

# Gas-injected diesels next on MAN agenda

With high fuel oil costs driving project development, gas-injected low speed diesels is MAN Diesel's third offering to the LNG carrier sector

The MAN Diesel organisation's entry into the LNG carrier sector has been dramatic by any standard. Since the first order for the large ships to carry Qatar LNG was placed in September 2004, MAN B&W two-stroke 6 and 7S70ME-C diesel main engines have been specified for the entire 45-vessel programme of 216,000m<sup>3</sup> Q-flex and 265,000m<sup>3</sup> Q-max LNG carriers. Each of the vessels is being provided with a pair of the heavy fuel oil-burning engines and a reliquefaction plant to handle cargo boiloff gas (BOG). The 31 Q-flex ships have six-cylinder engines while the 14 Q-max vessels have the seven-cylinder versions.

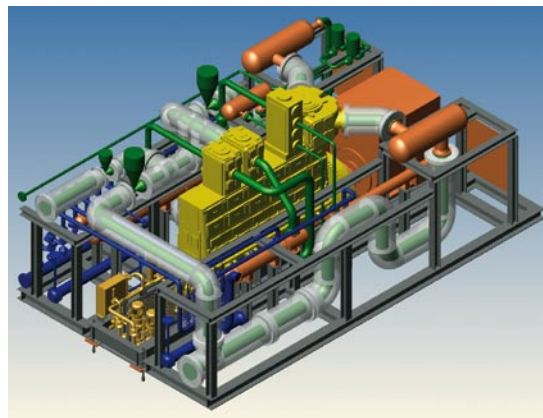
Besides the main engines all 45 of the large LNG carriers are also being equipped with MAN Diesel auxiliary engines. The Q-flex and Q-max orders represent the first time that two-stroke diesel engines have been specified for LNG carriers. The engine manufacturer carried out extensive project work with the shipowners, charterers and classification societies prior to the orders being placed for what is a trendsetting propulsion system for LNG carriers.

Also, as explained in the article on page 91 of this issue, MAN Diesel has developed a four-stroke dual-fuel diesel engine for use in dual-fuel diesel-electric propulsion systems on LNG carriers. A breakthrough order was gained in February 2007 when five MAN Diesel 51/60DF engines were specified for a 173,000m<sup>3</sup> LNG carrier to be built at STX Shipbuilding in Korea for the Spanish owner Elcano.

While DFDE propulsion systems may have replaced steam turbines as the power plant of choice for conventional size LNG carriers in recent years and low speed diesels hold the current monopoly in the large ship sector, the technological revolution in LNG ship propulsion systems is far from over. Change is endemic in maritime transport and today's drivers for change, not least escalating fuel prices and pressure to reduce atmospheric emissions, are keeping engine manufacturers at their drawing boards.



*A MAN B&W ME engine a the new Q-flex ships*



*A six-cylinder Burckhardt Laby-GI compressor*

In the case of MAN Diesel the rise in the price of heavy fuel oil (HFO) over the past year has added impetus to the company's ongoing development work on its dual-fuel, low speed diesel engine concept. MAN Diesel began development work on gas injection (ME-GI) version of its two-stroke MC/ME family of HFO-burning engines in the 1980s, shortly after the introduction of this popular line of low speed diesels. The first MC-GI engine was put into service in 1994 at a shore power plant.

As regards MAN Diesel's HFO-burning engines, electronically controlled, or ME, engines have begun to

replace the traditional MC engines in recent years due to the improved thermal efficiencies of the ME design. Even so, with the current high cost of fuel oil it is estimated that fuel costs will account for 90-95 per cent of the total operating costs for the recently delivered Q-flex and Q-max LNG carriers.

MAN Diesel points out that, from a technical point of view, there is little difference between the HFO and gas-burning engines. The ME-GI engine provides optimal fuel flexibility through its ability to burn cargo BOG, but it is necessary to introduce measures to accommodate the relatively high natural gas injection pressures.

The gas supply line is designed with ventilated double-wall piping and HC sensors for safety shutdown. In addition, the ME-GI control and safety system is an add-on to the established ME engine control system. Even though the gas is injected at a pressure of 250-300 bar, the thermodynamic conditions in the combustion chambers of an ME-GI engine are kept similar to those in a HFO-burning engine. Furthermore, there is no derating or knocking as a result of the high gas injection pressure.

Finally, exhaust gas temperatures and volumes and power output for an ME-GI engine are the same as those for HFO-burning ME engines. Because the air

flow and general working principles of the two-stroke engine, like the thermodynamic conditions and overall performance, remain unchanged, the cylinder liner, cover, piston and cooling system for an ME-GI engine can be the same as for an ME engine.

A key piece of equipment in the ME-GI system is the gas compressor which is sized to handle the maximum expected flows of gas at high pressure to the engine. MAN Diesel has signed a co-operation agreement with Burckhardt Compression under which the ME-GI engines will be marketed in tandem with a specially designed Laby®-GI compressor developed by Burckhardt. For the ME-GI application Burckhardt has designed a compressor which is based on similar equipment it markets for use at LNG export and receiving terminals but which incorporates additional compression stages to provide the necessary gas injection pressures.

Burckhardt has designated its Laby-GI compressor for use with the ME-GI engines as its 6LP250-5S\_1 and 4LP250-5S\_1 units, depending on whether it is a six- or four-cylinder model. A total of five compression stages are provided and arranged in a single vertical compressor casing, all directly driven by a conventional electric motor. The first three stages rely on the same oil-free, labyrinth sealing piston technology that characterises all existing Burckhardt LNG receiving



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terminal compressors while the final two stages rely on ring sealing pistons of the type used in high pressure applications at refineries.

MAN Diesel and Burckhardt Compression estimate that the optimum shipboard compressor arrangement is two compressors, each capable of compressing 75 per cent of the maximum amount of cargo boiloff gas to the required ME-GI engine injection pressure. This option has advantages over the alternative 2 x 50 per cent and 2 x 100 per cent solutions. The 2 x 100 per cent solution may provide full redundancy but it also has a major capital cost disadvantage. Also, it offers worse part-load operational behaviour than the 2 x 50 per cent option.

The downside of the 2 x 50 per cent approach, however, is that it provides only a partial backup system and parallel mode operation of the two compressors at full load is required. In addition, a separate gas combustion unit (GCU) compressor would be required with the 2 x 50 per cent approach. In contrast, a nominally oversized compressor, as would be provided with the 2 x 75 per cent solution, would ensure safe and reliable operation as well as adequate capacity to feed the required BOG amount to both the GCU and the ME-GI. In addition, this option offers efficient turndown behaviour.

MAN Diesel points out that the Laby-GI compressors could be operated in tandem with a shipboard reliquefaction plant, not least through a side stream from the compressor that feeds the reliquefaction plant with the necessary amount of BOG at the required pressure. In the same vein, with the price of HFO at or near all-time highs, Qatar Gas Transport Co (Nakilat) may wish to consider the retrofit of ME-GI engines on its Q-flex and Q-max ships to replace their existing ME engines.

The builders of the Q-flex and Q-max ships - Hyundai Heavy Industries, Samsung Heavy Industries and Daewoo Shipbuilding & Marine Engineering - are already carrying out vibration response and other feasibility studies for LNG carriers equipped with ME-GI engines. MAN Diesel believes that much of the preliminary retrofit work could be done during the course of a normal operating voyage while an extended drydocking would take care of most of the other necessary work. Any ME-GI retrofit project would require a hazard and operability (Hazop) study as well as an extensive testing programme as part of the system verification procedure. *LNG*



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