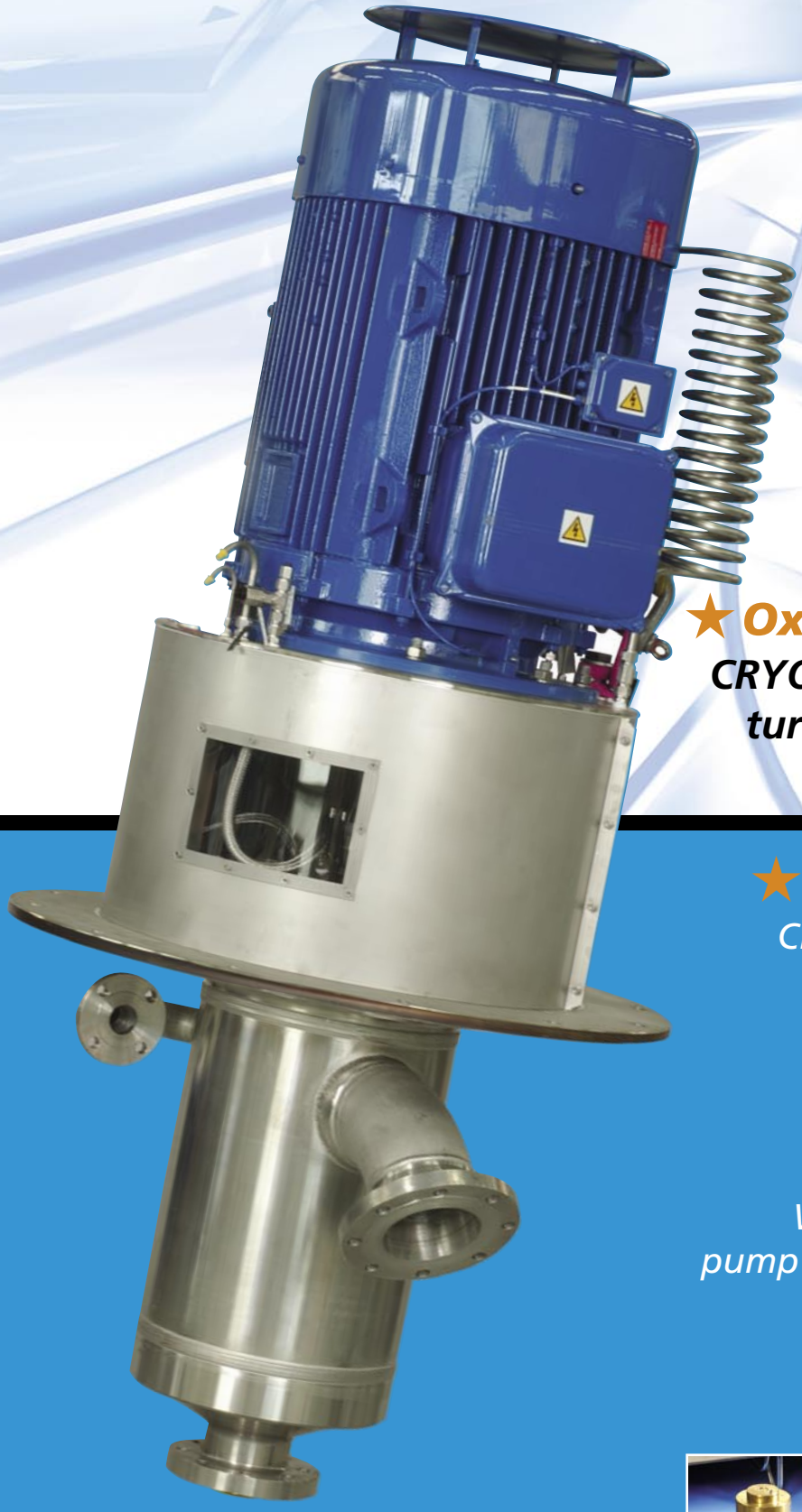
THE CRYOSTAR magazine
N°1 Spring 2003



★ Oxygen for cleaner Energy

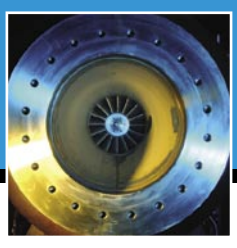
CRYOSTAR supplied all pumps and turbines to a SASOL GTL plant in South Africa

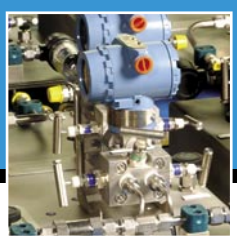
★ CRYOSTAR in the Americas

CRYOSTAR USA has become a main player in the Americas which represent one third of the world wide industrial gas business

★ The new MCP concept

With the new modular centrifugal pump concept CRYOSTAR demonstrates once more its reputation as innovative supplier





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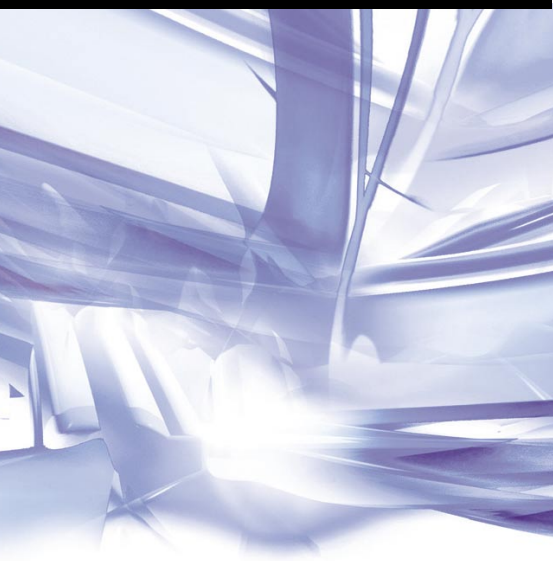


This is the first issue of the newly created CRYOSTAR magazine aimed at informing our customers all over the world.

Twice a year, in Spring and in Autumn, "The CRYOSTAR Magazine" will inform you about the CRYOSTAR products and their applications, the constant product developments and other innovations we are bringing to our respective markets, our worldwide organisation, and our personnel.

CRYOSTAR is present with operations and business centres in seven countries on four continents. Our pumps, turbines, cylinder filling stations, vaporisers, compressors and heat exchangers are installed in many countries on all five continents. Although our headquarter is located in France, we feel to be more a "citizen of the world" company as 90 percent of our products are installed out of France. Not only are we selling into many countries, but we are also buying parts or components from suppliers in America, Europe or Asia.

CRYOSTAR is definitely an internationally oriented company dealing in three main market segments: Industrial gas, LNG equipment and Hydrocarbon turbines, with customers on all five continents. CRYOSTAR's personnel, representing more than twenty different nationalities, speaking as many languages, are very proud to present you this first issue of "The CRYOSTAR Magazine".

Daniel MEYER
Managing Director

Oxygen for cleaner Energy

In January 2003, CRYOSTAR delivered a major order for expansion turbines and process pumps to L'Air Liquide, Champigny, France. These machines are required to equip the largest Air Liquefaction plant ever constructed, which will be built for the SASOL petrochemical company, in South Africa.

High efficiency 500kW saving 1MW.

CRYOSTAR's supply included:

> Vertical Multistage Pumps
> Modular Centrifugal Pumps
> Liquid Turbine
> Generator Loaded Turbine

The 3'500 ton/day Air Separation Unit (ASU) feeds large quantities of oxygen to the Sasol petrochemical plant in South Africa. Our high efficiency gas expansion turbine, with a cold production exceeding 500kW, together with a liquid expansion turbine, reduces the plant's overall power consumption by over 1MW. In addition, high-duty process pumps further improve the overall plant efficiency.

These huge volumes of oxygen are required by Sasol in their process to convert methane gas into liquid.

It is interesting to note that two of CRYOSTAR's main market segments - the industrial air gas and the LNG/hydrocarbon industries are involved in this project. CRYOSTAR's unique product portfolio allows it to overcome the challenges of managing energy in this natural gas process.

Natural gas can be delivered to the market in two forms : gas or liquid.
Natural gas currently represents around 18% of the world energy supply and is the fastest growing energy source today.
The energy potential of natural gas can be delivered to the market as a gas or a liquid.
For delivery of gas to the market, three options exist: directly via pipeline, liquefied natural gas (LNG) or compressed natural gas (CNG).

	Flow	Pressure
VP 4/310/7L	1'150 l/min	41 bara
VP 3/310/6,5L	752 l/min	40 bara
MCP 400/20L	3'370 l/min	4 bara
MCP 155/4,5L	73 l/min	3 bara

CRYOSTAR also supplies equipment for the handling of LNG. Gas liquefied at the production site, is then transported in large methane tankers to the consumer countries. CRYOSTAR equips these methane vessels with Boil-off gas compressors, vaporisers and heaters allowing, them to feed the vaporised LNG (Boil-off) to the ships engine, as propulsion energy.

Let us now consider the second way to bring natural gas to the market, liquid product distribution, which was chosen by Sasol for their Gas-to-liquids (GTL) technology.

GTL: a high-ranking alternative to LNG.

First, we have to understand why GTL technology exists, is developing, and can be considered as a strong alternative to regular LNG and the oil industry.

Natural gas is liquefied using a physical process, by cooling down the extracted pressurised gas, resulting in a cryogenic liquid (LNG) at a very low temperature of -160°C (-265°F).

GTL, however, is produced by a chemical process, and various methods are used to transform the gas into different liquids at ambient temperature.

Transportation of GTL products, due to their ambient temperatures, is much easier than that of very cold LNG.

The tanks and vessels containing the GTL liquids do not require special insulation to avoid vaporisation, as do those for the LNG. There are no product losses between production and utilisation. Furthermore, these GTL liquids can be considered as final products, such as Gasoline, Diesel or chemical products like Ethylene, etc. No additional refining processes are required in the consumer countries. A clean product is imported to the user country and this has a significant impact on the reduction of the pollution normally caused by refining processes.

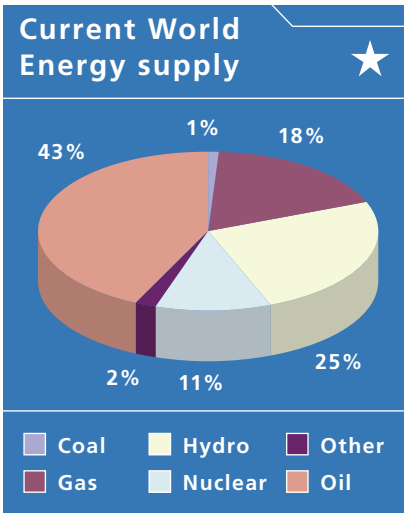
Natural gas therefore, has a real future, and will certainly compete more heavily with oil, which represents close to 43% of the current world energy supply.

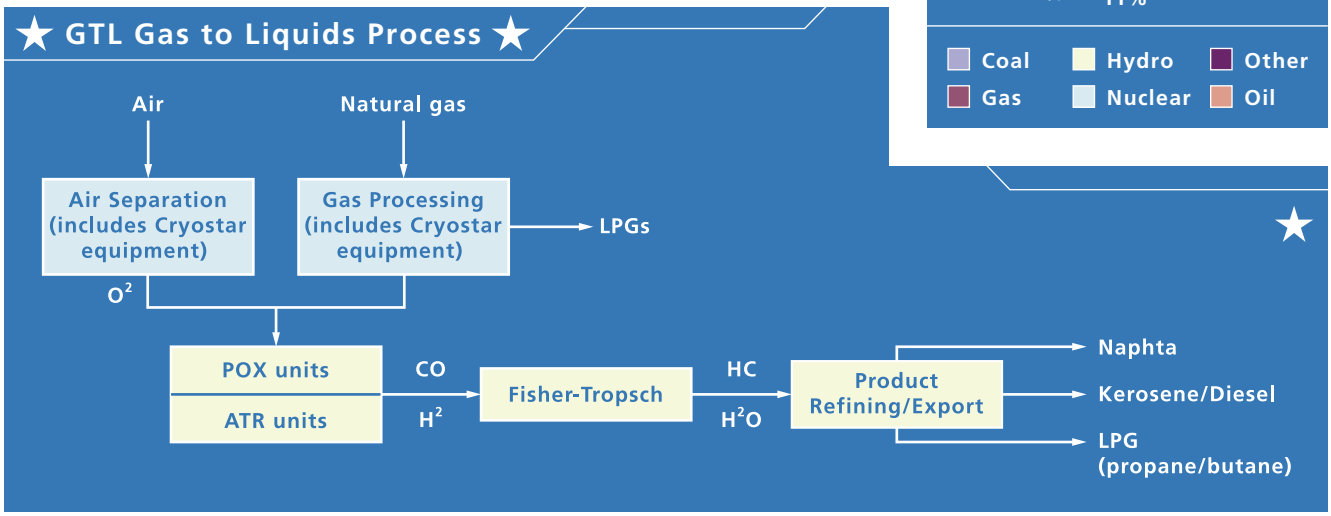
More about the technology

There are two major GTL technologies. The so-called **direct GTL**, which consists of Pyrolysis, Clorination and Oxidative Coupling of methane, or Direct Oxidation of methane to methanol. These methods are still considered very energy intensive, and are not used in the Sasol process.

The second technology route has two options. The first called **POX** (Partial Oxidation of LNG) is used by Shell for the Bintulu Plant in Malaysia, where Air Liquide also provided the ASU, equipped with CRYOSTAR machines.

The second option (used by Sasol) called **ATR** (Auto Thermal Reformer), using a steam-reforming step to create a synthesis gas CO: H2 (ratio 2-1). Thereafter, the Fisher-Tropsch (FT) reaction is used, to transform the synthesis gas into paraffinic hydrocarbons.





Typically, FT plants produce about 25% gaseous products. Part of this is recycled as feed to the synthesis gas generation. The propane and butane produced is liquefied and exported as LPG. The remaining 75% liquid products are split into gasoil, kerosene and tops/naphta. The gasoil is sold as diesel. Kerosene is used as aircraft fuel, with the naphta/tops product being used as feedstock for ethylene plants.
The GTL solution has some clear advantages concerning environment protection and the quality and diversity of the final products.

	Cold production	Flow up to
LTG 90	273 kW	130'000 Nm3/h
TG 300	503 kW	30'000 Nm3/h

Transportation of LNG or GTL

Pipelining is generally considered the cheapest transport option up to 2'500 km (1'500 miles), except in case of smaller fields, where on-site power generation could be a viable alternative if the conditions are right. Over 2'500 km (1'500 miles), pipelining can still be an option, depending on the size of the gas field and its location. There may be a case for LNG or GTL. Beyond 4'000 km (2'500 miles), pipelining is no longer a viable option, and exploiting the reserve will have to come from either LNG or GTL.
Despite the fact that GTL is still slightly more expensive than LNG, and that the competitiveness of LNG depends directly on oil- price levels, it seems that GTL should be considered as a main source of energy.

Future developments

The next project for a new plant, which will be built by Qatar Petroleum and Sasol, confirms this positive trend.
This new plant, called Oryx GTL Limited, in northern Qatar, is to be built by French-based engineering company, Technip-Coflexip.

The project, which jointly owned by Qatar Petroleum (51%) and Sasol (49%), will be operational in 2005. Nearly 10 million m3 of gas will be used daily to produce 34'000 barrels of oil products for the chemical industry.

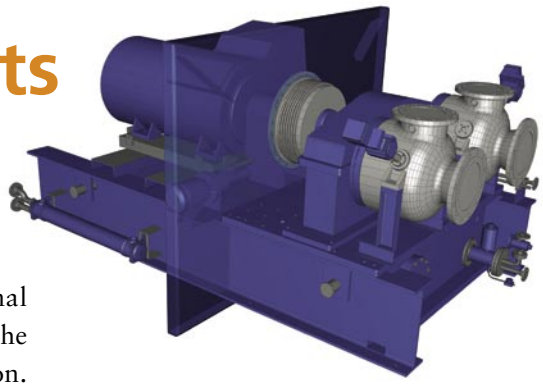
Qatar has the world's third largest gas reserves, after Russia and Iran.

The markets that could absorb those products are Singapore, Japan and Europe.
The ASU needed to fulfil the oxygen requirements for the plant, will be double the size of the first one for Sasol South Africa, with a daily production of 7'000 tons.

These mega-projects represent a challenging new opportunity for CRYOSTAR to show its expertise and competence in providing the required special turbines and pumps.

Two additional projects are under discussion for other major players in the GTL field - one for Shell requiring a 15'000 t/day ASU, and one for Exxon with a 20'000 t/day ASU.

New Propulsion Concepts for LNG Carriers



Boil-off gas Principle

Over large distances Natural Gas is transported in liquid state by using LNG Carriers. Since Liquefied Natural Gas (LNG) is transported and stored at a temperature of around -160°C, the heat creeping through the insulation always leads to a continuous boil-off of the LNG during transportation. Accordingly, equipment needs to be provided to handle this continuous boil-off.

Steam Propulsion: The Current Concept

As of today, the boiled-off natural gas was always used for the ship's propulsion: Low-duty compressors bring the natural gas to the boiler, steam is generated, and used in a steam turbine.

Cargo Handling System

The Cargo Handling System assures safe operation of the vessel by treating the natural gas and LNG during all operating phases of a vessel. During the voyage, one of the two Low-duty Compressors (cryogenic single stage blowers) keeps the tank pressure within an acceptable limit, by bringing the natural gas to the boiler.

Efficiency and Operation Aspects

With improved insulation techniques the reduced natural boil-off however is not enough to satisfy the speed requirement for an economic operation. Additional fuel is required, which is usually bunker oil, or additional natural gas that is gained on the vessel by a 'forced' vaporization. Each such additional gas means extra operating cost, which can be reduced by improving the efficiency of the propulsion system. For steam propulsion the overall efficiency is not more than around 30%. With modern propulsion systems however, the overall efficiency can be lifted to some 40%, which means 25% fuel saving.

New Propulsion Systems

The new propulsion systems which are being studied have in common, that a reliable, safe and economic solution must be found to use the inevitable boil-off gas.

Chantiers de l'Atlantique, the reputed French shipyard is currently building the first LNG Carrier with *Diesel-electric propulsion*. Considering the higher feed pressure to the dual fuel engine the Low-duty Compressors are here of a 2-stage design. These machines for the first vessel are on order at CRYOSTAR, and will be tested and delivered in autumn 2003.

Other shipyards put an emphasis on *Gas Turbine Propulsion*. The need of a feed pressure between 20 and 30 bar however calls for an innovative solution for the required cryogenic compressor, that CRYOSTAR will present shortly.

Most of the vessels of the world fleet use a low-speed Diesel engine as propulsion.

As the fuel injection pressure is around 250 bar however, there is no economic solution for feeding the boil-off gas to this type of engine and the tank pressure must be controlled by re-liquefaction of the boil-off gas.

Already involved in a re-liquefaction project in the mid-eighties, CRYOSTAR recently developed the *Re-liquefaction Plant , EcoRel'*. This *unique solution* assures full re-liquefaction without venting a methane/nitrogen mixture to the atmosphere. Therefore, *'EcoRel'* is not only an economic solution, but also satisfies the most demanding ecological criteria.

Design Optimization Operating Envelope

In designing adequate machinery, CRYOSTAR takes utmost care of providing an as-wide-as-possible operating envelope, to allow a reliable and safe operation under all operating conditions of the vessel. CRYOSTAR is reputed to use their outstanding experience and expertise for an extensive support of shipyards, ship owners and operators for an enhanced operation. And CRYOSTAR has the right solution available whatever propulsion system will be selected for a specific project.

CRYOSTAR in the Americas

In three years time, CRYOSTAR USA has significantly grown as a result of an aggressive sales and service strategy combined with two acquisitions. Ideally positioned on the East and West Coast of the US, CRYOSTAR USA is covering North, Central and South America.

With two US locations:

> Manufacturing and Service on the West coast, in Santa Fe Springs, Ca

> Sales and Service in the East, in Whitehall, Pa

CRYOSTAR USA is ideally positioned to well serve our customers in the area.

The recent acquisitions of the CCI and CVI pump lines have further diversified CRYOSTAR's offerings adding seven different pump types as well as their associated various stroke combinations. Therefore CRYOSTAR USA is in a position to respond to most of the customers' needs in terms of process, transfer or distribution pumps as well as turbines for industrial gas applications. Also we have developed a service and maintenance concept for all types of pumps including competitors products.

CRYOSTAR USA today counts close to 20 employees and manufactures locally all models of piston pumps as well as CSH/CSJ 260 - 10" centrifugal trailor pumps. We supply not only the North and South American markets but also the Asia/Pacific Rim as a source for piston pumps for CRYOSTAR Singapore. Our manufacturing facility in Santa Fe Springs is equipped with a nitrogen test stand as well as a clean room.

CRYOSTAR USA promotes and sells a unique lease program that enables for virtually trouble-free and totally expected and planned pump operation. This arrangement, spread over a period of 5 years, consists of a new concept of leasing for this type of equipment. During this period of time, all maintenance will be taken care of by the manufacturer on a preventive schedule basis thus enabling the operator to totally forecast the maintenance intervals for a monthly, fixed all-inclusive price. Not to mention this program includes a 5-year warranty on the pump and we keep a complete inventory of foot-mounted pumps in stock to sustain the program. At the end of the 5 year lease, the pump is yours for US$ 1.

CRYOSTAR USA is now the second largest CRYOSTAR business unit with plans to further grow.

CRYOSTAR Turbines for Processing Industries

Turbines for Hydrocarbon Processing

For more than 30 years CRYOSTAR is a manufacturer of expansion turbines for hydrocarbon and air gas industries. As a world class manufacturer CRYOSTAR is the preferred supplier of turbines for hydrocarbon gas processing for many engineering companies and end users for the Oil & Gas industry. This was confirmed by the recent supply of 8 large turboexpanders to Linde and 12 HC turboexpanders for other customers which are to be delivered in the year 2003.

The CRYOSTAR hydrocarbon expansion turbines are very robust, reliable and highly efficient machines built to latest API 617 Standards. The achieved isentropic efficiency level of up to 92% is outstanding in the industry and it documents the 30 years experience gained in aerodymanic wheel and nozzles design. The turboexpanders are utilized for cryogenic gas processing, i.g. for: natural gas plants for NGL recovery, olefin plants, LNG production, pipeline gas dew point control and H2/CO processing.

Lube oil and seal gas systems

To fulfil the Oil & Gas industry requirements the CRYOSTAR lube oil and seal gas systems follows the API 614 and API 617 Standards. Pressurized, drainer and atmospheric lube oil systems are utilized for hydrocarbon turbines and are built completely in stainless steel execution, to cope with the harsh environmental conditions in refineries.

Engineering and Technology

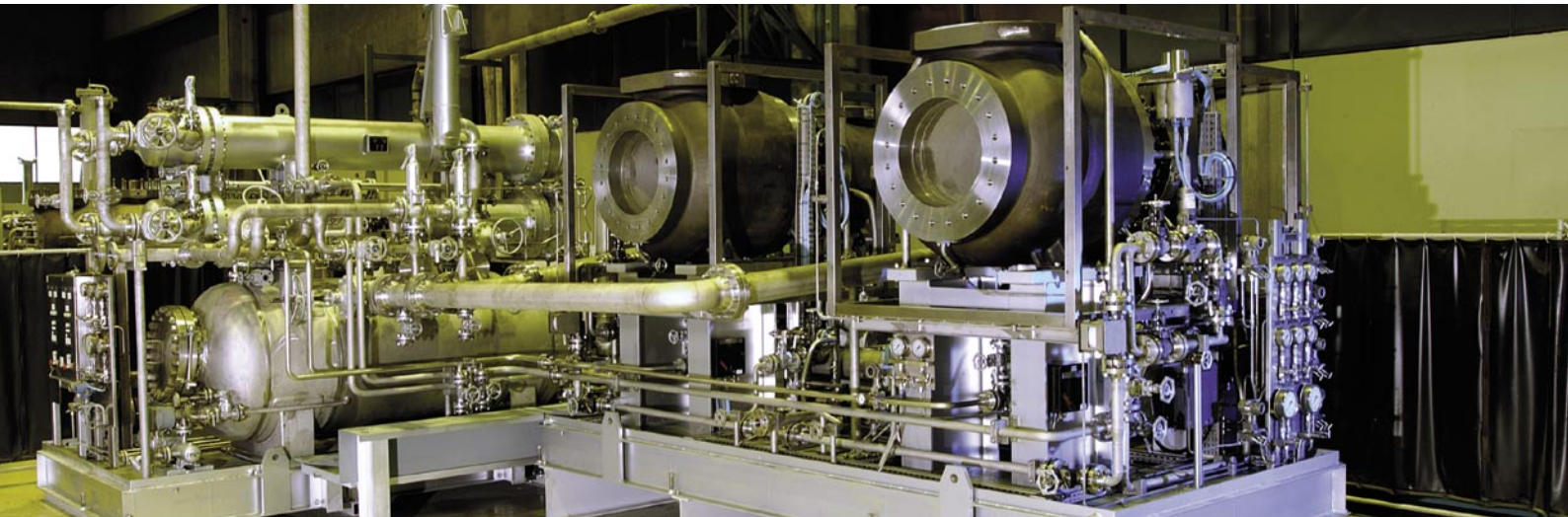
Full in house engineering capability and expertise enable fast reaction to the market and customers requirements. State of the art design, manufacturing and testing tools are utilized: CAD/CAM, FEA, CFD, aerodynamic, rotordynamic and stress analysis computer tools, PDM, outsourcing & supply management, automated data acquisition, ADRE vibration analysis, etc.

The Pioneer technology role of CRYOSTAR in turboexpander industry is underscored by:

- High pressure (185 bars) turboexpander for natural gas processing with API 614 pressurized lube oil system built in 1976
- First turboexpander worldwide with magnetic bear ings for air separation industry - prototype built in 1982
- First turboexpander with magnetic bearings for natural gas processing ordered in 1989

Testing

During the last decade CRYOSTAR invested more than 3 Mio € in modern and state of the art turbine test facility and data acquisition system with on line performance visualization. The testing of HC turbines follows the recognized ASME PTC 10 Code.



CRYOSTAR standard hydrocarbon Turbines

Model	Power (kW)	Pressure (bar)	Exp. casing (inch)	Comp. casing (inch)
TC 200	1500	60 - 120	6 - 8	8 - 12
TC 300	3000	60 - 120	8 - 12	10 - 16
TC 400	6000	60 - 120	10 - 16	12 - 24
TC 500	8000	50 - 120	12 - 20	20 - 28
TC 600	12000	50 - 80	16 - 24	20 - 36

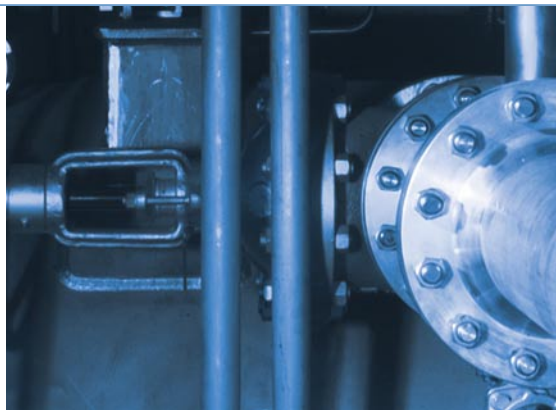
Other applications for CRYOSTAR turbines:

> Air separation plants and Nitrogen liquefiers
> On site air separation (Nitrogen generators)
> Energy recovery (pressure let down stations, geothermal energy)
> Dense fluid expanders for Air separation and LNG plants

CRYOSTAR turbine model designation:

TC Turbine, booster compressor loaded with oil bearings
MTC Turbine, booster compressor loaded with magnetic bearings
TG Turbine, generator loaded with oil bearings
TP Turbine, oil brake loaded with oil bearings
LTG Liquid turbine, generator loaded with oil bearings

News



New Test Stand at CRYOSTAR Automation

In December 2002, CRYOSTAR equipped its automation site at Capdenac with its own high pressure cylinder filling facility.
This installation includes:
> A high pressure reciprocating pump connected to a liquid nitrogen tank,
> A nitrogen line with an atmospheric vaporiser and gas control system,
> An automatic filling station for monogas and multigas up to 300 bars
> A supervision station for traceability and control,
The purpose of such an installation is to present our Automation product line to our customers, to test and validate in real conditions as well as to further improve our applications and software.

Extension of the Turbine / Compressor Test Facility

As a result of our great commercial successes, we have decided to extend our present turbine / compressor test facility by 200 square meters bringing the total test area to 1000 square meters.
The extended facility which will be operational in spring 2003, will accommodate up to 8 LNG ship compressors in the test area as well as several hydrocarbon or industrial gas turbines.

CRYOSTAR is developing a new Sealing System for Cryogenic Centrifugal Pumps

The dual gas seal principle consists of a complete cartridge containing two gas riding seals. The cartridge is purged by low pressure nitrogen seal gas with a very low flow. These seals are suitable for classical cryogenic liquids like LN2-LOX-LAr as well as for syngas, Hyco or any other cryogenic liquid

CRYOSTAR is CE Certified for Pressurised Equipment

Since October 2002, CRYOSTAR has been certified CE/97/23 under the European Pressure Equipment Directive. CRYOSTAR is now autonomous in the design and manufacturing of pressurised equipment, such as barrels for centrifugal multi stage pumps or cylinders for reciprocating pumps.
An annual audit by LRQA within our Q/A system guarantees the fulfilment of the requirements and regulations concerning our products.

The new MCP concept

CRYOSTAR has developed over the last three years a new range of single stage modular centrifugal pumps called MCP. This new concept of direct coupled pumps is designed to cover a large range of flows (50 to 20000l/min) and heads (up to 290m) in accordance with the today's liquefaction processes.

The modular philosophy

In the past, more than 20 different pump models were necessary to cover the given flow-head range. Now it is covered by 12 MCP models divided into four families with different impeller diameters from 120 to 400mm. Original hydraulics have been conserved and new ones developed to increase the pump efficiency and improve the curve shape for an easier control. Each pump can be installed vertically or horizontally and can be fitted with several motor sizes. The modular construction is adapted to all type of configurations. As an example, the same pump can be used horizontally with mechanical seal as a transfer pump or can be used horizontally with labyrinth seal and valve chest flange (see item 3 on figure) or can be used vertically with gas seal and cold box flange (see item 9) as a process pump. The different thermal barriers and the trace heater (item 4) allow for the pump to be maintained in continuous cold stand by.

Sealing cartridge

The sealing cartridge is common to each family of MCP. Three modules are available:

- the new CRYOSTAR labyrinth seal design with either two or three ports.
- the composite mechanical seal.
- the gas riding seal execution.

It is important to note that a pump equipped with a mechanical seal can be replaced by a labyrinth seal without changing the shaft or other internal parts.

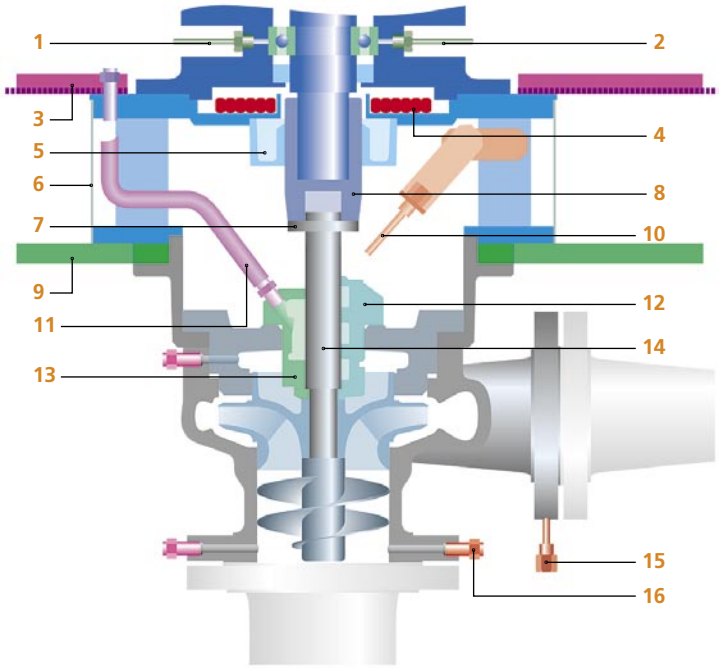
Controls and safety devices

All MCP pumps are designed to integrate all normally required control and safety devices. For example:

- temperature probes for motor bearings control
- temperature probes for seal leak detection
- motor flange heater (cold stand by)
- cool down detection temperature probe, etc...

Ease of maintenance

The main components are standardised and common to each MCP family, therefore easing inventory control. In cold box execution, the rotating parts can be disassembled and reassembled easily without removing the cold box insulation and disconnecting the inlet and outlet flexible hoses. In fact, the pump casing and the cold box flange (item 9) remain in place; then the motor, the support and the pump rotor are removed from the back of the pump casing. **Today, more than 170 MCP are in operation for different applications in all kind of cryogenic liquids.**



1. Bearing temperature probe
2. Heating temperature probe
3. Valve chest plate
4. Bearing heating coil
5. Purge grease retaining chamber
6. Purged warm box
7. Deflector disc
8. Motor/pump shaft coupling
9. Cold box flange Thermal barrier
10. Leak detection temperature probe
11. Nitrogen purge
12. Labyrinth seal
13. Mechanical or gas seal
14. Hollow shaft
15. Cool down detection
16. Pressure or temperature tapping

Events

★ **June 1-5, 2003**

22nd World Gas Conference, Tokyo, Japan.
For more details:
www.wgc2003.com

★ **August 26-28, 2003**

18th Industrial Gases Producers and consumers, Sao Paulo, Brazil.

★ **September 9-11, 2003**

EXPOGAZ 2003, The 26th International Gas Exhibition, Congress Hall at Porte Maillot, Paris, France.

★ **October 19-22, 2003**

Arab oil and gas Show, Airport expo Dubai, Dubai, United Arabes Emirates.
For more details:
www.araboilgas.com

★ **November 12-14, 2003**

5th China International Exhibition on Gases Technology, Equipment and Application, Guangzhou Jinghan Exhibition Center, Guangzhou, China.

Tools and datas:
Oxygen and Nitrogen Conversion Data

We have decided to dedicate this section of our magazine to include usefull tools and datas that are handy in our industry. In this issue, the Oxygen and Nitrogen conversion data table.

	Weight		Gas		Liquid	
	Pounds (Lb)	Kilograms (KG)	Cubic Feet (SCF)	Cubic Meters (Nm3)	Gallons (Gal)	Liters (L)
Oxygen						
1 Pound	1.0	0.453592	12.079015	0.317413	0.105003	0.397479
1 Kilogram	2.204622	1.0	26.629667	0.699775	0.231492	0.876292
1 SCF Gas	0.082788	0.037552	1.0	0.026285	0.008693	0.032907
1 Nm^3 Gas	3.150472	1.429030	38.044053	1.0	0.330809	1.252248
1 Gal Liquid	9.523543	4.319807	115.035013	3.022894	1.0	3.785412
1 L Liquid	2.515854	1.141172	30.389034	0.798564	0.264172	1.0
Nitrogen						
1 Pound	1.0	0.453592	13.803666	0.362752	0.148208	0.561030
1 Kilogram	2.204622	1.0	30.431873	0.799731	0.326743	1.236858
1 SCF Gas	0.072445	0.032860	1.0	0.026285	0.010737	0.040644
1 Nm^3 Gas	2.756704	1.250420	38.044053	1.0	0.408566	1.546592
1 Gal Liquid	6.747259	3.060506	93.136917	2.447582	1.0	3,785412
1 L Liquid	1.782437	0.808500	24.604169	0.646583	0.264172	1.0

SCF (Standard Cubic Foot) gas measured at 1 atmosphere and 70°F.
Liquid measured at 1 atmosphere and boiling temperature.

Nm3 (normal cubic meter) measured at 1 atmosphere and 0°C.
All values rounded to nearest 4/5 significant numbers.

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