



★ 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

Global ISO 9001:2008, ISO 14001:2004 & OSHAS 18001:2007 certified organisation

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



HEADQUARTER – HESINGUE / FRANCE



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CRYOSTAR – MARKETS AND PRODUCTS



★ DISTRIBUTION CRYOSTAR



★ LNG TRANSPORT & TERMINALS CRYOSTAR

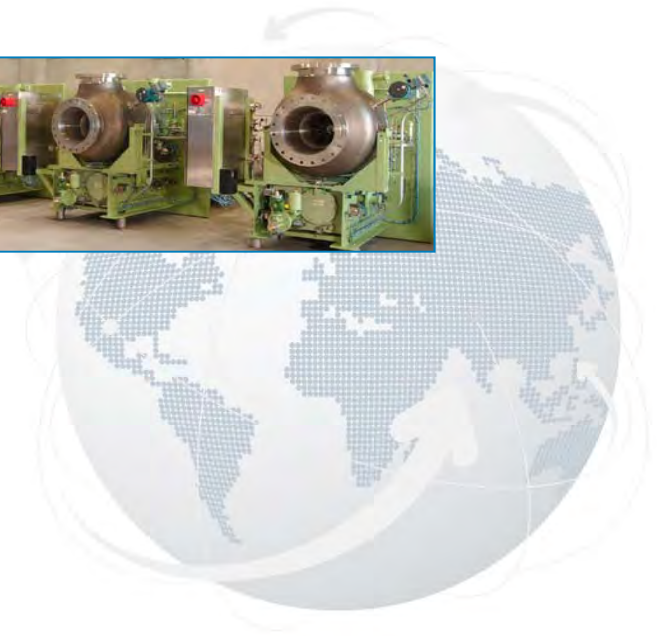


★ PROCESS CRYOSTAR



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LNG TRANSPORT & TERMINALS

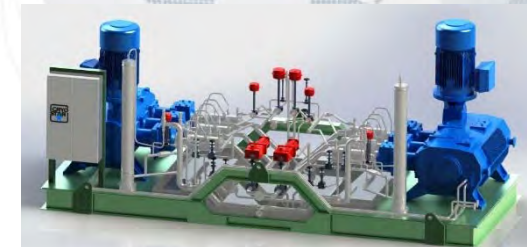
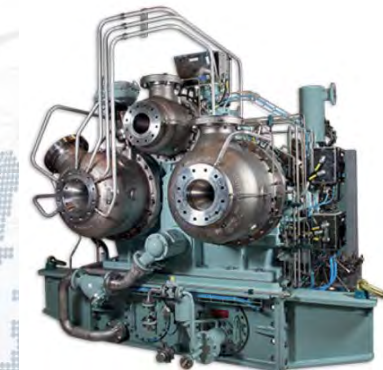


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LNG TRANSPORT CARGO MACHINERY



- 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



★ DISTRIBUTION CRYOSTAR



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★ DISTRIBUTION CRYOSTAR

★ 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

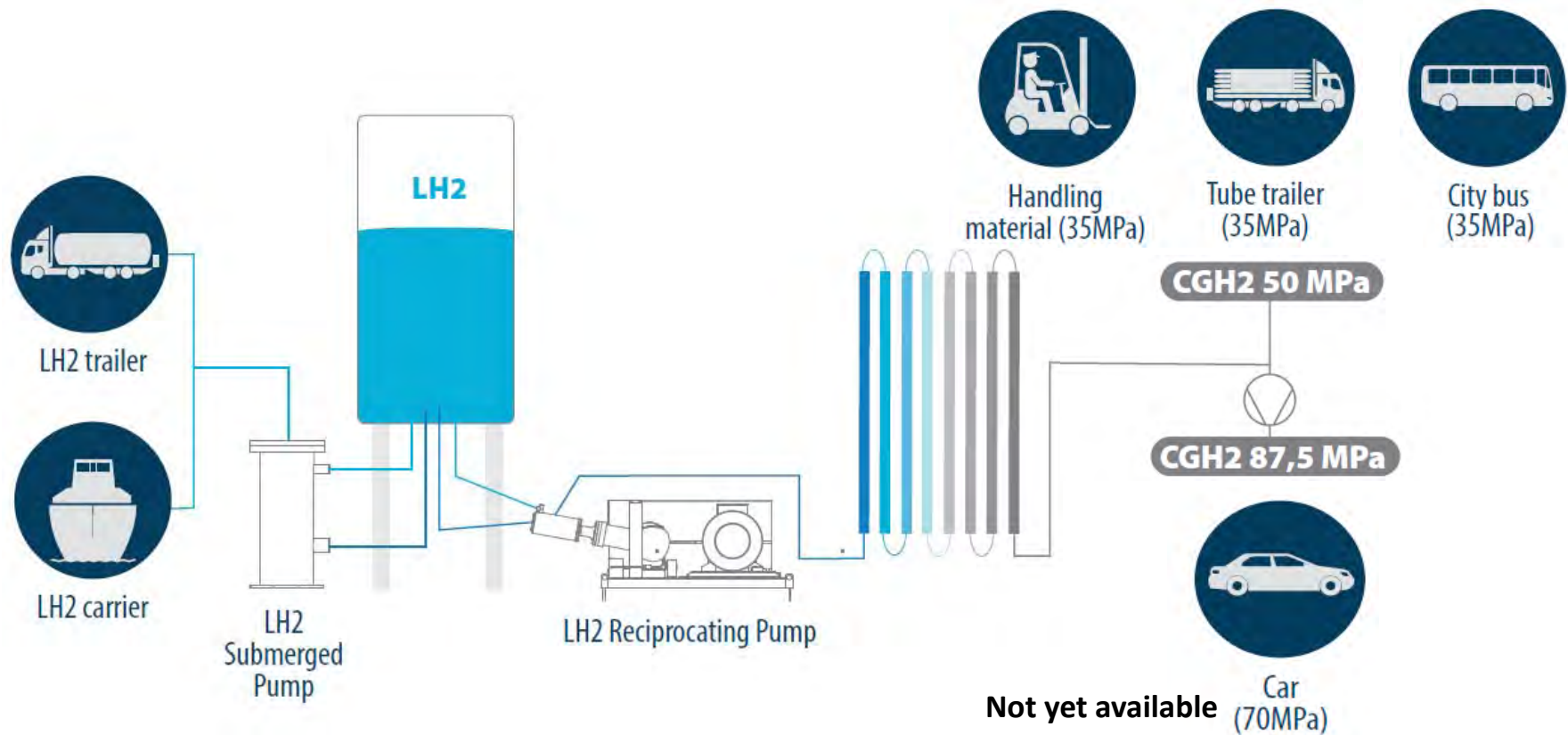
Market leader in automated gas filling systems
Specifically designed for customer requirements



★ 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



Introduction to cryogenic reciprocating pumps

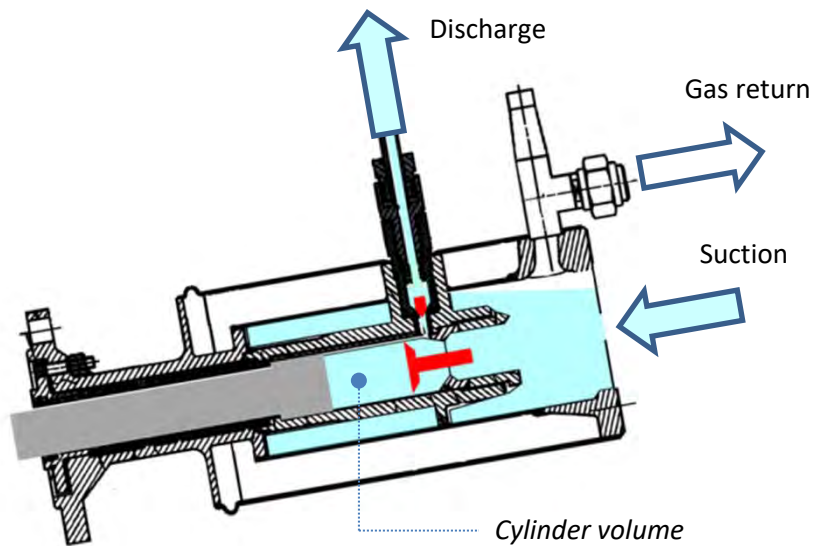


Unlike centrifugal pumps, a reciprocating pump produce the same flow at a given speed (RPM) no matter what the discharge pressure:

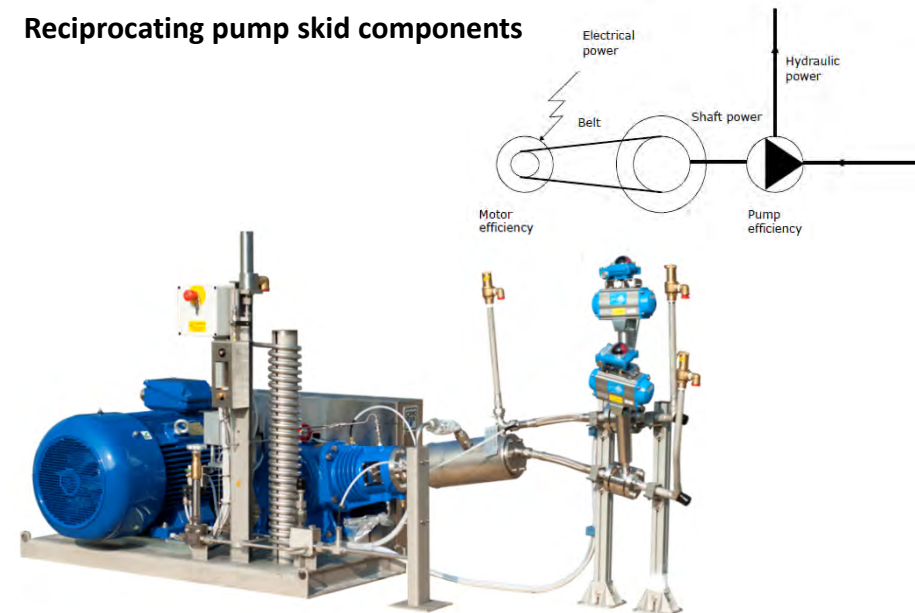
$$\text{Flow} = \text{Cylinder volume} \times \text{Speed} \times \text{Efficiency}$$

The pressure increases gradually in the line after each piston stroke

Liquid flow in the pump cold end



Reciprocating pump skid components



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



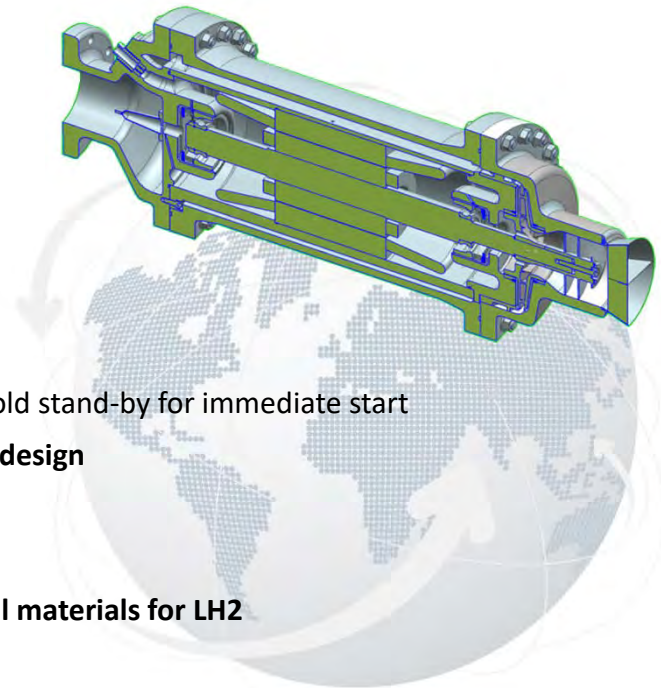
General characteristics

- ✓ Submerged pump for LH2
- ✓ Drive type: electric submerged motor

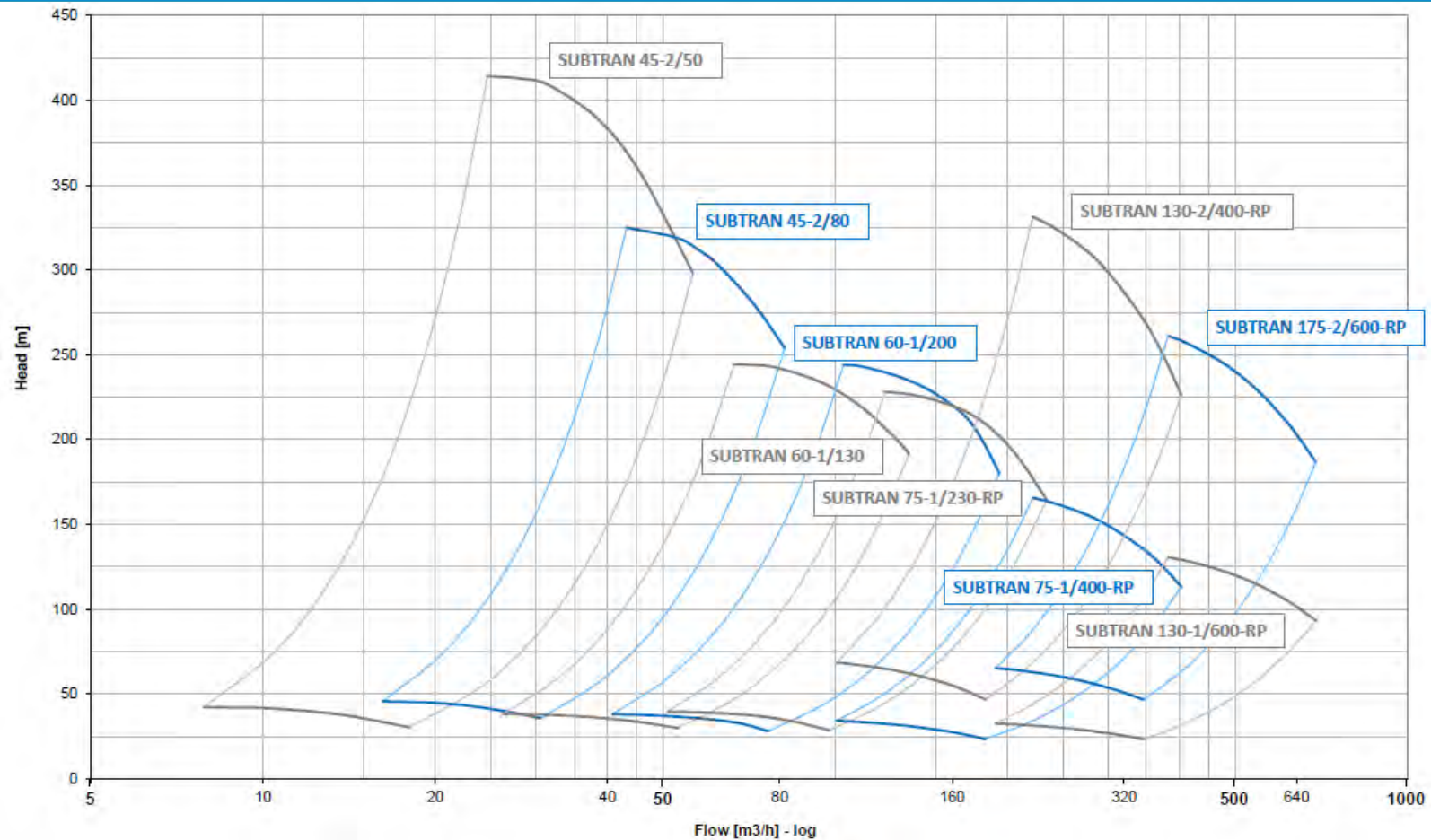
Highlights

- ✓ **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*



Performance Chart



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SUBTRAN LH2 Executions



	L B	R P
Designation	Low pressure Barrel (sump)	Removable Pump
Installation	In vacuum insulated sump Vertical	In-tank Vertical or horizontal
Accessories	Vacuum insulated sump, top plate and cable lead trough with junction box	Foot valve, cable system, top plate, vibration probes,...
Application	LH2 Trailer loading/unloading	LH2 terminal
Main use	External installation Instant start	Atmospheric flat bottom tank





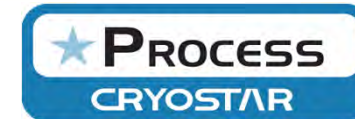
- ★ Hydrogen Expanders
- ★ Hydrogen Compressors



CRYOSTAR – PROCESS EQUIPMENTS LINE - HYDROCARBONS



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

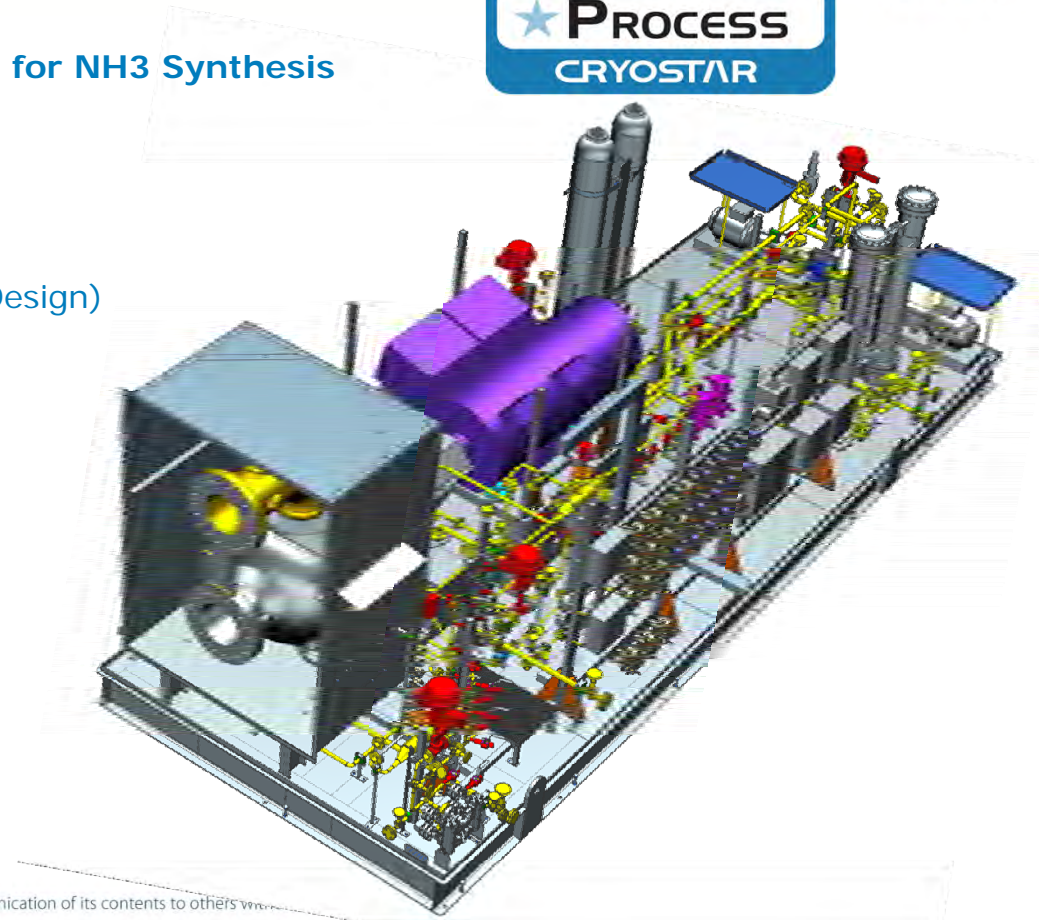
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CRYOSTAR – Hydrogen Expanders Experience



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



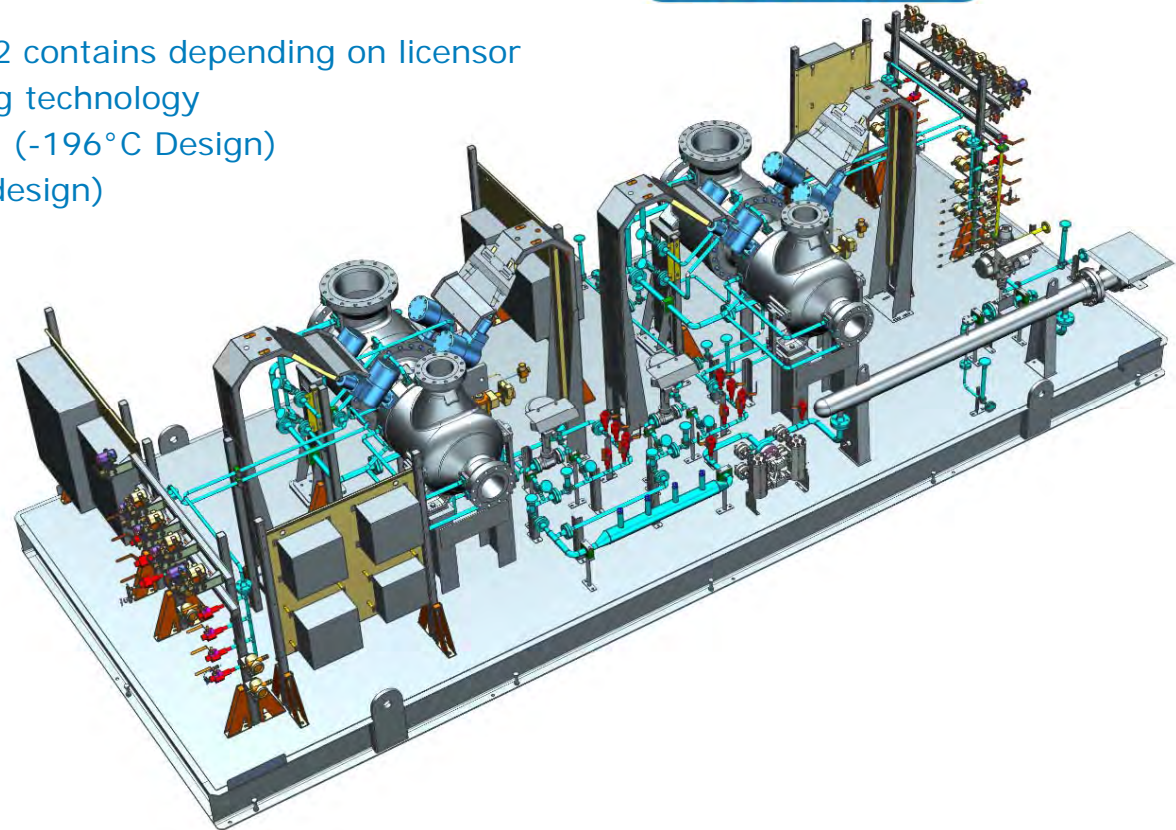
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CRYOSTAR – Hydrogen Expanders Experience



Ethylene Gas Turbo-Expander/Compressor (Componders)

- ✓ 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

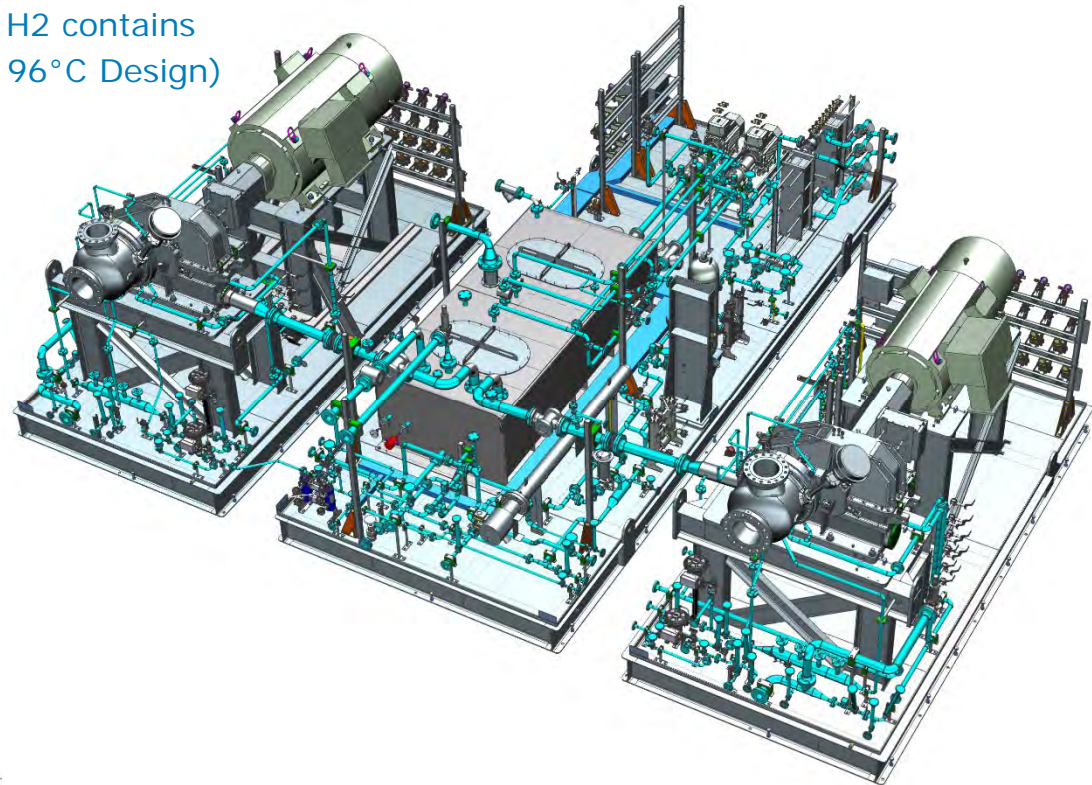


CRYOSTAR – Hydrogen Expanders Experience



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



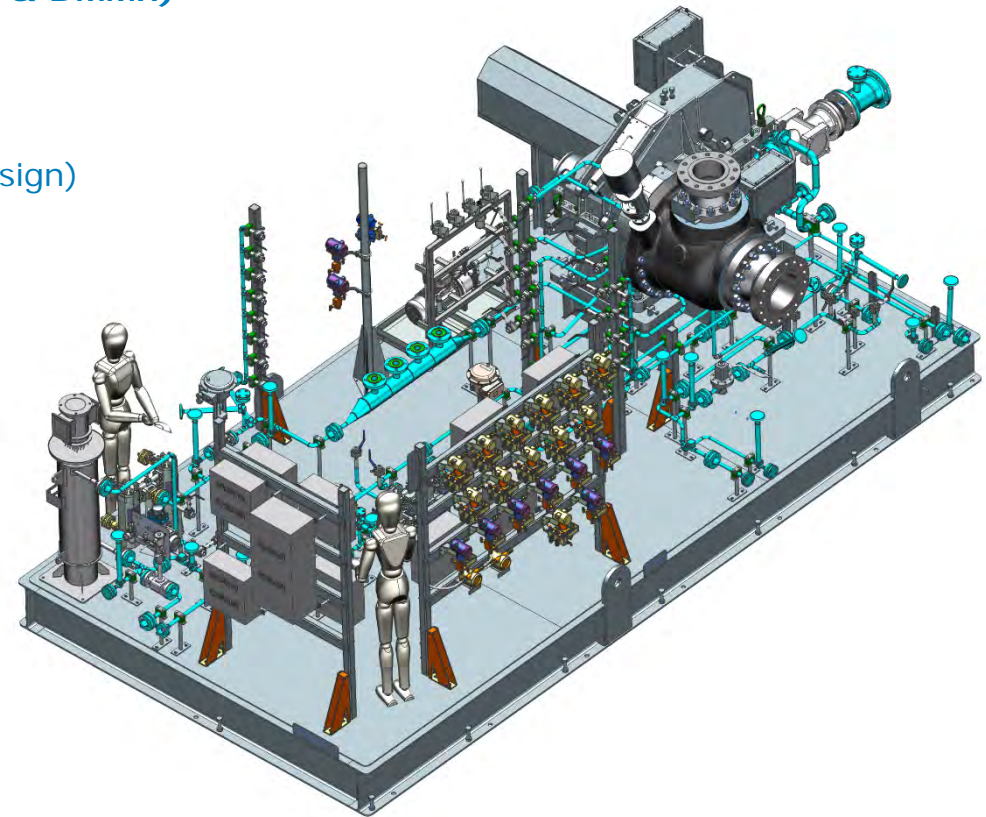
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CRYOSTAR – Hydrogen Expanders Experience



Others Synthetic Gas Turbo-Expander/Generator or Comander 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



CRYOSTAR – PROCESS EQUIPMENTS LINE - HYDROCARBONS



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

