the CRYOSTAR MAGAZINE

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INNOVATION PROCESS WITH CLIENTS

LNG CARRIER FUEL GAS SYSTEMS

VIRTUAL REALITY

edito

The customer experience

CRYOSTAR has always prioritized customer satisfaction, offering our customers the technical solutions they need and the benefits of the company's technological innovations and expertise, the delivery of high-quality products, and effective, professional customer service.

The time has come to strengthen our relationships with our customers even further, with the introduction of a "customer experience" plan, an initiative that is designed to play a central role in both CRYOSTAR's business strategy and the everyday lives of our employees.

What exactly is the "customer experience" initiative? It is both far-reaching and very precise.

It is a matter of measuring and more importantly, improving, the impression our brand makes on our customers and partners when we interact with them—which is what makes customers want to work with us again, on an emotional level.

We are confident that it is absolutely essential to our company's continued growth.

We are particularly enthusiastic about launching this initiative, which aims not only to raise awareness about the importance of the customer experience, but also to mobilize all our employees around a single theme in a sustainable way.

Our customers must always be our top priority!

Samuel Zouaghi

PRESIDENT

summary

PROJECT MANAGER

A KEY JOB

This new chapter of "A day with..." is dedicated to the essential Cryostar job of Project Manager (PM.) These people represent the customer internally, and represent Cryostar to customers. They act as control towers for ongoing orders, as they have the greatest overall visibility. One of our Project Managers is Julie Durst.

For Julie, a Cryostar employee since 2014, every day is different, thanks to the wide variety of tasks, situations, missions, and customer contacts she encounters in her job. She spends her days monitoring some sixty different projects at a time, primarily Process pumps.

For a PM, the most important contact person is the customer, with whom they communicate on a near-daily basis in order to establish a relationship based on mutual trust. Customers must be updated about the progress of their project(s), and deadlines, unexpected costs, and technical elements must all be discussed with them.

The PM holds a central role, serving as a link between the customer and the company, thereby ensuring that orders are fulfilled correctly.

In this job, people skills are important, as you must be able to communicate both internally and externally, be persuasive, negotiate, and deal with the pressure that can sometimes result from delicate situations that may arise over the course of a project.

Project managers must have a global vision of projects, but also be aware of the details (contract, budget, customer demands, deadlines, schedule, technical aspects, obstacles, specific requirements, risks, critical tasks, etc.) They are thus in the best position to define the priorities of a single project and also mediate between several projects if necessary. They ensure that contracts and specifications are respected, on both Cryostar's and the customers' ends, in order to guarantee customer satisfaction and prevent deviations from the contract, thus ensuring that margins are met.

Obviously, the management of each individual project requires collaboration with the scheduling team at all times. But in reality, PMs are likely to be in contact with nearly every department in the company, from sales to research, purchasing, production, testing, quality assurance, methods, finance (for keeping track of costs), the legal department (to ensure contracts are upheld), and logistics. The PM is at the center of the organization, and must be constantly sharing information to explain necessary actions and priorities. They are responsible for communicating, explaining, negotiating, moderating, determining priorities, motivating, leading follow-up meetings, and troubleshooting in order to ensure on-time delivery of quality products that fit within the established budget. To accomplish all of this, PMs are also supported by Project Assistants, who play an essential role in the management of paperwork and other administrative aspects of projects.

PMs are part of an organizational matrix, because they have no hierarchical responsibility, but are required to produce results. However, they must alert the hierarchy to any risks, in particular when a situation may have major financial consequences (late penalties or going over budget).

In addition to her work as a project manager, Julie is also a "product reference" project manager, which means that she organizes the activities of a team of four project managers all working on the same product line. To this end, her goals are to collect and coordinate transverse subjects for future projects, ensure the work load is distributed appropriately among team members, improve tools (follow-up meetings, work methods), help integrate new PMs, prioritize tasks, monitor general performance with regards to timing and costs, come up with suggestions for improvement, and take initiative.

Two of the most delicate problems project managers face are being able to absorb pressure from the customer without passing it along to the rest of the team in a negative fashion, and knowing how to distinguish the "urgent" from the "important" in a context where "urgency" is practically the rule.

This central role held by Project Managers does offer its own kind of satisfaction, notably when a large problem is resolved or when key indicators improve thanks to measures that have been implemented. Julie also appreciates working with a team, which is a requirement for success in her job, and having direct contact with customers and the market as a whole. And then there is the satisfaction of seeing large-scale projects, which require an incredible amount of personal and group investment and often come with their fair share of technical difficulties, come together!

For such orders, in particular hydrocarbon projects, Cryostar sometimes sets up "project command centers," offices dedicated to an entire team working primarily on a single project, where Project Management, Purchasing, Engineering, and Quality Assurance employees work side by side.

Project Managers play a central role in the company's structure. The job requires a range of skills, both technical and managerial, but it also takes interpersonal skills, which are not the easiest to develop.

Julie greatly appreciates working in a context where personal relationships are a priority, especially because of the opportunities to engage with the global market and very international customer base.

PREDICTIVE MAINTENANCE

Including your customers in the innovation process

When it comes to innovation, maintaining a close relationship with your customers is undeniably key to your success. This approach allows you not only to understand your customers' needs, but also to identify the issues they face and come up with an appropriate value proposition.

Traditionally, customer needs are analyzed during the product development phase through methods such as interviews or surveys. These interviews and surveys are focused on the needs expressed by customers, and provide access to quantitative data. However, they can lack precision when it comes to clearly identifying the difficulties customers face at work.

To avoid missing the most essential information, complementary approaches can also be used. The process of innovation is thus opened up to include your customers and/or users. They are involved in developing the new product, participating in a co-creation process.

To better understand difficulties faced by users, it is possible to use techniques originating in the design sector that are based on an empathic approach to the customer experience. Design approaches allow users to play an active role in the development process. The emphasis is placed on understanding what is most important to customers through accessing qualitative data.

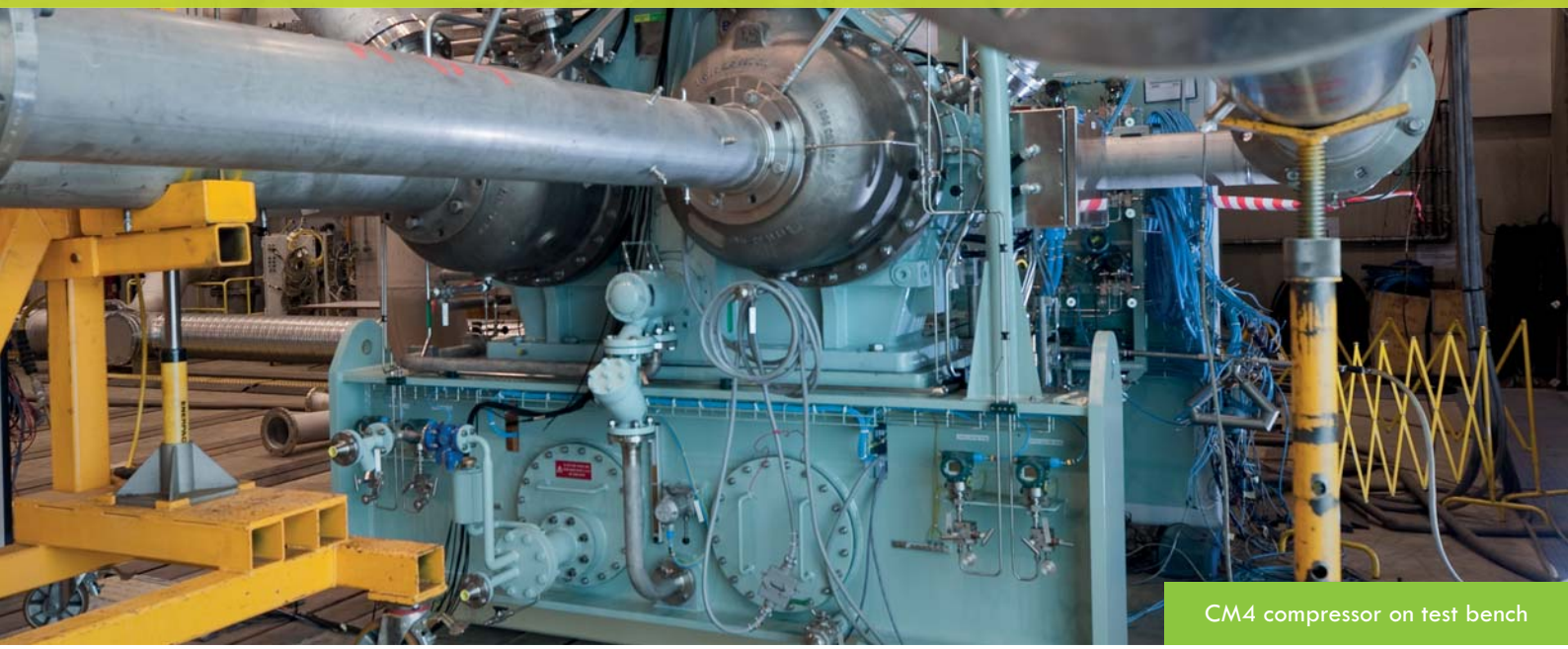
It is this approach that Cryostar chose to use when it came to designing a digital predictive maintenance bid. Two-day workshops were held, with several goals in mind:

- To build a shared vision of the medium- and long-term bid.
- To evaluate the impact of this bid on the internal value chain for customers and Cryostar.
- To establish the characteristics of a co-created prototype.

During these workshops, the co-creation of a prototype introduces an agile component to the process. It allows for the rapid evaluation of different versions of a concept by integrating real-time user feedback. Using this iterative approach, options are validated quickly and the shared learning process is accelerated. In the end, all parties agreed on a vision that was designed together, in which the value proposition is built based on the needs of different users.

An important part of Cryostar's digital transformation, predictive maintenance requires the use of complex technologies including big data and artificial intelligence. By including customers in the core development process, Cryostar commits itself to being able to offer customers the full potential of these technologies.

The evolution of fuel gas systems on LNG carriers



CM4 compressor on test bench

When the first XDF powered LNG carrier was ordered in late 2014, the improvement to vessel efficiency thanks to the implementation of a two-stroke engine designed by WinGD was a major step toward making the LNG shipping industry more fuel efficient and environmentally friendly.

The high-pressure direct injection fuel gas system required by the ME-GI design was no longer necessary, thus simplifying the system for these vessels since the gas could now be injected into the engine at medium pressure.

The need for a 17-bar fuel gas supply led Cryostar to develop, build, and deliver the highly successful 6-stage CM6-200 compressor model. Over 100 machines were ordered by the end of 2019, with some 12 vessels operating to date.

Industry collaboration to improve specifications

Operational data was gathered in 2018 from the first vessels outfitted with CM6 machines. The measurements showed that the fuel gas supply specifications were noticeably higher than the actual pressure in LNG carrier systems in practice. A workshop was organized between WinGD, Cryostar, and a major shipyard to lower the requirements and make the fuel gas system more forgiving, thus making fuel consumption safer and easier to adapt for different types of usage.

The fuel gas specification for XDF type engines was determined based on the engine load, fuel gas pressure, and gas composition. This led to industry-wide acceptance that a fuel gas pressure of 13 bar is suitable for 95% of operating cases on LNG carriers. At higher pressures, the maximum engine load is slightly lower, depending on the fuel energy available.

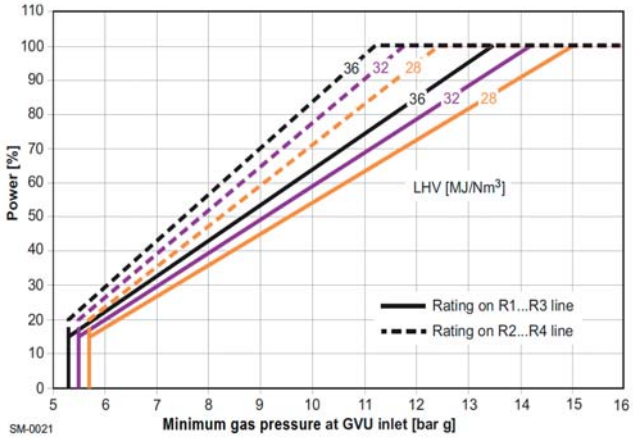


Diagram courtesy of WinGD

"Project CM4-X"

The next challenge was to come up with a competitive machine that met these new requirements. As the 2010 introduction of CM4 machines for DFDE propulsion was a great success (over 120 machines currently in operation), they were deemed to be the perfect platform on which to base the new machine.

Initially given the code name of CM4-X, this project led to a series of designs covering the whole range of flows needed for the new generation of XDF powered LNG carriers.

Extensive aero design studies were carried out to determine the best configuration and optimize the operation range in accordance with the operating cases most commonly cited by owners and shipyards. In order to achieve the new fuel gas pressure of 13 bar with only four centrifugal compressor stages, additional inter-stage cooling was necessary. A new, higher speed gearbox was also designed to meet the head requirement.

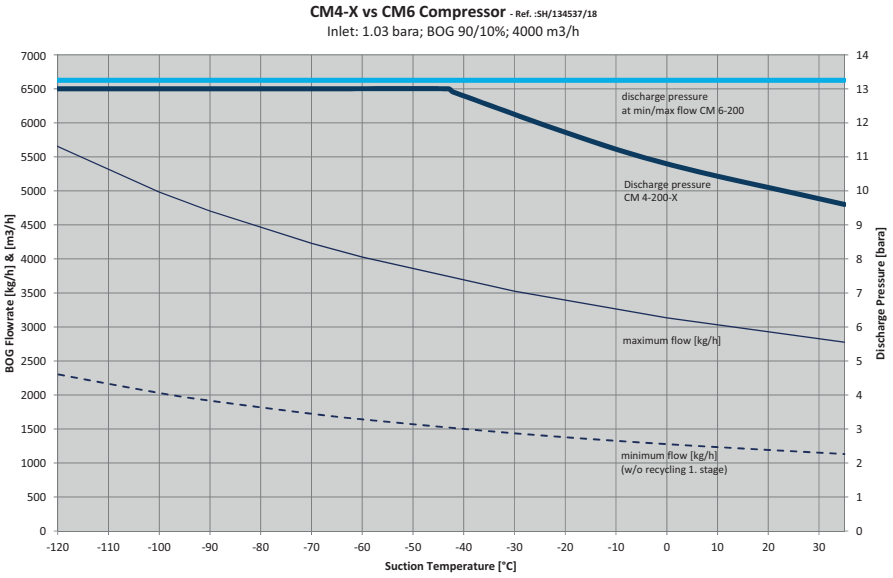
Cryostar then conducted a dynamic simulation of the compressor and its process environment using in-house tools. Cryostar's process engineers fine-tuned the parameters of the inlet guide vanes and control valves based on their calculations, which enabled Cryostar to run a complete simulation of the machine's operation before the first machine was ever tested at sea.

Evaluations of the CM4-X design showed power consumption savings of just over 20% on laden voyages in the commonly used flow range. These savings, along with the lower capital cost, allowed Cryostar to clinch the deal and finalize the first order for a new CM4-X machine. After consulting with both shipyards and owners, the first order for this machine was placed at the end of 2018.

Operation range

While most machinery in a process environment operates within a limited range, LNG carriers offer a unique setting, in which machines regularly encounter a very wide range of volume flows, mass flows, inlet temperatures, and gas compositions.

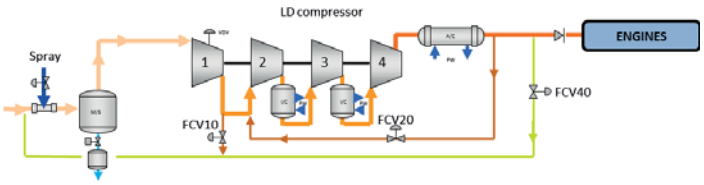
This poses a challenge when choosing where to set the "sweet spot" for operation. Designing machinery for this application requires a deep understanding of the relevant operating modes and conditions, as well as their frequency, which must be taken into consideration during the optimization process.



The figure above shows the relative operation ranges for the CM4 and CM6 compressors based on a pressure requirement of 13 bar. Considering that the inlet temperatures are mainly in the range of -120 to -80 °C, the CM4 provides more than sufficient coverage for vessel operation. In case of higher temperatures, precooling can be used.

Further optimization

In an effort to reduce the complexity of the machine, Cryostar conducted a study of the machine's behavior. The findings showed that if the control loops were modified slightly, the recycled gas cooler for the first stage of the compressor could be eliminated and replaced with a single additional control valve.



Configuration of a CM4-X compressor without recycled gas cooler

The cooler had been included in the design to avoid overloading Stage 1 during very low flow operation. With one additional line and control valve, the cooler could be safely removed without affecting the machine's overall performance. This reduced the installation cost and the footprint of the machine, with the added benefit of reducing the CAPEX. Shipowners are always searching for ways to reduce costs for competitiveness, and this relatively small change will deliver savings well into the future.

As of February 2020, Cryostar had received orders for 26 machines, confirming a strong market acceptance of the higher efficiency solution.

How can current owners of 6-stage machines benefit from the reduced fuel gas pressure specification?

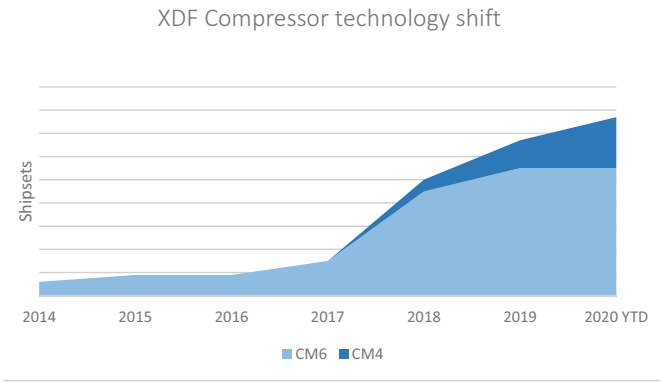
As soon as the fuel gas supply specification was lowered from 17 bar to 13 bar, it became apparent that all ship owners would be interested in benefiting from the potential savings on their original CM6 machines.

Due to the reduced fuel gas pressure specification, an evaluation of methods to derate the original CM6 designs with minimal disruption was carried out to explore power savings possibilities, considering options as drastic as the substitution of the 6th stage wheel with a dummy wheel.

Research showed that it was possible to reduce the power by 10% for usage in the most common flow range. This can be achieved through a simple change in control parameters, requiring no mechanical changes to previously installed machinery. A number of current machine owners have opted for this simple upgrade.

Due to the inlet pressure requirements of some of the reliquefaction solutions on board certain ships, this modification cannot be made to every vessel, but many vessel owners have requested it.

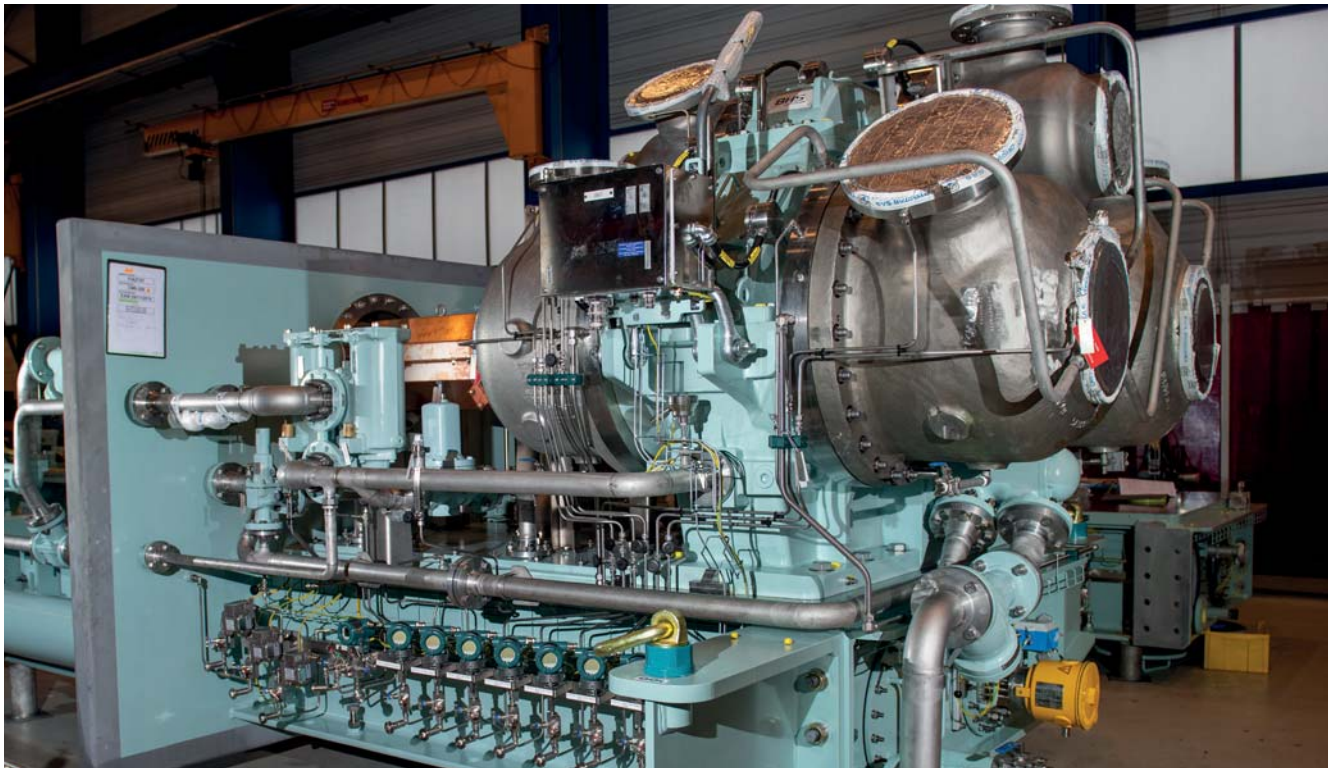
Lower pressure requirements lead a trend to simpler machinery



The obvious benefits of power reduction and a simpler machine have promoted a shift away from CM6 type machines to the CM4 design.

Although the growth in 2018 was high for CM6 machines, many being sold for sister vessels that shared similar designs, the clear trend from late 2018 into 2019 has been a shift to the new design, with at least one industry leader standardizing their recent fleet with the new machines.

The CM4 machine has a bright future ahead of it, as it is a highly competitive solution for the changing landscape of LNGC propulsion.



VIRTUAL REALITY

A TRAINING AND PRESENTATION TOOL

Virtual reality is defined as a digital technology that simulates the physical presence of a user in an artificial environment created by software.

Virtual reality creates an environment with which the user can interact. It artificially reproduces a sensorial experience, which can include sight, touch, and hearing.

In 2018, Cryostar undertook their first virtual reality project with the goal of producing an LNG filling application that would allow potential customers to take a virtual tour of the station during the bidding phase. The secondary purpose was to train Cryostar technicians and customer maintenance teams before the station went live. It also includes a dedicated module designed to train drivers on how to fill the trucks.

This application contains all the relevant parts of a filling station and places the user inside a virtual station where they can move from one place to another, put on protective equipment, approach the volume meter, and pick up the hose that must be connected to the truck to fill its tank- and of course, regulate the amount of LNG being pumped into the tank.

All steps of the process are recreated in digital form.
This first project, developed with a service provider, was designed with three goals in mind:

- To improve contact with customers and support sales teams
- To reduce quality issues during on-site operations with customers.
- To reinforce Cryostar's image as a market leader and an innovative company.

The HTC Vive equipment needed for the virtual reality experience is contained in a single briefcase that includes a headset, the motion tracking system, and reactive controllers, all connected to a PC with special software and a graphics card. The whole interface is easy to transport and can be set up in a matter of minutes. The creation of this portable solution with minimal restrictions allows us to offer Cryostar virtual reality to customers all over the world.

In 2019, Cryostar wished to become independent and create their own marketing and training applications, which was done by acquiring software that allows for the conversion of 3D source files from the research department into "VR format," as well as the creation of interactive scenarios with a soundtrack, texts, etc. A employee was thus chosen to be trained on the programming and use of these applications.

These days, Cryostar is still working on training and gaining familiarity with the equipment, but the company is already able to offer simple virtual tour applications and interactive training applications. VR applications for more technical operations are also being developed, such as the start-up of a piston pump and the disassembly of a CM6 compressor for LNG carriers.

2020 will be dedicated to considering the various ways the company may be able to use virtual reality in the future, for example the potential development of collaborative engineering applications with customers and suppliers.

And the next step- augmented reality, perhaps? Augmented reality consists of superimposing reality and elements imported from a digital system on top of one another. It is beginning to be used in the industry, and Cryostar may join the wave in the near future.

DETERMINATION, DEVOTION AND DONATION

The Covid-19 virus has turned the world of industry upside down. In response to this serious crisis, which affects all businesses, Cryostar's absolute priority is the health and safety of its employees and contractors, its clients, suppliers, and visitors.

Faced with this difficult, unprecedented situation, Cryostar's employees have shown great professionalism and come together around the shared values of solidarity and team spirit. Physical and social distancing are being scrupulously respected.

Almost all office staff for the company switched to working from home within a 24-hour period, continuing to do their jobs remotely without any interruption to the work cycle. Production has not been interrupted either, thanks to our employees' desire to continue working.

We have established two production teams in two distinct spaces in order to prevent all physical contact between them.

Our company is committed at every level to preventing the spread of the virus while maintaining operational continuity.

We salute your determination and devotion.
Thank you all for your efforts, which deserve to be recognized.

At this time of health crisis, Cryostar donated part of its hydroalcoholic solution stock to the Emile Muller Hospital in Mulhouse, which is in dire need of it. The other part remains stored at Cryostar for its teams still present on site and whose stock is sufficient to ensure the needs for several months.

Also 20 Personal Computers were given to students lacking IT resources to follow the distance courses during the confinement period.

NEWS

NEOVP N°1

Cryostar has reached an important milestone in the development of its new multi-stage vertical pump, the NeoVP. After several partial tests and numerous calculations, the first prototype was subjected to extensive testing on Cryostar's liquid nitrogen test bench.

The NeoVP unit n°1 performs exceptionally well in terms of efficiency, operating range, and net positive suction head. All performance targets have been met or exceeded. This new product will enable our customers to benefit from the best possible multi-stage centrifugal pump for air separation units and other applications.

A full range of NeoVP products is now being developed.

First Compressor CM4-200 tested

In February 2020, Cryostar conducted the FAT (Factory Acceptance Test) of it's first BOG compressor for LNG Carriers with XDF propulsion engine based on the new 4-stage compressor design. The FAT was conducted in Cryostar's dedicated test facility in Hésingue (France). It demonstrated that the new design achieves the rigorous acceptance criteria set to achieve the required mechanical integrity and aerodynamic performance of this CM4-200. The first set of two compressors was subsequently dispatched to the shipyard in South Korea where it will be installed on-board the LNGC and commissioned in the months to come.

Cryostar employees retired

Recently, our following colleagues have retired.
We thank them for their contribution and wish them a long and peaceful retirement.

NAME		RETIREMENT DATE	JOB TITLE	SENIORITY/ YEARS
MULLER	Jean-Paul	30/11/2019	Forklift driver	5y 4m
RUDELLE	Christian	31/12/2019	Balancing mechanic	6y 6m
RUNSER	Serge	31/03/2020	Pump foreman	39y 2m

more than
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