Hydrogen Expanders and Pumps

Equipment and expertise for Industrial Gas, Natural Gas, Hydrocarbons and Clean Energy

www.cryostar.com
More than 50 years experience Leading company in cryogenic machineries and related products:
★ Cryogenic Pumps, Gas filling stations
★ Turbo-expanders
★ Compressors and BOG reliquefaction systems

Turnover of around €300+ millions in 2019 of which more than 95% are exported


Around 700 employees (600 located in the headquarter in France) and 100 persons located in Cryostar business centres (in China, UK, USA, India, Brazil, Singapore)

Cryostar is divided in 3 Business Units

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LNG TRANSPORT CARGO MACHINERY

- Cargo machineries
  - Single stage Boil off Gas Compressors

- Fuel gas compressors
  - Single stage Compressors to 6 stages Compressors (up to 16 bar)

- High pressure pumps for 2-stroke LNG powered vessels
  - LNG fuel gas supply pumps (ME-GI) – up to 300 bar
  - Ethane fuel gas supply pumps

- LNG Bunkering / Transfer pumps
  - Submerged pumps
**DISTRIBUTION LINE**

★ **Centrifugal pumps**
  Cryogenic road tanker loading or offloading
  Transfer of cryogenic liquid between storage tanks

★ **Reciprocating pumps**
  High pressure and buffer and gas cylinders filling
  Very high pressure (up to 10,000 psig – 690 bars)

★ **Filling stations**
  Market leader in automated gas filling systems
  Specifically designed for customer requirements

★ **LNG/LCNG/LH2 fueling stations**
  Cryostar Vehicle Fueling Stations designs based on extensive experience in natural gas (Turbines, compressors, pumps)
Typical LH2 Loading / LCGH2 Refueling

### LH2 Carrier
- LH2 trailer
- LH2 carrier

### LH2 Submerged Pump

### LH2 Reciprocating Pump

### LCGH2 Refueling
- Handling material (35MPa)
- Tube trailer (35MPa)
- City bus (35MPa)
- CGH2 50 MPa
- CGH2 87.5 MPa
- Car (70MPa)

*Not yet available*

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Unlike centrifugal pumps, a reciprocating pump produce the same flow at a given speed (RPM) no matter what the discharge pressure: 
Flow = Cylinder volume x Speed x Efficiency

The pressure increases gradually in the line after each piston stroke
LCGH2 Reciprocating Pump (MRP LH2)

OVER 50 + Units produced

Max pressure: up to 500 bar
Available in 3 sizes
Max flow: 15 / 30 / 45 l/min
Max power: 37 / 75 / 90 kW
LH2 Submerged Pumps (SUBTRAN LH2)

Available in 3 sizes
Flow: up to 600 m³/h
Head: see performance chart
SUBTRAN at a glance

General characteristics
✓ Submerged pump for LH2
✓ Drive type: electric submerged motor

Highlights
✓ Fully submerged “seal-less” design allowing cold stand-by for immediate start
✓ High efficiency design with patented impeller design
✓ Ceramic ball bearings for extended lifetime
✓ Low NPSH requirements
✓ Reinforced motor insulation and use of special materials for LH2

* Designed based on API 610 / ISO 13709 / IGC 11/82
## SUBTRAN LH2 Executions

<table>
<thead>
<tr>
<th>Designation</th>
<th>LB</th>
<th>RP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low pressure Barrel (sump)</strong></td>
<td></td>
<td><strong>Removable Pump</strong></td>
</tr>
<tr>
<td><strong>Installation</strong></td>
<td>In vacuum insulated sump Vertical</td>
<td>In-tank Vertical or horizontal</td>
</tr>
<tr>
<td><strong>Accessories</strong></td>
<td>Vacuum insulated sump, top plate and cable lead trough with junction box</td>
<td>Foot valve, cable system, top plate, vibration probes,…</td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td>LH2 Trailer loading/unloading</td>
<td>LH2 terminal</td>
</tr>
<tr>
<td><strong>Main use</strong></td>
<td>External installation Instant start</td>
<td>Atmospheric flat bottom tank</td>
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</tbody>
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★ Hydrogen Expanders

★ Hydrogen Companders
Hydrocarbons Turbo expanders (almost 300 units)

Gas Turbo-Expanders as per API executions: API 617 and API 614 standards:

**Natural gas processing**: compressor loaded turbo-expanders with oil lubricated bearings or magnetic bearings, generator loaded turbo-expanders

**Ethylene / propylene applications**: compressor loaded turbo-expanders with oil lubricated bearings or magnetic bearings, generator loaded turbo-expanders

**Syngas for Ammonia plant**: generator loaded turbo-expanders, oil brake loaded turbo-expanders

**Synthetic gas applications (GTL Gas To Liquid, CTL Coal To Liquid)**: generator loaded turbo-expanders

**Liquid turbines**
For LNG plant, installation in mixed refrigerant service or LNG service consisting in generator loaded liquid turbines or oil brake loaded liquid turbines

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CRYOSTAR – Hydrogen Expanders Experience

Synthetic Gas Turbo-Expander/Generator for NH3 Synthesis

- About 66% (Mol. Fraction) of Hydrogen
- Fully API617 compliant
- 20 units delivered
- Cryogenic operating conditions (-196°C Design)
- Oil bearing technology
- Direct coupling (no gearbox)
- Up to 825kW
Ethylene Gas Turbo-Expander/Compressor (Companders)

- 50% to 92% (Mol. Fraction) H2 contains depending on licensor
- Proven Active Magnetic Bearing technology
- Cryogenic operating conditions (-196°C Design)
- Encapsulated design (sealess design)
- Fully API617 compliant
- 51 units delivered
- Up to 2MW per stage
CRYOSTAR – Hydrogen Expanders Experience

Polypropylene (PDH) Gas Turbo-Expander/Generator

- From 91% to 94% (Mol. Fraction) H2 contains
- Cryogenic operating conditions (-196°C Design)
- Integrally geared technology
- Parallel gear technology
- Fully API617 compliant
- 11 units delivered
- Up to 800 kW per stage
CRYOSTAR – Hydrogen Expanders Experience

Others Synthetic Gas Turbo-Expander/Generator or Compander applications (Rectisol, Glycol & DMMn)

- Up to 95% (Mol. Fraction) Hydrogen
- Fully API617 compliant
- Cryogenic operating conditions (-130°C Design)
- 10 units delivered
- Integrally geared design
- Parallel gear technology
- Up to 1MW
Pure Hydrogen Expanders Experience

- Market, so far, for Pure Hydrogen expanders was quite limited

- Only low power pure H2 expanders were produced on the market below Cryostar power range of products (<100kW)

- Internal Development at various stage on (not public):
  - Small Expanders
  - Large Compressors
  - 700+ bar pumps
THANK YOU FOR YOUR ATTENTION