the CRYOSTAR MAGAZINE

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"CALCULATION AND STRUCTURES" TEAM

DIGITIZATION

SPORTS AND BUSINESS

edito

In a world on the brink of becoming "ultra-connected," the digital revolution is changing not only how we communicate, but also how we work in general—both as individuals and as businesses.

The effects of this revolution are being felt more all the time. Some of these changes are reflected in this issue's feature article, which describes the increasing importance of IT tools in the heart of CRYOSTAR's core competence, the rotary assembly of our turbines (see page 3).

In the Spring 2019 issue, we highlighted our CRM (Customer Relationship Management) project. This project is part of the larger "Hercule" program, which is dedicated to modernizing our methods of administrative data processing and includes, in addition to the new CRM, the gradual implementation of new ERP (Enterprise Resource Planning) and PLM (Product Lifecycle Management) systems.

These new tools will have a noticeable effect in the everyday lives of our whole team, including in our workshops. In this issue we describe the digitization of our "workshop" files (see page 8), which has successfully introduced information technology into the heart of our equipment assembly areas. This development makes the lives of our technicians much easier, and will be continued in the coming months.

There are also other projects or improvements that reflect CRYOSTAR's commitment to improving its digital technology, such as the use of virtual reality to demonstrate and provide our clients with training on our equipment. It is already used to show the technique for fueling trucks at LNG service stations, and will be implemented for the rest of our equipment in the future. Another step we have taken is the acquisition of collaborative work tools like "Rainbow," which offers more advanced methods of internal communication (chats, document sharing, web conferences, scheduling, and optimization of contacts.)

CRYOSTAR and its employees, who are dynamic, enterprising, and resolutely open to adopting new technology, are well equipped to integrate and take advantage of current and future advances in digital technology.

Samuel Zouaghi

PRESIDENT

summary

from the DRAWING BOARD TO CALCULATION AND DESIGN SOFTWARE

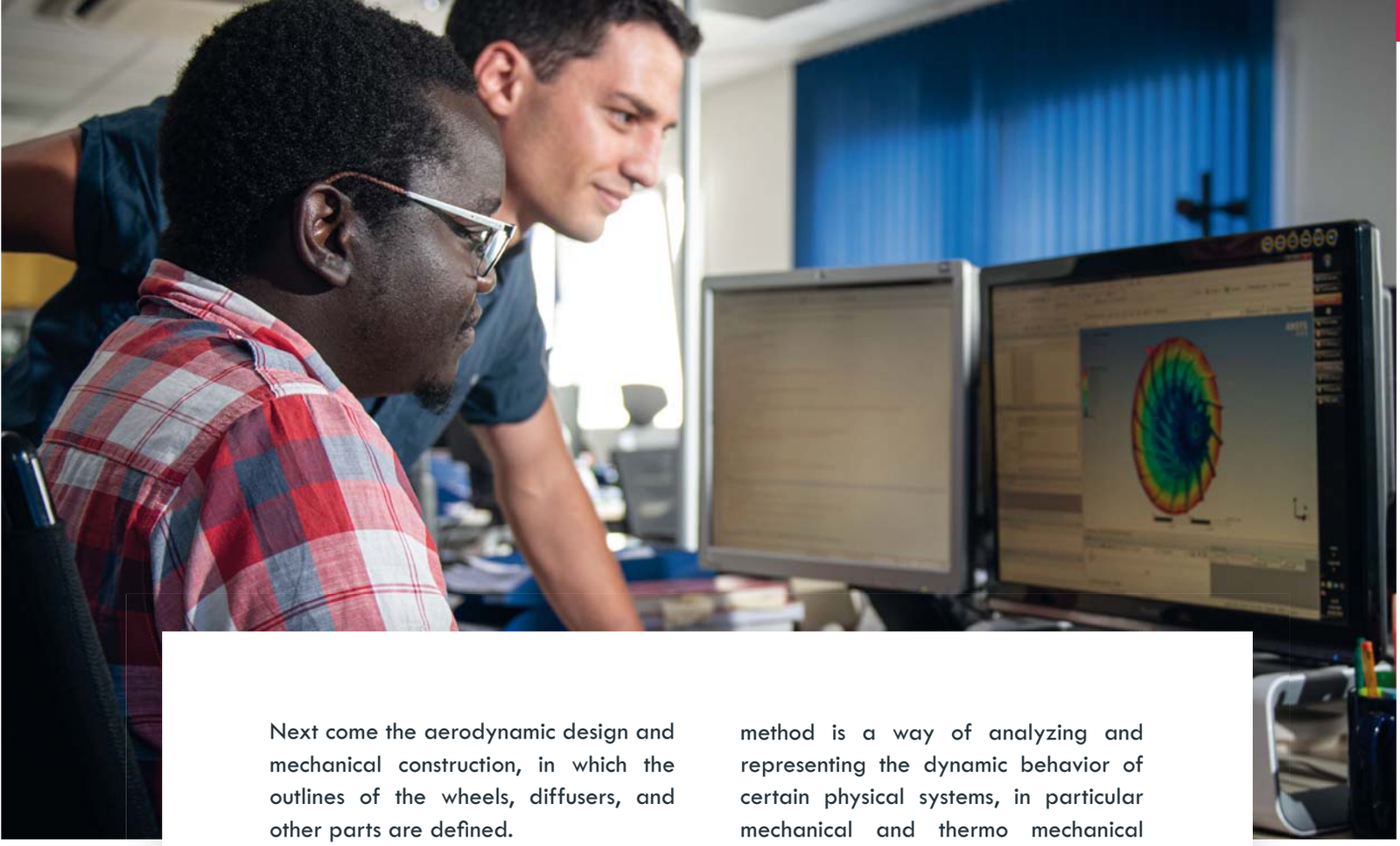
For our next article in the "A day with" series, we have chosen to feature an entire department, one that is central to the development of rotor assemblies of Cryostar turbines: the "Calculations and Structures" team, part of the CDM ("Construction and Development of Machinery") department, which is made up of Sébastien Jaouen, Joseph Walch, Adrien Blanc, Maxime Mille, and Makhtar Seye.

Let's travel back in time with the most experienced member of the team, Joseph Walch. When he first came on board in 1989, drawing boards were the norm. They were even used in the calculation of critical speeds, for which the team used a graphic method called "Stodola," named after a Slovakian engineer, physicist, and inventor.

Back then, the team would need at least three weeks to prepare the technical components of a bid-a far cry from the 24-hour turnaround we can achieve nowadays!

Computers slowly came into the scene, starting with AutoCAD stations, then computers and Basic applications, later on Pascal applications, which had graphic interfaces that made it possible to create databases and save calculations, allowing us to capitalize on our knowledge and thus facilitating the selection of machines and the creation of a bid.

The development of a rotor assembly is a four step iterative process. For any given project, we must first create a technical proposal, which includes choosing a machine that meets the specific requirements of the order.



Next come the aerodynamic design and mechanical construction, in which the outlines of the wheels, diffusers, and other parts are defined.

Once that is done, the whole piece is reviewed by the C&S team, which oversees the calculations for the structure and validates the mechanics of the impeller wheels. Furthermore, rotor critical speeds with no dwell zones are established, and shaft line integrity comprising aerodynamic excitations, checked.

The team generally spends around 30-40% of their time working on client projects, 20-25% in R&D, and the rest in problem resolution, a combination of internal and on-site testing. Tests can reveal vibratory problems that are often a symptom of a non-compliant piece or an assembly problem, or, much more rarely, a design issue.

The team relies on a range of programs to complete their calculations, and they use many different kinds of tools in order to respect all the relevant norms. The details of the software used are as follows:

• **ANSYS** to calculate the FEA structure. The FEM/FEA (Finite Element Analysis) method is a way of analyzing and representing the dynamic behavior of certain physical systems, in particular mechanical and thermo mechanical ones.

• **XL-Rotor** to determine the dynamics of rotor assemblies, including the critical speeds, the separation margins, and the amplification factor that is directly proportional to the damping capacity of the system. All that for lateral and torsional operations, as well as for stationary and transient states.

• **NX Siemens** to make adjustments to the 3D model provided by the Construction team in the CDM department.

• **ADRE** (Automated Diagnostics for Rotating Equipment,) which makes it possible to validate rotor's mathematical models, by measuring the behavior of the rotor assembly at the test bench, through a correlation between the theoretical and the experimental results.

• **Bruel&Kjaer** for Ping tests, which identify the rotors via transfer function between the measurement location and the active bearing location, for a machine with a magnetic bearing, and also

identify the chassis' own frequencies as potential interferences to the frequency of rotation of the machines.

• **And an internal bearing calculation tool** to calculate stiffness and damping coefficient matrix, oil film temperatures, oil consumption, power losses, etc.

Needless to say, this team has a wide range of responsibilities, which requires them to be learning all the time in order to keep up with technological developments and resolve new problems-especially with machines that are functioning close to their limits. These limits are often met, which naturally has an effect on the lifespan of the machines.

This continual learning is manifested through targeted workshops and meetings with international experts, which are scheduled each year.

The Calculations and Structures team is in regular contact with global industry specialists outside the company, with suppliers when it comes to integrating their parts into our turbines, and with clients when they need clarification on how a machine functions or when a service call is needed in order to adapt the machine to the on-site conditions.

Within the company, they communicate with all departments linked directly to fulfillment, from sales plans, to testing, to turbine start-up.

This team is, one of the few at CDM, at the heart of Cryostar turbine technology. Their work is complex and fascinating, varied and never routine. They face new challenges nearly every day!

AutoCad stations used in the 90's

SPORTS & BUSINESS

Sports are an integral part of the business culture at CRYOSTAR. From our football, tennis, badminton, and volleyball teams, to participation in prestigious races such as the New York, Paris, and London Marathons, to company-wide ski trips and bicycle rides, we offer a variety of activities that blend the mental and the physical to improve our employees' well-being.

On the occasion of the presentation of mid-year results, CRYOSTAR invited former professional athlete Daniel Constantini to speak to the company about motivation, performance, demands, and commitment, drawing parallels between the worlds of sports and business.

When Daniel Constantini stepped up as coach for the men's national handball team in 1985, he had one goal: to elevate the French team from 20th place to 1st place in the global rankings. After winning a bronze medal at the 1992 Summer Olympics under his leadership, the French national team won the World Championships in 1995 and again in 2001, in addition to acquiring a variety of world, European, and Olympic titles that France would hold on to for the first two decades of the 21st century.

The fundamentals

When Constantini took over as coach for the French team, he based his approach on the fundamental prerequisites for performance (what must you do in order to win in a group activity?) and advocated for change.

The prerequisites

Naturally, he began by putting the high-level handball players to work, increasing the amount of time they spent in training. Next, he highlighted the individual aspect of performance, which is related to the group aspect, emphasizing the fact that each individual player owed it to the team to improve and develop his own personal skills. This was achieved through an intense training regime that prioritized speed, bodybuilding, commitment, and resistance training, requiring each individual to make the same commitments and work towards the same goals with the same intensity.

Next, he had to generate and maintain motivation and develop the players' trust in themselves and belief in their personal and shared ability to succeed. Training was crucial, as Constantini expected the players to improve each and every day in accordance with the demands they put on themselves. The managers also had their role to play, working to help the stronger players improve all while supporting the weaker members of the team.

And of course, he couldn't forget about the group, which was governed by its own rules, a precise distribution of tasks, and clear instructions. He also created an environment where there was room for players to grow and learn about each other's roles on the team, helping the players learn to "read" each other's games and work together efficiently.

Managing change

After suffering a crushing defeat at the 1996 Summer Olympics in Atlanta, at which the rules for maintaining the team at its peak were not followed, Daniel Constantini changed over 60% of the team, recruiting a number of younger players. He also realized that he needed to change his management style, which he did by imposing fewer rules, listening to his players, and establishing a regular group debriefing session between the players and coaches to promote open communication.

In order to implement changes like these, a group must aim for continu-

ous improvement, communicate, and once the decision has been made, ALL forge ahead with enthusiasm.

For Daniel Constantini, the client is not the main focus of a given project-companies must realize that the project depends on the employees, each and every one of whom must feel supported by both their managers and their coworkers.

An interesting parallel between sports and the business world, and more specifically CRYOSTAR, as it is above all employees' "desire," when they are happy in their jobs, that leads to consistently high-level performance.

QUESTION & ANSWER SESSION

"People often talk about differentiation. What differentiated your team and helped you win the world championship? Everyone trains, so what made you stand out?"

DC: Once we knew how to do something and it became comfortable, we moved on to something less comfortable. We found tournaments in countries we didn't usually go to and got out of our comfort zone. The trips we took early on were very good for us; they helped us later on.

"How do you convince people who are resistant to change?"

DC: You have to at least have a majority who support the change, and then present things as positively as possible. You can't give the same speech to everyone; it has to be adapted for each individual.
You also have to demonstrate success right off the bat, even if it is only small victories at first. If you say the change is going to be effective but you won't see results until six months down the line, you will have a hard time convincing people!

"What do you do with people who have been around for a long time? Should they be put in center field, instead of on the sidelines?"

DC: People with experience play a very important role as mentors. New players are automatically paired up with someone who has held the same job for a while. The experienced employee shares the company culture with the new recruit, which also gives the experienced employee a chance to rediscover elements of their job that they may have forgotten, and shows them in their best light. It also gives new employees a sense of responsibility early on.

"How do you promote team cohesion and clarity of goals?"

DC: 90% of the time, it's through our training. The players owe it to themselves to progress both individually and as a team.

"How do you deal with ego issues in a group?"

DC: During training we make sure that even the strongest players can see that they need the rest of the team. And if one player thinks he is the best, he had better be prepared to prove it every single day.

"Once you have won everything the way you have, what motivates you to get up in the morning?"

DC: Adrenaline. Before, it was the adrenaline of the competitions. Once I stopped coaching, it became all about reaching out to companies and individuals. I replaced one kind of adrenaline with another.

"What is a manager's worst nightmare?"

DC: Having a team that could have become champions, but not managing to win the title!

"What's the worst kind of person to manage?"

DC: One who doesn't take responsibility.

"Do you think managers should be replaced as often as coaches?"

DC: I'm not in the right position to answer that-I was coach for 16 years, and so was my successor.

"What kind of relationship did you have with the team?"

DC: For me, it was first and foremost a question of working hard. As long as they were working hard, I let them live their lives.

"What advice would you give to the President and Board of Directors of Cryostar?"

DC: What's good is that you don't have 20,000 employees; your company exists on a very human scale. On the other hand, you always have to be on your toes in your market and especially as a leader in the industry. You can never rest on your laurels.

The end comment by Samuel Zouaghi:

"Make sure to avoid the risk of complacency!"

DIGITIZATION of "workshop" documents

As part of the "Assembly sequences & routings" program launched in 2016, we conducted a study on the digitization of paper "workshop" documents—that is, replacing hard copies of the drawings with digital versions that machine operators could consult directly via the workstations.

The first step was to roll out digital interfaces in Production in one or two test workshops, with the long-term goal of going entirely paperless. The objective was for operators to be able to use the workstation to access project workshop files, assembly plans, glossaries, parts lists, and plans, as well as to clock in and out and access the company Intranet.

A conclusive trial was conducted with tablets, and three VP pumps were successfully assembled. Tablets did not turn out to the best option, however, due to both battery issues (tablets are unable to run for more than a few hours without being plugged in) and difficulty in using the tablets while wearing protective gloves.

The results of this first trial allowed the research team, working together with users, to define two different types of workstations depending on the context: a setup consisting of a screen, keyboard, and mouse, which could be either stationary or mounted on a moveable cart, was preferable to a touch-screen tablet. The first large-scale test began in 2018, with the installation of nine workstations in two different workshops: the VP pump building in Hall 7 and the mechanical turbine (cartridge) assembly area in Hall 1. In practice, the transition from using all paper to a fully-digitized process turned out to be very easy for operators, who are delighted with this new way of working and appreciate the simplicity and ease of accessing data. Digitization thus represents a significant step forward in terms of both productivity and efficiency in the workplace.

The implementation of these new workstations throughout the Production area was given the go-ahead, and a goal was set of being fully operational by January 2021 to coincide with the startup of the new ERP.

The following steps were outlined:

- Systematization of assembly plans for all projects
- Progressive purchase and installation of 80-100 new workstations in 2020.
- Consideration of specific needs for the electrical workshop (possible use of tablets) and for soldering stations (due to magnetic interference.)

This initiative fits perfectly within Cryostar's digitization plan and has numerous advantages:

- Technical documents can be kept always up to date, whereas the paper equivalents rapidly became obsolete.
- A positive impact on the environment, with less printing required.
- Eliminating the risk of losing piles of papers and drawings, which also take up less space in assembly areas in their digital format.
- Screens make it easier to read the assembly plans and checklists as compared to their paper counterparts, which were sometimes too small (possibility of zooming in on digital format.)
- Improved ergonomics and thus productivity for operators, who no longer need to move to (and sometimes wait at) the time clock to punch in and out (which also carried the risk of mistakes in terms of the division of hours among different projects when clocking out at the end of the day, for practical reasons.)

This project will cost approximately 200,000-250,000€, with a short-term return on investment, thanks to the time that is saved.

CRYOSTAR AUTOMATION IN CAPDENAC

THE REVOLUTION IS HERE!

Cryostar Automation is at the heart of Cryostar's automated distribution system strategy. The development of this entity in the Aveyron, in southwestern France, is a clear demonstration of French expertise and a perfect illustration of the success we have had so far.

When they established Cryostar Automation on January 1st, 2001 with fewer than 10 employees, Cryostar's directors were acting on their belief that the entity had great potential-and they were right. Less than twenty years later, Cryostar Automation has become a major player in the industrial gas cylinder filling and natural gas fueling station industry. With more than 40 employees now in 2019, Cryostar Automation continues to expand and grow by offering its clients ever more innovative products. The company's growth has accelerated over the last two years, demonstrating that decisions made nearly twenty years ago were well founded. Cryostar has remained loyal to its vision and made carefully considered long-term industry investments that are paying off today.

When we first decided, in the early 2000s, to develop a range of solutions for the natural gas fuel market, we were part of a very small group of people who saw the potential for future development. Today, Cryostar Automation is a leader in the rapidly expanding market. We work for some of the largest oil producers in the world and are proud of the role we have played in the evolution of the European energy mix.

Cryostar Automation's expertise is also reflected in its automated systems for industrial gas cylinder filling, and the company now works with the largest suppliers of industrial gas. With more than 100 production sites, our teams have created a reliable, robust solution that can be used in a variety of sectors (industry, medicine, special gases, etc.)

Whether for natural gas or industrial gas, Cryostar's products and services are recognized by our clients. Thanks to our technology and product design, Cryostar has established itself as a brand, rather than as a simple manufacturer of equipment. Recognition from our clients and the market as a whole spurs us on to maintain a high level of performance and excellence as we continue to grow.
Innovation and safety are an integral part of our company's DNA, and this is reflected in our constant drive to offer new and improved services. The future of filling factories and fueling stations is dependent on our precise knowledge of clients' needs and processes, as well as the implementation of increased automatization to reinforce safety. The latter is achieved through the introduction of man/machine interfaces that are friendlier than ever before, in addition to preventive and predictive maintenance for increased reliability.

In order to keep up with this growth, we are constantly hiring more employees and improving our production tools. As a result some Cryostar Automation employees are being temporarily moved into offices located a few kilometers away from our current location to prepare for the arrival of new employees in 2019/2020. We are collaborating with the owner of our current space to build an addition, which will enable us to continue creating new offices and workshops in the future.

By continually hiring new staff, developing new production tools, and upgrading our spaces, Cryostar Automation will be able to maintain its position as a leader in a fast-growing industry that is already seeing the effects of the IOT revolution, virtual reality (already used in our training modules) and predictive maintenance. Cryostar intends to use these new technologies to their full extent in order to best serve our current and future clients.

Cryostar Automation: always looking toward the future!

Cryostar USA ready for the FUTURE

It is common knowledge that the US is a service-oriented market, one where it is not enough to merely get the job done-it must also be done quickly. Although Cryostar-USA has been improving upon its service capabilities and workshops for some time now, the company recently decided it was time to take things to the next level.

A little more than two years ago, we embarked upon a series of changes to ensure that we are prepared for the future and will be able to continue meeting customer expectations. We started by establishing a local presence in the Chicago area, a small repair operation on the premises of one of our distributors. A year later, we opened a fully functional Cryostar workshop in Rockford, IL. Now with four Cryostar workshops located around the country-Whittier, CA; Bethlehem, PA; Houston, TX; and Rockford, IL-we are strategically positioned around the USA in such a way that we can be effective in both supporting our existing customer base and growing our market shares.

The next phase of our plan focused on customer relationship management (CRM). Having four repair locations was a step in the right direction, but once we had established them, we realized that we needed to shift the focus towards the needs and wants of our customers. What better way to do that than by establishing a dedicated North American Distributor for the Distribution Market, an organization that would be able to respond to customers' questions and needs at a moment's notice? Thus our partnership with Cryostar-DNA was born.

Ever since, with constant feedback from Cryostar-DNA, we have been developing and expanding our parts exchange program, not only with Cryostar equipment, but also with other equipment that helps us meet overall customer needs. Pump Schools have been a great success and are now taking place regularly. This proactive approach has helped us gain new customers in the Midwest region and expand eastward. The positive impact of these actions is reflected in our ever-growing market shares.

Cryostar-USA has seen significant development in the Hydrogen market. Since the company installed its first high-pressure piston pump (MRP 40/55 LH2) for cylinder and tube trailer filling almost ten years ago, the hydrogen fuel cell market has taken off. Our primary hydrogen pump customer, has installed over 70 of our MRP pumps across the US. We recently signed an additional supply agreement to provide 50 more pumps over the next two years. We are confident that this pump is on its way to becoming the industry standard for hydrogen.

We are also seeing LNG activity starting up in Mexico, which will create new opportunities for LNG/LCNG fueling stations in the coming years. Although the vehicle fueling market in the US and Canada remains flat for the time being, we are seeing a number of plans for LNG transfer due to the ongoing expansion of production sites in the US.

We are confident that Cryostar-USA is well-positioned to deal with growth and customer demands in the coming years. As we continue this proactive approach, the ultimate goal is to anticipate client needs, making the ownership and maintenance of Cryostar equipment into an easy long-term, decision.

NEWS

NEW TYPE OF BOG COMPRESSOR

Cryostar has developed and successfully tested a new type of BOG compressor for installation on-board LNG carriers that are equipped with a XDF main engine. The initial development of a 6-stage BOG compressor was complemented by a EcoBOT (Economic Boil Off Gas Treatment) version that brings the advantage of smaller installed power as the forced gas is treated separately (a patented configuration by Cryostar). The new integrally geared compressor operates at a slightly higher shaft speed compared to the conventional 6-stage BOG compressor. A recent gastrial in collaboration with the Chinese shipyard Hudong Zhonghua and the Japanese vessel operator MOL proved the robust and reliable behaviour of this newest addition to Cryostar's broad portfolio of rotating equipment for the LNG industry. The combined mechanical and performance test was completed to the satisfaction of both the shipyard and the end-user. A similar development is ongoing at Cryostar for it's 4-stage BOG compressor destined for the same market application.

CRYOSTAR RUSSIA INAUGURATION

June 13 saw the opening ceremony of Cryostar's new premises in Saint Petersburg, with the participation of almost 50 key customers.

After the ribbon-cutting ceremony, the management committee and the Russian team were proud to show the spacious and functional premises to their invitees, prior to a memorable dinner and a canal cruise with an impressive view on Saint Petersburg moveable bridges.

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
ADAM	FREDERIC	30/06/2019	Responsible export financings	12y 10m
NUSSBAUMER	PATRICE	31/03/2019	Fitter mechanic	15y 9m
BURELLI	JEAN-PIERRE	30/09/2019	Welder	28y 11m

BRAZIL

CHINA

FRANCE

INDIA

RUSSIA

SINGAPORE

UNITED KINGDOM

UNITED STATES

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