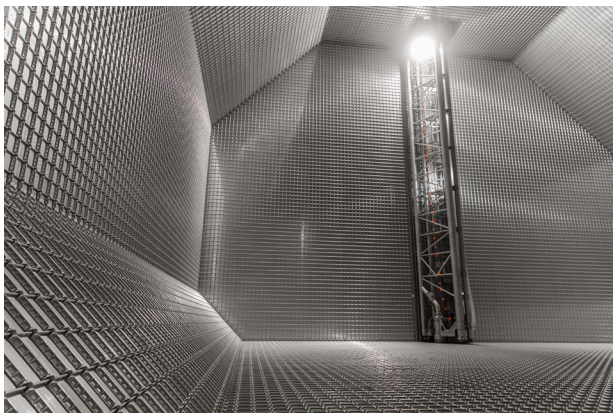

Figure 2. The inside of a membrane tank.

to outfit its vessel with GTT's membrane tanks. The contract was signed in July 2018. In order to meet the requirements of both the shipowner and the shipyard, GTT took on the role of the engineering, procurement and construction (EPC) contractor for the tanks for the first time in its history.

The vessel's design was first studied by Finnish firm Aker Arctic before being handed over to the Norwegian construction yard Vard, a subsidiary of the Italian group Fincantieri. Wärtsilä was selected to supply the latest generation of dual-fuel engines, which offer excellent performance and are specifically designed to run on gas.

The advantages of LNG propulsion

Ponant's decision to use LNG was not arbitrary. Designing its vessel to feature the latest innovations in environmental protection was a priority. *Le Commandant-Charcot* will not only meet the latest environmental requirements established by the International Maritime Organization (IMO), but will even go beyond the current regulatory thresholds. LNG cuts the vessel's sulfur oxide emissions by virtually 100% compared to heavy fuel oil (HFO) and reduces its fine particles emissions by over 95%. Furthermore, using LNG allows *Le Commandant-Charcot* to comply with future regulatory standards in terms of nitrous oxide, reducing these emissions by 85%. Finally, LNG propulsion reduces carbon emissions by 25% compared to fuel oil.

It should also be noted that LNG is an abundant and available resource. British Petroleum (BP) estimates that the world's reserves will last another 230 years.[1] The same cannot be said for low sulfur fuels, such as low sulfur heavy fuel oil (LSHFO).

Constraints and challenges

To successfully complete the design of the LNG tanks for *Le Commandant-Charcot*, GTT had to face a large number of constraints and challenges.

Maximised autonomy and space

One of the first challenges was to minimise the impact of LNG tanks on available space onboard, while maximising the autonomy. This autonomy should allow it to make all of its trips to the north and south poles, or the Arctic Circle and Antarctica, fuelled by LNG. GTT managed to develop a customised solution to meet the constraints of a very compact expedition vessel.

As membrane tanks can adapt to the geometric shape of a hull and to a vessel's design, their placement can be adjusted, which helps optimise space and limit encroachment upon areas that could be used for cabins. Two Mark III membrane tanks with a total capacity of 4500 m^3 will be located in part under the waterline at the back of the vessel. This capacity is impressive compared to competing bilobe Type C storage solutions, which have a total capacity of just 2900 m^3. The compactness of GTT's membrane containment system guarantees *Le Commandant-Charcot* an autonomy between two weeks and two months, depending on navigational conditions. This compact design optimises cargo capacity into very small spaces, and thereby increases the ship's autonomy, allowing it to make all of its voyages powered by LNG.

The location of the tanks also saves a deck over 200 m^2 compared to competing solutions. To do this, GTT worked with Ponant, Vard and Wärtsilä to develop a very compact design for the tank connection space (TCS) – a sealed enclosure generally located above each tank to contain the connections, equipment and major control instruments (control valves, exchangers, other valves and tank insulation).

Operational flexibility

An improvement relative to the increase of design pressure of the membrane tank was proposed to Ponant to offer more operational flexibility, especially during LNG bunkering. This will make it possible to load LNG at higher temperatures. Operators may also benefit from an additional pressure increase reserve in exceptional cases (for example, a safe return to the port with insulated LNG tanks).

Following IGF Code and class recommendations, an alternative design was put forward, and an in-depth risk assessment was carried out simultaneously, under the supervision of Bureau Veritas Solutions, in order to verify and guarantee to Ponant that a membrane tank with a greater design and service pressure was just as safe, or safer, than that stipulated by the IGF Code.

Untouched construction schedule

The construction of a vessel such as *Le Commandant-Charcot* lasts a little over two and a half years, from the steel cutting in November 2018, to the delivery of the vessel, which is currently slated for April 2021. The vessel's construction must be planned carefully so that each stage can be completed within a given amount of time in-keeping with a tight timetable. Given that various specialised teams must work at the same time in a restricted space, it is essential to plan well and to stick to a very strict schedule.

The tank installation, which will be handled by DSEC, a Korean subcontractor of GTT, was scheduled at the same time as other tasks, so that it would not delay the various vessel construction stages in Søvikness, Norway. The construction of the membrane tanks is due to take place between May and November 2020. Ahead of the insulation installation, a preparatory phase was carried out at Vard's Tulcea site. This included precise measurement and marking of the internal hull, verification of its levelness, painting and installation of studs and the domes, which will contain all of the connections to the tanks. A large prefabrication space was set up directly above the reservoirs to facilitate prefabrication of the

membrane tanks, in particular so that the panels can be stored and prepared ready for the tank assembly, which is scheduled to begin in May 2020.

Specific studies and new designs

Although the cryogenic containment systems that GTT has been delivering for nearly 60 years have proved their reliability, studies specific to these new LNG tanks were carried out to minimise the operational risks. The tank insulation, which keeps the LNG at a temperature of -160°C, was selected among the latest types of foam certified by GTT. The thermal performance and, in particular, thermal conductivity, was tested and verified by independent laboratories. The membrane is also designed in a way that compensates for dilations and contractions to prevent it from being subjected to excessive constraint.

Liquid movement studies specific to the characteristics of the vessel, the size and shape of the tanks and the exterior conditions (sea movements, wave pressures, acceleration, extreme polar conditions, etc.) that *Le Commandant-Charcot* will face were also carried out. The sloshing of the LNG inside the tanks, and its impact on the structural walls and their insulation system and internal pipes, were simulated using hexapods that reproduced the vessel's movements and yielded insight into the fluid behaviour under real conditions.

During the engineering phase, GTT's teams developed new technological bricks, in particular for the domes. Two new configurations were deployed. The first, known as a liquid dome, contains all of the pipework used to load LNG or transfer it to the engines. The second, called a material passing hole, is outfitted with a bolted flange of approximately 1 m in diameter, and will be used to access the tank for inspections.

A new mast design has also been developed that is much simpler than in traditional LNG carriers, and which maintains the tank loading/unloading pumps and pipework.

Figure 3. Inspection of a membrane tank.

Future challenges

The procedures, calculations and results obtained up to this point have been validated by the classification society Bureau Veritas. In the spring of 2020, the ship will be towed from Vard's Tulcea site in Romania to its Søvikness site in Norway. The tank installation will begin in May 2020, and many challenges are still expected in 2020 during this installation phase. A team of four experienced GTT representatives will be at the site to manage the installation of the membrane containment system. DSEC, which is experienced at assembling the Mark III technology, will work with GTT to install the insulation in the tanks.

GTT will also assist Ponant and the shipyard Vard with the gas trial phase, which will, in particular, verify the system startup, vessel performance and motorisation. Trials at sea under real conditions, and then trials under ice conditions, will follow before the final delivery of *Le Commandant-Charcot*, which is slated for April 2021. LNG

Reference

1. BP Statistical Review, 2016