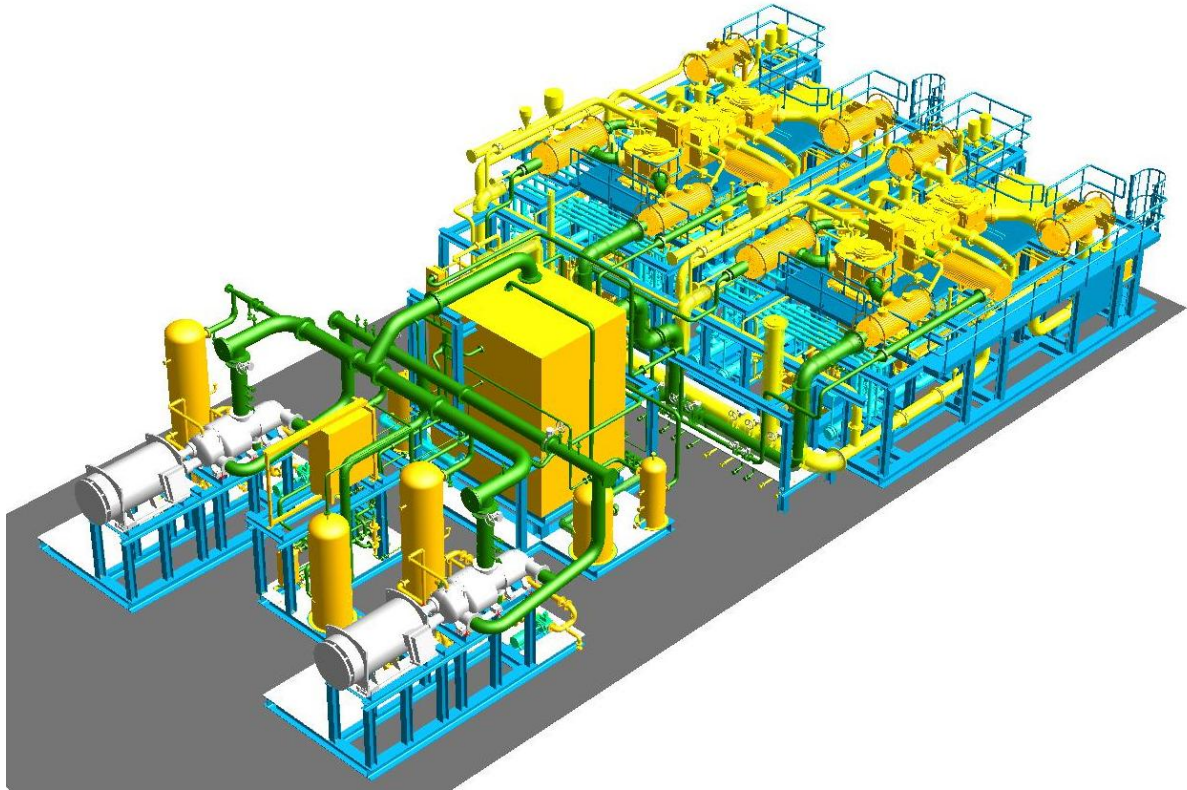


Fuel Gas Compression and Excess Boil-off Gas Reliquefaction for Dual Fuel LNG Carriers



Dual Fuel Propulsion with diesel engines has become a well accepted option for LNG carriers. Compared to the traditional steam turbine propulsion diesel engines offer higher efficiencies and are closer to current marine technology. Furthermore dual fuel engines offer more efficient utilization of the boil-off gas (BOG) as fuel. On the other hand excess BOG handling is required and reliquefaction with nitrogen expander processes has been established as the predominant solution although not being highly energy efficient.

Burckhardt Compression has developed and custom-engineered their six-crank Laby[®]-GI compressor as a fuel gas compressor to feed the ME-GI dual fuel main engine developed by MAN Diesel for diesel mechanic propulsion,

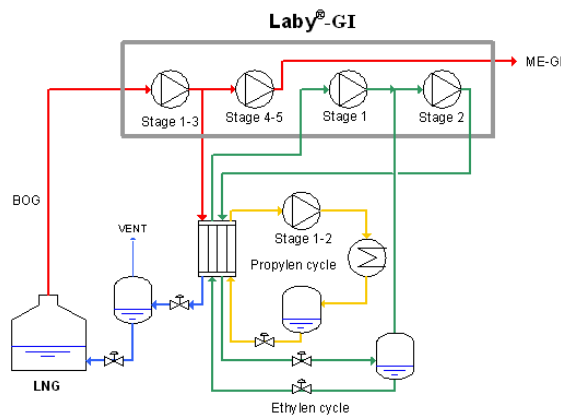
which utilizes heavy fuel oil or natural gas as fuel.

In close cooperation with Burckhardt Compression TGE Marine Gas Engineering has developed a tailor made BOG reliquefaction plant utilizing a cascade refrigeration system for LNG carriers of 170,000 m³ up to 210,000 m³. Being the world market leader in the supply of cargo plants for Ethylene carriers, TGE has gained vast experience and know-how in the design of cascade reliquefaction systems and now upgraded this technology for excess BOG reliquefaction of large LNG carriers.

The system is based on the unique features of the Laby[®]-GI compressor in combination with

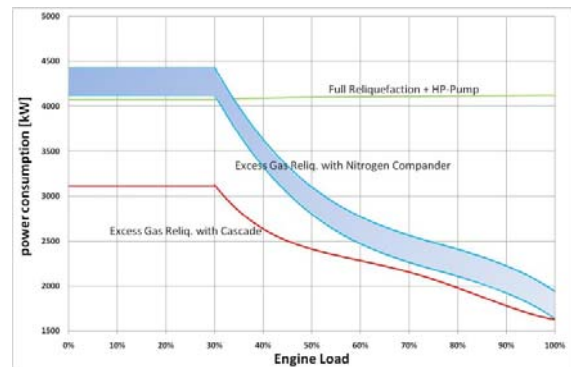
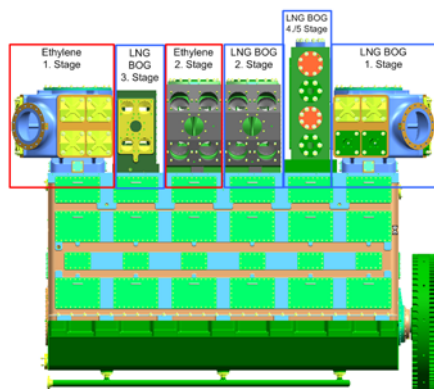
the MAN ME-GI dual fuel engines. The main advantages of cascade liquefaction system are:

- High efficiency of refrigerant due to phase transition
- High liquefaction pressure
- BOG and Ethylene compression in one compressor
- Standard oil injected screw compressors for the Propylene cycle



This design offers a very compact arrangement and the process is highly efficient when compared to a nitrogen cycle.

The energy efficient mass flow control concept of the Laby®-GI has been adapted to the combined duty of Ethylene and BOG compression. The balanced frame design guarantees with the possibility to operate the compressor in flow range 0-100% with any suction condition and supply pressure to consumers.



The particular advantage of the cascade process in combination with the Laby®-GI compressor is the low energy consumption during voyage.

While the current benchmark process is working on a full reliquefaction all the time the combined process is handling excess gas only.

Compared to a combination of Laby®-GI and Nitrogen comander the optimized adaption of cascade reliquefaction together with the inherent advantage in efficiency of the cascade process renders a better performance even in comparison to the most advanced comander cycles.

Additional to the low OPEX also the CAPEX are optimized and concludes the advantage of the cascade solution in combination with the Laby®-GI.

Key features of the design are:

- Ship capacity up to 210.000 m³ LNG
- 2 x 75 % fuel gas compressor (Laby®-GI) for Dual Fuel Diesel Mechanic Propulsion
- 2 x 75 % BOG / Ethylene compressor (integrated in Laby®-GI)
- 2 x 75% Refrigerant compressor (Oil injected screw compressor)
- 1 Cold Box (plate fin heat exchanger)
- 1 Refrigerant condenser

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