

THE NEXT GENERATION

*Cryostar's NeoVP pump
takes performance and
efficiency to new levels*

SETTING THE STANDARD

*a window into corporate
social responsibility at Cryostar*

COOL IN KOREA

*Cryostar technology
behind advanced
refrigeration project*

the **CRYOSTAR** **MAGAZINE**

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This autumn we are delighted to share our progress, as many of our technological projects continue to spread, mature, and evolve.

One of our key missions is to hold the leading edge of cryogenic pump technology. CRYOSTAR's multi-stage vertical pumps are established as a reference for all major industrial gas companies, and are used in air separation units all around the world. However, CRYOSTAR's expert engineers never cease to look for improvements that would benefit our customers. The result? We will soon be able to offer dramatically wider operating range and efficiency when our NeoVP pumps range launches in 2018.

CRYOSTAR's technology is also at the heart of an innovative food storage facility currently under construction in South Korea. By deploying LNG as a coolant and also using it in fuel cells to provide electricity, this distribution hub is aiming towards a "zero carbon" footprint. In addition to pioneering technology, this project also involves considerable work to meet Korean certification standards from the CRYOSTAR Quality team.

Another area where CRYOSTAR supports wider environmental goals is through its LNG

dispensers, which are in demand to meet the rapidly growing LNG-fuelled transportation industry. In addition to reducing emissions, the technology is designed to be safe and user friendly for truck drivers. The process is no more complicated than filling up at a petrol or diesel pump. To find out more, see our report on p.8.

We are extremely proud that our technical expertise continues to deliver exciting improvements for our customers to use and enjoy. Our commitment goes beyond compliance and recognizes that innovation also has a major social dimension. We strive to incorporate programmes into our working lives that have an ethical component, to support our staff, our communities and our environment. Making these values a priority benefits us all.

Samuel Zouaghi

PRESIDENT

Product innovation for a mature market: the NeoVP	3
Eugene Superfreeze: Action in the land of the morning calm	6
LNG truck refueling takes on new dimension thanks to CRYOSTAR Automation dispensers	8
Corporate social responsibility as a component of company culture	9
CRYOSTAR Russia	10

product innovation for a mature market

THE NEOVP

Multi-stage vertical pumps for air separation units: A CRYOSTAR success story.

Since the days of cryogenics pioneers, when Carl von Linde in Germany and George Claude in France first succeeded in separating air into its component gases, innovators have brought huge improvements to air separation processes in terms of the purity of produced gas, yield and installation safety.

One major step was the introduction of the so-called internal compression process, which made it possible to eliminate the risks linked to gaseous oxygen compression used in standard air separation processes until the late 1980s, while significantly improving the yield of air separation units (ASUs).

The internal compression process required a completely new type of cryogenic pump, able to pump liquid oxygen above 40 bar at high flows. The pump also needed to be easy to operate on a 24/7 operation scheme, in safe and reliable conditions. Last but not least, a modular design was required to adapt the machine to further process evolutions.

This was a motivating challenge that CRYOSTAR was ready to face, proving once more that innovation is definitively in the company's DNA. The VP pump was born.

CRYOSTAR delivered the first four VP6/145 to Air Liquide for an ASU in France in 1991. Start-up and operation of the machines and of the whole plant was a success, enabling the internal compression process to become the standard process for ASUs.

As the first VP was developed to be the first member of a large pumps family, CRYOSTAR was able to support ASU process designers and operators when the size of internal compression ASUs increased. Process variations from plant to plant have resulted in CRYOSTAR creating

dozens of different pumps, with increasing pressure requirements from 40 bars to more than 100 bars, and flows from 50 l/min up to more than 3000 l/min. Today, the VP range includes pumps fitted with impellers from 115 to 330 mm and up to 12 stages, with motor electrical power up to 550 kW.



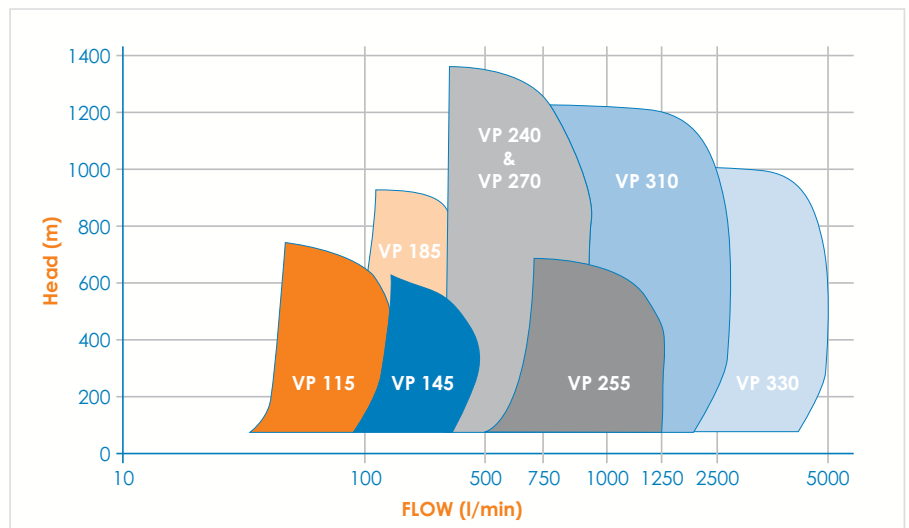
A couple of the first VP pumps on their test skids

The VP pump is now a reference for all major industrial gas companies: CRYOSTAR has sold more than 2200 VP pumps to be integrated into ASUs worldwide. Reliability has proven to be a key feature of this product: the fleet leader has been in operation for more than 25 years.

The success of the VP range is definitely due to intrinsic product quality and performance. Another key asset is the organization CRYOSTAR set up to fulfill the high level of user expectation in terms of service. This includes:

- Assignment of a project manager to each order, allowing open and smooth communication with customers from pre-order optimizations to on-site start-up;
- Cryogenic testing of every single pump supplied by CRYOSTAR (with the largest liquid nitrogen pump test bench in the world, located at CRYOSTAR's headquarters);
- Service engineer training in CRYOSTAR Business Centers close to customer sites;
- Engineering support for on-site installation and start-up.

A full range of maintenance contracts is available to users depending on their specific needs, to maximize machine and plant availability.



WHY THE NEOVP?

Listening to actual customers needs is the foundation of any new product development project at CRYOSTAR. A clear trend in the ASU market is to reduce CAPEX and OPEX, and to have easier plant operation and maintenance.

This applies to all components of the ASU, including the pumps. The VP pump needed to evolve, and so CRYOSTAR initiated a development program for a new pump, dubbed the NeoVP.

The new machine's specification is based on characteristics of the original VPs, which ensured their success on the market, improved for higher efficiency, a wider operating range and a leaner design to reduce costs. Again, a spirit of pragmatic and user-friendly innovation has driven this development so that the NeoVP brings significant added value to our customers and becomes the new reference on the market.

THE NEOVP'S MAIN CHARACTERISTICS

CRYOSTAR has used advanced computer tools to design the internal parts of the NeoVP.

The first step was to model the pump hydraulics, using computational fluid dynamics calculations, and validating the model with tests. To do so, our engineers simulated an existing VP pump and compared simulation results with actual test results. Results were more than satisfactory, it was confirmed that the CFD model used is robust and reliable.

CRYOSTAR's team then integrated the hydraulics of the NeoVP into the model. They optimized the design of the various parts so that operating range and efficiency are maximized.

Calculations show that operating range is dramatically



wider (maximum flow increased by up to 30%, minimum flow decreased by up to 30%) compared to current VP capability, and efficiency is increased by up to 10% compared to current VP efficiency.

We have attained the targets set by the specification; the next step is to confirm these results with tests in cryogenic conditions. Two different designs will be extensively tested.

PROJECT STATUS AND MARKET INTRODUCTION.

CRYOSTAR implemented an efficient and structured methodology to ensure the successful development of the NeoVP.

A core project team, including pumps experts, sales engineers, mechanical engineers and purchasers, has driven the project since the very beginning. In order to reach cost targets, relevant design and cost reviews are organized at the end of each development phase. This “stage gate” process is the best way to have all CRYOSTAR stakeholders validating intermediate results before moving to the next phase.

Suppliers have also been involved so that the NeoVP benefits from their expertise in industrialization of the pump. Manufacturing options have been discussed during reviews involving CRYOSTAR core project team members and suppliers’ experts, and some design adaptations have been commonly decided to optimize the manufacturing process of the parts as well as maintainability. This is a key part of the global process for minimizing CAPEX and OPEX for customers and users.

Meetings and discussions with major customers are also part of this collaborative product development process. Presentations of the new design, pump performance, and feedback on installation and operation of VPs are key topics to be discussed to make sure the NeoVP will actually fulfill market needs.

The next important step is to test two different hydraulics designs. CRYOSTAR will perform extensive tests in cryogenic conditions. We will be able to validate the CFD analysis, confirm the behavior of the fluid in the pump, select the best configuration and refine predicted performances. This is scheduled for summer 2017, and will lead to the assembly and testing of a complete pump by early 2018.

Beyond unit#1 testing, CRYOSTAR will design several frame sizes to cover all current and future requirements from ASU process designers. All pumps will continue to be individually tested before shipment: CRYOSTAR’s test bench enables tests at full capacity for pressures up to 150 bars.

Thanks to structured methodology for product development, involvement of customers and suppliers, the use of the most advanced design tools, and extensive tests in cryogenic conditions, there is no doubt that the NeoVP has been given the best assets to become a first-class product for ASUs.

With the NeoVP’s development, CRYOSTAR remains at the leading edge of technology for cryogenic pumps. This is definitely in line with our strong commitment to work hand in hand with customers and end users to support the evolution of their market through value-enhancing innovation.





EUGENE SUPERFREEZE

Action in the land of the morning calm

*Korean group **EUGENE Superfreeze** is building a mega-hub for frozen food products – a gigantic fast-track construction site. **CRYOSTAR**, the only foreign company involved in the project, is expected to deliver equipment for the beginning of 2018.*

EUGENE Superfreeze decided to invest in the construction of a frozen food distribution hub at Pyeongtaek, South Korea to cover South Korea and China territories. The site will include three huge warehouses, capable of storing around 120,000 tonnes of frozen products. To achieve this, EUGENE Superfreeze has developed an innovative energy optimisation solution, in particular for the cold production required for the refrigerated warehouses. Using LNG as the coolant, three distinct cold temperature levels are created, by vaporising LNG and transferring it through exchangers against a heat-transfer coolant.

Part of the vaporised LNG is used for fuel cells to produce electricity, while the remainder will be reliquefied and sent to the onsite LNG storage facilities, for further re-sale. In order to create an industrial hub geared towards achieving a “zero carbon” footprint, EUGENE Superfreeze will use the most advanced renewable energy technologies such as organic Rankine cycle (ORC) units, to recover the heat produced by the fuel cells and solar panels on the buildings’ roofs.

EUGENE Superfreeze’s business model attracts subsidies, as South Korea considers the energy produced by the fuel cells as green energy.

Due to its experience in liquefaction technology and its StarLite LNG™ product family, Eugene Superfreeze selected CRYOSTAR for the reliquefaction unit supply, which makes it possible to reliquify the gas after vaporisation. A StarLite LNG™ XS unit (24 tonnes/day) will be installed on the Pyeongtaek site. The flexibility

of the nitrogen loop technology was a decisive factor in EUGENE Superfreeze’s choice. CRYOSTAR was able to reduce the delivery time by being able to offer the unused main components from the ASEAGAS project, which was cancelled during implementation in the spring of 2014. This equipment therefore requires adaptation to meet the new project’s process conditions. This project is highly strategic for EUGENE Superfreeze, and requires certification from the authorities (KGS, KR, and Kosha). For CRYOSTAR, this requirement entails significant work from the Quality Team, in order to obtain all the certificates associated with the customer’s requirements.

Currently, the compander is back in CRYOSTAR’s workshops in order to complete the assembly. CRYOSTAR will conduct tests in the presence of the customer, in the autumn.

All the skids and ancillary supplies are contracted to a Korean packager based in Ulsan, which is also being considered for the onsite plant construction. The delivery of the CRYOSTAR unit is scheduled for the end of the Q1 2018, with the overall LNG part to be commissioned for the autumn of 2018.

EUGENE Superfreeze is already considering the development of additional warehouses, with a second plant of similar capacity, 40km from the current one, near to the Pyeongtaek LNG Terminal. This planned logistics centre would mainly serve the Chinese market. EUGENE Superfreeze is also planning to build further hubs, based on the same model in the future.

WHAT IS A HUB ?

A hub makes it possible to distribute food products such as vegetables, fruit and fish throughout the Korean territory without breaking the cold chain, using a new technology patented by Japanese company, Tokyo Engineering.

Japan pioneered the installation of these new frozen food hubs.

Tokyo Engineering's patents cover:

- The use of LNG and its temperature at -161°C as a coolant.
- The construction of high bay warehouses with quick freeze compartments.

THE PYEONGTAEK SITE (OSEONG INDUSTRIAL PARK) IN FIGURES

Surface area of the site	100,000 m ²
Food storage capacity	120,000 tonnes
Investment	€200 million
Duration of the work	2016 – 2018
Recruitment	600 people

Earthworks to shape the platform	600 lorries/day for three months
Support piles (20m x ϕ 600 mm) dug	2,000 in four months

Energy produced per fuel cell	10 MW
Energy produced by the ORC	0.8 to 1 MW
Solar energy	1 to 1.5 MW

Liquefaction unit	24 tonnes/day
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LNG truck refueling takes on new dimension thanks to Cryostar Automation dispensers

All players in the natural gas vehicle (NGV) industry agree that the deployment of LNG/LCNG fueling stations has been booming in France since 2016. CRYOSTAR is benefiting from these developments, notably through the growth of this activity within its Distribution business unit.

In 2016, CRYOSTAR Automation produced 10 LNG dispensers. And some twenty dispensers are being manufactured for a delivery scheduled for 2017.

A VARIETY OF TRADE BODIES

While mass-produced dispenser production is booming, production activities that cover the manufacturing process are diverse and include mechanical and electrical assembly, pressure testing and thermal insulation. This means that their production comes under the remit of a number of different trade bodies.

AREAS FOR IMPROVEMENT IN 2017

A study on the implementation of the Measuring Instruments Directive (MID) legal metrology certifications at CRYOSTAR Automation, including a test bench within the workshop, is underway. Currently implemented at our customers' sites, in-house certification would reduce the commissioning and start-up time and therefore cut costs.



AN OMNIPRESENT INNOVATION

The latest truck and engine technologies mean that today's trucks drive on LNG with the highest performance on the market with a high-efficiency power system, while preserving the environment through reduced emissions.

The Distribution business unit's LNG Cluster has offered solutions for trucks with this level of sophistication for many years. The spirit driving CRYOSTAR, which defines itself as an expert at the forefront of innovation, applies perfectly to the technological evolutions implemented within the Cluster over the past 12 years. As an example, CRYOSTAR LNG dispensers already incorporate a design adapted to filling new trucks using single hose technology. This differs to other technologies on the market, which, during filling, carry out the degassing operation via an independent hose. Filling an LNG truck is now just as simple as refueling light-duty vehicles with gasoline or diesel.

With this innovation, CRYOSTAR is already able to supply modern trucks with an offer tailored to the specific needs of both manufacturers and users.



CORPORATE SOCIAL RESPONSIBILITY AS A COMPONENT OF COMPANY CULTURE

Corporate social responsibility (CSR, also called corporate conscience, corporate citizenship or responsible business) is a form of corporate self-regulation integrated into a business model as a major component of company culture or company values.

CRYOSTAR's implementation of CSR goes beyond compliance and statutory requirements, which engages in "actions that appear to further some social good, beyond the interests of the firm, and that which is required by law". CRYOSTAR's aim is to increase trust through positive public relations and high ethical standards and to encourage the company and its personnel to make a positive impact on the environment and stakeholders, including customers, suppliers, communities, investors or the local public.

For many years CRYOSTAR has set an example by implementing high safety standards both for its personnel, and for its customers. We outline stringent internal rules in terms of environmental and ethical behaviors. The company also contributes to local development by supporting cultural and sports events or local teams.

CRYOSTAR personnel have recently been involved in a number of activities that serve as great examples of these values in action:

- Many employees took up a challenge involving

both the environment and sport by coming to work by bicycle. During a period of two weeks, staff covered a total of 7100 kilometers.

- On 28th April, World Day for Safety and Health at Work, various workshops were held in all CRYOSTAR entities around road accident prevention.
- CRYOSTAR boasts a number of its own sports teams, including basketball, volleyball (women's and men's teams), and petanque. The tennis team won the regional championship, qualifying to enter the final round of the French corporate championships.
- Via the workshop committee, the company subsidizes tickets for concerts, cinema and other events.
- CRYOSTAR subsidizes a shuttle (two trips in the morning and two in the evening) to transport personnel from the Saint-Louis station to its headquarters in Hésingue, France.
- The company also helps local sports teams by sponsoring team uniforms, among other things.

The target of CSR is to sustain a company's mission as well as serve as a guide as to what the company represents.

In the Alsace region, CRYOSTAR enjoys an exceptional reputation and is often named as an example of a healthy, highly ethical and future-oriented company. This is an image that has been shaped and maintained for many years by the appropriate behavior of the staff and the company.

CRYOSTAR IN RUSSIA

In the previous issue of CRYOSTAR Magazine we spoke about the Yamal LNG project in Russia, for which CRYOSTAR supplied three MTC 600/240 turbines (turbo-expanders with magnetic bearings). This represents an important milestone for CRYOSTAR in the Russian market, which led us to take the important step of opening of a new Business Centre in Saint Petersburg. This is an extract from an interview first published in Gasworld Russia & CIS with Natalia De Sangois, business manager of CRYOSTAR Russia who led the project.



- **CRYOSTAR is known worldwide as a cryogenic pumps supplier. What other equipment can you supply to the Russian market? Tell us about your company.**

It is true that we are very well known in Russia for this range of equipment. Our cryogenic pumps are a reference in the field of industrial gases and we have a large installed base of centrifugal pumps and piston pumps in Russia. Our flagship products for industrial gases are centrifugal pumps, submersible pumps, piston pumps, high-pressure pumps, expansion turbines, turbo-compressors and turbo generators. Our know-how gained in the field of industrial gases has naturally been applied to natural gas too, with great success. Historically speaking, our natural gas products were less well known in Russia than those for industrial gases, even though these are present all over the world: CRYOSTAR turbomachines are installed on some of the most demanding customer sites, and our equipment for LNG carriers has led us to become a leader in this market. Compressors with two or four stages have been on the market for a long time. We have recently developed and launched a 6-stage compressor for these ships, a technological challenge of which we are very proud.

- **What technologies for LNG can you offer?**

Having taken advantage of the experience we have accumulated on LNG tankers with boil-off gas

compressors, we have applied and developed our technology and offer our range of liquefaction units with a StarLite nitrogen cycle LNG™.

- **We also know that you can supply service stations for LNG. Can you tell us more?**

Indeed, our cryogenic pumps are part of, among other applications, solutions developed to meet the needs of the LNG market by offering “turnkey” LNG/LCNG stations to fill vehicles. With more than 80 references on all continents and 19 previous generation LNG dispensers already installed, we are developing and making available to our customers safer and more ergonomic equipment with improved user interface integration into existing stations.

- **How do you see your development in the Russian market?**

CRYOSTAR is currently working very hard on what is essential for our customers and therefore for us: Service. Being closer to our customers and responding as quickly as possible to their demands and needs is what matters to us today. Whether it's spare parts, predictive maintenance, or renovation, we make every effort to ensure that the customer benefits from equipment whose life span is optimized, guaranteeing savings in the long term.

- **What solutions do you offer to guarantee the service of your equipment? In which regions do you have service centres?**

As I said earlier, service is at the heart of our business. We strive to improve it continuously and to be closer to our customers.

To make this service even more accessible to our Russian customers, CRYOSTAR has decided to create a new business centre, CRYOSTAR Russia, which has joined the six existing business centres all over the world, with the opening held in St. Petersburg in January 2017.

Our numerous customers in Russia eagerly anticipated the new CRYOSTAR business centre. And we are certain that this proximity will generate even greater responsiveness, with a presence in the Russian market for all our product ranges, whether in industrial or natural gas, and a reactive, high-quality and accessible service that customers are entitled to expect. This centre will manage the inventory of spare parts, importing original, quality-assured CRYOSTAR parts. The presence of highly qualified service technicians will ensure interventions and start-ups on site, as well as repairs within our business centre, which is equipped accordingly. Technical training for our customers and continuous technical support to accompany the operation of our equipment over the long term sums up the service offer that we want to make available to our customers.

CRYOSTAR RUSSIA is another step forward in our strategy to be close to our customers and to offer a world-class service everywhere, in all regions where our machines and equipment are operational. Our presence in the UK, Singapore, the USA, China, Brazil, India, and now Russia, underline CRYOSTAR's determination to be at the forefront of customer service.



news

Arctic record

In late August, Sovcomflot's liquefied natural gas (LNG) carrier Christophe de Margerie, named after the former president of Total, made the world's first-ever crossing of the Northern Sea without the aid of an icebreaker.

This LNG carrier, owned by Russia's largest shipping company, Sovcomflot, is the first of 15 specially designed icebreaking LNG carriers, capable of transporting gas from the Yamal LNG project in the Russian Arctic, which is ice bound all year round.

All 15 vessels are (or will be) equipped with CRYOSTAR heat exchangers, low duty compressors and 2-stage high duty compressors.

CRYOSTAR Automation awarded GAMP 5 certification

CRYOSTAR Automation has obtained Good Automated Manufacturing Practice (GAMP 5) medical certification. This follows an audit by one of its major customers, which restated its trust in CRYOSTAR to equip its medical and industrial gas bottle filling plant, located in Germany, one of its largest sites.

CRYOSTAR, through its Distribution Business Unit and its entity in Capdenac, is the first company in this area to receive GAMP 5 certification. This guarantees that equipment and solutions conform with a reference base related to regulatory conformity for automated and electronic systems in the pharmaceutical and medical sectors.

Major order from the USA

In August 2017 CRYOSTAR was proud to be selected to design and supply two turbo-expander/compressors for one of the world's largest ethylene cracking plants in San Patricio County, Texas. The customer, Gulf Coast Growth Ventures (GCGV), a 50/50 joint venture between SABIC and ExxonMobil, is building a world-class plastics manufacturing facility at the site. GCGV has selected KBR's technology, benefiting from the licensing agreement between ExxonMobil and KBR.

CRYOSTAR has been selected based on proven know-how and expertise in designing active magnetic bearing turbo expanders and also based on its capacity to assist and serve customers in the USA from four business centers (Houston TX, Whittier CA, Bethlehem PA, and Chicago IL).

CRYOSTAR's well-known Frame 2MTC400/150 model has been selected for this project, further enlarging CRYOSTAR's installed base in the US Gulf Coast. This project confirms CRYOSTAR's competitiveness in a US market, historically dominated by several strong local suppliers.

These units will be delivered by the end of 2018 with commissioning due in 2020.



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