LNG Fuel Gas Systems

LNG carrier with ME-GI engine, high pressure compressor and boil-off gas reliquefaction system

Hamworthy Gas Systems (HGS) is a leading supplier of cargo handling technology and has more than 35 contracts on systems liquefying boil-off gases from LNG carriers.

Burckhardt Compression is one of the world's largest manufactures of reciprocating compressors with a long track record of all kinds of boil-off gas (BOG) handling applications around the world.

The combination of reliquefaction with dual-fuel engines offers a flexible system where it is possible to switch between fuels depending on fuel prices. The state of the art propulsion engines are efficient and not all BOG can be utilized in the engine in the different operating modes. Instead of burning excessive gas in the gas combustion unit, the gas can be liquefied and returned to the tanks.

Advantages:

- **Flexible fuel system**
- **Optimized fuel costs**
- **Increased cargo quantity delivered**
- **More profitable freight contracts**

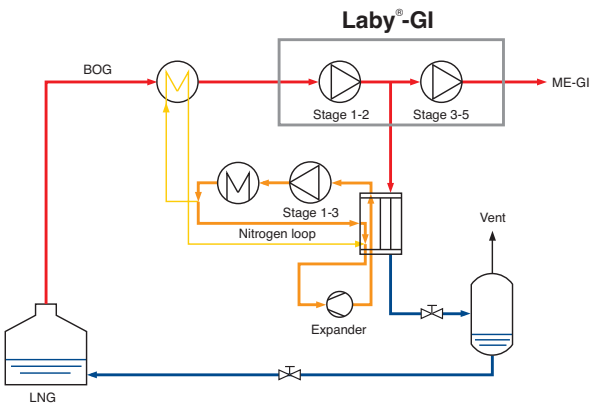
Hamworthy cooperates with ***Burckhardt*** to supply a complete concept for handling the boil-off gas and inject natural gas into the dual-fuel two-stroke diesel engines from MAN Diesel. The two companies have together developed a solution where the Laby®-GI fuel gas compressor from ***Burckhardt*** is integrated with the BOG reliquefaction system from Hamworthy (see figure 1). The Laby®-GI will replace the conventional BOG compressor upstream the reliquefaction plant. After the 1st or 2nd stage intercooler, at 5-6 bar, BOG can be partly – or fully diverted to the reliquefaction system. The remaining gas will be compressed in the last three compressor stages before being injected into the engine.

The system covers the following operating modes:

- **Compress BOG for utilization in the engine**
- **Compressor (low pressure) feed all the BOG to the reliquefaction system**
- **Compressor feeding the engine and excessive gas is liquefied in the reliquefaction plant**

When the ME-GI engine is running in gas mode, the required BOG is sent directly by the compressor to the engine, thereby bypassing the reliquefaction system. If any, excessive gas is liquefied in the reliquefaction mode. Alternatively the engine is running in HFO mode and the BOG is liquefied in the reliquefaction plant. In ballast voyage the operator can choose to run the vessel on HFO and liquefying the BOG in order to keep the cargo tanks cold or utilize the BOG for fueling the engine. The reliquefaction plant can be designed for full or reduced capacity. A typical arrangement with 1 x 100% liquefaction capacity and 2 x 100% capacity for the ***Burckhardt*** Laby®-GI compressors are shown in figure 2.

Figure 1: Simplified flow diagram



Hamworthy

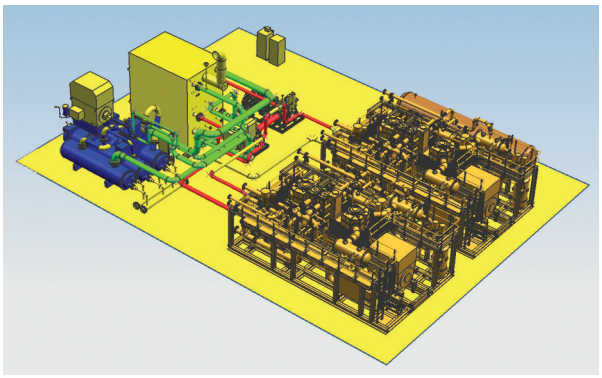


Figure 2: Layout of the CCR with 2 Laby®-GI compressors and BOG reliquefaction system

Boil-off reliquefaction plant

The principle of the reliquefaction system is Hamworthy's highly efficient Mark III concept. The standard BOG-compressor is substituted by the ***Burckhardt*** compressor.

The BOG with vapour header temperature is preheated in a heat exchanger upstream the compressor to utilize the cold duty in the BOG. This configuration ensures that the heat of compression can be rejected through cooling water in the intercoolers. The BOG is preheated in heat exchanging with the high pressure nitrogen taken downstream the nitrogen compander. Downstream the compressor the BOG is cooled at this pressure to about minus 160°C in a cryogenic plate-fin heat exchanger. This ensures condensation of hydrocarbons to LNG.

A special feature of the Hamworthy Gas Systems reliquefaction processes are that not all the nitrogen content has been condensed at minus 160°C for LNG with large content of nitrogen.

Nitrogen gas is compressed in a compander unit (3-stage centrifugal compressor and single expander on a common gear box).

After the 3rd stage cooler the stream is split into two different streams. One stream is used to preheat the BOG in a separate heat exchanger (preheater) and the other is led to the "warm" part of the cryogenic heat exchanger. After heating the BOG, the two streams are mixed together again, and reintroduced into the cold box core. In the cryogenic heat exchanger the Nitrogen is pre-cooled and then expanded to almost compressor suction pressure. The gas leaves the expander at temperature below minus 160°C and returned to the "cold" part of the cryogenic heat exchanger. The cold nitrogen continues through the "warm" part of the cryogenic heat exchanger.

Laby®-GI compressor

Handling of cryogenic natural gas with suction temperatures below minus 160°C in the pressure range of 10 to 50 barg (1.0 to 5.0 MPa g) is a common application in many onshore and offshore LNG or LPG facilities worldwide. The Laby® compressor design with its unique labyrinth sealing technology has proven it's second to none performance in this field.

The Laby®-GI fuel gas compressor (see figure 3) is designed for the same low suction temperatures as the Laby®. Only difference is the extension of the pressure range up to 300 bar. Therefore the three oil-free labyrinth sealed, low pressures stages are complemented with two stages of piston ring sealing systems, comparable to the proven API 618 design. All five stages are combined in a vertical crank gear and form the six-crank Laby®-GI fuel gas compressor. As a result of mass balancing, the compressor will be free from vibrations and moments - ideal for offshore installation.

Careful thermal design and material selection means that it is not necessary to pre-cool the compressor or to heat the gas prior to start-up. The rugged design in combination with the well proven equipment stands for longest meantime between overhaul (MTBO) for this and related applications.

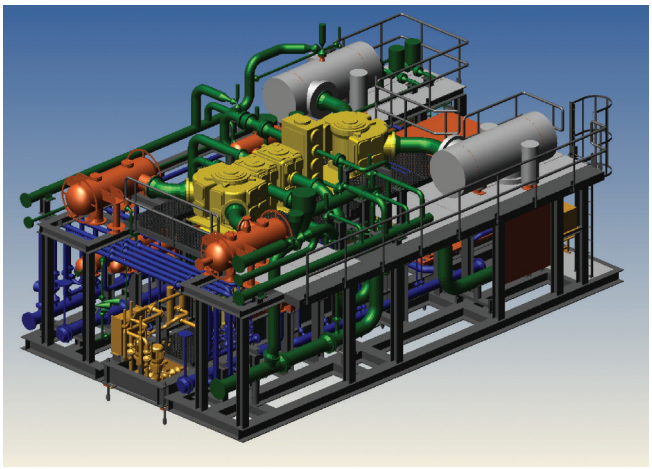


Figure 3: Layout of the Laby®-GI compressor

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