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Vacuum Barrier's Field Service Evolution | 38

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Vacuum Barrier Corporation's liquid nitrogen dosing systems, including the NITRODOSE and EasyDose lines, are used to deliver liquid nitrogen to containers. These systems are used in a variety of industries, including food and beverage, brewing, and automotive.
Credit: Vacuum Barrier

GARDNER CRYOGENICS

Gardner Cryogenics was CSA's newsletter sponsor for February.

In all instances, "CSA CSM" indicates a Corporate Sustaining Member of CSA.

ColdFacts

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From the Executive Director

On behalf of CSA, we are thrilled to present this month's issue of Cold Facts which includes one of my favorite features – "Women in Cryogenics and Superconductivity." As a cryo-adjacent woman myself, I might be slightly biased; however, I think we can all agree that spotlighting the incredible work of women in our industry is a worthwhile and necessary endeavor. Their contributions are shaping the future of the field, driving innovation and inspiring the next generation of cryogenic professionals. Check out the full feature on page eight.

A number of other exciting opportunities are coming up in the next few months. From May 13-15, 2025, CSA, in conjunction with NASA, will be hosting the 31st Space Cryogenics Workshop (SCW) at the Hyatt Regency Lake Tahoe in Incline Village, Nevada. All aspects of space cryogenics will be represented, with emphasis on those related to space exploration. Workshop participants representing industry, academia and government will share their expertise through oral and poster presentations.

Early bird registration is now open through March 14, 2025. Register early to take advantage of the discounted rates! For full details regarding SCW, including registration and sponsorship opportunities, please visit **https://spacecryogenicsworkshop.org**. A big thank you to those companies that have already supported the SCW through sponsorship: Alloy Valve and Control (AVCO), OPW Clean Energy Solutions, Omega Flex, Quest Thermal Group and Spaceline Technologies.

Another exciting opportunity with a deadline approaching soon: CSA has established several awards to honor persons who have contributed to the industry and to the society in a variety of ways. Nominations are now open for a number of these awards including the Robert W. Vance Award, the William E. Gifford Award, the CSA Technical Awards and the CSA Fellow recognition. The awards will be presented at the upcoming CEC/ICMC'25 in Reno, Nevada. The deadline to submit nominations for all of these awards is March 14, 2025. To read full details, please visit the CSA website at 2csa.org/award.

Prior to CEC/ICMC'25, CSA will be hosting a number of Short Courses on Sunday, May 18, 2025, in Reno, Nevada. This year, we will be offering one full-day course and four half-day courses. Course topics are Cryocooler Fundamentals, Cryogenic Hydrogen, Helium Cryogenics, Cryogenic Safety, and Cryogenic Thermometry & Instrumentation. We are offering discounted early bird rates through April 18, 2025. For full details and registration, visit the CSA website at **2csa.org/sc25**.

As always, I hope you enjoy this issue of *Cold Facts*!

ColdFacts Editorial Board

WOMEN *in* CRYOGENICS and SUPERCONDUCTIVITY

Iqra Azam

Postdoctoral Fellow under Dr. James Benson—University of Saskatchewan

What projects are you working on now?

I am currently investigating freezing-induced damage in liver tissue and exploring the use of ice recrystallization inhibitors to enhance cryopreservation outcomes. My research focuses on understanding how cells respond to freezing and developing new preservation strategies for both cell monolayers and tissues.

What accomplishment are you most proud of? What was the challenge and how did you and/or your team meet it?

During my doctoral research, I utilized advanced imaging techniques and mathematical modeling to investigate how cells and tissues respond to osmotic stress during cryopreservation. This work provided critical insights for developing improved preservation methods. Through collaboration with a multidisciplinary team, we devised a protocol that minimized osmotic stress and chemical toxicity during the freezing of cells and tissues, contributing to more effective preservation strategies.

What advancements in cryogenics are you hoping to make in the future?

I aim to contribute to the development of improved cryopreservation protocols for complex tissues and organs, integrating interdisciplinary approaches to minimize freezing damage. Advancing non-toxic cryoprotectants and optimizing ice formation control are key areas of interest. These advancements will improve the storage and preservation of biological products for biomedical research and therapeutic applications.

What advances for women would you like to see in the fields of cryogenics and superconductivity?

I want to see greater representation of women in cryobiology and cryogenics, especially since cryobiology is an interdisciplinary field that encompasses engineering, medicine, biology and physics. To encourage women to take on leadership roles, we need to recognize their contributions, expand funding opportunities and support work-life balance. Creating an inclusive environment will not only attract more women to the field but also ensure that they thrive in long-term careers.

What would be the best approach to getting more women into your field?

Bringing more women into cryobiology starts with breaking down societal and structural barriers. By fostering a culture that values diversity, we can create more pathways through scholarships, mentorship and hands-on research opportunities. When women see role models leading in this field and are provided the support to thrive, they are more likely to pursue and sustain careers in cryobiology—ultimately shaping the future of the discipline.

Vera Hansper

Technical Training Lead—Bluefors

What projects are you working on now?

My primary role is to further develop the Technical Training program for all Bluefors employees. I use the term "further develop" because I have been working on this initiative for the past five years, initially as a cryoengineer, focusing on training new cryoengineers. Now, my portfolio has broadened to include training for all employees, and when needed, I also provide training for customers.

What accomplishment are you most proud of? What was the challenge and how did you and/or your team meet it?

This is a tricky question! Most recently, I participated in the Bluefors Summer Brain Freeze 2024 (Summer School) and gave a comprehensive presentation/tutorial on how to install, run and manage a cryostat. The challenge was finding the right balance for the audience and identifying engaging material to support the dialogue. I was very pleased with the outcome as everything ran smoothly on my end. Additionally, I am proud of the cryostat installations I've completed for our customers over the years. The work is demanding but deeply gratifying.

What advancements in cryogenics are you hoping to make in the future?
I hope that the training program I provide will help future cryoengineers and technicians work productively and efficiently within the company. This will ensure that the products we create maintain the highest levels of functionality and quality—and, of course, result in the happiest customers.

What advances for women would you like to see in the fields of cryogenics and superconductivity?
Keeping women engaged and educated in the sciences will be instrumental in ensuring they encounter cryogenics and related fields. Good mentoring is invaluable and creating an inclusive environment will naturally draw talent. It's also important for senior scientists, researchers and engineers to recognize when someone has the potential to excel in a field and support them in pursuing their aspirations.

What would be the best approach to getting more women into your field?
When I was studying, science felt broad and daunting. There were no mentors or guides, and we were thrown into the deep end and expected to swim. To encourage more young women to enter fields like cryogenics, I believe hands-on experience in labs or factories early in their academic journey is essential. Seeing the real-world impact and possibilities of their work can be a powerful motivator for pursuing careers in science.

Jennifer Hennis
Product Development Specialist—GenH2 Corp

What projects are you working on now?
As a product development specialist at GenH2 Corp, I have the privilege of working on groundbreaking projects to bring liquid hydrogen (LH_2) equipment to the industrial worlds of transportation and energy storage. My work involves the manufacture and commissioning of advanced refrigeration systems for heavy-duty electric machines, iCAT cryogenic hydrogen storage tanks, CS900-1 and CS900-2 simulation test platforms, and the LS20 liquefaction and controlled storage system. Additionally, I contribute to the development of commercial cryostat products such as the CS500 and Macroflash manufacturing for leading institutions and universities. I am also involved in cryostat testing materials with LH_2 for leading industry companies and collaborate with Shell and CB&I on a mega-scale LH_2 storage project.

What accomplishment are you most proud of? What was the challenge, and how did you and/or your team meet it?
One of my favorite accomplishments has been being part of the teams that built and commissioned the LS20 mobile unit, along with the CS900-1 and CS900-2 simulation test platforms. It has been incredibly rewarding to see these innovative systems come to life and make an impact in the field.

What advancements in cryogenics are you hoping to make in the future?
In the field of cryogenics, I aspire to see advancements that lead to low-cost, standardized products for storing and conveying liquid hydrogen. Standardization and cost-efficiency are crucial for broader adoption and the development of scalable solutions for LH_2 applications.

What advances for women would you like to see in cryogenics and superconductivity?
In terms of advancing opportunities for women in cryogenics, I would like to see more hands-on, practical experiences in cryogenics and vacuum technology. It is also essential to integrate real-world data to support safety practices and establish design standards for LH_2 equipment. Providing more women with direct, practical engagement in the field will help them build expertise and confidence.

What would be the best approach to getting more women into your field?
To promote greater participation of women in cryogenics, I believe in fostering awareness and recruitment while providing a broad spectrum of opportunities across various specialties. These opportunities should include fabrication, testing, data analysis and laboratory practices. By creating a diverse range of pathways, we can inspire more women to pursue and thrive in this exciting and essential field.

Tamanna Joshi
Technical Sales Engineer—Bluefors Brooklyn

What projects are you working on now?
I primarily work with advanced cryogenic systems, focusing on dilution refrigerators that offer continuous cooling at extremely low temperatures, from 7mK to 4.2 K. I also work with some of our newer technologies, including systems that provide high power in the 1 K range, microwave modules for amplifying weak signals and improvements

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in measurement solutions for larger quantum systems. It's a great experience being involved in these innovations.

What accomplishment are you most proud of? What was the challenge and how did you and/or your team meet it?
Every day brings its fair share of challenges and rewards. Our team has been busy growing, not just with the new US office and local support, but also adapting to the fast-paced, ever-changing environment—something that's both exciting and fulfilling. It's amazing to see how this growth is having a real impact on our customers. One of the biggest highlights last year was presenting our second-generation gas handling system (GHS2) at the APS March Meeting 2024. Since then, we've been working closely with users to update the system with new features, making it more flexible, functional and safe to meet growing demands.

What advancements in cryogenics are you hoping to make in the future?
Looking ahead, I'm excited to keep working on making cryogenics simpler and more accessible so researchers can focus on their experiments instead of worrying about the hardware. We regularly share our latest updates on our website, and we really value the close collaboration we have with our customers to meet the needs of the industry. It's not just about manufacturing; we're also focused on strengthening the supply chain. With our expanded Syracuse facility, we're in a great position to improve the cryogenics supply chain and continue making progress in the field, making it more reliable and easier for everyone to use.

What advances for women would you like to see in the fields of cryogenics and superconductivity?
I believe more women, especially women of color, should thrive in fields like cryogenics and superconductivity. From my own experience in condensed matter physics, I've seen how important representation is and how much more needs to be done to support women of color. They often face challenges like higher dropout rates and difficulty finding mentors and leadership opportunities.

At Delhi University, India, I was lucky to be part of a mentorship program early on in my career. It helped me navigate challenges and gave me the confidence to take on leadership roles. That's why I'm so passionate about creating more mentorship and leadership opportunities for women in these fields. It's not just about keeping women in STEM but helping them rise to roles where they can inspire others and drive meaningful change.

What would be the best approach to getting more women into your field?
The best way to get more women into cryogenics and superconductivity is by creating an environment that supports them at every step. When I moved from India to the U.S. for school, I had mentors who truly believed in me, and that made all the difference. Now, in my company, I'm lucky to work alongside women in leadership roles, with policies like family leave that make it easier to balance work and life. I've seen how these kinds of supportive, flexible environments help women succeed. For women of color, seeing leaders who look like you is incredibly powerful. It's this kind of culture that helps women not just enter the field but thrive in it and bring new perspectives that can really make a difference.

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Nora Juhasz
Technical Sales Engineer—Bluefors

What projects are you working on now?
Currently, I'm working on several exciting projects. One of my main focuses is collaborating with research institutions, including Ivy League universities, to optimize their cryogenic infrastructure for superconducting qubit experiments. This involves tailoring dilution refrigerators to maximize stability, minimize thermal noise and improve thermalization at millikelvin temperatures, all while enhancing coherence times and signal integrity for quantum measurements.

In addition to that, I'm working on benchmarking cryogenic system performance, evaluating cooldown efficiency, temperature stability and vibration suppression to ensure reliable operation in demanding quantum computing applications. Optimizing these factors is key to scaling up experiments and ensuring consistency across setups.

I'm also leading the Women in Cryogenics initiative at Bluefors, collaborating with other departments and researchers to highlight the contributions of women in the field.

What accomplishment are you most proud of? What was the challenge and how did you and/or your team meet it?
One of my proudest achievements was managing a project where a customer required significant product customization to meet their specific experimental setup. Their requirements didn't fully align with our standard "off-the-shelf" offerings, so I had to bridge the gap between their needs and our capabilities. Through clear discussions, detailed technical analysis and close collaboration with our engineering team, we developed a tailored solution that met their requirements without compromising performance or reliability. This project highlighted the importance of adaptability, technical problem-solving and maintaining a customer-focused approach in my role.

What advancements in cryogenics are you hoping to make in the future?
I'm particularly excited about the development of new superconducting materials for quantum circuits. While niobium-based superconductors are widely used, they have limitations due to material properties like coherence length and critical temperature. Advancements in high temperature superconductors, such as rare-earth-based materials or iron-based superconductors, could lead to higher critical current densities and better coherence properties at elevated cryogenic temperatures. This would enable the creation of

more scalable quantum circuits, essential for building larger, more powerful quantum processors.

What advances for women would you like to see in the fields of cryogenics and superconductivity?

I would love to see more women involved in experimental quantum physics and cryogenic engineering, especially in areas where their expertise could drive critical advancements. For instance, encouraging women to lead research in materials science for superconducting qubits, Josephson junction fabrication, loss characterization, and the development of novel superconducting materials could significantly improve qubit performance and scalability. I also hope to see more women contributing to cryogenic system design, particularly in areas like low temperature thermodynamics or thermal anchoring strategies. These systems are essential for many cryogenic experiments, and improving their design could lead to breakthroughs in both quantum computing and fundamental physics. Advancements in these fields would not only address pressing challenges in cryogenics and superconductivity but also contribute to shaping the future of quantum technology.

What would be the best approach to getting more women into your field?

To increase the representation of women in cryogenics and superconductivity, I believe a combination of hands-on experience, strong mentorship and collaboration between academia and industry is essential. Early research exposure is key. Providing women with opportunities to gain experience in low temperature physics labs, superconducting device fabrication and cryogenic measurement techniques during their undergraduate and graduate studies can ignite interest and build the technical skills needed to thrive in the field. Strong scientific mentorship is also vital. Establishing networks where women can collaborate on high-impact cryogenic research, receive guidance and present their work at key conferences will empower them to take on leadership roles.

Finally, industry-academia partnerships play a crucial role. Encouraging women to work on cutting-edge projects with leading research institutions and companies will allow them to contribute directly to scalable quantum computing and next-generation cryogenic technologies. This exposure enables women to influence major advancements and create lasting change in the field.

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Susan Magi

Executive Vice President of Marketing—GenH2

What projects are you working on now?

I've been working with the Department of Energy-Shell Consortium (NASA, CB&I, University of Houston and GenH2) to communicate the benefits of hydrogen at scale. Recently, I partnered with the Kennedy Space Center Visitor Complex to educate the public about the advantages of liquid hydrogen during World Space Week. I've also leveraged hydrogen and clean energy events as platforms to teach about the safety and business benefits of LH_2. In addition, I created informational programs and materials that highlight liquid hydrogen's energy density and its ability to be a superior energy option. A significant part of my work involves publicizing hydrogen safety and stability, particularly LH_2 stored using cryogenic refrigeration, which enables complete molecule control. I also focus on educating the industry about the zero-loss benefits of cryogenically refrigerated storage, as non-cryogenic storage can result in losses of 20-40%.

What accomplishment are you most proud of? What was the challenge and how did you and/or your team meet it?

I am most proud to be a founding member of a company that launched revolutionary LH_2 infrastructure technology based on NASA research. This technology has the potential to change the direction of clean energy in a very short timeframe. Energy advancements tend to take decades, but with flexible, modular and scalable infrastructure, we can make a positive impact now.

One of the biggest challenges has been overcoming misconceptions about hydrogen. The first reaction is often that hydrogen is unsafe, unstable, or not viable. Addressing these misconceptions has required consistent education and communication to showcase both the business ROI and the environmental benefits. Another challenge has been helping new hydrogen companies understand the losses that can occur without cryogenics. Early on, the industry was hesitant to discuss these losses for fear of scaring people away from hydrogen. However, GenH2 and other experts are now addressing this issue openly, emphasizing that significant molecule losses and costs can occur without cryogenically refrigerated storage. Transparency and education are key to increasing adoption and speeding up infrastructure expansion.

What advancements in cryogenics are you hoping to make in the future?

Scientific advancements will always occur, but I believe cryogenics needs broad understanding and acceptance to gain continued support for significant breakthroughs. Educating business executives, policymakers, universities and other key stakeholders is essential for enabling strategic decisions that fund and advance cryogenic projects. There is a cost to progress, but if those who control funding understand the benefits, they will be more likely to support the research and infrastructure necessary to move cryogenics forward. Additionally, people need to better understand the critical role cryogenics plays in the future of clean energy.

What advances for women would you like to see in cryogenics and superconductivity?

I want to see more women involved in the business, communication and education aspects of cryogenics and superconductivity. While women are often encouraged to pursue STEM careers, they are not always encouraged to contribute to the advancement of these specialized fields. These

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brilliant scientists need a voice in business and education and among the general public. As our Chief Architect likes to say, “Cryo is so Cool, it’s Hot!”

What would be the best approach to getting more women into your field?
Women should not feel intimidated by science! While some aspects of the work may be “rocket science,” the general concepts are not beyond our grasp. Just as we use televisions, GPS watches and automobiles without fully understanding their complexities, we can approach cryogenics in the same way. Complex concepts and products can be simplified so that everyone can understand them—even a “marketing person” like me can grasp why cryogenics is essential for advancing our society.

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Kayla Rajsky
Senior Mechanical Engineer—Interlune

What projects are you working on now?
I am currently working on a cryogenic distillation column designed to separate Helium-3 from Helium-4. The column operates at approximately 2 Kelvin and is housed inside a cryostat. At Interlune, our mission is to be the first company to commercialize resources from space. We're starting with Helium-3, a rare isotope abundant in space but scarce on Earth. Helium-3 has numerous applications, including quantum computing, clean energy and advancements in global health.

What accomplishment are you most proud of? What was the challenge and how did you and/or your team meet it?
I’m most proud of contributing to the setup of our cryogenics lab. Over the past year, our team has established the method for isotopic separation, identified the necessary lab equipment, moved into a new facility and created a fully functioning cryogenics lab. In the coming months, we’ll begin testing our distillation column, marking a major milestone for the project.

What advancements in cryogenics are you hoping to make in the future?
I hope to leverage my background in both cryogenics and aerospace engineering to develop advanced cryogenic flight hardware. Our ultimate goal is to conduct Helium-3 separation on the lunar surface, which will require significant progress in cooling technologies and distillation systems designed for space applications.

What advances for women would you like to see in the fields of cryogenics and superconductivity?
I’d like to see more representation for women in the field at conferences and events. Representation is essential for inspiring the next generation of engineers and showing them that there’s a place for them in cryogenics and superconductivity.

What would be the best approach to getting more women into your field?
Engaging with universities and actively recruiting women out of college is one of the best ways to encourage more women to enter the field. Empowering young women and making it clear that they belong in engineering is vital. For women already working in engineering who are interested in cryogenics, I’d encourage them to apply for jobs, even if they don’t meet every single job requirement. Much of what I do now, I’ve learned through independent research and guidance from industry experts. To any aspiring cryogenics engineers, Interlune is hiring!

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Tara Ramsey
President and CEO—Instant Systems, Inc.

What projects are you working on now?

Our team is developing a fully validated cryogenic shipping system that addresses challenges in current shipper designs. This project is particularly exciting due to its potential impact on the biotech industry. A highlight of the project has been the creation of a “heat box” for validation testing, which our team affectionately nicknamed “The BORG” due to its resemblance to the Star Trek entity. The system is designed to take up less storage space, maintain proper frozen conditions for extended periods and provide real-time data for operators worldwide. We are also collaborating on a biopreservant that allows for cryogenic freezing without using DMSO, a widely used but toxic preservation agent. This new biopreservant aims to be safer and more effective, potentially revolutionizing the cryopreservation process by reducing reliance on toxic substances and improving outcomes for cell and tissue preservation.

We are partnering with NASA on projects that require materials capable of withstanding extreme conditions in space. This collaboration allows us to push the boundaries of cryogenic science while contributing to advancements in space exploration.

What accomplishment are you most proud of? What was the challenge, and how did you and/or your team meet it?
The development and enduring success of our CryoLoc™ product line is an achievement I am incredibly proud of. This flagship product has become the benchmark for flexible cryogenic packaging, renowned for its reliability and user-focused design.

One challenge was ensuring that the packaging could endure the extreme conditions of cryogenic storage and transport while remaining easy and safe for medical professionals to handle. A breakthrough feature is the debris-free peel of the overwraps, which ensures clean and efficient use in sterile environments. Achieving this required extensive research, development and collaboration with the medical community to refine the design.

Today, CryoLoc™ maintains an impeccable track record, with millions of patients worldwide benefiting from therapies preserved and delivered using this packaging. This accomplishment reflects our team's commitment to quality, innovation and meeting the needs of healthcare professionals.

What advancements in cryogenics are you hoping to make in the future?

We are striving for a breakthrough in developing a non-DMSO cryopreservant, which would be transformative for the industry. This safer, more effective alternative would enhance safety, streamline workflows, and it would expand applications in regenerative medicine and biotherapeutics.

Beyond that, we aim to innovate in cold chain storage, space materials and cryogenic processes that address the evolving needs of the biotech and medical industries. By staying at the forefront of cryogenic science and collaborating with industry leaders, we hope to shape the next generation of solutions that advance healthcare and other critical fields.

What advances for women would you like to see in the fields of cryogenics and superconductivity?

I'd like to see more representation and visibility for women in these fields. Mentorship programs, sponsorship opportunities and initiatives that support career growth are essential. Promoting awareness of how impactful cryogenics is—whether in healthcare, agriculture, biotherapeutics, or space exploration—can inspire young girls and early-career women to pursue these paths. It's also important to foster inclusive workplace cultures with equitable hiring practices, flexible work opportunities and collaborative environments. Diversity enriches the entire field by driving creativity and ensuring solutions meet a broader population's needs.

What would be the best approach to getting more women into your field?

It starts with early exposure to STEM fields through hands-on learning, mentorship and representation. Programs like coding camps, science clubs and school-industry partnerships can plant the seeds of interest in engineering and cryogenics. For women already in the workforce, clear pathways for growth and advancement are crucial. Companies must prioritize equitable hiring, mentorship and professional development. Networking programs and industry-specific organizations also help create a supportive community. Visibility of women thriving in these fields is key. When women see others succeeding as scientists, engineers and leaders, they can better envision themselves in similar roles. Together, these efforts can create a more inclusive and inspiring environment for women in cryogenics and superconductivity.

BS&B Safety Systems Accelerates Service to OEMs

by Del Williams, Communications

OEMs in virtually every market, from aerospace and automotive to refrigeration and fire protection, rely on rupture disk devices for pressure relief and pressure release of gases and liquids. The challenge of time faces all product designers; how do we get a custom solution in an acceptable timeframe?

Now, at least one industry innovator has streamlined the prototype process to expedite the delivery of customized solutions that meet a wide range of unique application requirements. Taking its cue from racing car pit crews, the fast-tracked development process involves the coordination of specialized internal teams with unique skill set to ensure timely delivery of dependable prototypes that are prepared for evaluation, additional adjustments, or full-scale production.

The expedited custom prototype program results in high quality rupture disks that quickly progress from concept to production-level performance. Credit: BS&B Safety Systems

Global Demand for Innovative Rupture Disk Designs

With the global energy pivot that is occurring combined with stronger sustainability strategies, the 2020s mark an aggressive period of innovation that impacts industries from transportation (air, rail, ship, road), to electric energy transmission, distribution and storage, with implications for the chemicals and systems such as refrigeration and fire protection that support these technologies. The pace of creativity is faster than ever with OEM product development cycles compressed to achieve the fastest entry to market.

"OEMs often require a unique rupture disk in terms of its dimensions, material combinations, or operating conditions. In many cases, the rupture disk is a last-minute consideration once other design parameters are defined and so they need a custom prototype delivered within relatively tight timelines as part of their product development," says Geof Brazier, Managing Director, BS&B Safety Systems, Custom Engineered Products Division.

OEMs increasingly require expedited delivery of prototypes without compromising on quality or performance. Recognizing the need, BS&B Safety Systems developed a comprehensive support program called the Prototype Introduction Team (PIT) for OEMs that require a 'white glove' experience for custom rupture disk devices.

According to Brazier, the program was developed and patterned after the race car pit crew strategy, where highly trained individuals quickly and seamlessly work together - each with a specific role in the process and with a high degree of anticipation of the customers' requirements. The PIT™ crew's individual responsibilities are fine-tuned for maximum efficiency, in coordination with the other members of the crew since every step can be critical to winning.

Achieving such rapid turnarounds requires meticulous planning, rigorous training and exceptional teamwork. At BS&B, the PIT team involves experts assembled from sales, engineering, purchasing, manufacturing and quality control. The PIT team incorporates design engineering throughout and manages all aspects of scheduling to ensure quality, performance and aesthetic condition with on-time completion and delivery.

According to Brazier, the PIT Program design team's expertise extends from rupture disks and buckling pin valve technology to explosion protection and prevention devices. The custom engineered products team has decades of machining experience, which now embraces 3D printing capabilities to reduce the time required for prototype manufacture.

One area of application that benefits from the PIT program is pressure safety management for e-mobility systems. In this case, BS&B manufactures battery pack and cell pressure relief e-vents used in the e-mobility industry, each of which must be tailored to each project to ensure design flexibility and required burst pressures.

BS&B typically streamlines the process of battery vent selection by offering an array of technology that can be customized. With this approach, many different design alternatives can be quickly winnowed down to those that work the best for the application. For the rupture disk application interface, choices such as threaded, clamped, bolted, snap-fit, quarter turn, or adhesive bonding can be chosen.

Taking its cue from racing car pit crews, the fast-tracked development process involves the coordination of specialized internal teams with unique skill set to ensure timely delivery of dependable prototypes. Credit: Courtesy of BS&B Safety Systems, KOTOIMAGES/Shutterstock.com

Additional considerations available to the OEM can include novel product marking, inclusion of integral flame arresters or Burst Alert® sensors, as well as cleaning, custom packaging and certifications. Extensive validation capabilities further support the OEM to achieve project targets on time and on budget.

"Every application is unique, so questions inevitably arise. To ensure the OEM can get answers at any time during prototype creation, we assign a project manager to serve as a single point of contact," says Brazier, adding that close coordination not only reduces potential technical issues but also supports the customer who may have evolving design factors that impact the pressure relief device and may trigger a running change.

According to Brazier, the PIT program's coordination and attention to detail has accelerated product development of custom rupture disks and accelerated OEM design decision-making.

For OEMs, the expedited prototype program results in rupture disks that quickly progress from concept to production level performance, price and quality.

The expedited custom prototype program results in high quality rupture disks that quickly progress from concept to production level performance. Credit: BS&B Safety Systems

"Approximately two-thirds of our prototypes progress to the next development step," explains Brazier. "Some become another prototype. Others move quickly into full production."

Rupture disk devices are a vital safety technology that can protect OEM equipment from potentially damaging overpressure or vacuum conditions in various processes. When customization is necessary to accommodate the OEM's specific processes, working with an expert partner capable of expediting prototyping can dramatically improve the equipment's reliability and longevity while reducing maintenance and overall cost of ownership. **www.bsbsystems.com**

Zenno Astronautics Gains Global Momentum with New Investment Round

by Sandra Lukey, Communications

In a landmark moment for Australasia's space sector, New Zealand-based Zenno Astronautics has closed a significant seed expansion investment round led by local venture capital firm Global From Day One (GD1). The round includes participation from some of Japan's most influential players, marking their first venture into the Australasian market.

The investment was spearheaded by Global Brain, one of Japan's largest venture capital firms, representing ANA HOLDINGS and Mitsubishi Electric. With over USD 2 billion in assets under management, Global Brain's decision signals strong international confidence in Zenno's superconducting technology for space applications.

Z01, the world's first superconducting magnetic torquer for fuel-free spacecraft attitude control. Credit: Zenno

A Leap for Superconducting Space Technology

Zenno Astronautics is at the forefront of developing superconducting technologies for the space industry. Its flagship product, the Z01, is the world's first superconducting magnetic torquer designed for fuel-free satellite positioning. The Z01 offers unparalleled precision, enabling satellites ranging from small 50kg devices to space station-sized platforms to reposition without the need for traditional propellants.

"Zenno builds for life in space," said Max Arshavsky, co-founder and CEO of Zenno Astronautics. "Our mission is to create enabling and highly scalable technologies that will allow humanity to prosper in space without dependence on Earth's resources, such as fuel and frequent resupply missions."

Arshavsky emphasized that the partnerships forged in this funding round would accelerate Zenno's progress. "Global Brain's expertise and their lead, Mr. Hidetaka Aoki, who joins our board as an observer, bring invaluable insight to our efforts. Collaborations with ANA HOLDINGS and Mitsubishi Electric ensure that our technology reaches and thrives in the Japanese market."

Strengthening International Ties

This investment round not only showcases Zenno's technological prowess but also highlights the growing partnership between New Zealand and Japan in the space sector.

"Zenno was the first company to take superconducting electromagnets to space," said Arshavsky. "Meanwhile, Japan leads the world in terrestrial applications and production of superconducting technologies. Together, we're advancing a shared vision for a thriving space ecosystem."

Global Brain's CEO, Yasuhiko Yurimoto, echoed these sentiments. "This represents Global Brain's first investment in New Zealand, and we are thrilled to support Zenno's groundbreaking innovations in superconducting technology for space applications. We are committed to leveraging our resources to support Zenno's global growth and expansion into the Japanese market."

Expanding Japanese Partnerships

In addition to the investment, Zenno Astronautics has signed a Memorandum of Understanding (MOU) with ANA Trading, a member of ANA Group, Japan's leading airline group. With the slogan "Next Stop, Space," ANA Group has identified space exploration as a strategic priority.

Under the agreement, ANA Trading will leverage its deep knowledge of aerospace industries to create business opportunities for Zenno in the Japanese market. The initial focus will be deploying Zenno's Z01 superconducting magnetic torquers for high precision satellite positioning.

The Z01 is engineered to address demanding requirements for satellites of all sizes, from 50kg devices to space station-scale platforms, enabling satellites to reposition in orbit and maximize their commercial value.

"We are excited to be part of the Japanese space ecosystem with our partnership with ANA Trading," said Arshavsky. "This collaboration will accelerate our growth in the Japanese market and supports Zenno's vision to build for life in space."

The partnership also paves the way for future collaboration on an ambitious roadmap of new technologies aimed at enhancing the competitiveness of the Japanese space industry.

Showcasing at ISIEX 2025, Revolutionary Applications

As part of the partnership, ANA Trading will exhibit Zenno's Z01 superconducting magnetic torquer at the ISIEX 2025 International Space Industry Exhibition. The event took place on January 29-31, 2025, at Tokyo Big Sight, South Hall. This marks a significant milestone in showcasing Zenno's cutting-edge technology to industry leaders and solidifying its presence in the global space sector.

Zenno's Z01 technology is just the beginning. While the immediate focus is on precision satellite positioning, the company is also exploring applications in radiation shielding and novel forms of propulsion—key challenges for long-term human habitation in space. By eliminating dependence on traditional fuel and enhancing scalability, Zenno's technology paves the way for more sustainable and economically viable space missions.

"The ability to reposition satellites efficiently and reliably is critical for maximizing their commercial value," said Arshavsky. "Our superconducting electromagnets are engineered to deliver unmatched reliability and scalability, making them ideal for the next generation of space infrastructure."

A Collaborative Ecosystem for Space Innovation

The funding round's diverse group of investors underscores the collaborative nature of the global space industry. Alongside Global Brain, contributions came from New Zealand's GD1, Shasta Ventures and other existing investors, including Nuance, K1W1, UniServices and New Zealand Growth Capital Partners (NZGCP)'s Aspire Seed Fund.

ANA HOLDINGS and Mitsubishi Electric's involvement further validates Zenno's technology. ANA, Japan's largest airline group, is a leader in aerospace innovation, while Mitsubishi Electric's century-long legacy in advanced electronics and space systems makes it an ideal partner for Zenno's cutting-edge developments.

Left to right: Zenno Astronautics co-founders Sebastian Wieczorek (CIO and Head of Product) and Max Arshavsky (CEO) with Dr Reuben Brown (COO), and Erica Lloyd (CRO). Credit: Zenno

Max Arshavsky, Co-founder and CEO, Zenno Astronautics. Credit: Zenno

Looking Ahead

With this new wave of investment, strategic partnerships and initiatives like the collaboration with ANA Trading, Zenno Astronautics is well positioned to expand its global footprint and continue innovating in the field of superconducting technology.

As the space economy grows, solutions like the Z01 will be instrumental in overcoming technical challenges and enabling new possibilities for exploration and commercialization.

"This investment round is not just about funding; it's about building a network of partners who share our vision," Arshavsky concluded. "Together, we're laying the foundation for a future where humanity thrives in space." **www.zenno.space**

Ebara Elliott Energy Secures Leadership in Testing Capabilities with Major Electrical Upgrade

by Meagan Price, Manager, Corporate Communications, Ebara Elliott Energy

Ebara Elliott Energy (EEE), a key solution provider in the energy industry, has announced a significant electrical upgrade at its Jeannette, Pennsylvania manufacturing facility. This development marks a critical step in the company's effort to enhance its compressor and electrical equipment testing capabilities. Upon completion, EEE will have the capability to test up to 100 megawatts (MW) or approximately 134,102 horsepower, solidifying its position as a leader in large horsepower compressor testing.

Ron Josefczyk, Vice President of Global Manufacturing at EEE, emphasized the strategic importance of this upgrade: "With the industry moving toward more electrification of large primary drivers, this upgrade positions Ebara Elliott Energy to be the leader in large horsepower compressor testing capability, being a one-stop shop for manufacturing, testing and service for turbomachinery that few global companies can provide."

Ebara Elliott's upgrade will enable testing compressors and electrical equipment up to 100MW (or 134,102 horsepower). Credit: Ebara Elliott

Comprehensive Project Execution

Capability studies for the upgrade began in collaboration with First Energy in late 2022, followed by detailed assessments, planning and engineering by EEE's team. Groundbreaking commenced in August 2024 with the installation of a new electrical line between a local substation and the Jeanette facility. Drilling for new utility poles began in October 2024. The project is slated for completion and full operational status in the third quarter of 2025.

Key components of the upgrade include:

- A main 138Kv breaker to provide protection and control for incoming utility power.

- A 100MVA power transformer to step down voltage from 138Kv utility power to a usable 34.5Kv for the Jeannette facility.

- Capacitor banks to regulate voltage, ensuring consistent power delivery and protecting equipment from voltage fluctuations.

- 34.5Kv breakers to safeguard downstream electrical equipment.

Enhanced Testing Scope and Industry Leadership

The upgraded facility will primarily test multistage centrifugal compressors driven by Variable Frequency Drive (VFD) motors. Although cryogenic pump and expander test stands remain separate from this upgrade, refrigeration compressors operating at cryogenic temperatures in service will undergo factory tests at ambient temperatures.

The upgrade supports EEE's mission to meet customers' evolving environmental and efficiency standards. According to Mark Babyak, Vice President of New Apparatus Sales, "Expanding our testing capabilities in Jeannette will enable us to help customers transition to greener solutions for a sustainable future." Specifically, the LNG market benefits from the enhanced capabilities as motor-driven primary refrigeration compressors offer cleaner emissions and efficiency improvements compared to gas turbine-driven alternatives.

Competitive Edge and Market Position

EEE's expanded testing capabilities provide a distinct advantage over competitors by enabling full-load testing of large motor-driven compressors that exceed existing industry standards. This positioning enhances EEE's ability to serve as a comprehensive partner in turbomachinery solutions.

While the project is progressing on schedule for a third-quarter 2025 completion, EEE acknowledges potential risks such as delays in the delivery of critical electrical components. "Challenges include the delivery of electrical components, similar to the challenges we are experiencing with our primary products," an EEE representative noted. Despite these challenges, current project progress indicates that timelines remain achievable.

Ebara Elliott Energy's investment in state-of-the-art testing capabilities reflects its commitment to innovation and leadership in the energy sector. The Jeannette facility's electrical upgrade not only strengthens its competitive position but also underscores its dedication to providing sustainable, high-performance solutions for its global customers. **www.elliott-turbo.com**


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The Cryomech PT205: A Compact Cryocooler with a Wide Range of Applications

by Mark Roberts, Bluefors

In today's rapidly evolving technological landscape, the demand for efficient and compact cryocoolers is more critical than ever. A wide range of applications increasingly require high performance cooling systems that can seamlessly integrate into limited spaces. Smaller cryocoolers prove invaluable in these contexts, offering the precision and reliability necessary to support advanced scientific and industrial applications without compromising space or energy efficiency.

The new Cryomech PT205 is an excellent example of a compact, high performance, two-stage pulse tube cryocooler designed to meet the cooling requirements of advanced scientific applications, including superconducting nanowire single-photon detectors (SNSPDs). This cryocooler is engineered to provide substantial cooling power at ultralow temperatures.

The substantial cooling power ensures reliable performance in demanding environments. Its key specifications include delivering a minimum of 10 milliwatts of cooling power at 2.5 K while consuming only 1.3 kW of power at 60 Hz. This makes the PT205 an energy-efficient and cost-effective option, an essential consideration for long-term operations in scientific and industrial settings where budget and operational efficiency are critical.

A standout feature of the PT205 is its pulse tube technology, which eliminates the need for moving parts in the cooling process. This design results in significantly lower vibration levels compared to traditional cryocoolers that rely on moving components. The absence of moving parts also reduces the mechanical wear and tear that can lead to system maintenance, enhancing the PT205's reliability and longevity. This is particularly valuable in applications where even the smallest vibrations can disrupt sensitive equipment or measurements.

Compact, efficient and low vibration, the Cryomech PT205 delivers precision cooling for advanced scientific applications. Credit: Bluefors

The PT205 plays a vital role in supporting superconducting technologies, particularly in the field of SNSPDs. SNSPDs are used to detect single photons, which makes them invaluable in quantum optics, communications and other applications requiring precise photon detection.

Measuring approximately 11" in length, from room temp to second stage, and weighing 19 pounds, the PT205 meets this need by providing the necessary cooling power in a compact and energy-efficient design. This cooling ensures that the nanowires within the detectors remain at the required temperature to operate at their full potential, allowing researchers to carry out sensitive measurements.

Another benefit of the PT205 is its lower cost of ownership. The absence of moving parts and compact design reduces both its initial cost and maintenance requirements over time. As a result, the PT205 has a longer lifespan and requires fewer refurbishments over its operational life compared to other cooling systems. Additionally, the PT205's energy efficiency, operating at just 1.3 kW of power consumption at 60 Hz, further contributes to its cost-effectiveness, as it minimizes energy usage while delivering substantial cooling power.

The PT205 offers an exceptional balance of performance, reliability and cost-effectiveness for demanding cryogenic applications. Its ability to deliver 10 milliwatts of cooling power at 2.5 K with only 1.2 kW of power consumption makes it an efficient solution for advanced technologies requiring cryogenic temperatures.

The innovative pulse tube design significantly reduces vibration and mechanical wear, enhancing system longevity and minimizing maintenance needs. With its energy efficiency, reduced operational costs and compact design, the PT205 is a durable and practical choice for long-term, high-performance cooling in an array of scientific applications. **www.bluefors.com**

Cool Fuel

by Dr. Jacob Leachman, Professor, Washington State University, jacob.leachman@wsu.edu

The Nobel History of Cryogenics

Many years ago, a friend of mine, who is a professor of engineering, said to a group I happened to be in, "Nothing practical or good has ever come out of cryogenics." The truth is that statements like these are not surprising. We cryogenicists tend to be both humble and busy behind the scenes – not the type for social media. The last true showman in cryogenics may have been James Dewar. Perhaps we're due for a little bragging.

I was fortunate enough to watch Ray Radebaugh overview the history of US cryogenics and some of the Nobel Prizes at the 2015 Cryogenic Engineering Conference. This inspired me to go through the full prize lists for Physics and Chemistry to see how many were explicitly derived from or relied upon cryogenics in some way.[1,2] While not an all-encompassing list of societal benefits, it's at least a respectable place to start gauging the "goodness" of our field.

Although Dewar was nominated several times, he never won a Nobel himself. However, his silvered vacuum flask that enabled hydrogen liquefaction led to many other Laureates, as the first four on the list stem directly from liquid hydrogen systems.

In total, I counted 26 of the 234 awarded prizes as being related to cryogenics. What's more, 17 of these have come since the halfway point in 1967, so the rate seems to be increasing. We should expect this trend to continue with future awards likely coming in the areas of quantum computing, fusion energy, astronomy and clean fuel. This is a truly impressive total, considering the number of researchers in cryogenics.

Some on the list could fall into a "maybe" category. For example, the citation from Peter Debye, who contributed the Debye model describing the heat capacities of metals at cryogenic temperatures, doesn't directly reflect cryogenics.

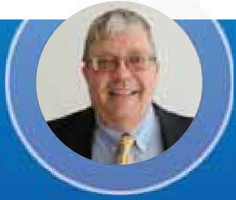
Table 1: List of Nobel Laureates by year with citation.

Year	Laureate(s)	Citation
1910	Johannes van der Waals	"for his work on the equation of state for gases and liquids"
1913	Heiki Kamerlingh Onnes	"for his investigations on the properties of matter at low temperatures which led, inter alia, to the production of liquid helium"
1932	Werner Heisenberg	"for the creation of quantum mechanics, the application of which has, inter alia, led to the discovery of the allotropic forms of hydrogen"
1934	Harold Urey	"for his discovery of heavy hydrogen"
1936	Peter Debye	"[for his work on] molecular structure through his investigations on dipole moments and the diffraction of X-rays and electrons in gases"
1949	William Giauque	"for his contributions in the field of chemical thermodynamics, particularly concerning the behavior of substances at extremely low temperatures"
1960	Donald A. Glaser	"for the invention of the bubble chamber"
1962	Lev Landau	"for his pioneering theories for condensed matter, especially liquid helium"
1963	Eugene Wigner	"for his contributions to the theory of the atomic nucleus and the elementary particles, particularly through the discovery and application of fundamental symmetry principles"
1968	Luis Alvarez	"for his decisive contributions to elementary particle physics, in particular the discovery of a large number of resonance states, made possible through his development of the technique of using hydrogen bubble chamber and data analysis"
1972	Bardeen, Cooper, Schrieffer	"for their jointly developed theory of superconductivity, usually called the BCS theory"
1973	Esaki and Giaever	"for their experimental discoveries regarding tunneling phenomena in semiconductors and superconductors, respectively"
1973	Brian Josephson	"for his theoretical predictions of the properties of a supercurrent through a tunnel barrier, in particular those phenomena which are generally known as the Josephson effect"
1978	Pyotr Kapitsa	"for his basic inventions and discoveries in the area of low temperature physics"
1987	Dgednorz and Muller	"for their important break\\through in the discovery of superconductivity in ceramic materials"
1991	Richard Ernst	"for his contributions to the development of the methodology of high resolution nuclear magnetic resonance (NMR) spectroscopy"
1994	Brockhouse	"for the development of neutron spectroscopy" and "for pioneering contributions to the development of neutron scattering techniques for studies of condensed matter"
1994	Clifford Shull	"for the development of the neutron diffraction technique" and "for pioneering contributions to the development of neutron scattering techniques for studies of condensed matter"
1996	Lee, Osheroff, and Richardson	"for their discovery of superfluidity in helium-3"
1997	Chu, Cohen-Tannoudji, Phillips	"for development of methods to cool and trap atoms with laser light"
1998	Laughlin, Stormer, Tsui	"for their discovery of a new form of quantum fluid with fractionally charged excitations"
2001	Cornell, Wieman, Ketterle	"for the achievement of Bose–Einstein condensation in dilute gases of alkali atoms, and for early fundamental studies of the properties of the condensates"
2003	Abrikosov, Ginzburg, Leggett	"for pioneering contributions to the theory of superconductors and superfluids"
2013	Englert, Higgs	"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"
2017	Weiss, Thorne, Barish	"for decisive contributions to the LIGO detector and the observation of gravitational waves"
2017	Dubochet, Frank, Henderson	"for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution"

Sir James Dewar lecturing on liquid hydrogen at the Royal Institution. Credit: Royal Institution

It would be challenging to rule out key cryogenics experience as not having contributed. Others, such as the 1994 Nobel for neutron scattering, simply used cryogenics to enable the work but didn't have this as an emphasis. Feel free to be as strict or loose as you like.

Regardless, I'll raise my silvered vacuum flask to toast the many cryogenicists who contributed to these awards, leading to many societal benefits. I suppose we could even use the 1991 Nobel, which resulted in MRI machines, to non-invasively scan my friend's head to see what pieces were missing.



Cryo Bios

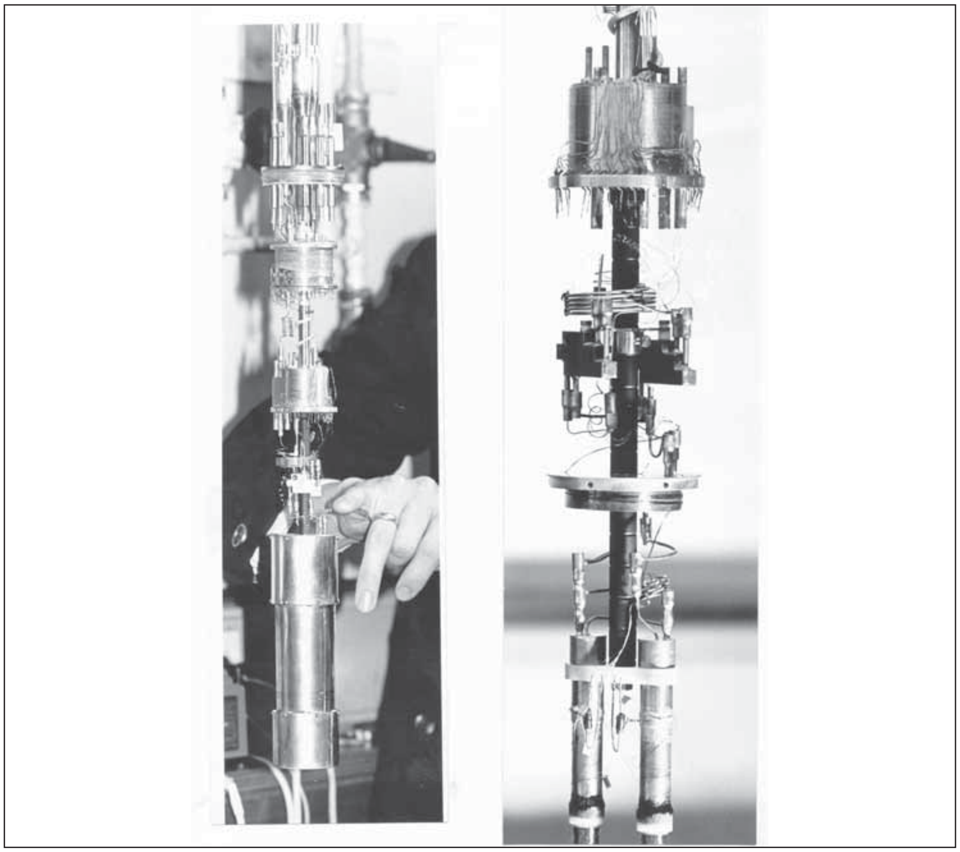
by Dr. John Weisend II, European Spallation Source ERIC, CSA Chairman, john.weisend@esss.se, with Anne DiPaola, *Cold Facts* Editor

Fons de Waele

Fons de Waele's distinguished career in cryogenics is marked by pioneering research, groundbreaking collaborations and an enduring dedication to education. From his early days as a student to his ongoing advisory roles, de Waele has made invaluable contributions to fields such as dilution refrigeration, pulse-tube refrigerators and superconductivity, influencing both theoretical foundations and real-world applications.

De Waele's journey into cryogenics began during his studies at Leiden University in the 1960s, where he pursued a curriculum combining theoretical and experimental physics. In 1966, he joined the Kamerlingh Onnes Laboratory and became part of a team exploring the Josephson effect, a phenomenon that had been predicted only a few years earlier. His doctoral research, completed in December 1972, provided critical insights into superconducting systems, including the governing equations of the DC SQUID. These equations have since become standard references in the field and have laid the foundation for advancements in superconducting technology.

After completing his Ph.D., de Waele joined the Eindhoven University of Technology, where he spent the entirety of his professional career. Initially, he focused on dilution refrigeration, a field that captivated him from 1973 to 1994. During this time, he was instrumental in developing new refrigeration techniques, including an inverted double mixing chamber capable of achieving sub-8 mK temperatures and a dilution refrigerator that operated without a 1 K bath. His research also explored the thermodynamics of helium-3 and helium-4 mixtures, uncovering the critical velocity of helium-3 when flowing through helium-4. These advancements not only expanded the practical applications of dilution refrigeration but also deepened the theoretical understanding of ultralow-temperature systems.

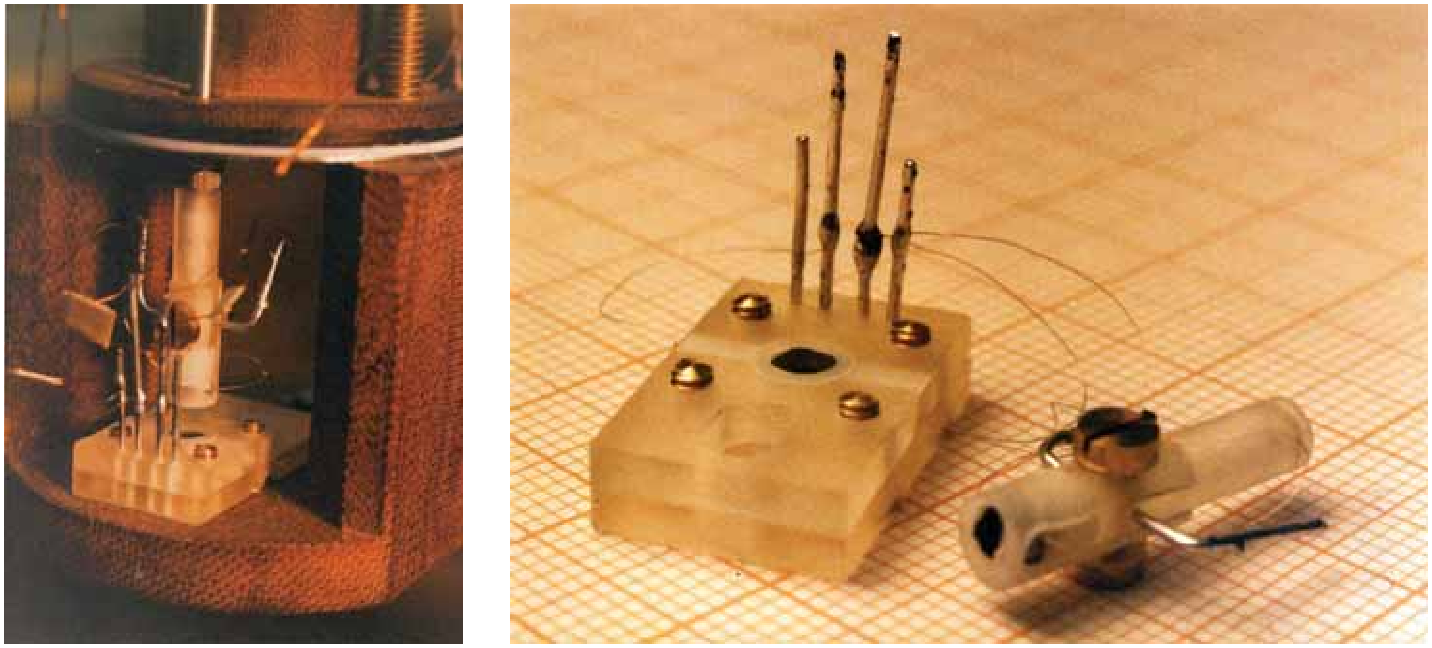


Pictures of the small dilution refrigerator of the low temperature group in Eindhoven. This DR has made more than 1000 cool-downs. One of the projects was the development of the double mixing chamber (right) breaking the 8 mK temperature barrier. Credit: A.Th.A.M. de Waele, A.B. Reekers, and H.M. Gijsman, A 3He circulating dilution refrigerator with two mixing chambers, Physica, 81B, 323-324 (1976).

In 1995, de Waele transitioned to a new challenge: pulse tube refrigerators, which had recently reached temperatures below 4 K. This shift reflected his ability to adapt and innovate as the field evolved. During the next phase of his career, he explored the fundamental mechanics of pulse tube refrigeration, including the effects of real-gas behavior and system performance near the low temperature limit. His team also pioneered the use of helium-3 in pulse tube refrigerators, achieving sub-2 K cooling for the first time. These contributions positioned pulse tube refrigerators as a cornerstone technology for modern cryogenics and expanded their utility in fields such as MRI systems and quantum computing.

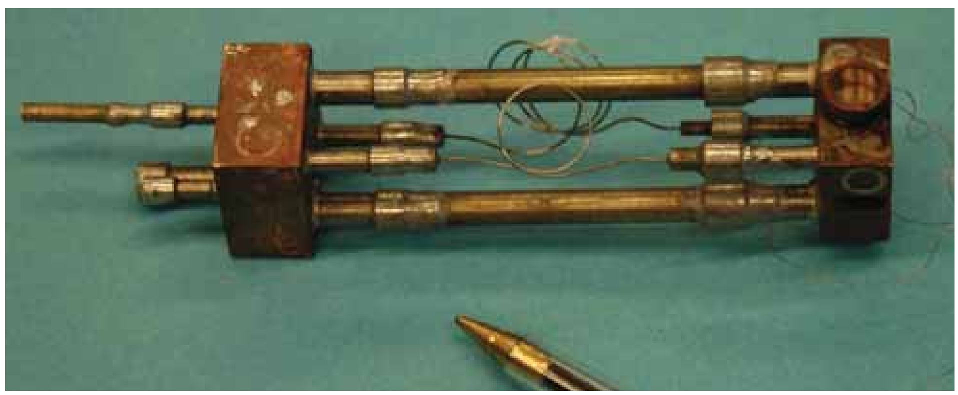
Throughout his career, de Waele combined research with a passion for teaching. At Eindhoven, he taught thermodynamics, mechanics and cryogenics, often emphasizing practical approaches to complex problems. He guided 19 Ph.D. students and organized CryoCourses that brought together European Ph.D. students for immersive training. His teaching also extended beyond Europe, as he delivered short courses on dilution refrigeration and cryocoolers to students and professionals around the world. Even after his retirement in 2001, de Waele continued to share his knowledge, advising on projects involving superconducting motors and other emerging applications of cryogenics.

His career is punctuated by several significant breakthroughs. In addition to his early work on superconductivity and the Josephson effect, his innovations in dilution



Improvised setup in which DC SQUID behavior was demonstrated (up to a temperature of 66 K) in high-Tc superconductors for the first time. Credit: A.Th.A.M. de Waele, R.T.M. Smokers, and R.W. van der Heijden, K. Kadowaki, Y.K. Huang, M. van Sprang, and A.A. Menovski, Macroscopic quantum phenomena in high-Tc superconducting material, Physical Review B, 35, 8858-8860 (1987)

refrigeration and pulse tube refrigerators advanced the field in fundamental ways. For instance, his research into the critical velocity of helium-3 in helium-4 mixtures contributed to a deeper understanding of quantum fluids. In collaboration with Sumitomo, he helped facilitate the transfer of pulse tube technology into the commercial sector. A postdoctoral researcher from his team joined Sumitomo and played a key role in the company's development of commercial pulse tube refrigerators, which are now widely used in MRI cryostats and other systems.



Picture of the superfluid vortex cooler which, combined with the pulse-tube refrigerator from Giessen, set the world record for lowest temperature with cryocoolers. Credit: I.A. Tanaeva, A.T.A.M. de Waele, U. Lindemann, N. Jiang, and G. Thummes, The superfluid vortex cooler, J. Appl. Phys., 98, 034911 - 034918 (2005).

De Waele's career also highlights the importance of collaboration and international exchange. He worked with organizations such as Shell on thermoacoustics, the Stirling company on cryogenic systems and Sumitomo on cryocoolers. He was involved in the GRAIL project, which proposed using a large copper sphere cooled to ultralow temperatures to detect gravitational waves. These collaborations reflect his ability to bridge academic research and industrial applications, fostering innovation across disciplines and borders.

The broader field of cryogenics has evolved significantly during de Waele's career. He notes the increasing importance of liquid hydrogen as both a coolant and an energy carrier, particularly in combination with high temperature superconductors. While the discovery of high temperature superconductors was revolutionary, its societal impact remains limited but promising. In the near future, de Waele predicts that this combination of liquid hydrogen and superconductors will lead to practical applications in superconducting motors for ships, trucks, airplanes and fusion reactors. Similarly, the growing interest in quantum computing has reinvigorated research into dilution refrigeration, with efforts underway to scale up cooling systems for larger capacities.

De Waele has also made lasting contributions to the educational and organizational aspects of cryogenics. He was a board member of the Dutch Physical Society and served on the organizing committee for LT25. He authored approximately 100 papers and helped organize CryoSchools to provide young researchers with specialized training in cryogenic techniques. His emphasis on clear, practical teaching methods has left an indelible mark on the next generation of cryogenic scientists.

Today, de Waele remains active in the field as an advisor, lending his expertise to projects that push the boundaries of cryogenic technology. His career, spanning more than five decades, exemplifies the intersection of theoretical exploration, practical innovation and global collaboration. Fons de Waele's legacy continues to inspire researchers and practitioners in cryogenics, ensuring that his contributions will resonate well into the future.

By Jason Wendell, Ariel Dimston, and Santo Padula - NASA Glenn Research Center

Shape Memory Alloys and Lunar Tires

The Lunar Environment Structural Test Rig (LESTR) project is advancing the development of shape memory alloy (SMA) wire as a foundational material for lunar rover tires, capable of withstanding the extreme environments of the Moon, including permanently shadowed regions (PSRs) where temperatures can be as low as 40 K. Lunar rover tires must balance compliance for smooth rides, durability and longevity to support extended missions.

NASA is looking toward spring tires inspired by the Apollo LRV "wire-mesh" tire, and shape memory alloys (SMAs) show promise as an ideal material for manufacturing spring tires due to their reversible phase transformations. SMAs allow for 30× more deformation and perform impressively at JPL Life Test Track 10 km with no noticeable deformations. As such, there is a need to effectively test SMA materials under relevant lunar environment conditions to develop the material properties that meet traction, durability, longevity, efficiency and load capacity requirements.

A key focus of the project is the ability to characterize SMA wire properties under simulated lunar conditions. This work involves identifying suitable SMA chemistries, refining processing techniques to ensure phase stability, and creating a comprehensive material property database for designers to leverage in the development of lunar spring tires.

The project is critical to NASA's mission to enable wheeled exploration in the harsh environments of the Moon. To achieve this, a specialized testing rig has been designed to replicate these conditions, maintaining a vacuum environment and temperatures ranging from 40 K to 125 K. This capability will support iterative evaluation of SMA processing techniques, ensuring the production of materials that meet NASA's requirements for tire durability, efficiency and load capacity.

Figure 1: LESTR hardware model. Credit: NASA

The LESTR test system offers a safer and more efficient approach to low temperature material testing by eliminating the need for cryogens. Instead, it utilizes a cryocooler system with integrated temperature control to achieve precise test conditions. Its rapid inline testing capability allows immediate feedback on SMA wire performance during development, enabling optimization of processing conditions. Beyond SMA materials, the system has potential applications for testing polymers, ceramics, textiles, additively manufactured structures and other materials designed for extreme low temperature environments.

The hardware integrates advanced tensile and four-point bending test protocols aligned with ASTM standards. An Instron Universal Testing System with an integrated

Figure 2: LESTR Assembly. *Credit: NASA GRC*

Who's New in the **Cold Facts Buyer's Guide?**

Cold Facts Buyer's Guide is the place to find suppliers in every area of cryogenics and superconductivity. These are the new suppliers added to the Buyer's Guide since the last issue of *Cold Facts*. Find it online at **csabg.org**.

Isotec Corporation*

Isotec Corporation produces non-magnetic and cryogenic, high frequency RF connectors and cable assemblies. High frequency connectors such as SMPS, 2.92mm and SMPM connectors are also available with cryogenic cupro-nickel or stainless steel cables.

Pelican Wire*

Pelican Wire manufactures custom engineered wire solutions with numerous product-specific applications for the cryogenics industry. The company ontinues to provide engineer-based product development to meet or exceed all technical requirements.

*CSA CSM

thermal vacuum chamber (see Figures 1 & 2) provides precise control of mechanical and thermal conditions. The chamber can maintain pressures as low as 10^{-6} torr. Heat is removed using a cryocooler system with thermal straps, ensuring accurate temperature control throughout the test volume.

Optical extensometry captures strain measurements, while data acquisition tools monitor thermal and mechanical performance metrics. Designed for durability, the first LESTR unit supports up to 100,000 continuous test cycles, with future iterations targeting 10 million and 60 million cycles, a requirement derived from the range of potential lunar tire wheel diameters and range of intended drive distances for lunar missions.

The system operates through a carefully orchestrated sequence. Initial conditions are established by engaging a scroll pump to achieve soft vacuum, followed by a turbo pump to create a hard vacuum within the chamber. Once stabilized, the cryocooler removes heat from the load train, cold box and sample space via thermal straps. Command temperatures ranging from 125 K to 40 K are maintained using integrated heater temperature controls.

During testing, an optical extensometer using digital image correlation measures sample strain, while electrical feedthroughs manage temperature sensors, heater cartridges and load cell data. Dynamic loads are applied via the load head, transmitted through the sample and grounded at the static base, enabling precise performance measurements under controlled conditions.

Significant progress has been made in the conceptualization, design and procurement of the LESTR system. The assembly of the first unit is underway, with initial operation expected in the second quarter. Additional units are planned throughout fiscal year 2026. Investments in laboratory infrastructure and personnel training are ongoing to ensure readiness for testing. The project has already generated substantial interest in its innovative approach to cryogenic material testing.

LESTR supports the closure of numerous NASA-identified gaps in environmental durability and stability for lunar technologies. While not designed to directly address these challenges, it provides an essential toolset for qualifying materials and technologies under the full spectrum of lunar conditions. This capability enables NASA programs to advance the development of materials and systems critically for long-duration lunar missions, contributing to the broader goal of lunar exploration excellence.


by Quan-Sheng Shu, cryospc.com, and Jonathan Demko, Le Torneau University

Superconducting Magnets for Current and Future Accelerators (II)

Collider detectors in superconducting (SC) accelerators are designed to meticulously track, measure, and analyze the properties of particles produced during high energy collisions. They leverage superconducting magnets cooled by various sophisticate liquid helium (LHe) to achieve ultrahigh magnetic fields and efficient energy use, facilitating precise particle acceleration and experimentation.

The large and strong SC magnets (each from tens to thousands of tones) with their LHe liquefiers/distribution systems are the most crucial components in the detectors.[1-3] The detector magnet is used to bend the paths of particles emerging from high energy collisions in the collider. The more momentum a particle has the less its path is curved by the magnetic field, so tracing its path gives a measure of momentum. The strongest magnet can bend paths more and allows accurate measurement of the momentum of even high energy particles.

Prodigious Achievements by Detectors with SC Magnets

By connecting Nobel-winning ideas to collider-driven discoveries, one can appreciate how these instruments with SC-cryogenic components continue to bridge the gap between conceptual breakthroughs and their experimental realization. Collider detectors have revolutionized our understanding of fundamental particles and the forces that govern them. Over the decades, these advanced instruments have been pivotal in discovering phenomena like the Higgs boson, which confirmed the mechanism behind mass generation, and quarks and leptons, which form the foundation of matter. Projects such as those at CERN, Fermilab, SLAC, BNL, DESY and KEK have facilitated global collaborations, uniting physicists to unravel the universe's deepest mysteries.[1,3] These achievements not only push the boundaries of science but also inspire the development of new technologies in imaging, data analysis, superconducting magnets and cryogenics.

Detector	Nobel Prize Year	Recipient(s)	Achievement Related
CDF (Fermilab)	1995	Martin Perl, Frederick Reines	Discovery of the **top quark**, confirming the Standard Model's quark structure.
CMS (CERN)	2013	François Englert, Peter Higgs	Detection of the **Higgs boson**, proving the Higgs mechanism for mass generation.
ATLAS (CERN)	2013	François Englert, Peter Higgs	Shared credit for the discovery of the **Higgs boson** at the LHC.
RHIC (BNL)	2004	Frank Wilczek, David J. Gross, David Politzer	Research supporting the theory of **quark-gluon plasma** and **QCD** interactions.
CMS, CDF etc.	1988	Leon Lederman, Melvin Schwartz, Jack Steinberger	Neutrino discovery at Fermilab
SLAC (Stanford)	1976, 1995	Burton Richter, Samuel Ting; Martin Perl	Discovery of the **J/ψ particle (charm quark)** and the **tau lepton**, expanding particle physics.

Table 1. Key Achievements Linked to Nobel Prizes from SC Magnet-supported Detectors. *Credit: Shu and Demko*

Laureates like P. Higgs and F. Englert, who were awarded for their theoretical predictions validated by collider experiments, exemplify the link between experimental achievements and theoretical advancements. These recognitions highlight the role of collider detectors in validating theories and transforming them into celebrated milestones in science. Table 1 captures the significant detectors' contributions to discoveries that earned Nobel Prizes directly or through their critical experimental infrastructure.

Fermilab's Tevatron is the first SC accelerator and the first utilizing the largest SC solenoid magnet in its collider detector (CDF) then in the world, illustrated in Figure 1.[4] The CDF focused on high energy proton-antiproton collisions, discovered top quark, studied Higgs boson, carried precision measurements of these particles and searched new physics.

The CDF Detector Superconducting Magnet is a cylindrical solenoid, approximately 4.8 meters in length with 3 m OD – 2.8 m ID, with a weight of SC magnet around 40 tons (if including yoke, about ~500 tones).[5] The hollow-shaped design provides space for the tracking system and calorimeters inside the magnetic fields. It uses NbTi SC cables generating a uniform magnetic field of 1.4 tesla within the detector and operates at cryogenic T of ~ 4.2 K LHe to maintain superconductivity. The cryostat houses the SC coil with its LHe vessel in a very narrow and long vacuum space and minimizes heat ingress. Thermal insulation is achieved using vacuum MLI to minimize heat transfer. The solenoid is supported by a rigid frame to handle Lorentz forces during operation, while suspension systems reduce thermal and mechanical vibrations for stability as shown in Figure 1. The Liquid Helium (LHe)

Refrigeration Plant for the CDF Detector has a capacity of ~500 W at 4.5 K, providing the necessary cooling to the SC magnet at cryogenic T.

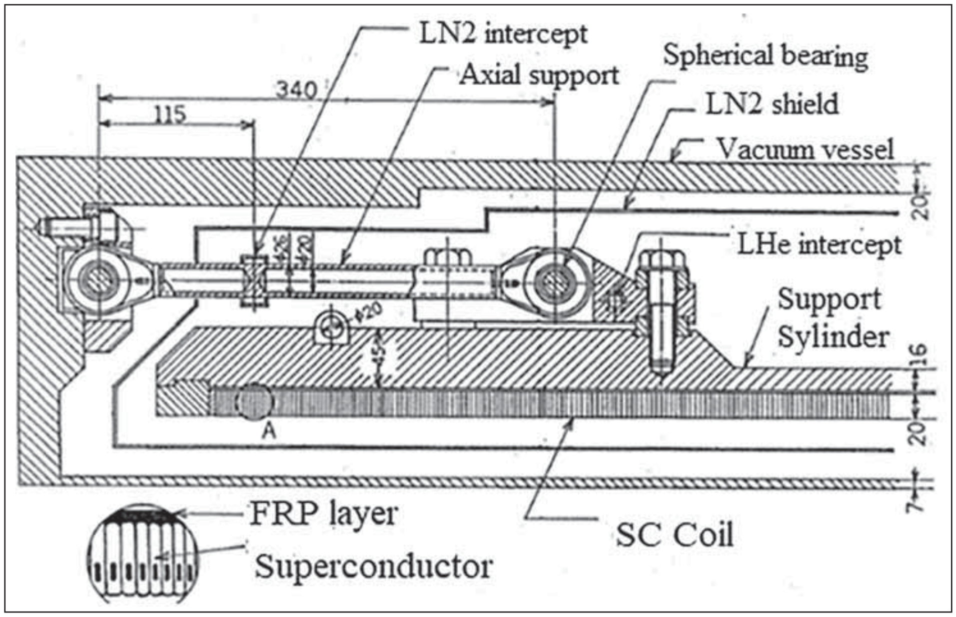
World's Largest SC Solenoid Magnets for CMS Detector

The Compact Muon Solenoid (CMS) is a general-purpose detector at the Large Hadron Collider (LHC). It has a broad physics program ranging from the Standard Model (including the Higgs boson) to dark matter, etc. The CMS detector (14,000 tons) is built around a huge solenoid magnet (Figure 2). This takes the form of a cylindrical coil of superconducting cable that generates a field of 4 tesla, The field is confined by a steel "yoke" that forms the bulk of the detector's 12,500-ton weight. The complete detector is 21 m L, 15 m W and 15 m H.[6-7]

This solenoid is the largest magnet of its type ever constructed, which bends the trajectories of the particles and serves two purposes: 1. Identify positive and negative of the charged particle, and 2. Measure the momentum of the particle. When electricity (18,500 A) is circulated within 220 tons SC magnet (coils and cryostat) generate a magnetic field of ~ 4 tesla with the stored energy of ~ 2.7 GJ. This high magnetic field must be confined to the volume of the detector by the steel "yoke" of 12,500 tonnes, the CMS's heaviest component.

The CMS solenoid employs supercritical helium as its cooling medium, operating at approximately 4.5 K and pressures of 5-6 bar, keeping helium in a supercritical state above its critical T (~5.2 K) and P (~2.2 bar), as illustrated in Figure 3. This state eliminates phase transitions, ensuring homogeneous cooling and precise temperature control across the massive solenoid. Supercritical helium's high density and thermal conductivity enable efficient heat removal, making it ideal for managing the CMS solenoid's immense stored energy of 2.7 GJ and its magnetic field strength of 4 tesla. The cryogenic plant supporting this system has a cooling power of 18 kW at 4.5 K, incorporating advanced helium refrigerators and compressors to maintain supercritical helium conditions, as in Figure 3.[8] The cooling system circulates helium through an intricate

▶ *continues on page 30*



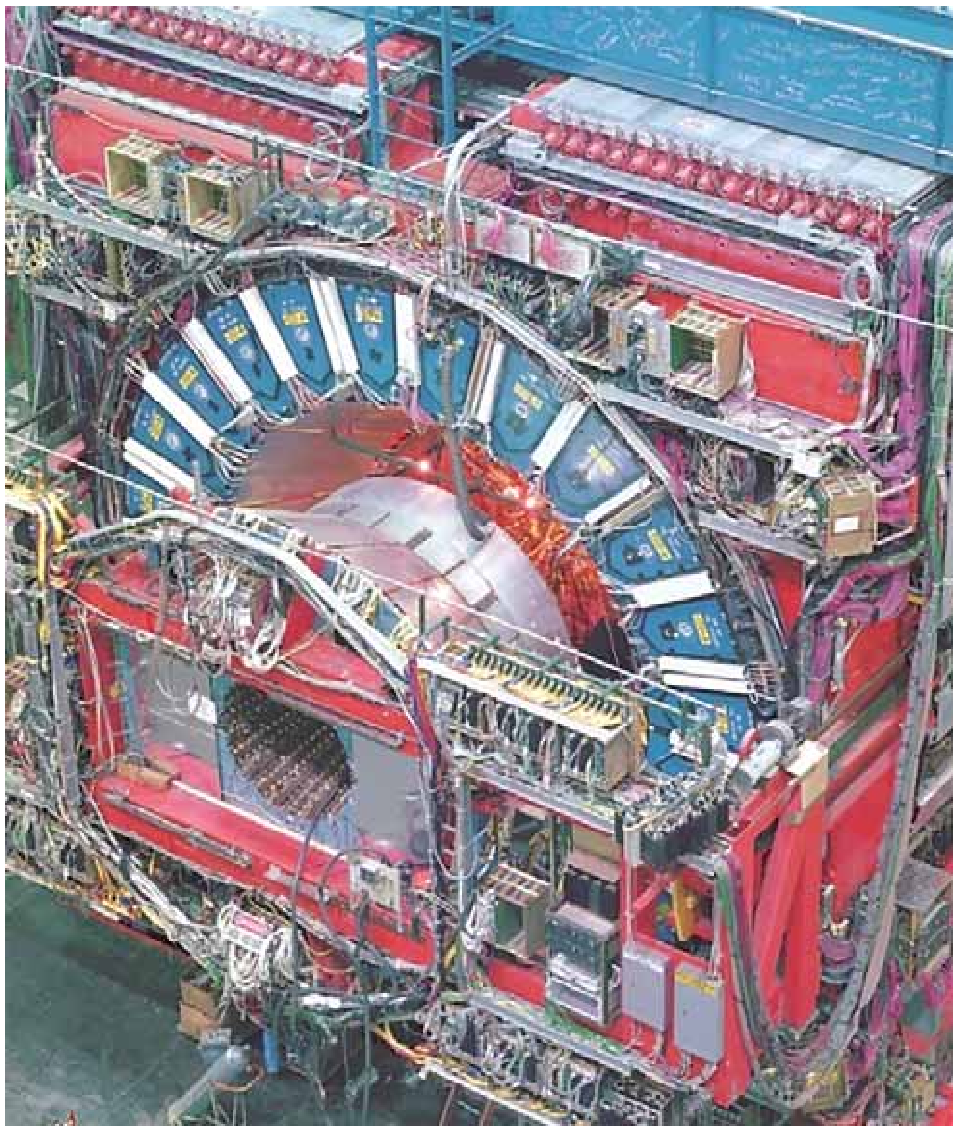


Figure 1. Upper: Design of high thermal efficient support system of CDF Solenoid. [4] Credit: Fast Lower: Photo of CDF detector. Credit: Fermilab

network of channels embedded within the aluminum-stabilized NbTi conductor, ensuring stable and efficient thermal management for one of the world's largest superconducting magnets.

Largest Toroidal Magnet Ever Constructed of ATLAS Detector

The CERN ATLAS detector utilizes the sophisticated types combination of three types of one SC solenoid magnet and two SC toroid magnets.[9-10] The ATLAS solenoid surrounds the inner detector at the core of the experiment. This powerful magnet is 5.8 m long, 2.56 m in diameter (4.5 cm thick), weighs over 5 tons and stored energy 38 MJ. It provides a 2 tesla magnetic field and minimize possible interactions between the magnet and the particles being studied. At 25.3 m in length, the central toroid is the largest toroidal magnet ever constructed, as illustrated in Figure 4. It is unique in particle physics and an iconic element of ATLAS. It uses about ~100 km of SC wire and weighs about 830 tons (370 tuns of cold mass). The end-cap toroid magnets extend the magnetic field to particles leaving the detector close to the beam pipe. Each end-cap is 10.7 m in diameter and weighs 240 tons. The SC magnets are cooled by 4.7 K supercritical LHe.

Extreme Detector Designs for a Future Circular Collider

Encouraged by recent advancements, several ambitious accelerator projects have been proposed globally, including the HL-LHC and FCC at CERN, the Muon Accelerator at Fermilab, the EIC at BNL, Super-KEKB and ILC in Japan, and the SPPC in China.[1-3,11] Among these, the FCC-hh, operating in a 91 km circumference and at 100 TeV, would push the energy frontier nearly tenfold compared to the LHC.[11] Advanced superconducting magnets and cryogenic designs are key to these projects, exemplified by a massive 4 T solenoid and an innovative detector layout, as shown in Figure 5. The dipole magnets are designed to generate fields up to 16 T. The LHe refrigerator for the FCC-hh magnets is designed to provide continuous cooling at temperatures as low as 1.8 K to maintain the superconducting state of

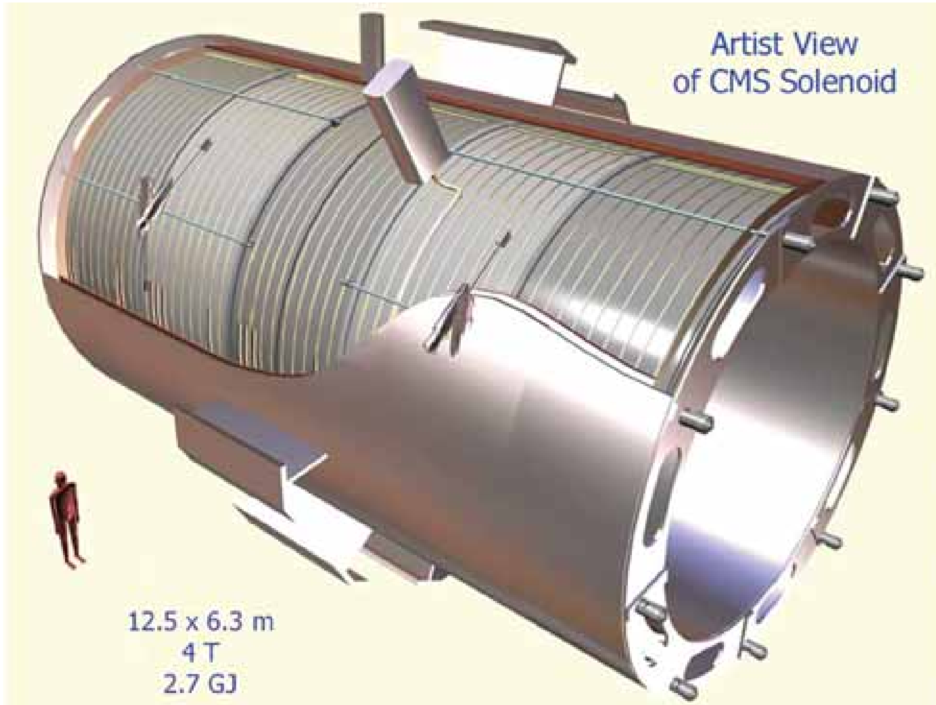


Figure 2. The largest solenoid SC magnet of its type ever constructed for CMS.[7] Credit: Herve

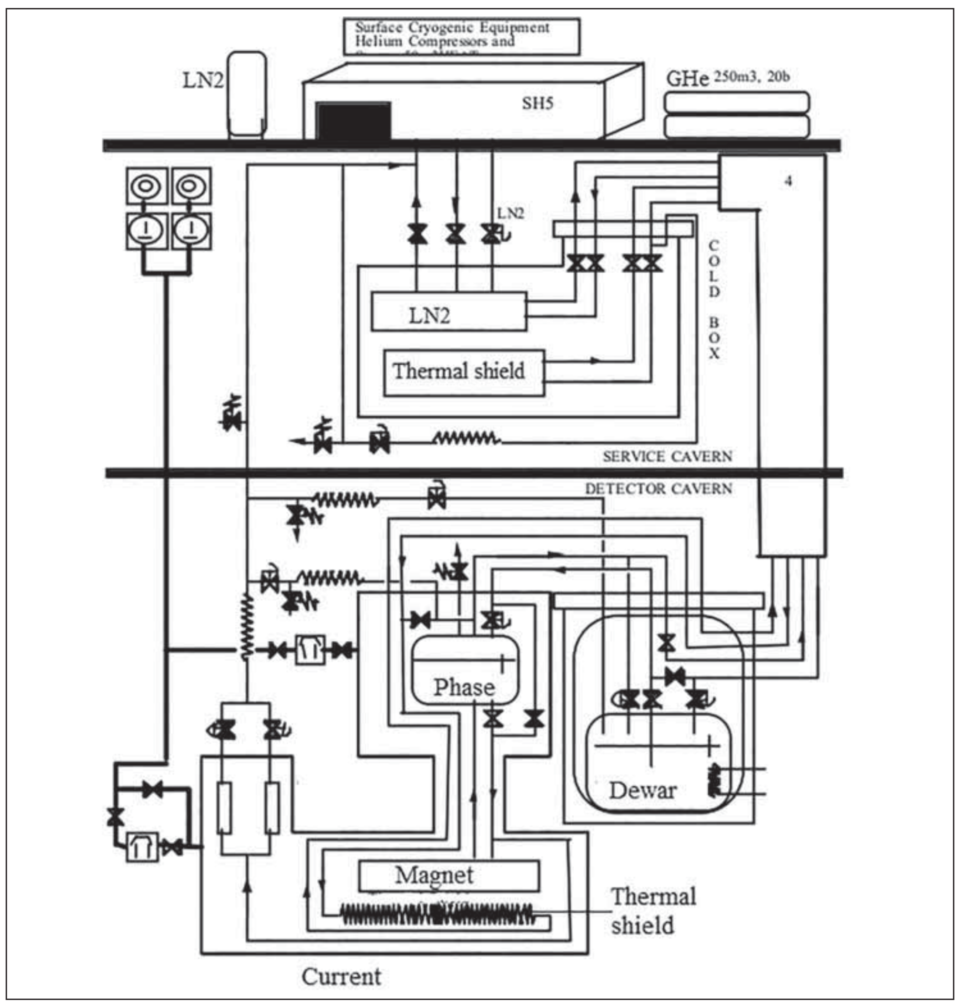


Figure 3. Schematical flow-sheet of the CMS cryogenic equipment.[8] Credit: Delikaris

Figure 4. Central toroidal magnet of ATLAS, first ever constructed in the world. [10] *Credit: Woithe*

the Nb_3Sn magnets. The plan is set to be operational in the 2030–2040 timeframe.

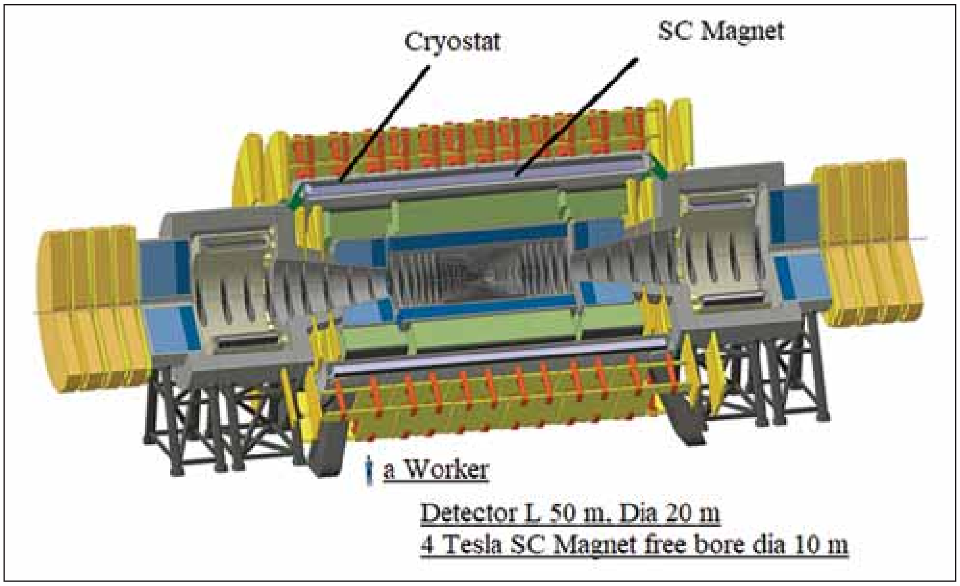


Figure 5. The layout of the FCC-hh reference detector, Dia 20 m, L 50 m. and much heavier than ATLAS detector. The 4T SC magnet with a free bore dia. of 10 m (purple). [11] *Credit: Aleksa*

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by James E. Fesmire, President, Energy Evolution LLC, james@321energy.us

Making Liquid Hydrogen Flow Like Water Part 1 – Utilization of Boiloff

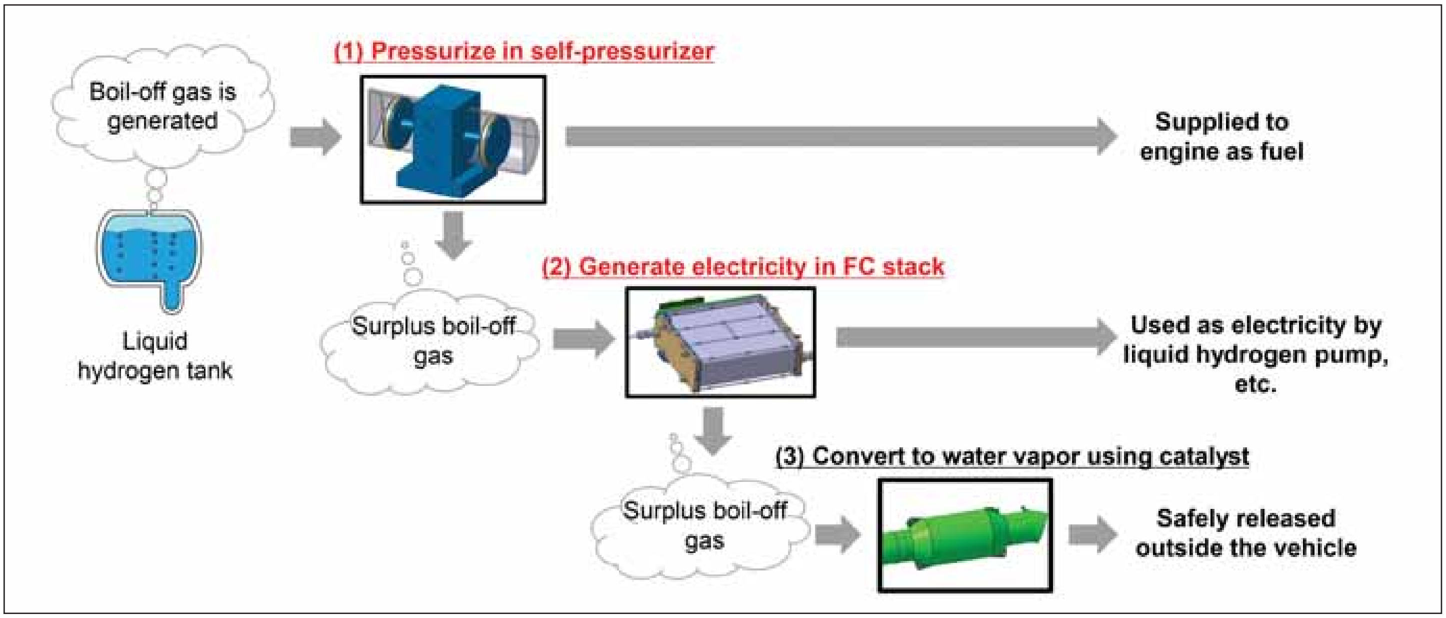

Figure 1. Reusing onboard LH_2 boiloff gas to provide electrical power for vehicle functions. Credit: Toyota[1]

To put liquid hydrogen (LH_2) in the fast lane for transportation and other heavy-duty electric propulsion machines, we must get off the dead-end street called 700-bar high pressure gas storage. And it is beginning to happen that LH_2 onboard is the choice, out of a solution space of one, for these important applications. From the infrastructure side, we call this liquid-to-liquid dispensing. It was only four years ago that liquid-to-gas dispensing became the norm. This move was also born out of a solution space of one due to the sharp limitations, in both energy density and system weight, of 700-bar gas storage.

When I started the Cryogenics Test Laboratory at NASA Kennedy Space Center over 25 years ago, we had two main technology focus areas, thermal insulation systems and refrigerated process systems. From the beginning, the overarching goal I put forward was to make the cryogenic liquid flow like water, first for LN_2 (for superconducting power and other cooling applications) and for LH_2, the harder one, for transportation and energy applications. Previous technology projects under the banners of X30, Space Shuttle, X33 and others provided insights into what to do and what not to do with LH_2.

For clean energy applications to succeed at scale, in the sense of both large-scale high power demands and the wide-scale, ubiquitous adoption of hydrogen-electric machines, the landscape is built around LH_2 and its practical keeping and conveyance in all directions, downstream and upstream of production and usage. And for LH_2 to work, it must not be lost to the atmosphere at amounts of 15%, 25% or even 50%, which is all too familiar to those with experience in LH_2 dispensing.

It doesn't have to be this way, and it no longer is this way. With modern controlled storage systems, the pressure does not build up because the heat is continually being lifted from the bulk liquid inside. With this system, the liquid is densified to a prescribed level so that it can be transferred without loss.

The issue of LH_2 losses, aka "boiloff problem," is solved in three parts. In priority order, these parts are summarized as follows:

1) Condition the liquid so that it can absorb heat: A liquid will not boil if it can absorb heat. The ability to absorb heat, or "enthalpy margin," is created by the continuously refrigerated keeping of LH_2 in the controlled storage system.

2) Recondense the vapor from the vehicle tank blowdown: This cold vapor at higher pressure is otherwise unusable. The cold vapor can also come from, as applicable, a pump blowby or an initial cooldown process. The vapor is recondensed inside the same controlled storage system.

3) Utilization of the excess boiloff of hydrogen gas to provide electricity: Feed the

Figure 2. Toyota's LH2-Powered GR Corolla. Credit: Toyota[1]

gas to a hydrogen electric cell to produce electricity that is used directly or indirectly to charge a battery. The battery, for example, can be onboard the vehicle or on the ground side and even connected to an electrical grid.

The general principle here is to do the second one only after the first one and to do the third one only after the second one. In terms of efficiency in both energy and time, this order is the priority. In this three-part series, we will look at the three parts of making LH_2 flow like water and solving the boiloff problem. Starting with the third one, the easier one and working back to number one, the most impactful one, we can see many examples in the news about boiloff utilization.

Motorsports is a leading area for incorporation and advancement of new technology. One example is a Toyota race car, the Corolla H_2 shown in Figure 1, and the planned development of a miniature hydrogen electric cell used to consume the boiloff gas and provide electricity for vehicle functions.[1] If realized, this technology is expected to improve the energy efficiency of the entire LH_2 system by recovering and using boiloff gas as energy.

Another key advantage of LH_2 systems is that "self-pressurizers" can be used, tapping the infinite heat from the ambient environment and thus avoiding the needs for complex pumps or sophisticated heat exchangers (see Figure 2). Another prototype race car, the MissionH$_2$4 H$_2$4EVO, is moving to liquid hydrogen onboard storage this year.[2] With up to 14kg of hydrogen stored in liquid form, the car's target weight remains at 1300 kg with a planned top speed of 211 mph to help reach the performance target of GT3 pace.

The MissionH$_2$4 project is a proof of concept for motorsport to push the target of competing with hydrogen-powered prototypes at Le Mans and at the FIA World Endurance Championship by 2030. Another example is the new Mercedes-Benz long-haul Class 8 hydrogen electric truck with LH_2 onboard. This vehicle by Daimler Truck, the GenH$_2$, includes an electric battery in a hybrid but pure electric architecture. The pair of 40-kg high performance, super-insulated tanks will still have a small "boiloff" flow rate when idle, but this gas is fed to the hydrogen electric cell to generate electricity and charge the battery.[3]

In the next installment, we'll examine the needs for capturing the boiloff from the blow-down of vehicle tanks and the requisite approaches for recondensing and reusing those valuable hydrogen molecules.

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CO2Meter's Critical Gas Safety Solution

by Emily Mahlon, CO2Meter

CO2Meter has long been recognized for its remote oxygen depletion safety alarm, which warns staff before they enter areas with dangerously low oxygen levels caused by pressurized gas leaks.

Pressurizing a gas in a tank or cylinder provides a convenient way to transport and store it. Flower shops use helium cylinders to fill balloons. Restaurants rely on carbon dioxide tanks to carbonate soda. Outdoor grills use propane tanks to cook steaks. A common characteristic of these gases is that under pressure, they transition into a liquid state.

Pressurized gases are integral to many industries, including:

- CO_2: Restaurants, Breweries, Wineries
- Nitrogen: Food Packaging
- Argon, Helium, CO_2: Welding
- Oxygen: Hospitals, Medical Facilities
- Tetrafluoroethene, CO_2: Refrigeration
- Helium: Cryogenics and IVF Facilities

The College of American Pathologists (CAP) detailed new safety requirements to address hazards associated with liquid Nitrogen (LN_2) and dry ice storage. These regulations aim to ensure the safety of laboratories, clinics and reproductive facilities following many incidents due to oxygen deprivation. As safety standards evolve, the Compressed Gas Association's (CGA) also is advocating safety at the forefront, with its new push on liquid nitrogen safety requirements. With an expected update to code addressing enhanced monitoring and alarm standards, CO_2Meter solutions are designed to help businesses stay ahead of regulatory changes while prioritizing personnel protection in environments where low oxygen levels pose a life-threatening risk.

The Dangers of Pressurized Gas

Cryogenic fluids are a specialized subset of pressurized gases. Cryogenics, the study of extremely low temperatures, encompasses all temperatures below 120 Kelvin (-244 °F or -153 °C). At such temperatures,

CO2Meter highlights the importance of oxygen deficiency alarms in ensuring safety and compliance in environments using pressurized gases. Credit: CO2Meter

gases like nitrogen, oxygen, helium, methane, ethane and argon condense into liquids. Cryogenic liquids are essential in modern science. For instance, at CERN's Large Hadron Collider, liquid helium (4 K or -452 °F) enables the superconducting operation of beam positioning devices.

However, all cryogenic gases—except oxygen—are asphyxiates. Asphyxiate gases are nontoxic or minimally toxic but can displace oxygen in the air, leading to suffocation. For example, one volume of liquid nitrogen expands to 696.5 volumes of nitrogen gas at room temperature. Expansion ratios for most pressurized gases range between 700 and 900, meaning even a small leak can quickly reduce oxygen levels in an enclosed area.

Why Oxygen Deficiency Alarms Are Essential and Key Features

While personal oxygen monitors are useful for routine operations, they are insufficient for overnight or unmonitored situations. By the time a personal alarm sounds, escape may no longer be possible. Human error also poses risks; even with proper training, accidents can occur. The remote oxygen deficiency alarm from CO2Meter addresses these challenges. It provides real-time oxygen level monitoring and warns staff before they enter hazardous areas. Additionally, the alarm can integrate with ventilation systems, HVAC controls, or facility alarm systems.

When selecting an oxygen deficiency alarm monitor, prioritize devices with features that enhance accuracy, reliability and usability:

- Real-Time Monitoring and Rapid Alerts: Continuous readings with immediate alarms when oxygen drops below safe levels.
- High-Visibility Alarms: Clear visual and audible notifications, even in noisy environments.
- Reliable Power Source: Long battery life or uninterrupted power to ensure continuous operation.
- Ease of Calibration and Maintenance: Simplified calibration ensures consistent accuracy and performance.

Devices like the RAD-0002-ZR provide proactive safety measures, protecting employees while ensuring regulatory compliance.

Excess Oxygen and Safety

Liquid oxygen tanks also pose risks. Breathing oxygen at pressures above 0.5 bar (approximately 2.5 times normal) for extended periods can cause irreversible lung damage and, ultimately, death. Oxygen concentrations exceeding 60% can act as asphyxiants. Additionally, oxygen's oxidizing properties make it highly combustible, amplifying fire risks when combined with heat and fuel.

Oxygen deficiency alarms are critical for adhering to safety regulations in environments with pressurized gases like liquid nitrogen. By monitoring oxygen levels and providing early warnings, these devices help prevent accidents. Following guidelines from organizations like the Compressed Gas Association (CGA) ensures best practices. These include proper ventilation, personal protective equipment and reliable oxygen deficiency alarms. Proper placement—near potential gas buildup sites—and visible, audible alarms further enhance safety.

When an oxygen deficiency alarm detects a gas leak, immediate action is essential. Employees should follow a standard operating procedure (SOP):

1. Evacuate the Area: Move to a safe, oxygen-rich environment.

RAD-0002-ZR

By remotely monitoring oxygen levels in real time, the Oxygen Deficiency Alarm will warn staff before they enter an area that may be unsafe. In addition, the alarm can control ventilation fans or can be connected to a facility's HVAC and/or alarm systems. Credit: CO2Meter

2. Activate Emergency Ventilation: If safe, initiate protocols to restore oxygen levels.
3. Notify Safety Personnel: Alert the safety team or emergency responders to locate and resolve the leak.
4. Wait for Clearance: Re-enter the area only after authorized personnel confirm safe oxygen levels.

Best Practices for Alarm Installation

Proper installation ensures accurate detection and timely alerts. Key considerations include:

- Strategic Placement: Install monitors near storage areas, confined spaces, or gas dispensing equipment.
- Correct Height: Position monitors at breathing level for optimal accuracy.
- Alarm Visibility: Ensure alarms are audible and visible throughout the workspace.

Regular testing, maintenance and integration with emergency response systems further enhance safety. CO2Meter is a leader in gas detection and safety solutions, offering more than 250 innovative gas sensor products for diverse industries, including restaurants, agriculture, industrial safety, and cryogenics.

Founded in 2006, CO2Meter grew from a garage startup to a global leader, partnering with major brands and advancing multi-gas detection with safety-focused solutions. **www.co2meter.com**

Jefferson Lab Dedicates Niobium-Tin Particle Accelerator Prototype

by Kandice Carter, Jefferson Lab Communications Office

More than 30 of the world's most advanced particle accelerators rely on one technology: superconducting radiofrequency (SRF). This technology, typically powered by pure niobium metal, has seen recent advancements with the introduction of niobium-tin alloys, which promise greater efficiency. The US Department of Energy's (DOE) Thomas Jefferson National Accelerator Facility (Jefferson Lab) is at the forefront of this new era, testing an accelerator based on niobium-tin alloy technology. The team has successfully tested the first niobium-tin alloy cryomodule, a prototype section of a particle accelerator, which can accelerate electrons to energies exceeding 10 million electron-volts. This cryomodule, named Gray Enid I, is now being prepared for its first electron beam tests.

The dedication of Gray Enid I. *Credit: Aileen Devlin*

A team of Jefferson Lab staff members who contributed to the Gray Enid I project poses with the quarter cryomodule after successful testing. *Credit: Aileen Devlin*

Grigory Eremeev, a former Jefferson Lab staff scientist and now a senior scientist at DOE's Fermi National Accelerator Laboratory, sees Gray Enid I as a major milestone. "This cryomodule was built with my early career award and partnerships among researchers and national labs," Eremeev said. "I hope it works well in the upgraded injector test facility and that it does what we hope it will do. This would be a significant milestone." At a recent event to dedicate the new cryomodule, Michelle Shinn, DOE's program manager for Industrial Concepts in the Office of Nuclear Physics, emphasized the difficulty of the achievement. "To actually not just coat a cavity, but coat two cavities, put them into a cryomodule, fully check them, and accelerate electrons—that's gutsy," said Shinn.

Superconducting Radiofrequency Particle Accelerators

Niobium, a metal known for its superconducting properties, has been used in a variety of applications, from strengthening materials to improving the efficiency of solar cells. However, its most critical application is in superconducting technology. Niobium loses its resistance to electricity at low temperatures, making it essential for high-powered magnets and quantum computers.

In particle accelerators, specially formed niobium cavities are cooled to just a few degrees above absolute zero—around 2 Kelvin. These cavities, shaped like a stack of donuts with a hollow center, accelerate particles by imparting energy from radio frequency waves. When superconducting, the cavities can store energy with minimal losses, accelerating a continuous beam of particles. The Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab was the first large-scale linear accelerator to use SRF technology. Due to its efficiency in delivering high-precision beams, CEBAF has been instrumental in groundbreaking experiments in nuclear physics. Today, CEBAF continues to be a key research facility, supporting over 1,650 nuclear physicists worldwide.

Jefferson Lab has since led the way in SRF research, contributing to advancements in particle accelerators used at various DOE labs, including the Spallation Neutron Source at Oak Ridge National Laboratory and the Linac Coherent Light Source at SLAC National Accelerator Laboratory. Despite these successes, researchers have recognized that the current generation of accelerators, which rely solely on niobium, is reaching its efficiency limits. This realization has spurred the exploration of niobium alloys, such as niobium-tin, as a way to continue pushing the boundaries of SRF technology.

The first niobium-tin alloy cryomodule, a prototype section of particle accelerator, that is capable of accelerating electrons to energies exceeding 10 million electron-Volts. Credit: Aileen Devlin

Advancing Particle Accelerators with Niobium-Tin Alloys

Niobium-tin (Nb_3Sn) alloys, which become superconducting at 18.3 K, offer a significant improvement over pure niobium, whose transition temperature is lower. Researchers have started using a vapor diffusion process to create a thin niobium-tin layer on niobium cavities. This process involves vaporizing tin inside a niobium cavity at temperatures exceeding 1,100 °C, resulting in the formation of the superconducting layer.

The initial tests of this new cryomodule did not go as planned. Eremeev explained that earlier prototype cavities did not perform well in tests. "We started with some original CEBAF cavities that we still had available, but we realized that we couldn't get a good coating on the older surfaces," he said. Additionally, the assembly process posed challenges. Tuning the cavities to the correct frequency typically requires deforming them, but this warped the carefully crafted niobium-tin coating. "We went and bought some new cavities from the vendor. These new cavities had a good niobium substrate to work with," Eremeev said.

The new cavities performed much better. Uttar Pudasaini, a Jefferson Lab SRF scientist, noted that while older coated cavities struggled to dissipate heat, the new cavities demonstrated improved superconductivity at higher temperatures. "They are able to remain superconducting at higher temperatures," Pudasaini said.

The success of the new cavities led to the creation of a one-quarter cryomodule, a section of SRF accelerator that includes components to support and insulate the cavities. This cryomodule was tested in Jefferson Lab's Cryomodule Test Facility, where it was cooled to 4.4 K and 2 K for testing with SRF fields. The tests confirmed that the cryomodule could accelerate electrons to over 10 MeV at both temperatures.

Eremeev emphasized the significance of these results. "It basically got similar results to what we saw in the vertical tests," he said. This successful demonstration could signal the possibility of operating SRF accelerators at higher temperatures—around 4 K—rather than the current 2 K. This would reduce the complexity of cryogenic systems and lower operational costs.

If the results hold in electron beam tests, it could pave the way for more efficient and cost-effective SRF accelerators. These accelerators have the potential for a wide range of applications, including cancer treatment, sterilization of medical devices and the remediation of wastewater.

Moving Forward with Gray Enid I

The team is now preparing to install Gray Enid I into a small accelerator at Jefferson Lab's Upgrade Injector Test Facility (UITF), which will test its performance in a real accelerator environment. "Gray Enid I is named after earlier technology installed here in CEBAF in 1990," said Rongli Geng, who heads the SRF Science and Technology department at Jefferson Lab.

Gray Enid I represents four decades of investment in SRF technology, spearheaded by the DOE's Office of Science and Office of Nuclear Physics. "If there is a will, there's a way. After all the hard work and overcoming obstacles, it's good to see this project finally coming to fruition," Eremeev concluded. **www.jlab.org**

Vacuum Barrier Corporation Enhances Customer Support Through Field Service Evolution

by Lisa Angelli, Vacuum Barrier

Vacuum Barrier Corporation (VBC) has long been recognized for its commitment to excellence in cryogenic systems and liquid nitrogen (LN_2) solutions. Recently, the company has made significant strides in bolstering its customer support by establishing a dedicated department for reliability and technical support. Dana Muse, Reliability and Technical Support Manager, shared insights into this evolution and its impact on VBC's service strategy, training programs and customer experience.

From left to right: Dana Muse, Reliability and Technical Support Manager and Andrew Gonzalez, Field Service Coordinator. Credit: Vacuum Barrier

A Dedicated Focus on Field Service

For years, VBC has distinguished itself by providing comprehensive post-sale support. From supervising equipment installation and commissioning to operator training and quick responses to urgent needs, the company has always prioritized its customers. However, as VBC's customer base expanded across industries, it became evident that additional resources were necessary to maintain this high level of service.

"In the past, our field service efforts were managed as part of the sales department. But as our customer base grew, we needed more horsepower to ensure we could continue to meet their needs," Muse explained. "This led to the creation of a dedicated Reliability and Technical Support department, complete with a field service coordinator, Andrew Gonzalez, to manage service requests and schedule visits efficiently."

Consolidating field service technicians into a single department has also fostered greater knowledge sharing. This structure enables faster, more accurate resolutions to customer challenges. "Our technicians are trained in-house and work directly for VBC, which ensures a level of expertise that distributors or resellers often can't provide," Muse noted.

Addressing Urgent Needs with Regional Expansion

With downtime becoming increasingly costly for industries ranging from biotech and semiconductor manufacturing to food and beverage production, VBC has made geographic expansion a priority. By placing additional staff on the West Coast, alongside their Northeast headquarters, the company can respond more rapidly to customers nationwide.

"Whether it's a bottled water company in California or a semiconductor manufacturer in Texas, we're committed to delivering the same level of responsiveness," Muse said.

This regional presence has already proven invaluable. Muse shared an example of a customer dealing with ice buildup in their cryogenic equipment. "Our field service engineer on-site had to think creatively when the usual defrosting solutions weren't feasible. By using argon gas – a substitute for nitrogen gas – they were able to speed up the defrost process and reduce downtime significantly. This type of outside-the-box thinking is what sets our team apart."

Training That Builds Confidence and Expertise

Effective operator training is central to VBC's customer support strategy. Muse emphasized that training cannot always be completed during a single visit, especially when new systems are being commissioned amidst the installation of other machinery.

"In the short term, we ensure every operator gets hands-on experience with the basics of cryogenic safety and system operation. But follow-up visits are key to providing more comprehensive training when the environment is less hectic," he said. Over time, VBC encourages customers to designate senior maintenance technicians for in-depth training, enabling them to serve as on-site experts.

The addition of service contracts has further enhanced training consistency. "These contracts allow for regularly scheduled visits, which help new hires stay up to speed and minimize downtime," Muse explained.

The Role of Field Service Engineers

VBC's Field Service Engineers (FSEs) are at the heart of the company's customer support. They undergo rigorous, ISO 9001-certified training through VBC's exclusive certification program before ever hitting the road. However, Muse noted that technical expertise alone isn't enough.

"We prioritize strong communication skills and a solid work ethic. Our engineers partner with customers' staff to ensure knowledge transfer and keep equipment running smoothly. This collaboration is essential to building trust and ensuring long-term success," he said.

Bridging Customer Insights and Innovation

Field service engineers also play a crucial role in driving product development and upgrades. Working closely with customers, they identify areas for improvement and share feedback with VBC's engineering and sales teams.

"Our engineers are often the first to recognize trends or recurring requests. Their input helps accelerate our response to customer needs and ensures that new features address real-world challenges," Muse said.

One such trend is the increasing demand for remote system access. Many customers now require integration with central building management systems or the ability to monitor systems from off-site devices. VBC is meeting these demands by upgrading to advanced programmable logic controllers (PLCs) and ensuring its field service engineers are trained to support the latest technologies.

SEMIFLEX® Liquid Nitrogen Pipe. *Credit: Vacuum Barrier*

Liquid Nitrogen Dosing. *Credit: Vacuum Barrier*

Looking Ahead

As cryogenics continues to evolve, VBC remains committed to delivering innovative solutions and exceptional service. Muse summed it up best: "Our field service engineers are more than just technicians. They're highly skilled professionals who embody our mission of helping customers maximize productivity and minimize downtime. Whether it's resolving an immediate issue or shaping the future of cryogenic systems, we're here to meet our customers' needs every step of the way."

By investing in its people, processes and technology, Vacuum Barrier Corporation is setting a new standard for reliability and support in the cryogenics industry – a standard built on expertise, responsiveness and a commitment to customer success. **www.vacuumbarrier.com**

Argonne Empowers Female Energy Leaders

by Argonne National Laboratory Media Team

Argonne National Laboratory (CSA CSM) recently hosted 12 women leaders from Net Zero World partner countries for a two-week training program under the Climate Smart Women Energy Leaders (CSWEL) initiative. In collaboration with the U.S. Department of Energy's (DOE) Net Zero World Initiative, the program aimed to equip participants with technical skills, leadership training and networks to advance sustainable energy solutions globally.

Cohort 2 of the CSWEL program. *Credit: Argonne*

Participants from Argentina, Chile, Egypt, Indonesia, Nigeria, Thailand and Ukraine explored advanced building technologies, electric mobility and battery energy storage systems. The training included visits to Argonne's Smart Energy Plaza, Advanced Mobility Technology Laboratory, and Materials Engineering Research Facility, as well as DOE's National Renewable Energy Laboratory. These sessions emphasized practical applications of renewable energy, grid resilience and technology deployment.

Leadership workshops complemented technical training, helping participants translate expertise into actionable energy strategies for the Net Zero World Initiative.

Participants praised the program's collaborative environment and peer-learning opportunities. The CSWEL initiative supports DOE's mission to foster resilient, sustainable energy development while building a global network of leaders dedicated to a sustainable future. **www.anl.gov**

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Cryogenic and Vacuum Jacketed Assemblies are oven dried and purged with argon to a moisture content of 2 PPM and verified with a moisture analyzer. Assemblies are helium leak checked to 1 x 10-9 std. cc/sec.; and can be charged with helium to maintain dryness during shipping and storage.

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- Superior insulation properties
- Multi-layer insulation creates a low heat transfer rate
- Minimizes cryogenic liquid boil-off
- Containment of the media in case of inner hose rupture
- Bayonet connections available for quick, leak-resistant installations

Metal Hose

- Allows for the transfer of liquids or gases, usually at high pressure and high or cryogenic temperature

Cryogenics Applications

- Nitrogen
- Hydrogen
- Oxygen
- Carbon Dioxide
- Helium
- Argon
- Other Natural Gases

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Product Showcase

This Product Showcase is open to all companies and related manufacturers offering new or improved products for cryogenic applications. We invite companies to send us short releases (150 words or fewer) with high-resolution JPEGs of their products to editor@cryogenicsociety.org.

nEXT2807M and nEXT3207M Magnetically Levitated Turbomolecular Pumps

Edwards Vacuum

Edwards Vacuum has introduced the nEXT2807M and nEXT3207M Maglev pumps, oil-free turbomolecular pumps designed for contamination-free vacuums in industrial and research environments. These compact, lightweight pumps are hydrocarbon-free, virtually maintenance-free for up to 80,000 hours and equipped with efficient water cooling to ensure durability and low vibrations. With pumping speeds of up to 3,200 l/s, the nEXT M series is ideal for applications such as coating, thermal vacuum chambers and high-energy physics, ensuring process reliability and productivity in challenging environments. **www.edwardsvacuum.com**

DURADRY Dry Screw Vacuum Pump

Leybold

Leybold has launched the DURADRY, a dry screw vacuum pump designed for medium-harsh industrial processes involving high temperatures, oxygen levels and corrosive conditions. Available in 160 and 250 m³/h pump speed models, with a 450 version forthcoming, the DURADRY features low maintenance, efficient heat regulation and intelligent variable speed control to minimize energy use and enhance durability. With a quiet, ergonomic and contamination-free design, the DURADRY is ideal for applications like crystal pulling, plasma cleaning, heat treatment and battery production, offering robust performance and user-friendly operation. **www.leybold.com**

The ICE-G2 Family

Iris Technology

Iris Technology offers a range of radiation-hardened, space-qualified control electronics (CCEs) designed for cryocooler systems and infrared imaging. The ICE-G2 series, developed under NASA contracts, is a flexible, cooler-agnostic solution with power options ranging from 30W to 1000W. It features vibration control, input ripple filtering and mission customization for enhanced image stability and noise reduction. The SPLCCE is optimized for single-piston cryocoolers, offering active vibration cancellation (AVC) to minimize exported vibrations and improve image quality. Sotira Systems are tailored for infrared space sensors, supporting various focal plane arrays with advanced image processing for defense, industrial and space applications. With options for SmallSat configurations and interfaces like SpaceVPX, these systems deliver high reliability in harsh radiation and EMI/EMC environments. These CCE solutions provide versatility, cost-effectiveness and durability across a wide range of space missions and applications. **www.iristechnology.com**

MSC2 Fixed Multi Gas Safety Detector

CO2Meter

Ensure cryogenic facility and personnel safety with CO2Meter's MSC2 fixed multigas safety detector. The CO2Meter MSC2 fixed multigas safety detector is a reliable solution designed for cryogenic industry professionals to protect both personnel and facilities from potential gas hazards. Engineered for safety-critical environments, the MSC2 ensures compliance with gas safety regulations while delivering accurate monitoring of multiple gases, including CO_2 and O_2. The system offers multigas monitoring, capable of detecting up to three gases (O_2, N_2, CO_2) simultaneously, which is specifically tailored for cryogenic applications. With customizable alerts, it allows for configurable alarm thresholds that provide both visual and audible notifications to prevent hazardous conditions. The MSC2's durable modular design is built for harsh environments, ensuring easy installation, maintenance and scalability. Protect your workforce and maintain operational safety with CO2Meter's advanced gas detection safety solutions. **www.co2meter.com**

People & Companies in Cryogenics

Dr. Michael Schweitzer. *Credit: attocube systems AG*

attocube systems AG has announced **Dr. Michael Schweitzer** as the new member of its Management Board. Dr. Schweitzer, a physicist with a doctorate, brings extensive technical expertise and years of management experience, having most recently served as General Manager Europe at AMETEK GmbH, where he oversaw the Electron Microscopy Technologies business unit. He has also held leadership roles as Managing Director of Gatan GmbH and in management positions at Carl Zeiss AG.

....

Standex International Corporation recently acquired Michigan-based advanced cryogenic equipment manufacturer **Custom Biogenic Systems (CBS)**. Under the terms of the deal, CBS will become part of SXI's scientific business segment. CBS expertise includes the manufacturing of unique isothermal freezers with dry liquid nitrogen technology for the pharmaceutical and biobank end markets within the life sciences market.

....

Graham Corporation announced plans to build an advanced cryogenic propellant testing facility near its P3 Technologies subsidiary in Florida, with operations expected to begin by mid-2025. Designed to meet growing demand across the space, defense and new energy sectors, the facility will test liquid hydrogen, liquid oxygen and liquid methane under various conditions. This investment highlights Graham's commitment to providing timely, cost-effective testing solutions while expanding its capabilities to support current and future programs. The project is expected to deliver a return on investment within two to three years, further solidifying Graham's role as a leader in cryogenic and space launch technologies.

....

Google's recent patent filing reveals its focus on advancing cryogenic cooling systems for quantum computing, addressing the critical challenge of maintaining the near-zero temperatures necessary for quantum systems to function while also supporting the hybrid quantum-classical environments expected to emerge. The patent, titled "Cryogenic Cooling Systems for Multi-Unit Scaling of Quantum Computing," outlines a seven-stage cooling system specifically designed for superconducting quantum computers. Each stage progressively lowers the temperature, bringing quantum computing hardware close to absolute zero, approximately -459 degrees Fahrenheit, on the Kelvin scale.

....

PsiQuantum, a private quantum computing firm, is aiming to build a large-scale quantum computer using light-based silicon photonic qubits by late 2027. With over

PsiQuantum is testing quantum computing using light in silicon chips. *Credit: PsiQuantum*

$1 billion in funding, the company is aiming to create a machine with millions of qubits, surpassing the scale of most competitors. Unlike other companies using atoms or superconducting materials, PsiQuantum leverages massless photons, which offer benefits such as reduced susceptibility to environmental noise. Despite some skepticism due to the technical challenges involved, such as generating and manipulating single photons efficiently, PsiQuantum has gained attention for its progress and innovative approach.

....

AMSL Aero's Vertiia eVTOL is Australia's first passenger-capable, zero-emission electric vertical take-off and landing aircraft, combining helicopter-like agility with fixed-wing efficiency. Designed for long-range travel of up to 1,000 km at a cruising speed of 300 km/h, Vertiia is powered by hydrogen, ensuring clean energy use and no emissions. Accommodating four passengers and a pilot, it aims to revolutionize transport for remote and regional

Credit: AMSL Aero

communities. Following its milestone free flight in 2024, Vertiia is set for hydrogen-powered trials in 2025, moving closer to commercial operations by 2027.

....

The **US Department of Energy's Office of Science** has released the **2024 Quantum Information Science Applications Roadmap**, outlining the scientific challenges and technical milestones necessary for advancing real-world applications of QIS. Developed by a collaborative committee of experts from national labs, academia and industry, the roadmap reflects a long-term vision for driving innovation in QIS technologies. The DOE remains committed to supporting cutting-edge research and fostering partnerships across government and industry to unlock the transformative potential of quantum technologies.

....

sureCore has teamed up with **Sarcina** to create custom chip packaging designed for cryogenic temperatures, supporting the integration of Cryo-CMOS solutions into the quantum computing ecosystem. This collaboration follows sureCore's development of cryogenic IP, including its CryoMem™ memory range and recharacterized libraries for low temperature operation. The packaging enables cryogenic control electronics to be colocated with qubits inside the cryostat, reducing power consumption, heat, cost, size and latency. The partnership is part of an Innovate UK-funded project to accelerate the development of cryo-tolerant semiconductor IP for scaling quantum computing systems.

....

Dover has acquired **Cryogenic Machinery Corp. (Cryo-Mach)**, a California-based manufacturer of cryogenic centrifugal pumps, mechanical seals and accessories, integrating it into PSG within its Pumps and Process Solutions segment. The acquisition strengthens Dover's presence in cryogenic applications, including industrial gases and transportation, while diversifying PSG's portfolio with advanced cryogenic pump technology. This move aligns with Dover's strategy to expand its core offerings and access adjacent markets for sustainable growth.

....

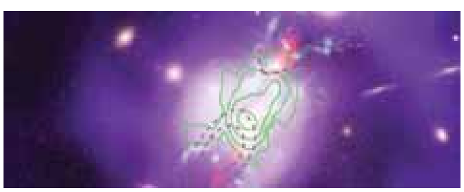
Cryoport has introduced the Express® Cryogenic HV3 shipping system, designed to maintain stable temperatures of -150 °C for advanced therapies while meeting airline compliance standards. The HV3 enhances

The Cryoport Express® Cryogenic HV3 Shipping System. *Credit: Cryoport Systems*

storage efficiency, provides space for accessories and integrates with Cryoport's Safepak® System to minimize transport risks, ensuring the safe delivery of cell and gene therapies. This innovation supports growing demand in the life sciences industry, expected to reach $97.33 billion by 2033, by improving patient access to critical therapies in remote and underserved areas.

....

NASA's James Webb Space Telescope has confirmed how the Phoenix Galaxy



Spectroscopic data collected from NASA's James Webb Space Telescope is overlayed on an image of the Phoenix cluster that combines data from NASA's Hubble Space Telescope, Chandra X-ray Observatory and the Very Large Array (VLA) radio telescope. *Credits: NASA, CXC, NRAO, ESA, M. McDonald (MIT), M. Reefe (MIT), J. Olmsted (STScI)*

Cluster sustains an unusually high rate of star formation, resolving a long-standing astrophysical puzzle. Located 5.8 billion light-years from Earth, the cluster's core contains a massive black hole that, unlike in other clusters, does not prevent gas from cooling enough to form stars. Webb's advanced mid-infrared instruments detected an intermediate-temperature cooling gas, previously undetected, which bridges the gap between extremely hot and cold gas phases. This discovery, supported by data from the Hubble Space Telescope, Chandra X-ray Observatory and the Very Large Array, validates theories about the galaxy feeding cycle and offers a new method for studying star formation in other clusters.

....

Photographer **Jan Hosan** visited **ITER** in December 2024, aiming to highlight the human aspect within the highly technological

ITER image *credited to Jan Hosan, photographer*

environment. Specializing in industrial and scientific photography, he focuses on capturing both the aesthetic and functional elements of his subjects. His ITER portfolio showcases the scale and complexity of the project while also emphasizing the human presence amid the massive components. You can view the images at **www.hosan.eu/portfolio/iter**

....

We inadvertently referred to **West Coast Solutions (WCS)** as WSC in the last issue of *Cold Facts*. We apologize for this

The West Coast Solutions team. *Credit: WCS*

error and deeply value the contributions of all our corporate sustaining members. We remain committed to accurately highlighting our members' progress and innovations.

Meetings & Events

18th Cryogenics 2025 IIR International Conference & Exhibition
April 7-11, 2025
Prague, Czech Republic
www.cryogenics-conference.eu/cryogenics2025

31st Space Cryogenics Workshop
May 13-15, 2025
Incline Village, Nevada
https://spacecryogenicsworkshop.org

CSA Short Courses at CEC/ICMC'25
May 18, 2025
Reno, NV
www.cryogenicsociety.org/2025-short-courses

CEC/ICMC 2025
May 18-22, 2025
Reno, Nevada
www.cec-icmc.org/2025

CRYOCO Cryogenic Engineering and Safety Course
July 14-18, 2025
Golden, Colorado
www.cryocourses.com

30th International Conference on Low Temperature Physics
August 7-13, 2025
Bilbao, Spain
www.lt30.es

European Conference on Applied Superconductivity (EUCAS)
September 21, 2025
Porto, Portugal
https://eucas2025.esas.org

24th International Cryocooler Conference
June 2026
Syracuse, NY
https://cryocooler.org

Thank you for being an essential part of the greater cryogenics community. WCS has grown from a one-person operation to a multidisciplinary team excelling in cryogenics, aerospace electronics and power technologies. Renowned for its cryocooler control electronics and innovative solutions like hybrid battery supercapacitors, WCS continues to support groundbreaking space and defense missions with advanced, high performance technologies.

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