LNG TRANSPORTATION & STORAGE
Gas Handling Equipment & Systems
The Cryostar Group

Specialising in equipment and expertise for industrial gas, LNG, hydrocarbons and clean energy, Cryostar is an international company exporting more than 90% of its products and serving customers worldwide.

Founded in 1966, Cryostar is present on all continents, supported by its business centres and subsidiaries. Today the company combines the resources and competencies of a local network with decentralised, customer facing teams and its management and research headquarters in France.

Cryostar delivers pumps, turbines, compressors, heat exchangers, automatic filling and refuelling stations, natural gas liquefaction/regasification plants and power plants to customers with the most demanding requirements. Cryostar’s innovative solutions have a proven track record of improving customers’ process performance.

Cryostar has always been at the forefront of cryogenic technology. Since 1969 Cryostar has been supplying equipment for the transportation of LNG by sea.

Building on technology from industrial gas applications, Cryostar has led many new developments in equipment and systems.

Think global, act local

To stay close to its customers around the globe, Cryostar has established several Business & Service Centres and collaborates with experienced local agents and distributors.
LNG POWERED VESSEL TECHNOLOGY

FUEL GAS SUPPLY SYSTEMS:
Steam Turbine, 4-stroke DF Diesel, 2-stroke DF Diesel, Gas Turbine

- “Gaslog Singapore” – First Tri Fuel 4-stroke - Diesel Electric powered LNG carrier with 4-stage fuel gas compressor

- “Mozah” – World’s largest LNG Carrier 2-stroke Diesel with BOG Reliquefaction

- “Laeita” – Cryostar’s first Steam turbine powered LNG carrier

- “Francisco” – First Dual Fuel Gas - Turbine powered High speed Ro-Pax ferry

- “Gaz de France Energy” – First 4-stroke Dual Fuel Diesel Electric powered LNG carrier

“Cryostar’s cutting-edge technology was selected on all these world firsts ....”
CARGO HANDLING SYSTEMS – ONBOARD AND ASHORE

Marine LNG transport applications

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<th>STEAM TURBINE</th>
<th>DUAL/TRI FUEL 4-STROKE DIESEL</th>
<th>DUAL FUEL 2-STROKE DIESEL MP</th>
<th>DUAL FUEL 2-STROKE DIESEL HP</th>
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<td>CM 300</td>
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<td>High duty Compressor</td>
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Land-based LNG storage applications

Return Gas Blowers based on the proven single and multi-stage compressor designs. Built to API, with exceptions, these machines offer less expensive, safe, reliable and efficient operation than competing technologies.

Multi-stage BOG compressors are also suitable for some send-out applications.

Stepless flow control over a wide range, using Inlet Guide Vanes or a combination of IGV and speed control.
CARGO HANDLING SYSTEMS - ONBOARD AND ASHORE

BOIL-OFF GAS HANDLING: Cargo Handling on LNG Carriers

Cryostar’s High Duty Compressors are responsible for tank pressure control on the vast majority of the current LNG carrier fleet. This key function is performed seamlessly to assure safety of the Cargo tanks during cargo loading operations.

It is essential that the volume of vapour returned to shore perfectly matches the liquid volume loaded to maintain the tank pressures within the narrow pressure range permitted.

Tank Maintenance Heat Exchangers

Natural Gas Heaters and LNG Vaporizers are an essential part of the equipment installed on LNG carriers. Heaters are used during tank maintenance operations to assist with the removal of flammable vapour and for tank warming.

A proven split-range control philosophy allows accurate flow and temperature settings to be achieved, while minimizing system pressure losses.

Reliable control systems also provide protection to prevent icing in case of steam flow disruptions and to ensure that steam condensate is effectively removed for return to the boiler.

“a simple flow bypass system allows for accurate flow and temperature control ....”
Fuel gas feed to Dual or Tri-fuel Diesel Engines requires operation covering a wide range of inlet conditions as the tank temperature, gas composition and flow varies.

Ranging from high flows of cold nitrogen-rich gas directly after loading to small flows of warm gas on the ballast passage.

Precisely these challenging conditions led to Cryostar’s development of the 4-stage BOG compressor. This machine allows operation over a full temperature range, while still providing enough pressure for feeding the multi-fuel engines to allow heel-out of the tanks.

2-stage BOG compressors use a spray pre-cooler and mist separator to cool the inlet under warm gas conditions. However, as tank levels drop, it becomes more difficult to pump the liquid for precooling and the compressor discharge pressure is reduced.

This limitation prevents heel out operations. On laden voyages with cold gas, the 2 and 4-stage machines have similar performance.
CARGO HANDLING SYSTEMS - ONBOARD AND ASHORE

LNG fuel gas pumps and systems

Cryostar has always been a key supplier of cryogenic pumps and pump systems globally. This experience, often in conditions more extreme than LNG, places Cryostar in the unique position of having a strong combination of vast marine and pumping experience, unlike any competitor.

This experience base, allows well designed integration of pumps and pumping systems into LNG powered vessels. This may be for lower pressure 4-stroke Dual/Tri Fuel Diesel, high pressure 2-stroke Dual Fuel engines or medium pressure gas fuelled turbines. Fuel gas delivery pressures in excess of 300 bar are readily available.

Cryostar’s world renowned designs include vacuum insulated pump chambers, designed to minimise heat inleak, which leads to unwanted vaporization of LNG. Robust crank drives ensure substantial maintenance intervals, while the hard-working pump chambers are simply maintained.

Pumps can be supplied loose or skid-mounted for simple installation, either with or without vaporizers and control systems. Pumping systems to feed fuel gas for vessels with up to 60 MW installed power are available.

Cryostar’s experience of Fuel Gas supply systems exceeds 50 operational vessels.

“Cryostar’s experience of cryogenic pumping, coupled with marine experience, is unrivalled....”
Gas Sealing
All rotating machinery requires sophisticated sealing between the Process Gas and atmosphere. Cryostar typically uses multiple carbon ring sealing technology on its low pressure applications. This robust design minimises buffer seal gas consumption, while protecting from leakage. This technology, jointly developed with a major specialist seal maker, ensures a simple but efficient system.

Flow control
Typically flow control is achieved using Inlet Guide Vanes (IGV), Variable Diffuser Vanes (VDV) or a combination of one of these and variable speed controllers. IGV’s are suitable for machines with modest pressure ratios, while VDV’s are preferred for high pressure ratios.

High speed bearings
High speed shafts require special measures in order to maintain stability at high speeds. Specialised lubrication systems are responsible for maintaining sufficient flow of high-performance turbine oil to the bearings, while maintaining the correct viscosity through accurate temperature control.

Cryostar utilises tilting-pad radial bearings and fixed geometry axial bearings to ensure that positional accuracy of the shaft is maintained over the entire operational range of the machine.

“cutting edge technology and service gives Cryostar customers a distinct advantage ....”
CARGO HANDLING SYSTEMS - ONBOARD AND ASHORE

Gas processing Plants - BOG Reliquefaction plants

Cryostar developed a nitrogen loop reliquefaction system using the Brayton cycle in 2004. This process was continually refined and 14 plants were delivered between 2006 and 2008 for installation on the largest LNG carriers in existence (266,000 m³ LNG transport capacity).

The plants take boil-off gas from the cargo tanks and compress it before full reliquefaction. The derived condensate is returned to the cargo tanks for later sale at the offloading point. A novel de-superheater is placed upstream of the BOG condenser, allowing much faster process transitions and faster plant startup, which is essential in this application due to the nature of the operations and cargo loading.

The Nitrogen Compander forms the heart of the refrigeration loop and uses energy recovery technology pioneered by Cryostar in the ‘90s.

Cryostar’s EcoRel technology can be applied to all LNGC propulsion types.

“the majority of the world’s LNG vessels are equipped with Cryostar machinery or systems …”

Regasification Plants

Many countries consider Floating Storage and Regasification Units (FSRU) and as attractive alternative to short term gas supplies.

With this in mind, and the growing FSRU fleet, Cryostar has developed an open-loop system using propane as an intermediate fluid. In-depth knowledge of cryogenic pumping and LNG behaviour has allowed optimisation of the process and packaging of a robust system which has approval in principle from a major Classification Society.

The modular design allows for easy up and down-scaling and easy customisation to match the available deckspace.
Marine LNG transport applications

Safety
All machinery is designed and built to exacting standards, especially with safety and compliance in mind. Safety is paramount in our organisation, on installation sites and throughout the life of the equipment.

Advanced test facilities
Every machine only leaves Cryostar’s manufacturing facilities after successfully completing stringent testing including operation under cold conditions. Pressure, performance, noise, vibration and mechanical running tests are routinely performed.

Factory Acceptance Testing is frequently witnessed by Shipyards, Ship Owners, Classification Societies, EPC Contractors and independent parties.

The well-equipped test facilities include on-line data collection and in most cases live performance values are displayed on monitors in the control rooms.

Quality
Cryostar has held ISO 9001 certification since the ‘90s and more recently added ISO 14001 and 18001 to this list. Regularly audits continue to fine-tune an already comprehensive quality programme.

Frequent interaction with bodies such as Lloyds Register, American Bureau of Shipping, Det Norske Veritas, Bureau Veritas, Nippon Kaiji Kayokai, Russian Maritime Register of Shipping, Registro Italiano navale and Korean Register of Shipping and China Classification Society has led to type approvals for some equipment.
Customer Support

Special applications, new developments
Cryostar is no stranger to new applications and developments.

An in-house group of process engineers is able to evaluate systems and define the necessary machinery. In addition, aero-, mechanical- and electrical designs are all carried out in-house.

Close collaboration with potential and existing clients often leads to novel approaches resulting in an optimised solution with benefits for both parties.

New developments, like standard products, are allocated to experienced project managers who will follow for the life of the project, providing a single point of contact during the clarification and execution phases.

New operating conditions requiring adaptation of existing designs, or complete new designs, are smoothly handled.

Contact us: sales@cryostar.com

Service
With a lifetime of some 40 years, selection of key equipment is very important. Even more important is the level and quality of service. Cryostar recognises that machine reliability is crucial to the profitability and safe operation of vessels or plants.

An experienced group of service personnel in key locations are on tap for quick deployment in case of emergency or for well planned maintenance. Coupled with solid support from an experienced team based in the Head Office, your machines are secure in our hands.

Planned Maintenance kits are available, customised to individual or groups of similar machines. Larger customers can also benefit from Cryostar’s input for the selection and control of Capital Spares

A 24-hour helpline is available, and with a footprint in all time zones, help is always at hand.

Contact us: CryostarCustomerService@cryostar.com

Training
Cryostar’s training centre has a highly qualified staff of engineers, travelling around the globe to customer sites or business centres, where they train equipment users to get the most out of Cryostar technologies.

Contact us: CryostarTrainingCenter@cryostar.com
For contact and address of the Cryostar locations worldwide, please go to www.cryostar.com/locations/