UNIQUE RECIPROCATING COMPRESSOR SOLUTION FOR OFFSHORE APPLICATIONS

PRODUCT DEVELOPMENT, TECHNICAL IMPLEMENTATION AND ITS FIRST INSTALLATION

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Rainer Duebi holds a degree in B.Sc. Mechanical Engineering and a master degree in advanced studies of Business Administration.
He started his professional career as Commissioning Engineer of large onshore gas turbine power stations for ABB and Alstom.
In 2003, he joined the Compressor Sizing Department of Burckhardt Compression in Switzerland. As Sizing Engineer and Sizing Manager he conducted projects for LPG marine and LNG BOG onshore and offshore installations. Since 2010 he is Senior Sales Manager and heading a Sales Team.

Cover: Laby®-GI Compressor package installed between the first two spherical LNG tanks on an FSRU

Burckhardt Compression has developed a unique reciprocating compressor aimed at a number of applications in the offshore market. The various duties that are specified for these applications need a highly flexible compression solution with variable suction conditions from cryogenic to ambient temperatures. The demanding installation and operation requirements have been considered in the mechanical design of the compressor and in the compressor package layout.

This paper describes the development of the fully balanced Laby®-GI Compressor and the special steps in its engineering, design and manufacture that were taken to ensure that the first, and any subsequent installation, would be executed successfully in order to fulfill all requirements.

The successful first installation and commissioning of a Laby®-GI Compressor with a detailed experience report will complete the paper. This final part will focus on handling cryogenic boil-off gas and the special installation requirements on an LNG (Liquefied Natural Gas) carrier to be retrofitted as a FSRU (Floating Storage and Regasification Unit).

CHAPTER 1

REQUIREMENTS FOR MARINE/OFFSHORE COMPRESSOR DESIGN

The application requirements for the compressor include:

- Compression range from atmospheric pressure up to 350 bar
- Temperature range suction side –160 °C to 45 °C discharge side 45 °C
- Reduced vibration
- Flexible capacity control to meet system requirement
- Energy efficient base and part load operation
- Reduced installation space requirements (vertical compressor design of advantage)
- Reliability and availability in the high 90%, mean time between overhaul (MTBO) 20'000 hours or more
- Easy maintenance which can be conducted with on-board engineers
- Short erection and installation time
- Investment and operating costs optimized

These are the main points which have to be considered in the development of a specialized offshore compressor installation. The following chapters will highlight the unique design of the Laby®-GI Compressor and also the steps conducted to fulfill the list of requirements for such a compressor installation.

CHAPTER 2

KEY FEATURE OF THE LABY®-GI COMPRESSOR

For offshore applications the compressor's physical dimensions must consider the restricted space available, such as within a deck-mounted machinery room. The vertical design of the Laby®-GI optimizes the required footprint on deck. The Laby®-GI Compressor is designed to deliver low-temperature natural gas or forced BOG from atmospheric tank pressure at an inlet temperature as low as −160 °C, up to a gas pressure in the range of 150 to 300 bar. Intermediate side streams after each compression stage to and from the gas processing plants can be integrated due to the flexible design. The compressor control system is designed to handle all applications at the same time, which gives full flexibility to the operator. The compressor design can be adjusted to suit the design capacity in the design calculation phase when the number of compression cylinders, piston diameters and compressor speed are determined. The Laby®-GI can be built with a maximum of six cylinders, however, fewer cylinder configurations are also available. Besides the high pressure application the Laby®-GI can also be designed for lower discharge pressures with a reduced number of stages and therefore increased mass flow.

2.1 SPECIAL DESIGN OF HIGH AND LOW PRESSURE SEALING SYSTEMS

The unique compressor design allows the selection of the best applicable cylinder sealing system according to the individual stage operating temperature and pressure. In this way, very high reliability and availability with low maintenance can be achieved. For oil-free compression, required for very cold low-pressure stages one to three, the well-proven labyrinth sealing system is used. There are many applications in the area of LNG terminals and LPG carriers where these systems have been applied over decades.The extreme reduction of mechanical friction in the contactless labyrinth cylinder, results in an extraordinary long lifetime of sealing components. The high-pressure stages four and five employ conventional API 618 lubricated piston ring sealing technology.

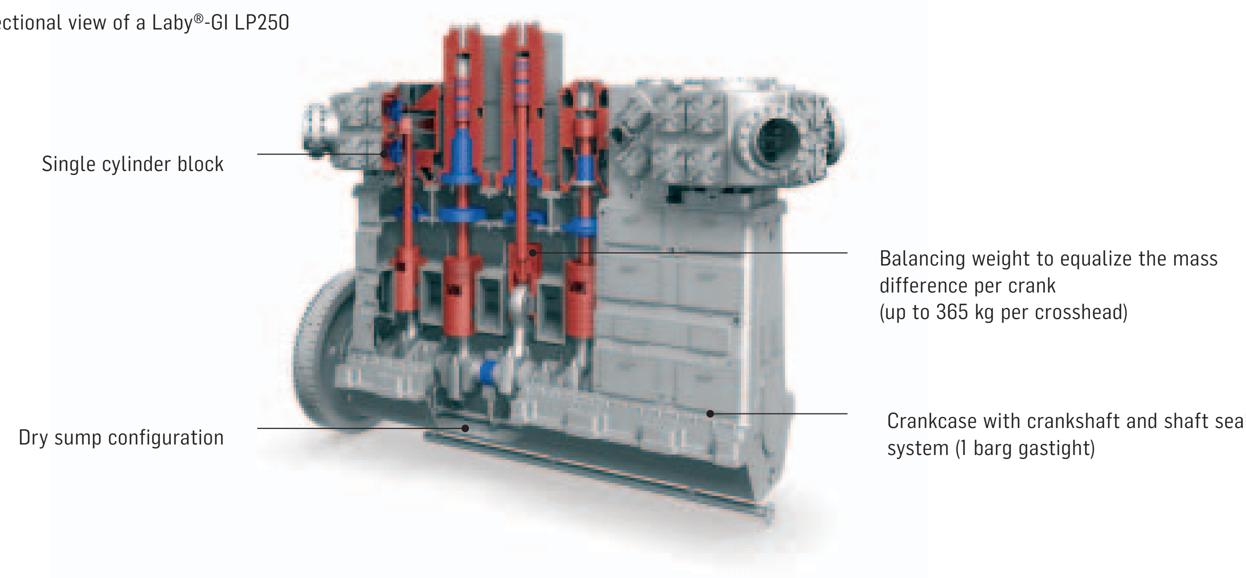
Six or four cylinders are mounted on top of a vertically arranged crankgear. The double-acting compression stages one to three with labyrinth sealing are typically of the same design as those employed at an LNG receiving terminal. The single-acting stages four and five are a design commonly used for the compression of high-pressure hydrocarbon gases.
The used common crankcase of the compressor are gastight and will allow to operate the compressor with absolute no gas loss to atmosphere or vent system. **Fig. 2**

2.2 MASS BALANCING

The physical design of the LNG carrier requires the installation of the compressor package on the deck in a compressor house above the cargo tanks. Normal vibration levels of a reciprocating compressor would require a compensator to meet the vibration limits of the deck structure. A conventional piston compressor design imparts to the foundation forces and moments which are related to the compressor speed, to the stroke of the piston and to the weight of the moving parts such as pistons, piston rods, crossheads, connecting rods and crankshafts.

Because the reciprocating mass of each piston/stage is different, there are additional forces and moments which would have to be considered in the design of the support structure. With the unique design of the mass balanced crankgear, the free forces and moments of the first six orders are eliminated. The remaining orders can be neglected due to their very low amplitude. The

Fig. 2
Cross sectional view of a Laby®-GI LP250



Laby®-GI may therefore be safely included in a machinery room on top of the cargo tank within acceptable structure vibration limits.

2.3 MODULAR SYSTEM OF THE LABY®-GI COMPRESSOR

The layout of the cargo handling equipment and the design of the supporting structure is a task for the naval architects similar to the optimization of the LNG tank deck, where space is considered a premium. The total compressor size is given not only by the compressor itself, but also by the surrounding auxiliary systems such as gas piping, pulsation dampers, heat exchangers, control system, oil system and main drive motor. The system is designed for offshore installation and includes a dry sump configuration with external oil reservoir and special measures to prevent liquid carry-over by appropriate condensation traps in the pulsation devices and the piping arrangement. The complete package is arranged in a configuration with the smallest possible footprint around the compact, vertical compressor. The overall dimensions are reduced to a minimum, but consider free access to the compressor for maintenance. The design employs a modular assembly arrangement whereby three main modules are prefabricated and aligned before installation on the LNG carrier.
The modules are designed to be easily installed without "hot work" on-site and the flexibility required for transportation to the yard. This modular concept was developed to allow the separation of the compressor package into three modules which can then be easily installed and re-assembled on the carrier later. **Fig. 3**

2.4 FLEXIBILITY OF COMPRESSOR DESIGN AND RELATED SYSTEMS

The flexibility of the compressor design to use fewer cylinders and still have a fully balanced machine reduces the investment cost for lower flow applications. The operating characteristics of the reciprocating compressor enable it to be used for all of the different systems that are required. Parallel operation of two or more such systems can be handled by one compressor package. Efficient part load operation is achieved by operating the compressor using valve unloading and bypass controls. The labyrinth sealing system allows cryogenic compressors to start-up and operate at ambient suction conditions without any pre-cooling procedure. This means that continuous operation of the compressor can be achieved without any restriction on discharge pressure requirements. Fast start-up and shut-down are a key benefit of this system. **Fig. 4**

Fig. 4
Cool down of Laby® LNG Compressor

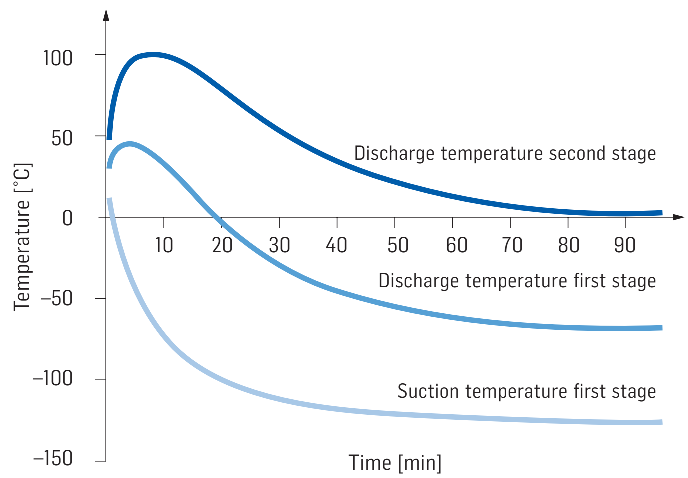
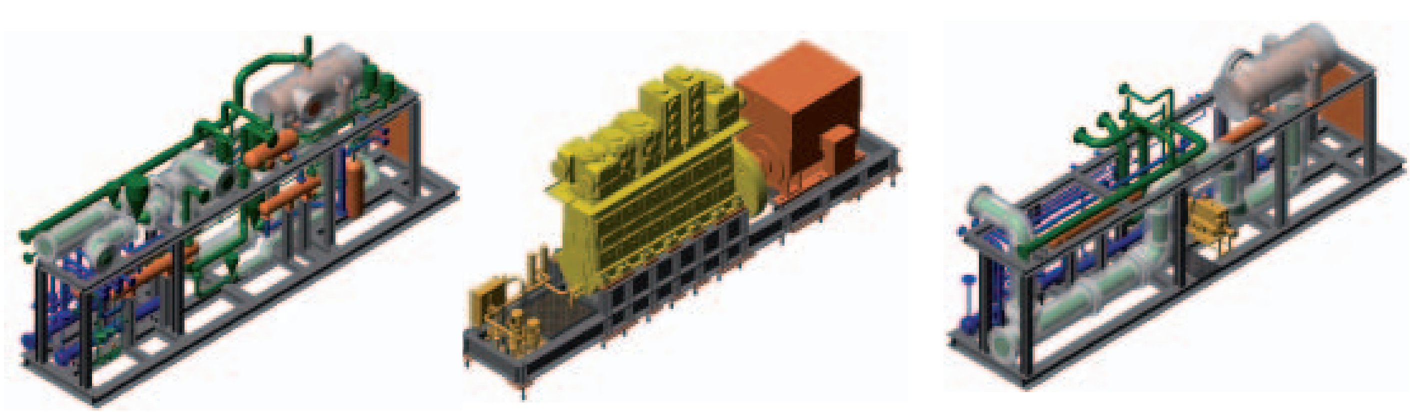
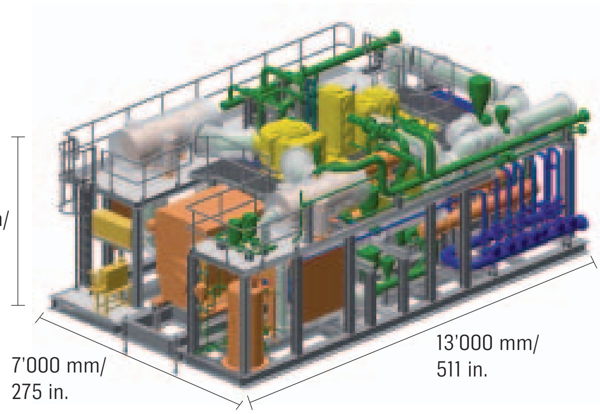


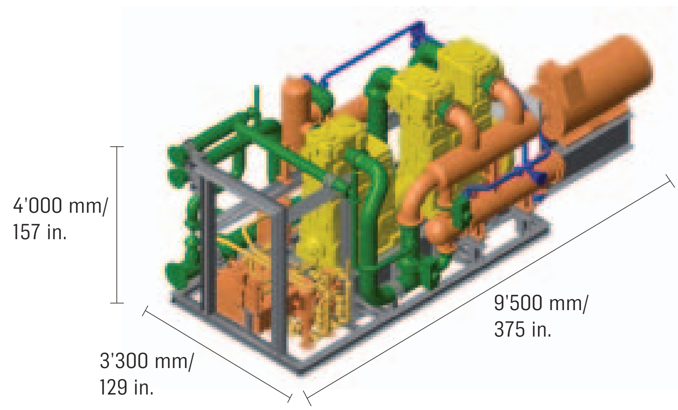
Fig. 3
Module concept of the Laby®-GI compressor system



Module 2 Module 1 Module 3

Fig. 5
Package size of LP250 and LP190





For smaller compressor shaft power applications another smaller compressor frame with reduced stroke was introduced with the advantage of having a reduced plot area but with the same advantage as the Laby®-GI LP250 frame. With this smaller compressor LP190 most other applications below the current range of LP250 applications are believed to be covered. **Fig. 5**
The next chapter will highlight the engineering steps which have been conducted during the design of the Laby®-GI including conventional up-to-date engineering practice and special studies and analysis methods to verify the design results.

CHAPTER 3

SPECIAL ENGINEERING FOR MARINE AND OFFSHORE APPLICATIONS

The following studies were conducted to check and optimize the layout of the Laby®-GI skid. Endurance strength of the piping and supports and reliability regarding pulsation-induced vibrations, thermal stress and reaction forces due to the movement of the ship, torsional and lifting cases were all verified. The system was designed to guarantee failure-free operation due to these influences. The following information is given without detailed results. Detailed results of the calculations can be requested from Burckhardt Compression AG.

3.1 ACOUSTICAL AND VIBRATION STUDIES

3.1.1 CALCULATION AND INTERPRETATION OF THE RESULTS

The study of the gas pulsation is carried out with the digital simulation program PULSIM which has been developed by the TNO/TPD Institute in Delft (NL). Modifications are made to meet the requirements of API 618. A system comprises several complex parts and elements which must be simplified for calculations. For example volumes of a cylinder casing between valves and connecting flange, heat exchangers, separators, dampers, etc.

The data of the gas might also change during operation. In order to take these uncertainties into account, Burckhardt Compression conducts several calculations at different velocities of sound. Because there are differences in every new project for the suction and discharge piping, the calculations are done for the "worst pulsation cases" regarding the wavelength in the piping.

Admissible limits: If the customer does not specify other criteria, Burckhardt Compression applies the API 618, 4th edition, design approach two or three by default for the Laby®-GI Compressors. For systems operating at a line pressure between 3.5 bar and 200 bar and based on normal operating conditions, the peak-to-peak pulsation levels shall be limited to API 618 4th edition, section 3.9.2.7. For operating pressure above 200 bar Burckhardt Compression uses a peak-to-peak line pulsation level in design phase of between 2 to 4% related to the median line pressure.
The reason is to reduce the size of pulsation damper with still reasonable results for safe operation.

3.1.2 MODELING THE VIBRATION SYSTEM

The system is modeled within the Finite Element Analysis Program ANSYS. It consists of a piping modeling tool, with several different elements and modeling possibilities. Calculations were only done for the Burckhardt Compression skid with boundaries at the battery limit to client's piping on suction and discharge. On the compressor skid the supports are modeled with beam elements. On the customer side of the piping, supports are modeled by restricting at least one degree of freedom of a node. During a standard project execution the customer part will be included in the study. Without restriction a node has six degrees of freedom, translations and rotations in each direction.

If friction forces are high enough, a support can possibly restrict an additional direction. For cases with a slight excess in vibration Burckhardt Compression checks if this additional restriction can be furnished by the expected friction. For static thermal analyses, with in general higher force values than for vibration calculations, the friction is neglected.

3.1.3 CALCULATION PROCEDURE

The calculation for the vibration analyses is carried out in two steps. The first step is the calculation of natural frequencies and mode shapes. This indicates which excitation frequencies will cause resonance effects, and which part of the system will be the most affected. This gives a general overview of the vibration behavior of the system. In step two, Burckhardt Compression performs a dynamic response analysis. The excitation comes from the shaking forces, which are a result of the pressure pulsation in the piping system. The forces are calculated with the PULSIM program (see pulsation study, 3.1.1) and are given as harmonics of the compressor speed for the first twelve orders. Shaking forces occur in case of a change of the flow area or direction (inlet/outlet of a volume, elbows, orifices, ...). Burckhardt Compression uses the "worst case" shaking forces, which means the forces from the calculated deviation of velocity of sound that delivered the highest overall values. The results of this calculation are the dynamic displacements, vibration velocities and bending stresses of the pipes as well as the reaction forces on the supports. The peak-to-peak values are compared with the maximum allowable limit.

3.2 **THERMAL STUDY**

3.2.1 MODELING THE THERMAL EXPANSION SYSTEM

The system is modeled within the Finite Element Program ANSYS. For the thermal study Burckhardt Compression uses the same model as for the Vibration study (see vibration study, 3.1). Calculations are only done for the skid with boundary at the battery limit to client pipe on suction and discharge piping. If friction forces are high enough, a support can possibly restrict an additional direction. For static analyses, with in general higher force values than for vibration calculations, the friction normally is neglected.

3.2.2 CALCULATION PROCEDURE

The mechanical model of the vibration study is used. It is initially stress-free at ambient temperature. System temperatures are applied in a static calculation. Additionally, gravitation or gas pressure is added to the system if required. Displacements and stress is calculated at the nodes of the model. Due to the modeling of the dampeners with pipe elements instead of shell or solid elements, higher stress is calculated in dampeners. If these values remain below the yield stress, they can be tolerated.

3.3 **SHIP ROLL STUDY**

In accordance with the functions of the compressor and its relationship with the safety and operability, all structures, components and systems shall keep their operational function following a roll movement of the ship. In consequence, the calculated stress should not exceed the yield stress. The stresses due to horizontal and vertical acceleration are determined by a static analysis based on the model which was established for the vibration study.

3.3.1 MODELING THE SHIP ROLL SYSTEM

The system is modeled within the Finite Element Program ANSYS. For the roll study Burckhardt Compression uses the same model as for the Vibration study (see 3.1). Calculations are only done for the skid with boundary at the battery limit to client pipe on suction and discharge piping. If friction forces are high enough, a support can possibly restrict an additional direction. For static analyses, with in general higher force values than for vibration calculations, the friction normally is neglected.

3.3.2 CALCULATION PROCEDURE

For the static analysis the combinations of the accelerations are used in one case as shown in the following, including the gravity acceleration in vertical direction. The acceleration is assumed as:

Vertical acceleration	a_v = 1.80 g [m/s^2]
Longitudinal acceleration:	a_l = 0.30 g [m/s^2]
Transverse acceleration:	a_t = 0.94 g [m/s^2]

3.4 **LIFTING DEFLECTION STUDY**

The lifting study is conducted to verify the stiffness, lifting and transportation hook-up and the centre of gravity for each module. For the lifting cases the modules are analyzed based on expected maximum shock factor and weights of the packages during the production, transportation and installation process. The resulting values are analyzed on maximum stress according to DIN 18800 to be allowed for each module and the lifting devices expected stress values.

The transport case is considered as maximum acceleration which could arise during land or see transportation to the modules and to the fixing points of the packages. The maximum values are based on industrial standards for transportation. Additional deflection checks were conducted during analysis and also life test at the packager to verify a maximum of package deflection 1/600 for the compressor module during lifting of the modules with real measure deflection of 1/1'800.

3.5 **TORSIONAL ANALYSIS AND FOUNDATION BOLT STUDY**

The torsional study of the rotor train including motor, coupling and compressor is required for such installations. The analysis is conducted to verify excitation frequency of the different orders to the lateral frequency of the system according to API 618 and API 671. Special considerations apply to the arrangement of the bulk head seal systems with double coupling and shaft seal system. Due to the small package size, the expected ship structure movement will be compensated by the flexible coupling used between electric motor and compressor. Without such a flexible coupling the deflection would have to be considered, therefore Burckhardt Compression recommends to use torsionally stiff or fully flexible couplings for their packages. The use of explosion-proof motor design for shipboard applications has been accepted under IMO rules since 2007. Therefore Burckhardt Compression recommends using this configuration for all new installations.

The foundation bolts are used to tie down the motor and compressor to the supporting structure. In addition to that, special attention has to be paid to ship movement as mentioned (article 3.3). The given design should also withstand sea water atmosphere and additionally shall compensate for unevenness of the structure. A combination of epoxy resin and adjustable supports from VIBRACON® is the recommendation of Burckhardt Compression. **Fig. 6**

3.6 DESIGN ASSESSMENT FOR TYPE APPROVAL AND CONDUCTED HAZID AND HAZOP STUDIES

In the shipping industry, classification societies are non-governmental organizations or groups of professionals, ship surveyors and representatives of offices that promote the safety and protection of the environment of ships and offshore structures. This is achieved by setting technical rules, confirming that designs and calculations meet these rules, surveying ships and structures during the process of construction and commissioning, and periodically surveying vessels to ensure that they still meet the rules when in operation. One of the major steps is to conduct a pre-assessment of a new system by different measures. One of the first steps which were conducted for the Laby®-GI is the design assessment by DNV for the compressor package back in 2006. Even though a type approval for the compressor is not necessary for the compressor installation, it will confirm that the overall system would be accepted by the class. In addition, FMEA, HazId and HazOp studies for a typical installation were conducted with all the major Korean yards and part supplier. The Laby®-GI and the MAN Diesel ME-GI diesel engine were analyzed in connection with new LNG carrier designs including reliquefaction plants. This process is required to confirm the overall design of a LNG carrier concept prior to a commercial offer.

All these design studies are useful, but without putting the concept into a real installation only half the work is done. Therefore the next chapter will highlight the first installation of a Laby®-GI package and the result.

CHAPTER 4

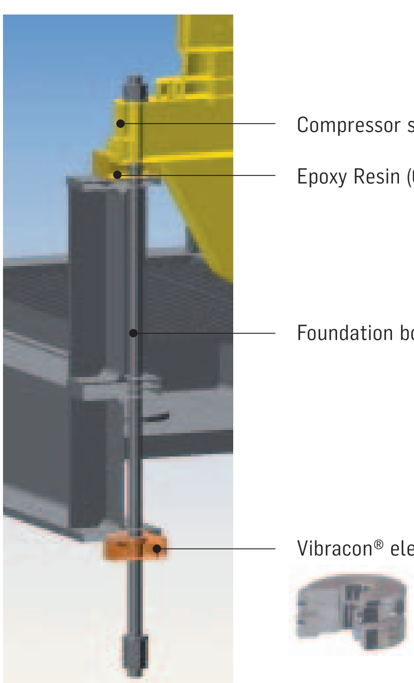
CASE STUDY INSTALLATION LABY®-GI 4LP250-3A GOLAR FREEZE FSRU

4.1 DESCRIPTION OF GOLAR FREEZE FSRU

The LNG carrier Golar Freeze is equipped with a spherical tank design and steam turbine propulsion. It got converted into a floating storage and regasification unit (FSRU). The LNG carrier was delivered in 1977 and used until summer 2009. The capacity of the containment system is 125'858 m³ of LNG. It will be stationed in the port of Dubai with a gas jetty connection to shore for feeding evaporated natural gas to the onshore gas consumers.

The FSRU is equipped with LNG loading arms for ship to ship LNG transfer, three LNG regasifiers and a send-out compressor for the BOG handling, the Laby®-GI 4LP250-3A. **Fig. 7**

Fig. 6
Foundation bolt and driver train



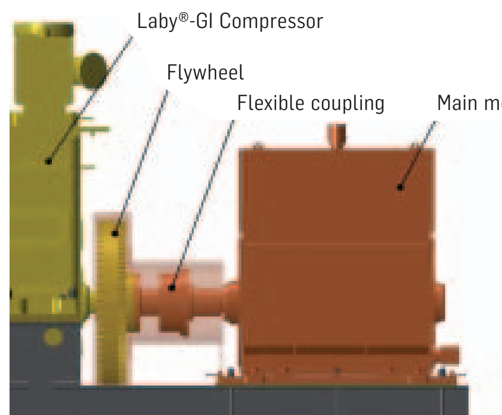


Fig. 7
Golar Freeze LNG Carrier, before conversion

Table 1
Laby®-GI 4LP250-3A operating data

Suction pressure	1.04 to 1.70 bara
Suction temperature	–140 to –80 °C (transient up to +45 °C)
Discharge pressure	45 bara
Gas composition	Methane (add. Ethane, Propane and Nitrogen)
Rotational speed	445 rpm
Rated Motor Power	1'300 kW
Order date 4LP250-3A	March 2008
Mechanical test run	June 2009 (Compressor only at work shop Winterthur)
Packaging completed	October 2009
Arrival at Keppel Yard	November 2009
Installation completed	December 2009
Pre and Commissioning	October 2010
First Gas Operation	December 2010

4.2 LAYOUT AND CONFIGURATION OF LABY®-GI 4LP250-3A

The 4LP250-3A type is based on the labyrinth sealing system for all three stages. The first stage cylinder design is based on low temperature application without a cylinder cooling jacket whereas the second and third stages are equipped with a water/glycol cooling system. The mass balancing is implemented to reduce the free forces and moments, as described in article 2.2. The frame is gastight with a shaft seal system at the drive end. In addition, a dry sump lubrication system with outside frame lubrication oil containment is used for the installation. **Table 1, Fig. 8**

The compressor control system consists of shell and tube heat exchanger after each stage, bypass valves and pressure safety valves as well as valve unloading devices. The heat exchanger after the first stage will be bypassed during operation with suction gas below –80 °C.

The compressor is driven by an Ex e direct coupled electric motor with fully flexible coupling. The total package includes also a glycol water distribution system, nitrogen connection, process gas connection, cold insulation of main gas pipes, industrial safety protection, local operating panel signal transfer as well as electric lighting and gas detection. **Fig. 9**

Fig. 8
Module 1 – Golar Freeze send out compressor 4LP250-3A

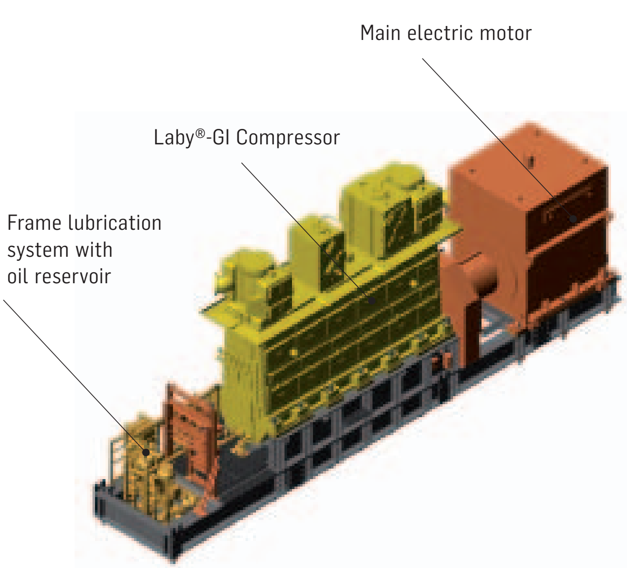


Fig. 9
Package size Golar Freeze 4LP250-3A

Dimensions [m]:
Length ~12.5 – 13.0
Width ~7.0
Height ~5.1

Weights [t]:
Module 1 ~80
Module 2 ~20
Module 3 ~20

Total ~120

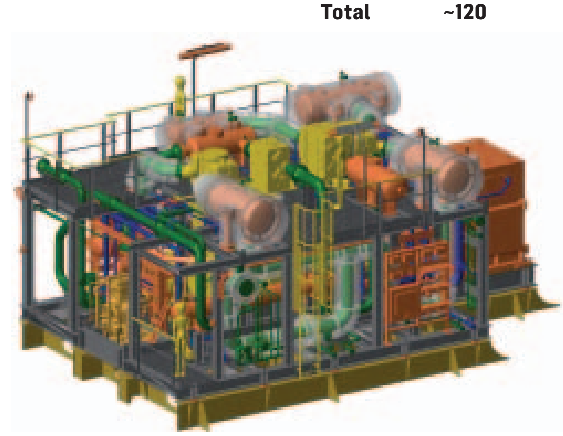


Fig. 10
On-board installation area of the Laby®-GI 4LP250-3A on Golar Freeze FSRU

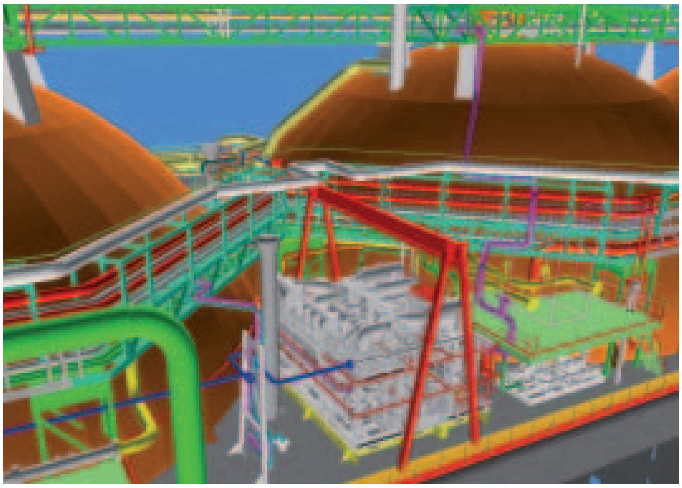


Fig. 11
Laby®-GI 4LP250-3A packaged unit in the workshop (three module concept)

The compressor package was designed to be installed on the port side between the first and second spherical tank. In addition, Burckhardt Compression also delivered the glycol/water closed cooling water system for this project. **Fig. 10**

4.2.1 DESIGN AND MODULAR CONCEPT

The three module concept was used for the installation. The modules are packaged and pre-adjusted prior to transport to the yard. The design is based on the original concept of the Laby®-GI with only minor adoptions. **Fig. 11**

The module sizes are suitable for European road and sea transport. The individual modules are of different weight and size.

Module 1: Consisting of Laby®-GI Compressor, main electrical motor, barring device and frame lubrication system
Dimension: 11.3 x 1.9 x 4.6 m, Weight: 80'000 kg

Module 2: Access ladder to upper platform, local operating panel, pulsation damper, suction piping and gas intercooler
Dimension: 9.0 x 2.65 x 4.7 m, Weight: 20'000 kg

Module 3: Control valves, pulsation damper, gas intercooler and discharge piping
Dimension: 9.6 x 2.45 x 4.7 m, Weight: 23'000 kg

4.2.2 CONDUCTED DETAILED STUDIES

Additional to the studies outlined in chapter 3, the following detailed studies have been conducted to verify the design for the dedicated compressor package. Pulsation, vibration, thermal, torsion and foundation bolt studies have been conducted. In addition to that, the operating concept was reviewed in a HazId and HazOp in collaboration with the customer to verify the safe and reliable operation of the compressor.

The lifting study was verified by a lift test in the module fabrications workshop.

4.3 INSTALLATION PROCEDURE AND EXPERIENCES

The installation of the three modules was based on following steps:

1. Check of ship structure and foundation alignment underneath the compressor package prior to installation
2. Place and adjust VIBROCON® elements
3. Place module 1 on the prepared foundation
4. Tight the foundation bolts of module 1
5. Place module 2 and adjust it against module 1
6. Tight the foundation bolts
7. Place module 3 and adjust it against module 1
8. Tight the foundation bolts
9. Installation of the interconnecting piping between the modules, handrail and ladder
10. Connect the interchanging signal cabling between the modules
11. Install the piston, flywheel, filling of lubrication oil and glycol/water system
12. Prepare for pre-commissioning

The installation steps one to eight were able to be completed in two days. For step eight and nine two additional days were needed. The following steps could be completed in one more week; two months after the initial installation took place. Due to the situation that the Golar Freeze was in the yard from the end of October 2009 until April 2010, the installation was allotted over several months. Steps one to nine were completed in December 2009. The rest of the steps were conducted in February 2010. **Fig. 12**

Fig. 12
Real installation of the Laby®-GI 4LP250-3A Golar Freeze

4.4 SITE ERECTION AND COMMISSIONING

The site erection, final inspection and commissioning were conducted in the port of Dubai, the final destination of the Golar Freeze FSRU.

4.5 RESULTS AND POSSIBLE IMPROVEMENT

The results of the installation approved the concept of the Laby®-GI especially the modular concept. It also highlighted some possible potential improvements of the concept for future projects.

- If possible use a one module concept:
  This could be feasible if the packager is adjacent to the dedicated yard. If road transportation is not required this could be feasible.
- Don't pre-insulate interconnecting piping:
  The reason is that these pipes are very short and can be easily insulated during the process of final insulation.
- Delivery of appropriate tightening device or change the foundation bolt tightening design:
  Due to the limited space and the lack of appropriate tools from the yard, consideration should be taken to either reduce the required torque or to use of hydraulic or Superbolt™ systems for some connections. Alternatively a suitable torque wrench shall be delivered with the compressor package.

CHAPTER 5

CONCLUSION

The unique design of the Laby®-GI, extensive studies and detailed analysis led to a successful first installation of the 4LP250 on-board the Golar Freeze. Even though Burckhardt Compression is experienced in this kind of project execution, it was a remarkable job to conduct.

With our in-house capabilities in combination with up-to-date engineering and design tools, it was possible to analyze and define the Laby®-GI 4LP250-3A in a very short time. The successful installation and commissioning, even with the new module concept and mass balancing were possible within a very short time.

The Laby®-GI has proven its advantages for the offshore market. The flexibility of the LP frames allows adjusting the compressor to the respective duties also for the future.

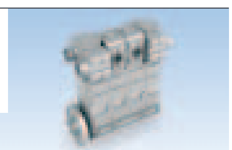
List of Abbreviations

°C	Degree Celsius
4/6LP250	Type designation of Laby®-GI Compressor with six and four cylinder configuration
ANSYS	Finite Element Analysis Software
API	American Petroleum Institute
BOG	Boil-off Gas
DIN	Deutsches Institut für Normung
DNV	Det Norske Veritas
EEx e	Safety Class Electrical Motor
FMEA	Failure Mode and Effect Analysis
FSRU	Floating Storage and Regasification Unit
HazId	Hazard Identification (Engineering Process)
HazOp	Hazard and Operability (Engineering Process)
LNG	Liquefied Natural Gas
ME-GI	Slow Speed Dual Fuel diesel engine from MAN Diesel SA
MTBO	Mean Time Between Overhaul
PULSIM	Digital pulsation calculation program from TNO/TPD
TNO/TPD	Independent research institute Delft (NL)

Burckhardt Compression

RECIPROCATING COMPRESSORS
LEADING TECHNOLOGY FOR
LOWEST LIFE CYCLE COSTS

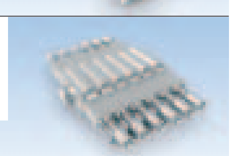
Laby® Compressors
Contactless
and oil-free



Laby®-GI Compressors
Fully balanced

Process Gas Compressors
API 618 –
full compliant

Hyper Compressors
Safe and reliable
up to 3'500 bar



COMPRESSOR COMPONENTS
BEST PERFORMANCE
AND LONGEST LIFETIME

Valves:
- Burckhardt Poppet Valve™
- Burckhardt Plate Valve™
- Manley® valve, licensed by Burckhardt Compression

Piston rings

Guide rings

Piston rod packings

Packing rings

Oil scrapers

Hyper/secondary compressor parts

CUSTOMER SUPPORT SERVICE
THE FULL RANGE OF SERVICES

Burckhardt Valve Service

Spare parts logistics

Field service

Technical support

Component repair

Engineering services

Revamps

Condition monitoring & diagnostics

Training

FOR ALL YOUR RECIPROCATING COMPRESSORS

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