EQUIPMENT SOLUTIONS FOR LNG AND LBG
SAFETY AND STANDARDS

Safety is an integral part of CRYOSTAR’s management and manufacturing commitments. For each new development or project, the company performs a risk analysis using approved techniques such as HAZOP (Hazard Operability) and FMEA (Failure Mode and Effects Analysis). CRYOSTAR’s equipments and solutions comply with most stringent machine and safety regulations such as the Pressure Equipment Directive 97/23/CE (Module H and H1) and ATEX.

FACTORY AND ON-SITE ACCEPTANCE TESTS

CRYOSTAR’s headquarters host the world’s largest and most sophisticated liquid nitrogen test facility for cryogenic pumps as well as a testing facility dedicated to turbines. CRYOSTAR engineers submit each pump and turbine to a performance test prior to shipment, offering customers guaranteed performance. CRYOSTAR provides commissioning, start-up and support for onsite performance test for liquefaction plants and refueling stations.

QUALITY AND ENVIRONMENT

CRYOSTAR is ISO 9001-2008 certified. To structure its environmental approach, CRYOSTAR has used the ISO 14001 standard to set up all the organizational and operational processes necessary for an aspiring Environmentally Responsible company. In parallel, CRYOSTAR has applied this approach to Health and Safety through the OHSAS 18001 standard. ISO 9001-2008/ISO 14001-2004/OHSAS 18001-2007 quality assurance system.
Industrial LNG applications
- Trailer unloading skid
- Control system

Power Generation
- LNG feed pump

Off-road applications (HHP)
- Refueling system
- LNG fuel pump

LCNG/LNG Refueling Station
- High pressure pump
- Submerged pump
- LNG dispenser
- Control system
- Satnow® & LIN Assist®

LNG Trailer
- Unloading pump

Satellite plant
- Peak Shaving plant
- Trailer unloading skid
- High pressure pump
- Control system

LNG Fuel injection
- High pressure pump
- Submerged pump

LNG Receiving Terminal
- Trailer loading pump

Ship-to-ship LNG Bunkering
- Submerged pump

Shore-to-ship LNG Bunkering
- Submerged pump

EQUIPMENTS AND SOLUTIONS FOR LNG AND LBG
MOBILE TANKER UNLOADING PUMPS

Most of LNG trailers including pumps are equipped with CRYOSTAR centrifugal pumps, which are recognized for their high performance, reliability and safety. Pumps are equipped with high efficiency closed impellers and helical inducers for low NPSH requirement. Rotating parts are balanced individually. The complete pump assembly is ATEX certified and includes all safety devices for safe operation.

**Plug’in and Mixtran**

Electric-driven pump with electric control panel powered through on-site electrical network or alternator driven by truck power take off (PTO)

<table>
<thead>
<tr>
<th>Pump Type</th>
<th>Flow (m³/h)</th>
<th>Differential head (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric-driven pump with gearbox (type GBS/CBS) with shaft seal</td>
<td>up to 30</td>
<td>200</td>
</tr>
<tr>
<td>Electric-driven submerged motor pump (type VS) no shaft seal</td>
<td>up to 75</td>
<td>140</td>
</tr>
<tr>
<td>Electric-driven submerged pump (type SUBTRAN) no shaft seal</td>
<td>up to 55</td>
<td>160</td>
</tr>
</tbody>
</table>

**Hytran**

Hydraulic-driven pump with control panel and hydraulic system powered through truck power take off (PTO)

<table>
<thead>
<tr>
<th>Pump Type</th>
<th>Flow (m³/h)</th>
<th>Differential head (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic-driven pump with gearbox (type CBSH) with shaft seal</td>
<td>up to 50</td>
<td>450</td>
</tr>
<tr>
<td>Hydraulic-driven pump (type CSH) with shaft seal</td>
<td>up to 60</td>
<td>450</td>
</tr>
</tbody>
</table>
STATIONARY TRANSFER PUMP SKIDS

Skidded unit
- CRYOSTAR centrifugal pump with external or submerged motor
- ATEX skid with piping, valves, instrumentation and safety devices
- ATEX control panel
- Manual or full automatic execution

Interface panel
- Control box with start/stop buttons, lights, pressure and level indicators
- Automatic management of trailer offload process which ensures a higher safety
- Accessibility to the trailer flexible hose outside of the equipment area
- Possibility to have a wired connection

Metering skid
- Coriolis technology based flow management
- Weights and Measures approval option available
- Measurement of loading and gas return flows
LNG TRANSFER PUMPS
A wide range of centrifugal pumps suitable for any kind of installation and duty. These pumps are available in different constructions and executions.

<table>
<thead>
<tr>
<th>Pump type</th>
<th>CS/CBSD</th>
<th>GBS/CBS</th>
<th>MCP</th>
<th>VS</th>
<th>SUBTRAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>External</td>
<td></td>
<td></td>
<td></td>
<td>External or in tank</td>
</tr>
<tr>
<td>Duty</td>
<td>Intermittent</td>
<td></td>
<td></td>
<td></td>
<td>Intermittent or continuous</td>
</tr>
<tr>
<td>Suitable for cold standby</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Construction</td>
<td>Direct coupled with shaft seal</td>
<td>Gearbox coupled with shaft seal</td>
<td>Direct coupled with shaft seal</td>
<td>Direct coupled Submerged motor</td>
<td>Direct coupled Submerged pump</td>
</tr>
<tr>
<td>Max. flow rate</td>
<td>130m³/h</td>
<td>60m³/h</td>
<td>600m³/h</td>
<td>90m³/h</td>
<td>150m³/h</td>
</tr>
<tr>
<td>Max. differential head</td>
<td>240m</td>
<td>285m</td>
<td>220m</td>
<td>220m</td>
<td>410m</td>
</tr>
</tbody>
</table>
EXTERNAL PUMP with SHAFT SEAL
Type CS, CBSD, CSH, GBS, CBS, CBSH, MCP

- Volute separated from electrical motor by an open intermediate piece with four hollow arms. This intermediate piece only presents four contacts points for low thermal conductivity.
- Hollow shaft to reduce thermal conductivity to minimum and slinger ring for improved safety.
- Thick insulation plate provides low thermal conductivity.
- Front opening of housing offers easier maintenance.
- Cryostar shaft seal.
- Helical inducer allowing low required NPSH.
- High hydraulic efficiency closed impeller.

EXTERNAL PUMP with SUBMERGED MOTOR
Type VS

- Motor bearings lubricated by the process fluid resulting in a “zero-maintenance” design.
- Special submerged electric motor cooled by the pumped fluid.
- Hermetically encapsulated pump eliminating the need for a shaft seal.
- High hydraulic efficiency closed impeller.
Internal flow recirculation

Two functions/benefits:
• Lubrication of the bearings
• Motor and bearing heat dissipation

Recirculation flow is calculated to evacuate maximal heat produced without evaporation of LNG
### VARIOUS EXECUTIONS

<table>
<thead>
<tr>
<th></th>
<th>FV</th>
<th>LB</th>
<th>RP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESIGNATION</strong></td>
<td>Flanged Version</td>
<td>Low pressure Barrel (sump)</td>
<td>Removable Pump</td>
</tr>
<tr>
<td><strong>INSTALLATION</strong></td>
<td>In line Vertical or horizontal</td>
<td>In sump Vertical</td>
<td>In-tank Vertical or horizontal</td>
</tr>
<tr>
<td><strong>ACCESSORIES</strong></td>
<td>Flanges on suction and discharge</td>
<td>Sump, top plate and cable lead trough with junction box</td>
<td>Foot valve, cable system, top plate, vibration probes, etc</td>
</tr>
<tr>
<td><strong>APPLICATION</strong></td>
<td>Trailer loading/unloading Bunkering</td>
<td>Trailer loading/unloading Bunkering Peak shaving</td>
<td>Send out pump LNG terminal, Peak shaving</td>
</tr>
<tr>
<td><strong>MAIN USE</strong></td>
<td>External installation Cooling down time allowed</td>
<td>External installation Instant start</td>
<td>Atmospheric flat bottom tank</td>
</tr>
</tbody>
</table>
HIGH PRESSURE PUMPS

Used for LNG processing, LNG peak shaving/satellite plants and LNG fuel injection, CRYOSTAR high pressure pumps are recognized for their reliability and can run 24 hours a day without any maintenance for up two years depending on site conditions.

Multistage Vertical Pumps (VP)

The Vertical Pump (VP) is an external multistage cryogenic pump designed for cold standby and continuous operations. VP pumps are the best alternative to multistage submerged motor pump when LNG is stored in pressurized storage tanks.

*VP are available in several sizes and multiple stages of the same design to meet the most demanding requirements in discharge high pressures up to 60 bar.*

**Highlights**

**Continuous duty:**
More than 600 references on the five continents running continuously.

**Legendary reliability:**
Preferred high duty, high performance process pumps by all major industrial gas companies.

**Temperature insulation and stability:**
The VP is mounted on its “COLD BOX FLANGE” with a unique isolating flange in a “Composite” material for rigid mounting of the complete machine on the cold box and an efficient temperature break.

**Continuous cold stand-by:**
Closed and purged distance piece; this is the “Warm Box” execution avoiding any humidity penetration and ice building. Permanent standby in cold conditions with the bearing heating system. The pump is kept ready for an immediate restart any time.
Reciprocating pumps

Complete range of cryogenic reciprocating pumps available in simplex, duplex or triplex execution. These pumps can remain in cold standby and can operate in intermittent or continuous duty for various applications such as LCNG refueling stations, peak shaving or high pressure injection for natural gas engines.

- ATEX certified skidded pump for increased safety
- High efficiency design with vacuum insulated cold end for minimum product losses
- Extended lifetime thanks to self-adjusting low pressure seals on cold end and new generation oil lubricated crank drives

**Capacity**

- Pressure: up to 600 bar
- Flow: up to 520l/min (18,500 Nm³/h)

**MRP/LDPD - Belt driven**

- Capacity
  - Pressure: up to 500 bar
  - Flow: up to 337l/min (~12,000 Nm³/h)

**HPP - Belt driven**

- Capacity
  - Pressure: up to 300 bar
  - Flow: up to 520l/min (18,500 Nm³/h)

**HPP - Gearbox driven**

- Capacity
  - Pressure: up to 600 bar
  - Flow: up to 520l/min (18,500 Nm³/h)
LNG REFUELING STATION
SUBTRAN™ pump skid

The SUBTRAN™ is a multistage submersed pump transferring LNG from the storage tank to the LNG dispensers. The SUBTRAN™ skid is a complete package mounted on rigid base frame with vacuum insulated sump, insulated piping and ATEX instrumentation and junction box.

MAX FLOW RATE: 360l/min
(1x pump for 2x dispensers)

MAX DIFF. HEAD: 320m

LinAssist™ boil-off minimizer

The LinAssist™ is a patented system using liquid nitrogen to maintain the LNG storage tank at a constant temperature and therefore at constant pressure. This system eliminates any possible gas releases of the storage tank.

SatNow™ saturation system

The SatNow™ is a patented system converting cold LNG at -162°C (3bar) to saturated LNG at -125°C (8bar) during the fueling (onthefly). Thanks to SatNow™ a station with cold LNG inside the storage tank can fuel both type of vehicles. Besides there is no need to warm up the LNG in the storage tank => no down time.

LNG Dispenser

The LNG Dispenser refuels vehicles with cold or saturated LNG. Its registered design ensures high safety and ergonomics to the operator. Its proprietary electronic card CRYO-FUELTRONICS™ allows a standalone use and IFSF communication with payment system. The flow meter and electronics are approved according to MID directive.

FLOW AT NOZZLE: 160l/min
(3 minutes for 450 liters tank)
LCNG reciprocating pump

CRYOSTAR MRP™ pump series available in simplex/duplex/triplex with all necessary ATEX accessories for the safest and most efficient use:
- High efficiency design with minimum product losses
- Long lifetime wear parts for reduced downtime
- Robust design based on Finite Element Analysis (FEA)

FLOW RATE: 800 to 2'700Nm³/h
PRESSURE: up to 360 bar

Buffer panel / Heater / Odorizer

The buffer panel controls both line and buffer pressure to deliver the right pressure to the CNG dispensers. It also controls the buffer capacity in order to open or close automatically the gas valve to the buffer storage.

The heater ensures that cold gas is not entering the buffer storage and the odorizer allows to readily detect any accidental leak in the process.

Ambient air vaporizer

Efficient ambient air vaporizer with aluminium fins fitted around high strength stainless steel inner tubes. The heat exchange is done by natural convection. For 24 hours a day operation 2 vaporizers are installed in parallel with an automatic switch every 4 hours.

OPERATION TIME: up to 8h
PRESSURE: up to 420 bar

User interface / Station control

Full automatic execution for smart and reliable operation. Able to interface with industrial system / CRYOSTAR process control software with integrated modules for easy equipment upgrades / Data & defaults recording with automatic report and warning message sending / Remote station monitoring through internet connected devices (smartphones, touchpads…). Electronics are approved according to MID directive.
For contact and address of the Cryostar locations worldwide, please go to www.cryostar.com/locations