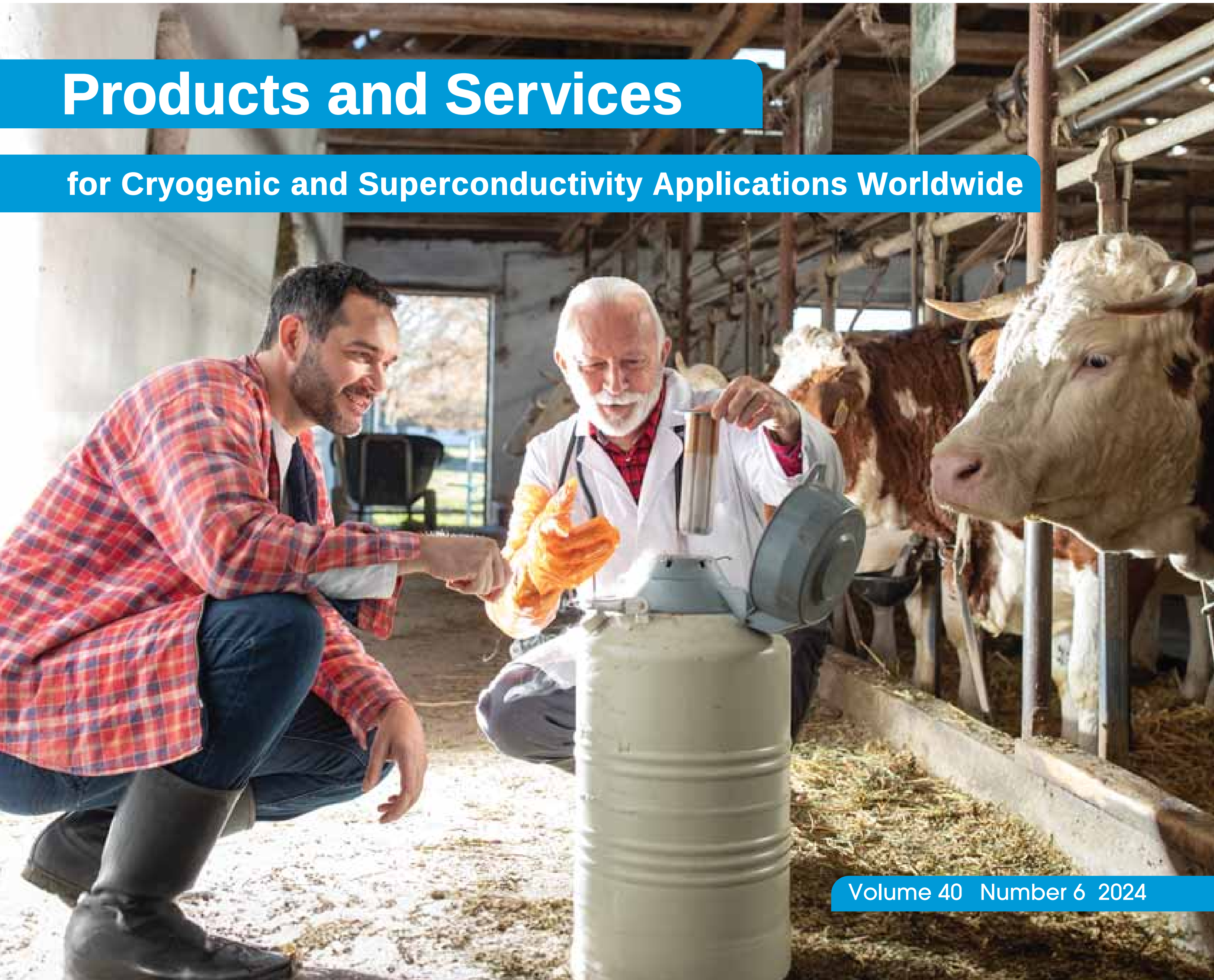
Cold Facts

2025 Buyer's Guide | Corporate Directory

The Magazine of the Cryogenic Society of America, Inc. INTERNATIONAL



Products and Services

for Cryogenic and Superconductivity Applications Worldwide

Volume 40 Number 6 2024

Join Our Growing Family of CSA Corporate Sustaining Members

Get connected to the cryogenic community worldwide. Let your voice be heard and your contributions known.

- Abbess Instruments and Systems, Inc.
- Ability Engineering Technology, Inc.
- Acme Cryogenics, Inc.
- Ad-Vance Magnetics
- Aerospace Fabrication & Materials
- Air Liquide Advanced Technologies
- Alkegen
- Alloy Valves and Control
- American Magnetics, Inc.
- Ampo Poyam Valves (AMPO)
- Amuneal Manufacturing Corp.
- Argonne National Laboratory
- Atlas Technologies
- Barber-Nichols LLC
- Beyond Gravity GMBH
- Bluefors
- BRUGG Pipes
- Canadian Nuclear Laboratories
- CCH Equipment Company
- Chart Inc.
- Chase Research Cryogenics
- Clark Industries, Inc.
- Coax Co., LTD.
- CoolCAD Electronics, LLC
- Commonwealth Fusion Systems
- CO2 Meter
- CPC-Cryolab, an MEC Company
- Creare LLC
- Criotec Impianti SpA
- Cryo Industries of America
- Cryo Service LTDA
- Cryo Technologies – A Chart Industries Company
- Cryoco LLC
- CryoCoax
- Cryocomp
- CryoEdge
- Cryofab, Inc.
- Cryogenic Institute of New England
- Cryogenic Limited
- Cryogenic Specialty Manufacturing SDN BHD
- Cryoguard LLC
- Cryomagnetics, Inc.
- Cryomech, Inc.
- Cryonova Process Systems, LLC
- Cryospain
- CryoSRV, LLC
- CryoTechnics LLC
- CryoVac GmbH
- CryoWorks, Inc.
- Cryoworld BV
- Danaher Cryogenics
- Demaco Holland BV
- DMP CryoSystems, Inc.
- EPSIM Corporation
- Equigas, Inc.
- Eta Space
- Fabrum Solutions
- Facility for Rare Isotope Beams—Michigan State University
- Fermi National Accelerator Laboratory
- Fin Tube Products, Inc.
- Fives Cryo
- Gardner Cryogenics
- Gas Equipment Company
- Herring Systems, Ltd.
- IC Biomedical
- Imtek Cryogenics
- Independence Cryogenic Engineering, LLC
- Iris Technology
- Isotec Corporation*
- Kelvin International Corporation
- KEYCOM Corporation
- kiutra GmbH
- Lake Shore Cryotronics, Inc.
- Lihan Cryogenics
- Linde Cryogenics, Division of Linde Engineering Americas
- Magnatrol Valve Corporation
- Magnetic Shield Corporation
- Meyer Tool & Mfg., Inc.
- Micro Harmonics Corporation
- Midalloy
- Molecular Products, Inc
- NASA Kennedy Cryogenics Test Laboratory
- NASA Marshall Space Flight Center
- National High Magnetic Field Laboratory
- Niowave, Inc.
- Oak Ridge National Laboratory
- Omega Flex, Inc.
- Oxford Cryosystems
- Oxford Instruments NanoScience
- Penflex
- Photon Spot
- PHPK Technologies
- Princeton CryoTech
- Quantum Design, Inc.
- RegO
- RIX Industries
- Scientific Instruments, Inc.
- shirokuma GmbH
- Sierra Lobo
- SLAC-National Accelerator Laboratory
- Space Dynamics Laboratory
- Spaceline Technologies Inc.
- SPS Cryogenics BV
- STAR Cryoelectronics
- Stirling Cryogenics BV
- Sumitomo (SHI) Cryogenics of America, Inc.
- Sunpower, Inc.
- SuperPower, Inc.
- Technifab Products, Inc.
- Technology Applications, Inc.
- Tech4 Imaging LLC
- Tempshield Cryo-Protection
- The Phoenix Company of Chicago
- Thermal Management Technologies
- Thermal Space
- Thermionics Lab
- Thomas Jefferson National Accelerator Facility
- TRIUMF
- Turbines Inc.
- Vacuum Barrier Corporation
- Vacuum Energy Inc.
- Web Industries
- WEKA AG
- Wessington Cryogenics
- West Coast Solutions
- XMA Corporation

* New member since last issue

Inside This Issue

2025 BUYER'S GUIDE

FEATURES

COLUMNS

SPOTLIGHTS

ON OUR COVER

Stirling Cryogenics' onsite liquid nitrogen for storage and preserving semen for artificial insemination. *Credit: Stirling Cryogenics*

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

OPW/Rego/Acme was CSA's newsletter sponsor for November.

Gardner Cryogenics was CSA's newsletter sponsor for December.

Cold Facts (ISSN 1085-5262) is published six times per year by the Cryogenic Society of America, Inc.

From the Executive Director

It's that time of year again! We are proud to present to you our 2025 edition of the printed Buyer's Guide – a resource of products and services designed for cryogenic applications. We hope you find this year's edition to be a useful tool for you to use throughout 2025 and beyond. As a reminder, you can always access the online version of our Buyer's Guide, which is updated regularly at **www.csabg.org**.

With 2024 coming to a close, I enjoy reflecting on the successes CSA has experienced in the last year. The year began with a personal 'success' – I welcomed my third child and was on leave for a few months. The CSA team did a great job covering for me, and I am forever grateful to them for it! Upon my return, we headed to Madison, Wis., to attend ICC23 and to host a CSA Short Course on Foundations of Cryocoolers that took place the day prior to the conference. This course was co-instructed by Dr. Ray Radebaugh and Dr. Fons De Waele. An added bonus: the course was a complete sell out!

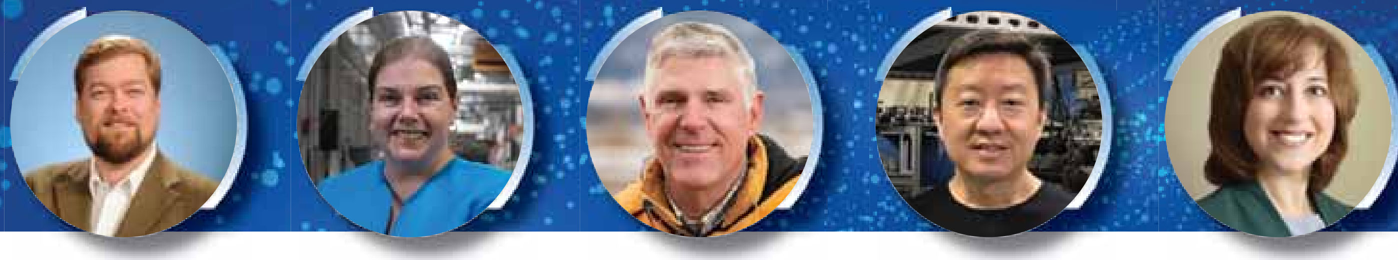
In September, we headed to Salt Lake City to attend the Applied Superconductivity Conference (ASC). During ASC, CSA was able to host an exhibit table where we got to meet and visit with many of you. It's always a pleasure to chat with our readers and members to learn about your new and ongoing projects. Also at ASC, we presented the Roger W. Boom Award to Dr. Ram Dhuley of Fermi National Accelerator Laboratory for his pioneering work on cryocooler conduction-cooled superconducting radio frequency (SRF) cavities, which demonstrated first-ever practical accelerating gradients on an SRF cavity without the use of liquid helium.

Looking forward to 2025, CSA has a lot of exciting things on the horizon. We will be hosting our 31st Space Cryogenics Workshop on May 13-15, 2025, at the Hyatt Regency Lake Tahoe in Incline Village, NV. 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. For full details and registration, visit **www.spacecryogenicsworkshop.org**.

Directly following the Space Cryogenics Workshop, CSA will host numerous short courses in conjunction with CEC/ICMC in Reno, Nevada, May 18, 2025. More details regarding the short courses can be found on CSA's website at **www.cryogenicsociety.org**.

As always, I hope you enjoy this special Buyer's Guide issue of *Cold Facts*. Happy New Year!

Meet Our New Board Members



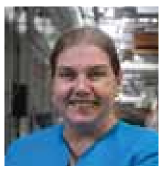
As the Cryogenic Society of America moves into an exciting era of innovation and exploration, we're thrilled to introduce the talented professionals who will help guide our organization forward. This year's new board members bring a wealth of expertise from diverse sectors within the field, as well as a shared passion for advancing cryogenic science and technology. Join us as we highlight their unique journeys, perspectives, and vision for the future of cryogenics—a future they're already shaping through their leadership and commitment.

President-Elect

Franklin Miller, Ph.D., Associate Professor, University of Wisconsin - Madison

Franklin Miller is Associate Professor of Mechanical Engineering at the University of Wisconsin-Madison. Before joining the faculty at the University, Professor Miller worked in the Cryogenics Branch at the NASA Goddard Space Flight Center. While at NASA he worked on developing cooling systems for space flight missions, including systems in operation on the James Webb Space Telescope. Professor Miller has a Ph.D. in Mechanical Engineering with a minor in Physics from the Massachusetts Institute of Technology. His Ph.D. work included modeling the thermodynamic behavior of superfluid 3He-4He mixtures and the development of a novel superfluid Joule-Thomson refrigeration cycle for sub-1 Kelvin cooling. Professor Miller has supervised 23 MS students and 14 Ph.D. students. He has also served on the Board of Directors for the Cryogenic Engineering Conference since 2009, as program chair of the 2013 Cryogenic Engineering Conference, as co-Chair of the 27th Space Cryogenics Workshop and as the Chair of the 23rd International Cryocooler Conference.

Directors



Kathleen Amm, Ph.D., Director, NHMFL FSU

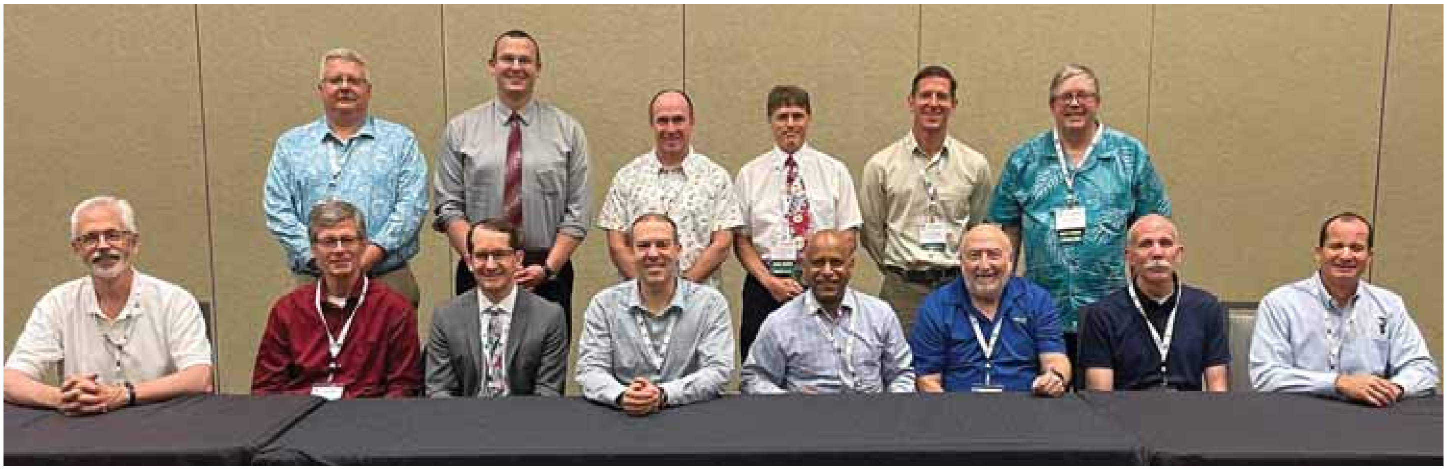
Kathleen Amm received her B.Sc. in Mathematics and Physics from the University of Toronto and Ph.D. in Condensed Matter Physics from Florida State University. She spent nearly 20 years at GE Global Research, starting as a physicist, climbing through several leadership positions to eventually direct the entire research portfolio for the GE MRI business at the GE Global Research Center. She then served as director of the Magnet Division at Brookhaven National Laboratory (BNL) leading a team of scientists, engineers and technicians developing the future of superconducting magnet technology. In May 2024, she joined the MagLab as director, bringing her more than 25 years of experience in superconductivity and magnet design to the world's largest and highest-powered magnet laboratory. In this role, she oversees the National MagLab's headquarters location at Florida State University, as well as the MagLab facilities at Los Alamos National Laboratory and the University of Florida.

Charlie Danaher, President, Danaher Cryogenics LTD

Beginning a career in cryogenics in 1998 under Glen McIntosh at Cryogenic Technical Services, Charlie Danaher went on to work at HPD in Boulder, Colorado, from 2002 to 2020. There, they collaborated closely with NIST scientists to design, build, test, and install a range of cryostats, including wet and dry dilution refrigerators (DRs) and a line of Adiabatic Demagnetization Refrigerator (ADR) cryostats. After years of designing cryostats, their career evolved to include work with scientists around the world, assisting in the planning, specification, and procurement of specialized cryogenic tools. They've had the unique opportunity to develop lasting professional friendships within the field and have contributed articles to Cold Facts Magazine. With gratitude for the support and opportunities offered by the cryogenic community, they are now eager to help guide its future as a board member for the Cryogenic Society of America.

Wei Guo, Ph.D., Professor, Florida State University

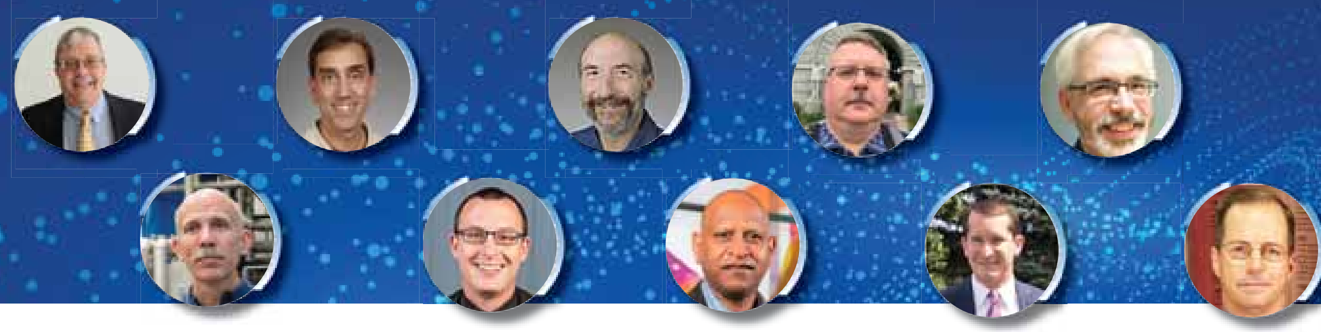
Dr. Wei Guo is a Professor of Mechanical Engineering at FAMU-FSU College of Engineering and holds an associate position at the National High Magnetic Field Laboratory. His research centers on cryogenics, with applications in quantum fluid dynamics, liquid-helium-based dark matter detection, cryogenic accelerator physics, quantum-fluid-based qubits R&D and liquid hydrogen aviation. After earning his Ph.D. in Physics from Brown University in 2008, he conducted postdoctoral research at Yale University until 2012, then joined Florida State University. Supported by agencies including NSF, DOE, NASA, the Army Research Office, and the Betty Gordon Moore Foundation, Dr. Guo has received many accolades, including the JSPS Invitation Fellowship, the Moore Foundation EPI Award, and the Outstanding Research Accomplishment Award from the FAMU-FSU College of Engineering. In 2023, he was elected an American Physical Society Fellow.



CSA's 2023-2024 Board of Directors. Top row from left to right: Robert Duckworth, Jacob Leachman, Carl Kirkconnell, John Pfotenhauer, Jason Hartwig, and John Weisend II. Bottom row from left to right: John Jurns, Michael Meyer, Adam Swanger, Lukas Graber, Sastry Pamidi, Al Zeller, Peter Knudson, and Christopher Rey. *Credit: CSA*

Sarah Mitchell, Marketing Communications Manager, Sumitomo (SHI) Cryogenics of America, Sarah Mitchell has been the Marketing Communications Manager at Sumitomo (SHI) Cryogenics of America, Inc. (SCAI) since 2008, where she plays a pivotal role in driving the company's marketing initiatives supporting their range of cryocoolers, cryopumps and compressors. She joined SCAI, a longtime CSA corporate sustaining member, in 2006 and holds a bachelor's degree in International Area Studies from Drexel University. With 20 years of progressive marketing experience, Mitchell combines creative and technical expertise to oversee SCAI's marketing operations and provide support and guidance to the SHI Cryogenics Group's global network. In addition to developing marketing collateral, including occasional content for Cold Facts magazine, she executes several events on behalf of the SHI Cryogenics Group each year. Mitchell is a member of the International Cryocooler Conference (ICC) Board, having served as president from 2020-2022 and chaired ICC22 in June 2022, including coordination of the CSA's Foundations of Cryocoolers course.

Returning Directors

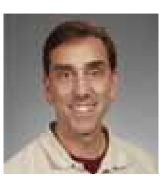


Chairman

J.G. Weisend, Senior Accelerator Engineer, European Spallation Source

John Weisend is a Senior Accelerator Engineer at the European Spallation Source and Adjunct Professor at Lund University in Sweden. Dr. Weisend's interests include He II, cryogenic safety, large scale accelerator cryogenics and the development of large international science projects. His publications include: Superfluid, He is for Helium, Going for Cold (co-authored with T. Meaden), Cryogenic Safety (co-authored with T. Peterson), Cryogenic Two-Phase Flow (co-authored with N. Filina) and editor of the Handbook of Cryogenic Engineering and of Cryostat Design. He writes a regular column "Cryo Bios" for the publication Cold Facts. He is Editor in Chief for the journal Interactions. He is the chair of the Cryogenic Society of America and the International Cryogenic Engineering Conference Board.

President



Rich Dausman, President, Bluefors Syracuse

Richard Dausman is currently the president at Bluefors Syracuse. Dausman holds a B.S. in mechanical engineering from Syracuse University. He joined Cryomech in 1976 and has held numerous positions with the company under the tutelage of William "Bill" Gifford and his son Peter. Mr. Dausman continues to be a key contributor in fostering the steady growth and development of Cryomech into a leading manufacturer of cryogenic systems. Before his current position, Mr. Dausman was vice president of engineering. His activities focused on the design, development and manufacturing of the company's broad product line. He has extensive experience in a wide range of cryogenic techniques, applications and systems integration. He chaired the 18th International Cryocooler Conference hosted in Syracuse, N.Y and is a past member of the Cryogenic Engineering Conference Board of Directors.

Past President

Al Zeller holds a Ph.D. from Florida State University (1974) and has over 40 years of experience in cryogenics. His career includes roles as a Research Associate at FSU, Australian National University, and Texas A&M (1974-1978), Senior Physicist at NSCL/MSU, and Associate Project Manager for FRIB/MSU, retiring in 2017. He has served as ASC Chair (2006), ASC Co-chair (2016), and CEC Chair (1999 and 2011). On the CSA Board, he has held positions as Treasurer, President, Past-President, and served as Editor-in-Chief for ASC 2018, 2020, and 2022. He is also a CEC Technical Editor, with over 120 publications in refereed journals and numerous DOE and NSF grants.

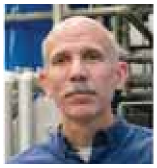
Directors

Robert Duckworth, Ph.D., Senior R&D Staff / Fusion Technology Group Leader, Oak Ridge National Laboratory

Robert Duckworth has been working in the fields of cryogenics and superconductivity for the past 20 years. This work started in the cryogenics group at the University of Wisconsin-Madison where he worked under Dr. John Pfotenhauer on a variety of cryogenic and superconducting materials projects. He joined the Applied Superconductivity Group at Oak Ridge National Laboratory in 2001 to work primarily on high temperature superconducting applications such as power cables, transformers and motors for the electric grid. As this program ended, Robert transitioned into the Plasma Technology and Applications Group in the Fusion Energy Division to work on cryogenic and vacuum R&D supporting plasma fueling and disruption mitigation for the fusion demonstrations with an emphasis on supporting ITER. He currently leads the Fusion Technology group at Oak Ridge National Laboratory and is responsible for the superconducting magnet system construction and installation for the Material Plasma Exposure eXperiment.

John Jurns, M.S.M.E., Senior Cryogenic Engineer, National Institute of Standards and Technology

John Jurns is a senior engineer with a B.S. from SUNY at Buffalo and a M.S. from Cleveland State University. His technical background focuses on cryogenic system and component design, development, research, testing and operations. He began his career at what is now Praxair, designing bulk cryogenic storage systems. He then moved on to research and technology, working at the NASA Glenn Research Center. At NASA, he was responsible for cryogenic program development, design, build-up and operation of cryogenic test facilities. Following NASA, he worked at the European Spallation Source in Sweden as lead engineer responsible for the specification, procurement, and installation of a helium refrigeration system. John currently works at the NIST Center for Neutron Research, leading a team responsible for design and operation of the cryogenic infrastructure supporting NIST's research reactor.



Pete Knudsen, Ph.D., Engineering and Physical Sciences Researcher, US Department of Defense, CSA Fellow

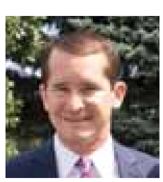
Dr. Pete Knudsen began his career over 30 years ago for NASA at the Kennedy Space Center (KSC) as a systems engineer for the Space Shuttle. He then worked in KSC's Design Engineering Directorate on orbiter vehicle ground support systems requiring high pressure gas, cryogenic fluids and propellants. His last position was as a senior staff engineer in the cryogenics group at the Thomas Jefferson National Accelerator Facility (JLab), where he was responsible for the process and mechanical engineering design of many helium cryogenic systems, including those at other DOE labs and for NASA. Presently he works as senior cryogenic process engineer at the Facility for Rare Isotope Beams (FRIB) at Michigan State University, and co-leads a collaboration between the College of Engineering and FRIB. His responsibilities include the process design and planning of helium cryogenic systems, cryogenic system R&D, and the oversight and teaching of students in cryogenic engineering.

Jacob Leachman, Ph.D., Associate Professor, School of Mechanical and Materials Engineering, Washington State University

Jacob Leachman is an Associate Professor in the School of Mechanical and Materials Engineering at Washington State University (WSU). He initiated the Hydrogen Properties for Energy Research (HYPER) Laboratory at WSU in 2010. He earned a B.S. degree in Mechanical Engineering in 2005 and a M.S. degree in 2007 from the University of Idaho. His master's thesis has been adopted as the foundation for hydrogen fueling standards and custody exchange, in addition to winning the Western Association of Graduate Schools' Distinguished Thesis Award for 2008. He completed his Ph.D. in the Cryogenic Engineering Laboratory at the University of Wisconsin-Madison in 2010 under the advisement of John Pfotenhauer and Greg Nellis. He is the lead author of the reference text "Thermodynamic Properties of Cryogenic Fluids: 2nd Edition." In 2018, he received the Roger W. Boom Award from the Cryogenic Society of America.

Sastry Pamidi, Ph.D., MBA, Professor and Associate Director, FAMU-FSU College of Engineering and The Center for Advanced Power Systems

Dr. Pamidi is a professor and the chair of the Electrical and Computer Engineering Department at FAMU-FSU College of Engineering. He is the Associate Director of the Florida State University Center for Advanced Power Systems (CAPS), where he leads a multidisciplinary research group in large cryogenic systems, superconducting devices, cryogenic dielectrics, and advanced cryogenic measurement systems. His current research interests include cryogenic and superconducting technology for electric aircraft and ships. Prof. Pamidi's group has established advanced experimental facilities and expertise for the characterization of superconducting devices under pressurized cryogenic helium gas and liquid nitrogen circulation. Many researchers and small businesses use his facilities collaboratively. In his 35+ years in cryogenics and superconductivity, Professor Pamidi published 200+ papers. He is professionally active in the superconductivity and cryogenics communities. He served on the organizing, program, and editorial committees of several conferences in the cryogenics area. He was the chair of the International Cryocoolers Conference 2020. He is on the boards of the ICC and CEC Conferences. Dr. Pamidi is a Fellow of the Cryogenic Society of America.



Adam M. Swanger, Principal Investigator, Cryogenics, NASA Kennedy Space Center / Cryogenics Test Laboratory

Adam M. Swanger is the Principal Investigator for the Cryogenics Test Laboratory at NASA Kennedy Space Center. Mr. Swanger holds a MS in Mechanical Engineering from the University of Central Florida, and a BS in Aerospace Engineering from The Ohio State University. He has been working in the field of cryogenics and liquid hydrogen for over ten years, with a focus on providing practical solutions to low temperature problems in both active and passive thermal systems. He has led projects for NASA, the US Department of Energy and National Institute for Occupational Safety and Health, and collaborated with many commercial and academic partners from around the world. He is a lifetime member of the Cryogenic Society of America, and regularly contributes to international conferences such as the Cryogenic Engineering Conference and Space Cryogenics Workshop, and publications such as *Cold Facts* and *Gasworld* magazines.

Steven Van Sciver, Ph.D., Emeritus Professor, Florida State University, Mechanical Engineering Department

Dr. Van Sciver is an Emeritus Professor at Florida State University. Before retirement, he was a Distinguished Research Professor and John H. Gorrie Professor of Mechanical Engineering. He was also a Program Director at the National High Magnetic Field Laboratory (NHMFL). Dr. Van Sciver joined the FAMU-FSU College of Engineering and the NHMFL in 1991, initiating and teaching a graduate program in magnet and materials engineering and in cryogenic thermal sciences and heat transfer. He also led the NHMFL development efforts of the cryogenic systems for the NHMFL Hybrid and 900 MHz NMR superconducting magnets. Between 1997 and 2003, he served as Director of Magnet Science and Technology at the NHMFL. Dr. Van Sciver is a Fellow of the ASME and CSA and former American Editor for the journal *Cryogenics*. He is the 2010 recipient of the Kurt Mendelssohn Award and the 2017 recipient of the Samuel Collins Award.

Streamlining Industrial Gas Distribution with Cylinder Outsourcing

by Chris Manning

By streamlining the acquisition, recertification and repair of gas cylinders, industrial gas distributors can increase profitability. Industrial gas distributors, responsible for filling and supplying compressed gas cylinders for sale or rental, are crucial to diverse sectors. They deliver essential gases like nitrogen, oxygen, argon, carbon dioxide, hydrogen, helium, methane and propane to a variety of industries, including electronics, government, medical, welding, food and beverage, fire protection and aviation.

Nevertheless, they are in business to turn a profit and must leverage the most economically efficient methods to maximize revenue and minimize operational costs. This is equally important when acquiring new or refurbished gas cylinders or recertifying or repairing existing ones. “By outsourcing to a third-party cylinder supplier, small to mid-sized independent gas distributors can save time and reduce costs, allowing them to focus on serving their customers,” says Ed Burcham, area manager of Ozarc Gas and Equipment.

Over the past 30 years, Burcham has acquired new and refurbished cylinders and has sent cylinders out for recertification to established third parties. He states that even the largest distributors outsource due to the complexities involved in specifying, refurbishing and testing cylinders. Ozarc Gas and Equipment supplies industrial gases and welding equipment in Missouri and, along with other locations, is part of a larger network of distributors owned by Meritus Gas Partners.

According to Burcham, when choosing a reputable supplier, it is important to look for key traits: a supplier should be able to source cylinders worldwide, which lowers the distributor’s shipping costs. They should provide cylinders that not only function properly but also adhere to precise specifications. Finally, whether dealing with cryogenic or non-cryogenic cylinders, a supplier should manage these processes themselves, reducing costs and time for the distributor.

To maximize revenue and reduce costs, industrial gas distributors should consider outsourcing cylinder acquisition and recertification to third-party suppliers. *Credit: Quest Cylinders*

Ultimately, a distributor should clearly discern the value and benefits of any chosen cylinder supplier before entering a partnership with them.

New Gas Cylinders

The business model for industrial gas distributors typically involves acquiring cylinders and renting them to customers. Consequently, they need a substantial inventory of cylinders in various sizes. As the business expands, these demands increase correspondingly.

Today, new cylinders are available from only a handful of U.S.-based manufacturers. However, U.S.-based third parties can source cylinders from reputable overseas sources that conform to U.S. specifications (including those related to coatings, markings and legal requirements).

According to Burcham, Quest Cylinder effectively navigates this challenge by sourcing the primed shell offshore. The company specializes in new and refurbished compressed gas cylinders as well as performing cryogenic repairs, service and sales. The shell arrives with all the legal markings and a valve, if specified. Quest Cylinder then takes the shell and performs all necessary steps to prepare the cylinder for the distributor, including adding the valve if needed, which must meet stringent safety standards and be tailored to the specific gas type to prevent leaks, overpressure, or cross-contamination between gases.

Refurbished Gas Cylinders

Distributors might also consider purchasing refurbished cylinders. While large distributors are gradually moving toward refurbished cylinders as a cost-saving measure, it is typically the small- to mid-sized distributors who recognize refurbished cylinders as a perfectly viable alternative to new ones. Of course, refurbished cylinders must meet the same specifications as new cylinders.

For small to mid-sized independent gas distributors, the decision to acquire refurbished cylinders is driven by “cost and the bottom line,” says Burcham, adding that there are also times when new cylinders are in short supply.

Quest Cylinder's refurbished cylinders, which can be cryogenic or non-cryogenic, are shot-blasted, hydrostatically tested, painted/embossed/stenciled, stamped per DOT specifications when required and outfitted with new valves. They can bring a distributor's entire fleet of cylinders up to code by refurbishing them, or the distributor can purchase the cylinders "as is" and take the required steps themselves to meet compliance.

Recertifying Cylinders

Distributors can realize value in more areas than just cylinder acquisition. Generally, non-cryogenic cylinders must be recertified every 5 to 10 years, depending on the cylinder type, the material it is made of and the regulatory standards it falls under. Some cylinders, particularly those used for high-pressure gases or under DOT regulation (like DOT-4L cylinders for liquid gases), must be recertified every 5 years. For certain cylinders, particularly low-pressure or specific stainless-steel models, recertification can extend to 10 years.

Regardless of how often recertification is required, Burcham says the investment in the equipment required for in-house testing is cost-prohibitive for most independent distributors. "Outsourcing testing and recertification is beneficial because it reduces any potential liability," says Burcham, adding that a company like Quest Cylinder takes full responsibility for testing and recertification, as well as maintaining all the required documentation. He also appreciates the speed of turnaround, "which is important to me because if the cylinders sit at their location, they are not at the customer's site generating rental income."

Repairing Cryogenic Cylinders

To achieve cryogenic temperatures, many companies, such as those in the health care, aerospace and energy industries, require gas in cryogenic cylinders and often purchase cryogenic tanks and equipment for long-term use. This is common in high-volume operations that require continuous access to large amounts of gases. Smaller companies or those with intermittent needs for cryogenic gases (e.g., research institutions, small manufacturers) often only rent cylinders.

Outsourcing cylinder acquisition allows small to mid-sized distributors to focus on customer service while benefiting from cost and time savings. *Credit: Quest Cylinders*

Regardless, like all cylinders, cryogenic cylinders are prone to wear and tear and must eventually be repaired to ensure their safety and structural integrity. Repair procedures vary, but they are often long and involved. A technician typically performs a visual inspection of the outer tank and components, removes the float gauge assembly for inspection, breaks the vacuum or backfills with GN_2, replaces the POV, checks for leaks using a helium mass spectrometer, bakes the vessel at a range of 250-350 degrees F to reactivate the molecular sieve, reevaluates the annular space to 10 microns or less, repairs/replaces any defective plumbing, performs a bench-set pressure build, economizes the regulators and pop-tests the relief valves.

Finally, they perform gas pressure and liquid tests to check for leaks, ensuring the tank, regulator and valves meet industrial gas and manufacturer standards. To save time and money, it is worth outsourcing this process to an outside supplier who can quickly and efficiently perform this work in their facility and then ship the repaired cylinder back to the distributor.

Like any other business, a distributor must focus on reducing costs and improving time efficiency. Since gas cylinders must be replaced, refurbished, recertified and repaired, the most economical way to achieve this is to outsource this work to a credible third party, freeing the distributor to concentrate on their own business as well as their customers' needs. **www.questcylinder.com**

INFICON's Cryo Tech Uncovers Volcanic Secrets on Vulcano and Stromboli

by Séverine Grimberg, INFICON GmbH

Volcanism is one of Earth's most powerful forces, reshaping landscapes and impacting ecosystems in dramatic ways. To advance the prediction of volcanic eruptions, INFICON GmbH, a leader in measurement and sensor technologies, is partnering with scientists and research institutions to monitor volcanic activity on Italy's Vulcano and Stromboli islands. This collaboration uses INFICON's advanced instruments to perform geochemical measurements of gases emitted from the ground, offering insights that could help forecast eruptions with greater accuracy.

To improve the prediction of volcanic eruptions, INFICON, a specialist in measurement and sensor technologies, is working with scientists and international research institutions on the Italian islands of Vulcano and Stromboli. *Credit: INFICON*

Vulcano, one of the seven inhabited Aeolian Islands in the Tyrrhenian Sea, has been a focal point for volcanic research since June 2022. The island's volcanic activity, marked by sulfur emissions and a rich history, has made it an ideal research site. According to Professor Andres Diaz and Josef Grenz, the data collected here holds significance beyond volcano studies, contributing to environmental safety for future generations.

This research project includes a team from INFICON's Syracuse and Cologne sites working alongside the Italian National Institute of Geophysics and Volcanology (INGV), NASA, ESA, and ASI. Together, these experts aim to improve monitoring methods and enhance civil protection protocols for people living near active volcanic craters.

One critical focus of this study is understanding the behavior of liquid magma. Italian researchers from INGV's Geological Institute in Palermo explain that geochemical monitoring allows them to quantify outgassing magma, indirectly indicating the amount of magma present. This information helps categorize eruption risks, as magma often seeks a path toward the Earth's surface under increasing pressure.

INFICON's specialized instruments, which detect gases at the crater and nearby, are essential to this project. "When working directly at volcanic craters, we need robust, reliable equipment that can withstand extreme volcanic conditions," says Emre Germen, INFICON's market manager. Their tools, including portable gas analyzers and leak detection technology, monitor gases such as CO_2, H_2S, SO_2, and helium. The data collected reveal patterns in gas composition and flow that signal changes in volcanic activity.

In this challenging environment, INFICON's mobile devices have transformed from large lab equipment into compact, user-friendly units powered by solar modules and batteries. The advanced sensors enable in-situ and real-time monitoring, wirelessly transmitting data to provide a comprehensive picture of volcanic outgassing processes. This continuous monitoring complements other techniques like seismometry, magnetic measurements, and remote sensing.

For example, INFICON's helium sensor, "He-Man," detects trace amounts of helium via a helium-permeable membrane using Penning ionization. These readings help refine existing instruments and contribute valuable data for future development.

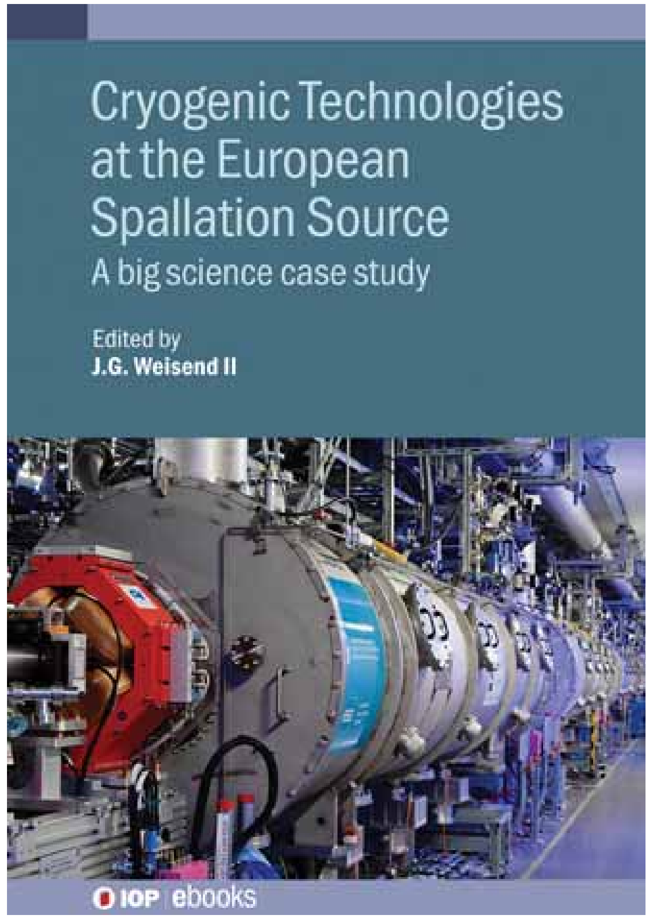
INFICON also provides advanced instrumentation and sensor technologies that optimize productivity and quality across diverse sectors, including semiconductor manufacturing, air conditioning, and automotive advancements. With a global presence and headquarters in Switzerland, INFICON supports critical processes in industrial applications, life sciences and environmental monitoring.

The Vulcano project not only strengthens local safety protocols but also benefits global volcano monitoring efforts. The data from these field campaigns calibrate remote sensing tools such as NASA-JPL's HyTES (Hyperspectral Thermal Emission Spectrometer) and support the development of future satellites, including HyspIRI. The information gathered here will contribute significantly to the global monitoring of volcanic activities, allowing civil protection agencies to prepare better emergency responses. **www.inficon.com**

Book Review—*Cryogenic Technologies at the European Spallation Source: A Big Science Case Study*

Reviewed by Tom Peterson, tjpete@slac.stanford.edu

The European Spallation Source (ESS), nearing completion, will be a state-of-the-art research facility for probing materials with neutrons. Neutrons, in a manner complementary to X-rays from light sources, serve as a valuable tool for studying properties of matter at the atomic level. Various cryogenic systems support ESS, including 2 Kelvin helium cooling of the proton linac, the liquid hydrogen moderator for cooling the neutrons produced by proton-target collisions, and various test facilities.



Quoting from the preface of Cryogenic Technologies at the European Spallation Source: A Big Science Case Study, the goals of this book are to:

- Describe in detail the final installed cryogenic system at ESS and its performance to date.
- Describe the processes by which the system was designed, procured, and installed, including collaborations with in-kind partners.
- Provide lessons learned that are useful for future projects.
- Ensure that proper credit is given to everyone who contributed to the ESS cryogenics system.

In 12 chapters spanning over 430 pages, the authors skillfully and thoroughly accomplish these goals.

ESS has been a 14-year effort since the project's start in 2009. The large, complex cryogenic support systems represent more than 50 million euros of value. ESS is not only a large science project but a new laboratory built on a "green field" site. Thus, the design, procurement, and construction of the ESS cryogenics system included not only new physical infrastructure but also a fully new organization, large procurements, and in-kind contributions from other laboratories. Documenting this endeavor to build not only a large science facility but also a new laboratory provided a prime motivation for this book.

True to its name, ESS is a European effort. Sweden and Denmark serve as the host states for ESS, with the laboratory in Lund, Sweden, and with Denmark hosting the data management and science center in Copenhagen. Sweden and Denmark provide about half of the costs, with the balance coming from 11 non-host European states. The book lists the names of more than 250 people who contributed to the development of ESS, 17 of whom served as co-authors of various chapters and for whom biographies are provided.

The authors essentially provide a series of detailed design reports about all things cryogenic at ESS. The editor, John Weisend (CSA Chairman), authored the introduction and a closing chapter on "Lessons Learned and Final Comments" as well as co-authoring Chapter 2, "An Overview of the ESS Cryogenic System and Its Design Evolution." Chapters 3 through 11 each describe a system in detail: the accelerator cryogenic plant, cryogenic distribution system, target modulator cryogenic plant, cryogenic moderator system, the test and instruments cryoplant and auxiliary systems, elliptical cavity cryomodules including ESS superconducting radio frequency collaboration, spoke cavity cryomodules, cryogenic testing of elliptical cryomodules at ESS, and cryomodule testing in the FREIA laboratory at Uppsala University. These cryogenic systems and

▶ *continues on page 16*

low-temperature devices presented an impressive variety of technical challenges. Chapters are written by different experts or teams of experts who were among the leaders of their portions of the project, with some people contributing to more than one chapter.

A valuable feature of the book is an organizational pattern common to each chapter. Authors provide motivation and goals, detailed accounts of requirements, design, procurement including source selection processes, testing, and a summary of lessons learned for their project.

The depth of information is most impressive. Chapter 6, for example, on the cryogenic moderator system with a focus on the liquid hydrogen neutron cooling system, spans 74 pages, includes 42 references, and could serve as a text on fluid-flow and pressure design for cryogenic systems. Management and organizational issues are also presented, and this chapter, like the others, concludes with specific lessons learned. The other chapters cover their respective topics with a similar level of rigor, depth, and clarity.

Lessons learned cited by the authors include:

- Bring skilled people, including technicians, on board early.
- Good communication and transfer of knowledge via open and free communication among ESS and partner lab staff was crucial.
- Early engagement with suppliers is also valuable; get their input.
- Provide as much time and budget as possible for prototype development and testing.

None of these lessons comes as a surprise to people involved in this kind of large-scale science project, but these messages deserve repeating. Too often, such activities are victims of budgetary or schedule constraints, and the long-term costs and schedule delays from such cuts may exceed the short-term gains. This book documents the impact and importance of these activities for ESS.

The scope of information provided will make Cryogenic Technologies at the European Spallation Source a valuable reference for scientific project managers while also providing a wealth of technical information about ESS cryogenics and large-scale cryogenic systems.

Hardback: $190.00 USD
Ebook: $159.99 USD

https://2csa.org/mn6


GARDNER CRYOGENICS

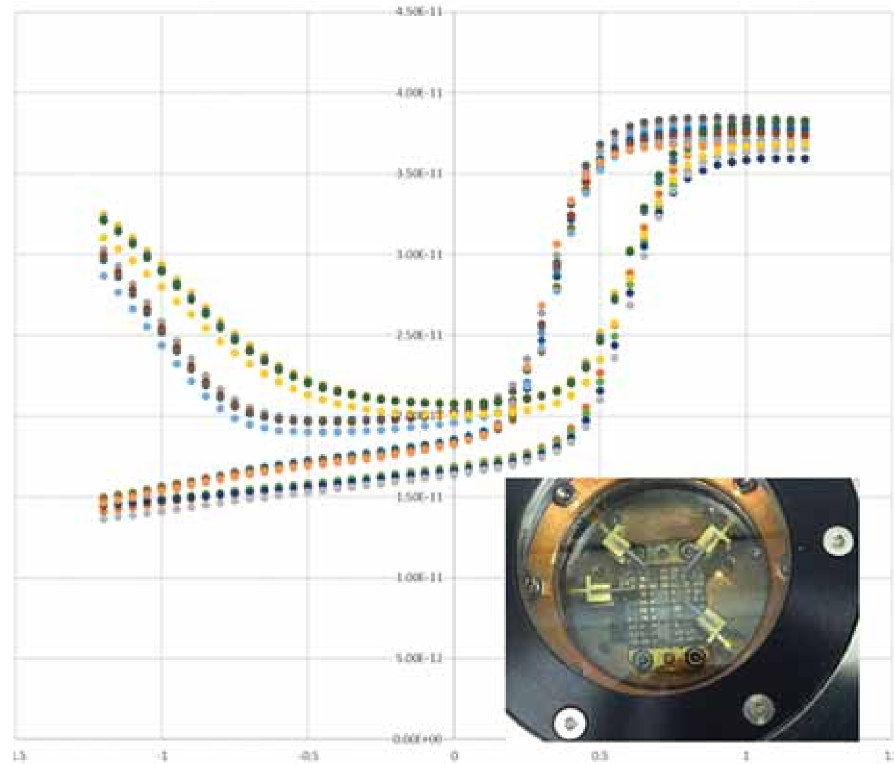
CoolCAD Electronics Pioneers Precision in Cryogenic Testing and Modeling

by Doug Dixon, CoolCAD Electronics

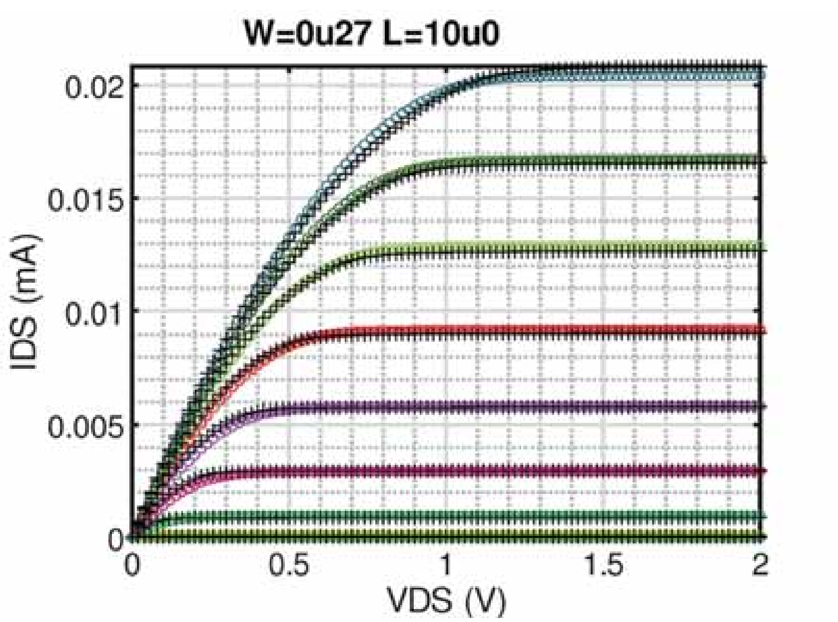
CoolCAD Electronics is a leading provider of electrical test services (current-voltage, capacitance-voltage, noise, transients, etc.) and compact modeling (SPICE) for companies and agencies fabricating and/or designing electronics for low temperature operation. CoolCAD Electronics is a leading-edge company specializing in cryogenic electronics design, testing, and characterization of semiconductor devices operating at ultralow temperatures. With the growing importance of cryogenic technologies in fields like quantum computing, superconducting circuits, and high-performance computing, CoolCAD addresses the unique challenges posed by extreme environments. The company's work enables precise device characterization at temperatures as low as 4 K, offering insights into semiconductor behavior and performance in cryogenic conditions. As demand for robust, high-performance cryogenic electronics increases, CoolCAD provides the tools and expertise required to ensure reliability and functionality in these challenging environments.

Cryogenic testing presents challenges that conventional room-temperature testing methods cannot address. Near absolute zero, semiconductor materials undergo significant changes in electrical properties, including variations in carrier mobility, material structure, and electron trapping behaviors. These effects can lead to performance degradation that traditional testing systems cannot detect. CoolCAD has developed state-of-the-art testing platforms to capture these temperature-induced phenomena with unprecedented accuracy. Their advanced equipment, such as ultra-fast I-V (current-voltage) measurement systems, allows engineers and researchers to observe device behavior at cryogenic temperatures in real time, with a time resolution down to 20 nanoseconds. This ability to conduct fast timescale measurements is crucial for uncovering complex transient dynamics in cryogenic devices.

▶ continues on page 20



Top view of the cryogenic probe station showing all the probes and high-speed cables in the chamber with devices under test and the cold sample stage that is temperature controlled down to ~4 K. Low temperature capacitance voltage measurements are used to characterize various CMOS technology nodes. *Credit: CoolCAD*



Gate voltage dependent drain current versus drain voltage curves of a narrow device (W/L = 10/0.27, both dimensions are in micrometers) measured at 4K. These measurements along with measurements of other size devices are used to extract a SPICE modelcard. The simulated curves (black lines with + symbol) are compared with an example set of measurements (colored lines). *Credit: CoolCAD*

OPW
CLEAN ENERGY SOLUTIONS
a DOVER company

DURABLE

Ball cage interface with receptacle adapter ring guides and locks the nozzle in place for optimum engagement and user interface to increase environmental seal life.

REGO CRYOMAC®4 LNG FUELING NOZZLE

- Safe, with added safety to operator
- High Durability, increases seal life
- Certified with ISO12617:2017

Patented nozzle safety feature is recognized in the market as a major failsafe advantage for the operator.

Continuing innovations coming soon, Cryomac®5!

Scan the QR code to learn more about the Cryomac®4

CPC-Cryolab MODEL CV8BS BELLOW SEAL

- Lightweight valve
- Bellows seal technology ensures zero leakage
- Valves size up to 12"
- Tailored to meet your specifications

Bellows rigorously qualified by leading industry companies for critical applications.

Scan the QR code to learn more and contact us

MANUAL OR ACTUATED

The CV8BS offers a Standard quick open, EQ%, Linear Hyperbolic Purge Riser Over Seat and/or Under Seat.

Specially designed for higher rated working pressures, and a special extended length for helium service.

BELLOWS OR NON-BELLOWS

Globe, "Y" pattern, and Right Angle pattern designs.

Electric Trim Heaters

Electric Vaporizers

Shell and Tube

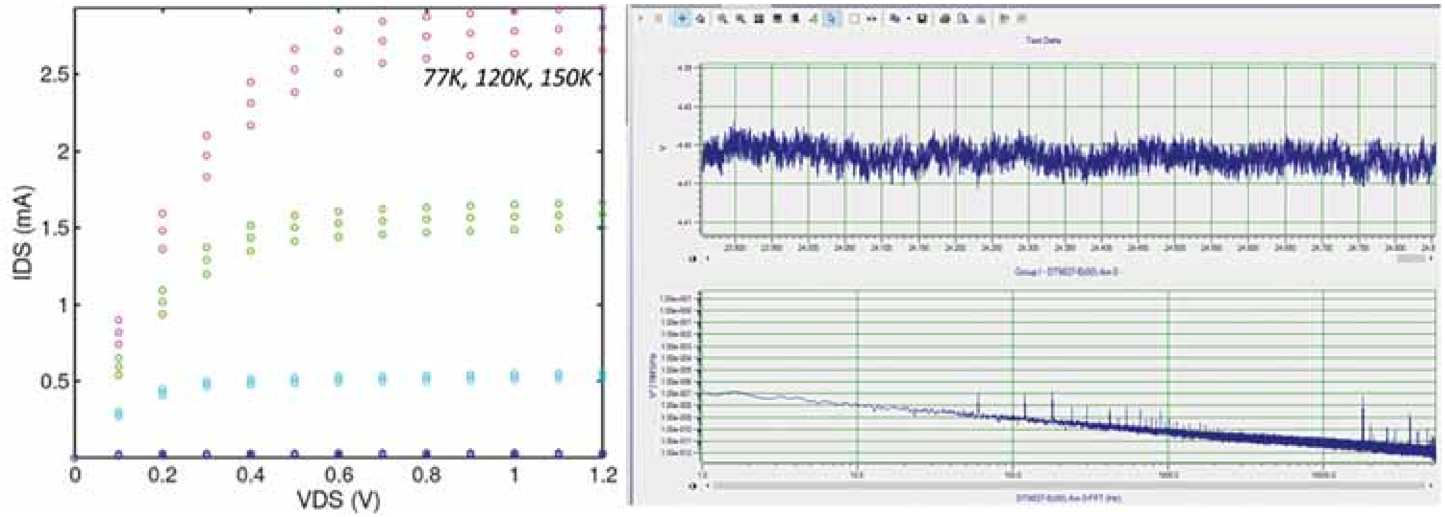
Water Bath Vaporizers

ACME CRYOGENICS | CEXI CRYOGENIC EXPERTS

VAPORIZERS

- Full line for both process and disposal
- Several styles for custom-designed systems
- Design & specify 1kW gas heaters to large capacity custom-designed systems

Scan the QR code to learn more about ACME Cryogenic Experts (CEXI) vaporizers.



The CMOS device measurements obtained in a low temperature probe station show that the drive current of a CMOS device usually increases with temperature decreasing. In addition to current-voltage and capacitance-voltage measurements, we regularly perform 1/f and random telegraph noise experiments. A typical 1/f time domain signal and its frequency domain counterpart are shown on the right. *Credit: CoolCAD*

One of CoolCAD's key innovations is its ultrafast I-V measurement system, which enables detailed analysis of charge trapping and de-trapping dynamics in low temperature semiconductor devices. Charge traps—often caused by defects or impurities—can impact cryogenic circuit performance, especially in applications where precision and reliability are paramount, such as quantum computing. By tracking shifts in device parameters like threshold voltage and transconductance (gm), CoolCAD's testing platform provides insights into both fast and slow charge traps that degrade performance. These measurements are essential for understanding cryogenic device operation and play a critical role in high-performance cryogenic electronics development.

The ultrafast I-V measurement system developed by CoolCAD and NIST researchers also allows analysis of transient effects over a broad range of pulse durations, from nanoseconds to milliseconds. This flexibility enables researchers to capture both fast, short-lived phenomena and slower, thermally driven trapping events. The ability to observe both behaviors is essential for understanding device operation in low-temperature environments. For example, some charge traps may be linked to interface states that become apparent only at cryogenic temperatures. By capturing these effects, CoolCAD's technology identifies potential performance bottlenecks, allowing engineers to optimize device performance before deployment in real-world applications.

Two of our low and high temperature probing setups are shown here. Using these setups, we perform chip measurements from 4 K to 1000 K, with current and voltage ranges spanning from a fraction of a picoamp to an amp, and a microvolt to hundreds of volts, respectively. These also allow for the measurement of a fraction of a picofarad. *Credit: CoolCAD*

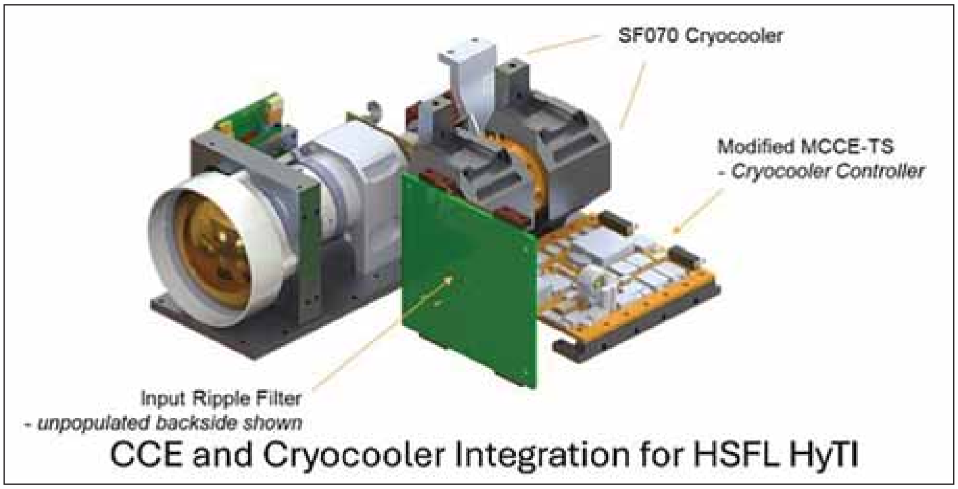
In addition to its testing capabilities, CoolCAD is innovating in semiconductor device modeling and simulation for cryogenic environments. Temperature-induced effects can alter material and device behavior unpredictably, making accurate modeling essential for reliable low-temperature device design. CoolCAD's simulation tools help engineers anticipate how different materials and design choices will respond in cryogenic conditions, supporting a holistic approach to cryogenic electronics and enabling the development of optimized, reliable devices.

CoolCAD Electronics also emphasizes the importance of understanding materials science and device physics for successful cryogenic electronics. The company's experts work closely with researchers, engineers, and institutions to bridge fundamental materials research and applied device engineering. This collaborative approach drives the development of novel semiconductor materials, such as high-k dielectrics, essential for cryogenic circuit performance. CoolCAD's solutions help create devices that operate efficiently in demanding cryogenic regimes by understanding material interactions with the environment. The company's work is especially relevant to quantum computing, where precision and reliability are critical for the stable operation of qubits and other low temperature components. CoolCAD's testing platforms help ensure these devices operate as intended at the cryogenic temperatures required for quantum operations. By providing a detailed understanding of device behavior at ultralow temperatures, CoolCAD advances the performance and scalability of quantum technologies, which rely on precise quantum state control. **www.coolcadelectronics.com**

WCS Redefines Boundaries in Cryogenics

by Dr. Carl S. Kirkconnell, P.E., President, West Coast Solutions

West Coast Solutions (WCS) has experienced remarkable growth since its founding in 2015 by Dr. Carl Kirkconnell. From its origins as a one-person operation, the company has expanded to a team of over 40, 80% of whom are engineers. Anchored by a core group of seasoned professionals—many former Raytheon colleagues—and bolstered by a dynamic team of early-career engineers, WCS has cultivated a unique balance of experience and innovation. Cryogenics remains a central focus, reflecting Dr. Kirkconnell's expertise in the field. This foundation, combined with technical adjacencies, has enabled WCS to establish three thriving business sectors: cryogenics, aerospace and electronics and power.



HyTI – CCE and Cryocooler Integration for HSFL HyTI. *Credit: WSC*

Within the cryogenics community, WCS is best known for its high-performance, cost-effective, radiation-hardened cryocooler control electronics (CCE) designed for airborne and spaceflight applications. While many projects remain confidential, notable contributions include the NASA EXCITE (Exoplanet Climate Infrared Telescope) program. For this mission, WCS delivered two sets of cryocooler electronics to drive and control Thales LPT 9310 pulse-tube cryocoolers on a balloon-based platform. In addition to providing the flight electronics, WCS supported real-time tuning of the exported vibration minimization servo—a technical achievement detailed in Cryocoolers 23. Similarly, WCS played a pivotal role in supporting Creare's MCCE-TS manufacturing effort for L3Harris Technologies' Tranche 0 (T0) and hypersonic and ballistic tracking space sensor (HBTSS) programs.

WCS's capabilities in cryogenics extend far beyond cryocooler electronics. As detailed in Cryocoolers 21, the company served as the cryocooler system architect for the Hawaii Space Flight Laboratory's hyperspectral thermal imager (HyTI) program. This involved developing the mechanical integration scheme, performing the thermal design, assessing exported vibration effects and delivering cryocooler flight electronics. The success of HyTI led to WCS's selection as the CCE supplier for HyTI-2. Recent advancements also include performing exported force and torque (EFT) measurements using the company's 6-DOF "Kistler table" dynamometer, evaluating the cooling performance of commercial off-the-shelf cryocoolers under high-vibration conditions and leading the design of next-generation cryocoolers to meet emerging requirements. In essence, WCS serves as a comprehensive cryogenics expert, offering expertise spanning from cryocoolers and their integration to CCEs tailored for specific applications.

The company's ventures into aerospace electronics have evolved organically from its cryogenics work, drawing on decades of experience with space infrared sensors from the team's Hughes and Raytheon roots. Building on its success with CCEs, WCS has developed a robust focal plane electronics (FPE) portfolio, achieving technology readiness level (TRL) 9 in this area. The company has also delivered custom power distribution electronics for flight programs with complex infrared sensor demands and is currently designing thermal control electronics for another space mission. Collaborations with Creare have further broadened WCS's portfolio, such as the development of high-accuracy sensing electronics for a next-generation spacesuit oxygen flowmeter. This blend of rapid design capability, adaptability and radiation-hardening expertise has positioned WCS as a leader in aerospace electronics, expanding its impact well beyond its origins in cryogenics.

Completing WCS's triad of capabilities is its growing power portfolio. Among its most notable achievements is the TRL 6 flight qualification of the hybrid battery supercapacitor (HBS) for the Missile Defense Agency. By hybridizing battery and supercapacitor electrodes within a single core, WCS—collaborating with a local battery cell manufacturer—has pioneered a novel space battery with approximately three times the power density (~450 W/kg) of standard lithium-ion competitors. This compact 1U (10x10x10 cm) unit delivers a continuous 700W for over six minutes, unlocking a new class of high-power payloads for satellites. Applications include supporting large longwave infrared (LWIR) and very longwave infrared (VLWIR) sensors in duty-cycled orbits, synthetic aperture radar (SAR), electric propulsion, high-data-rate transmitters and directed energy systems.

WCS redefines industry standards through advances in cryogenics, aerospace electronics, and power technology. The company's multidisciplinary expertise and commitment to excellence ensure its position as a trusted partner for solving the complex challenges of modern space and defense missions. **www.wecoso.com**

BLUE FORS

Enabling Quantum Technology, Physics Research, and Life Sciences.

From cryocoolers to liquid helium management, our Cryomech products cover all your low-temperature experimental needs.

PT450 Pulse Tube Crycooler
5.0 W @ 4.2 K w/ 65 W @ 45 K

LHeP28 Liquid Helium Plant
≥28 L/Day

AL630 Gifford-McMahon Cryocooler
100 W @ 20 K

CRYOMECH

BLUEFORS.COM

Zero Resistance Zone

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

Design Considerations for Cryogenic Supports

Supports used in low temperature or cryogenic systems have several factors that are part of the design considerations. First, the supports must be capable of carrying all the expected mechanical loads. Complications exist because of the extreme temperature difference that usually accompanies these support structures. The temperature differences must consider heat load to the cold mass and any thermal contractions during cooldown. In most situations, the supports are also required to withstand shipping transportation loads, which can either be under warm or cold conditions. Figure 1 shows examples of many common support designs.

This article provides an overview of some of the factors which must be considered in the design of cryogenic supports and some examples of common applications. A more comprehensive discussion of support structures used in cryogenic applications can be found in our first references.[1,2]

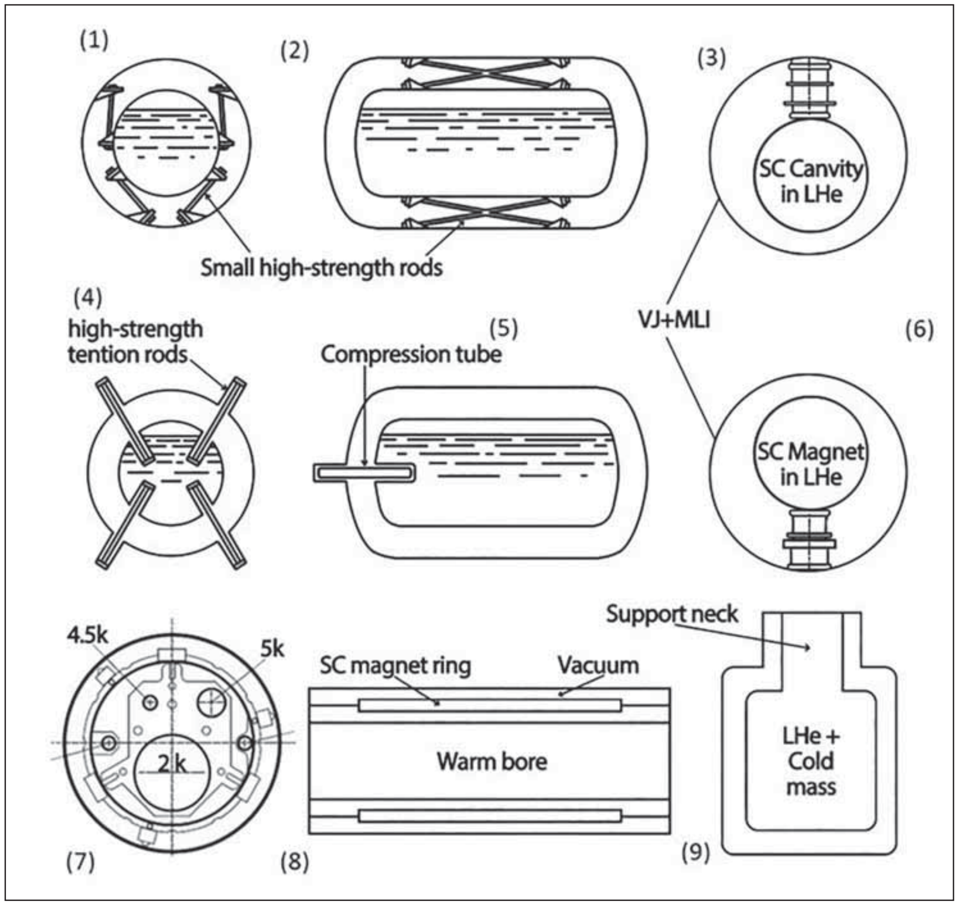


Figure 1. Simplified sketches of cryogenic supports, which thermally isolated various cold-masses from outer vessels at environment temperatures. 1,2,4 and 5: Tension and compression rods. 3 and 6: Tension and compression post. 7: Ring shaped support, 8: Horizontal tension bars. 9: Neck tube support. *Credit: Shu and Demko*

Thermal and Mechanical Considerations

Structural supports for cryogenic equipment must sustain the required loading under tension or compression as well as thermal stresses. Mechanical loads for structural supports are developed by tension and compression along a member's axis, bending, and torque or twisting. Lateral loads are also present in applications such as superconducting accelerator magnets as described in Nicol, [3] and Nieman et al.[4] which can introduce bending and twisting. Loading can be present from several sources, including the weight of the cold mass, thermal contractions, and shipping loads. In some situations, the cold mass may be provided with additional shipping supports that will be removed after the device has been installed. The mechanical load carrying requirement is often in conflict with the minimization of heat transfer to the cold mass.

This discussion is not intended to be comprehensive of the mechanics of materials and stress calculations, but only to provide an overview of stress considerations needed in the design of supports. The designer should consult more comprehensive references such as Beer[5] and Shigley[6] for more complete discussions of stress analysis.

Materials

The selection of materials used in cryogenic applications depends on compatibility with low temperatures.[5] Many materials become brittle when they are cooled below their glass transition temperature. Some of these materials include metals such as iron, carbon and low alloy steels, molybdenum, niobium and zinc. In general, most body centered cubic (bcc) metals, and most plastics become brittle at low temperatures. The commonly available polyvinyl chloride (PVC) pipe is commonly used to replace piping at room temperature, but PVC is very brittle at low temperatures and should be avoided.

Acceptable materials include body centered cubic structure (bcc) metals such as copper, nickel, copper-nickel alloys, aluminum and its alloys and austenitic stainless steels, titanium, and zirconium remain ductile at low temperatures. In general face-centered cubic (fcc) metals remain ductile.

▶ *continues on page 80*

Materials such as polytetrafluoroethylene (Teflon™), also remain ductile at low temperatures.

High vacuum is often used as part of the thermal isolation, so metals must provide the capability to maintain high vacuum inside the vessel. Outgassing of hydrogen trapped in stainless steels during the formation process is usually accounted for through getters in the vacuum space. In some applications, corrosion resistance is also needed.

Many composites are used due to the ability to tailor thermal and strength properties. These tend to be more porous than metals and have the potential to outgas. The fiberglass composites, such as G-10 and G-11, are widely used because of their strength, low thermal conductivity, very low outgassing and for many applications their dielectric strength. Kevlar straps have been applied in some situations because of the high strength.

Thermal Optimization

Thermal optimization of a support system seeks to balance the load-carrying capability of the support with the competing factor that the support structure minimizes the heat load during operation. There are many approaches available that rely on the choice of high strength low thermal conductivity materials and the location relative to the cold space. In other more complex situations, heat stations can be used to reduce the heat load to the coldest part of the system.

Barron[6] provides an example of a composite support link used in some support systems for cryogenic fluid storage vessels as shown in Figure 2. Using a particular set of material properties, he shows that the heat transfer for arrangement A, with the fiberglass on the cold side, is 120.9 mW and for arrangement B, with the stainless steel on the cold side, the heat load is 111.9 mW or a 7% decrease due to the placement of the materials. Other factors, such as the length of the tubes, will also have an effect.

In situations where a support is a direct connection between a room temperature outer structure and a cold mass, heat intercepts at various location along the member

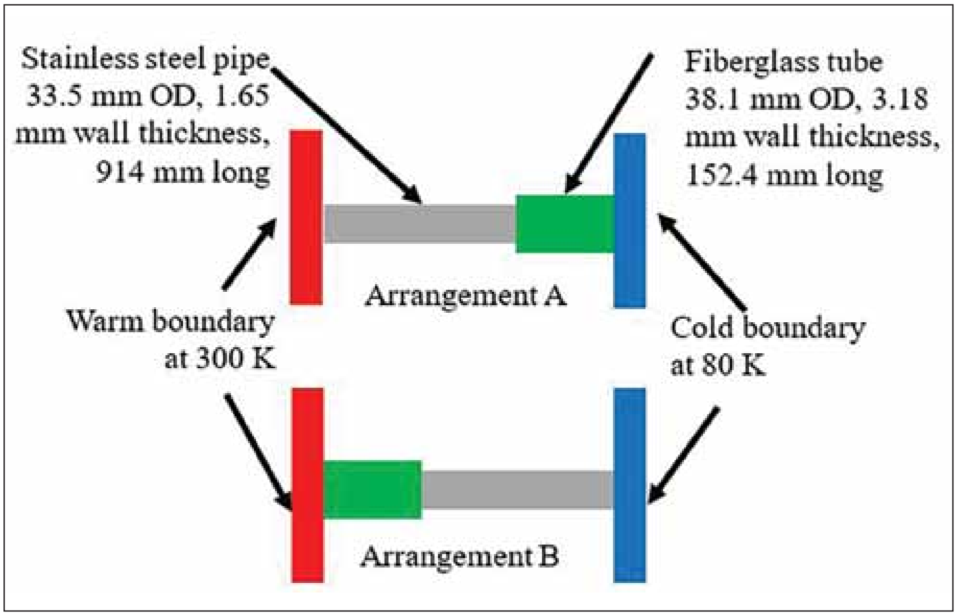


Figure 2. Example of a structural support indicating the effect of the material arrangement on the heat load. *Credit: Demko and Shu*

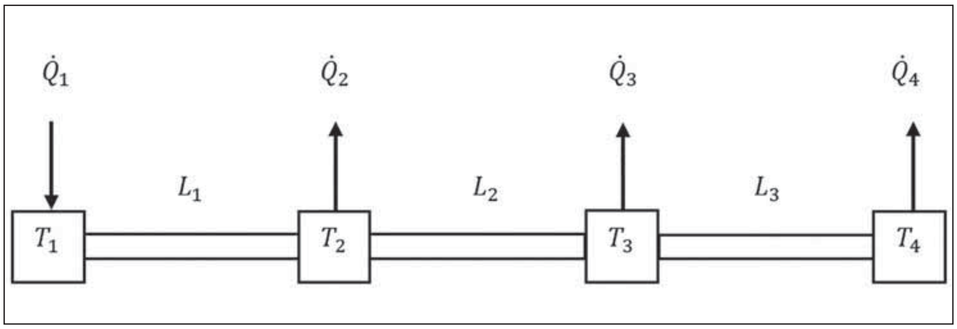


Figure 3. Uniform support between room temperature, T_1, and liquid helium temperature, T_4, with two heat stations at intermediate temperatures T_2 and T_3. *Credit: Demko and Shu*

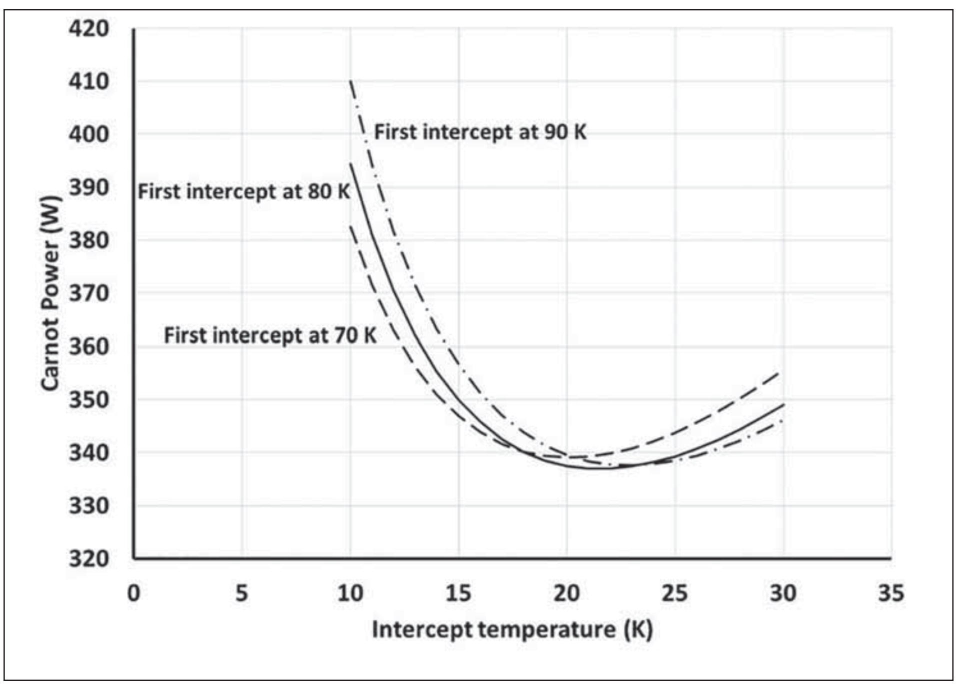


Figure 4. Calculated Carnot power for varying second heat station temperatures at the optimum locations along the support. *Credit: Demko and Shu*

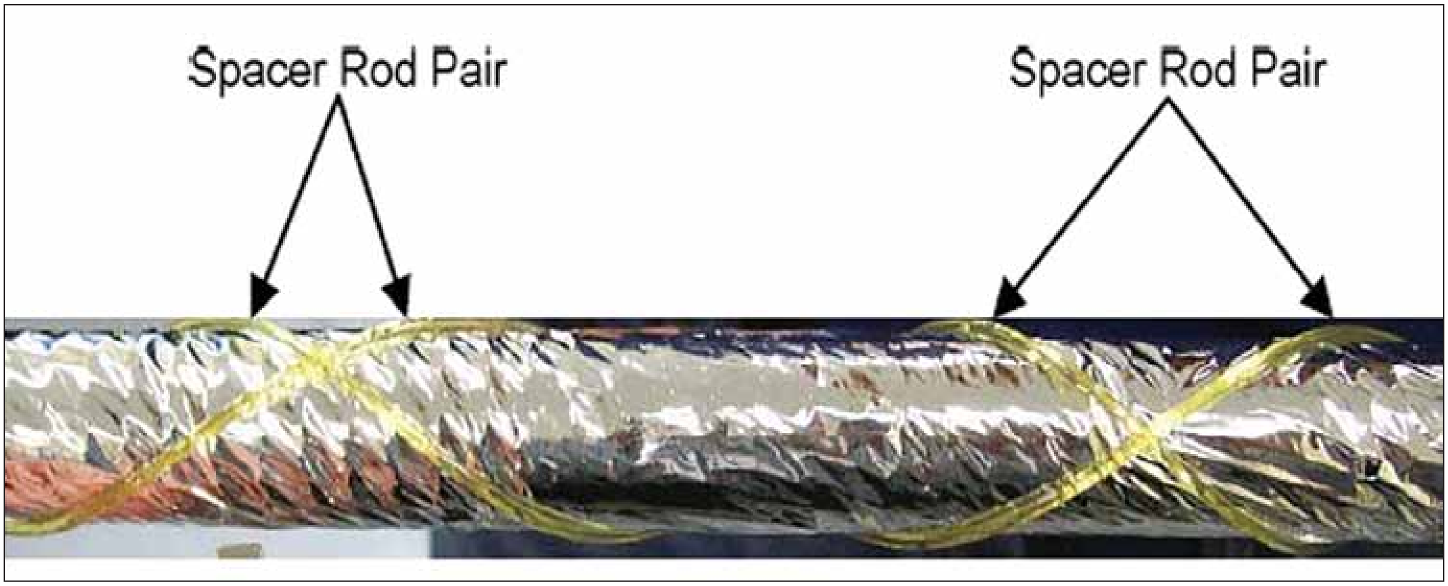


Figure 5. Flexible vacuum jacketed line supports and insulation. *Credit: Demko and Shu*

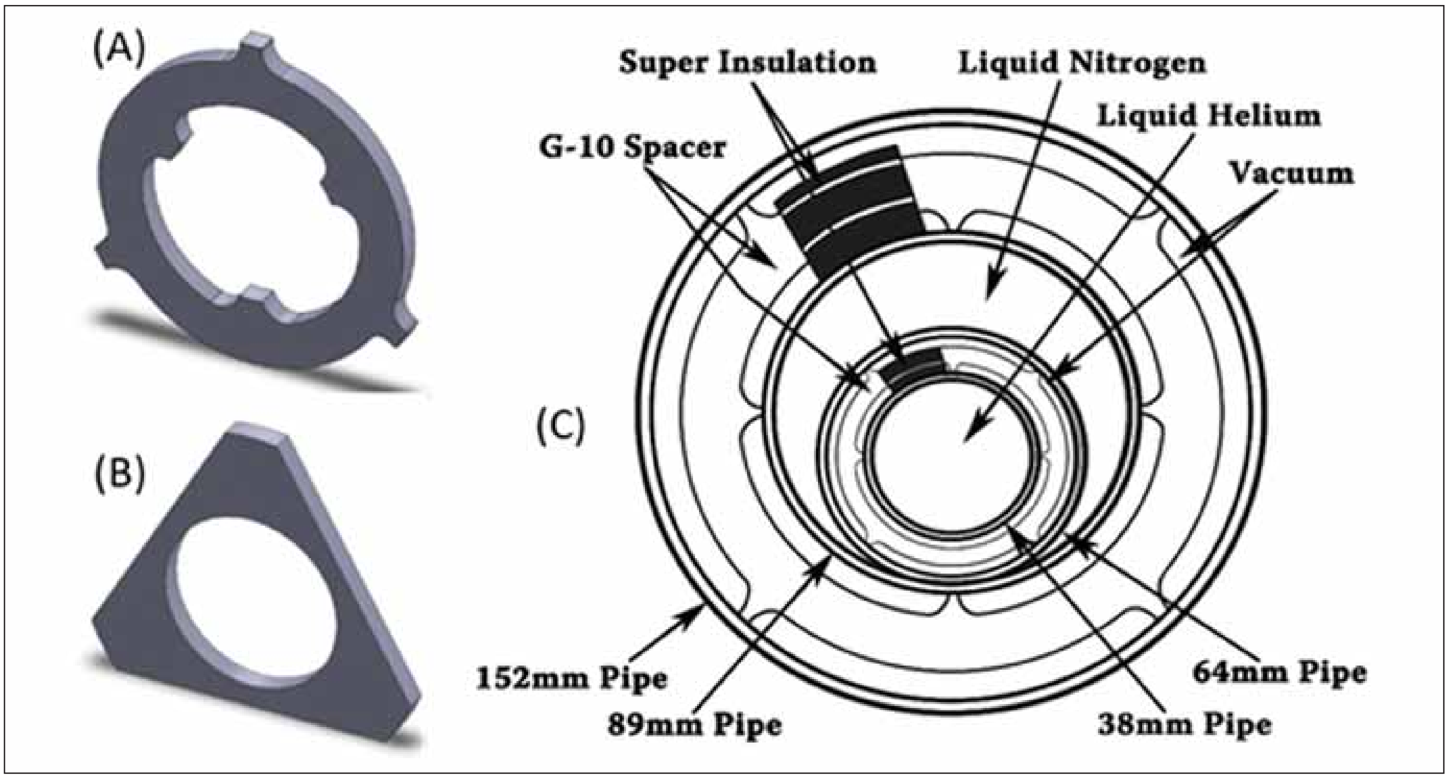


Figure 6. (A) and (B) Rigid vacuum jacketed line supports. (C) Nested vacuum jacketed transfer lines. *Credit: Demko and Shu*

are often used. The temperature stations depend on various system constraints, such as if using a cryocooler which may have specified heat stages. Another way that was described by McAshan relies on minimizing the Carnot refrigeration power. This simple but very instructive analysis was performed by McAshan for the Superconducting Supercollider (SSC) cryogenic system.[1,7] It assumes a uniform cross-section member with heat stations as an example. The optimization is based on the fact that the power needed to remove a heat load at a given temperature decreases as the temperature increases. In this memo, McAshan performs an optimization of the refrigeration requirements along a stainless steel (UNS S304000) and an Ultem-2100 support assuming uniform cross-section, and variable thermal conductivity with heat stations at two locations along the post. The uniform cross-section simplifies the analysis but is a reasonable assumption since it is the mechanical load that determines the area of the support. The optimization clearly shows that refrigeration requirements can be minimized for the 4 K level with heat stations around 80 K and 20 K.

The situation is illustrated in Figure 3 for a case with two heat stations. The cross-sectional area of the support, A, is assumed

▶ *continues on page 82*

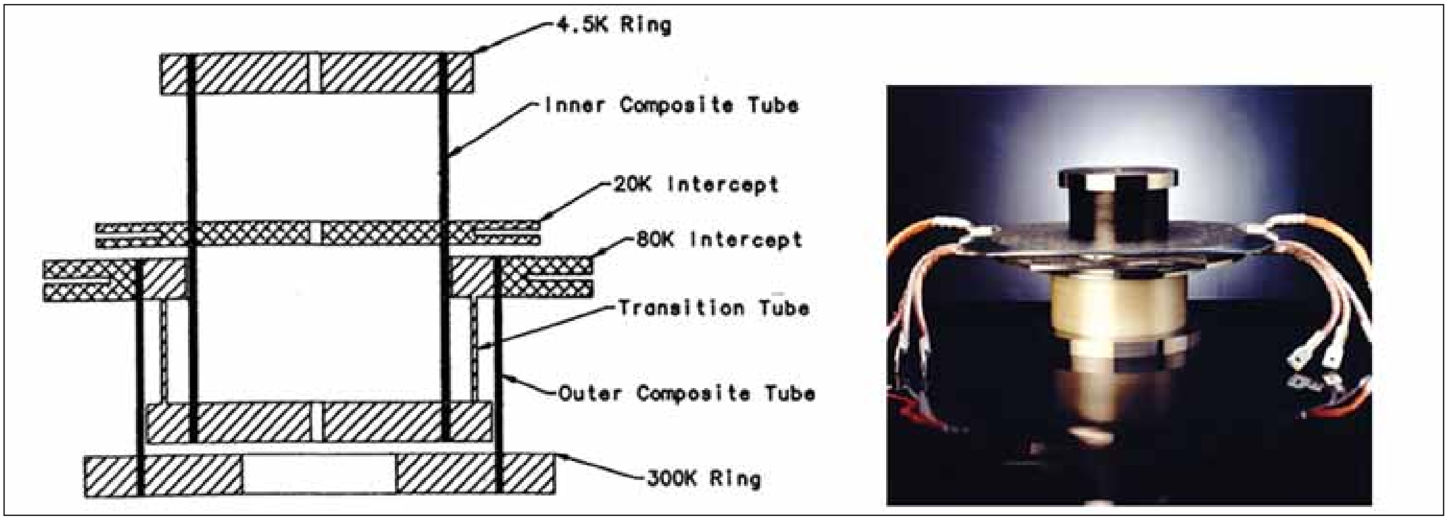


Figure 7. Sketch and photo of the SSC magnet post. *Credit: Nicol*

to be constant. This would most likely be the case since the area would be determined by the stresses in the member. The total length of the support is L, which is broken into segments L_1, L_2, and L_3 which separates the heat stations at the different temperatures. The thermal optimization is performed by minimizing the Carnot refrigeration power, P_Carnot, needed for this member.

The solution shows that the distance along the support at which a heat station is located depends on the temperature of the heat station. The Carnot power at the optimized locations for this support is provided in Figure 4. The first stage or warm heat station was assumed to be at temperatures of 70 K, 80 K, and 90 K.

Examples of Support Structures

There are many different cold masses that can be used as examples. The vacuum jacketed pipe is widely used in most cryogenic fluid distribution systems. Heavy cold masses, such as accelerator magnets, frequently experience complex combined stresses (vertical, shear and bending moments) which provides examples of the wide range of support structures that are needed in cryogenic systems.

Vacuum Jacketed Line Pipe Supports

A vacuum jacketed line pipe support is used to hold the outer vacuum enclosure separate from the cold inner pipe. Pipe supports have different structures depending on whether the pipe is a flexible line or rigid. A description of the design of a flexible line and some methods of measuring the thermal performance are described in Knoll.[10]

Reentrant Post Magnet Support

The unique and sophisticate reentrant post design is for the suspension system of Superconducting Super Collider (SSC) dipole magnets to meet the rigorous thermal and structural requirements. The design is shown in Figure 7. First, it resists structural loads imposed on the cold mass assembly, ensuring stable operation over the course of the magnet's operating life. Second, it serves to insulate the cold mass from heat conducted from the environment. The evolution and selection of the suspension system for SSC magnets has been well documented by Nicol, Nieman et al.[3,4]

The magnet assembly is supported vertically and laterally at five places along its length. To accommodate axial shrinkage during cooldown, the magnet assembly is free to slide axially at all but the center support. The center serves as the anchor position. The cylindrical post constructed with fiber reinforced plastic (FRP, such as G10 and G11) tubing and having metallic heat intercepts and end connections.

Summary

A brief description of the factors which must be considered in the design of supports for cryogenic applications: The requirement for strength conflicts with minimizing the heat load to the cold mass. In some situations, this can be mitigated through careful selection and placement of materials. Other, more complicated systems may rely on removing heat at higher temperatures along the structure with heat stations. The placement of these can also be arranged to minimize the refrigeration load on the system.

References

[1] Demko, J., Fesmire, J. and Shu, Q.S. *Cryogenic Heat Management, Technology and Applications for Science and Technology*.

[2] Shu, Q.S., Demko, J. and Fesmire, J. "Developments in Advanced and Energy Saving Thermal Isolations for Cryogenic Applications." IOP *Conference Series: Materials Science and Engineering*, 2015.

[3] Nicol, T., et al. "Design and Analysis of the SSC Dipole Magnet Suspension System." *International Industrial Symposium on the Super Collider* (IISSC), 1989.

[4] Nieman, R.C., Gonczy, J.D., Nicol, T. et al. "1985 Design, Construction, and Performance of a Post Type Cryogenic Support." Fermilab TM-1349, September 1985.

[5] Beer, F., Johnston, Jr., D., DeWolf, J. and Mazurek, D. *Mechanics of Materials*. Sixth Edition, McGraw-Hill, 2012.

[6] Shigley, J. and Mitchell, L. *Mechanical Engineering Design*. Fourth Edition, McGraw-Hill Book Company, 1983.

[7] Flynn, T. *Cryogenic Engineering*. Marcel Dekker, New York, 2005.

[8] Barron, R.F. *Cryogenic Heat Transfer*. Taylor and Francis, 1999.

[9] McAshan, M. "Optimization Studies for the Conceptual Design of the SSC Cryogenic System." Internal Communication, 1986.

[10] Knoll, D. et. al. "Evaluating Cryostat Performance for Naval Applications." *AIP Conference Proceedings*, vol. 1434, pp. 265-272, 2012. doi: 10.1063/1.4706929.

Clean Energy Future

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

Advanced Thermal Insulation Systems for Low Temperature Applications, Part 3 (Engineered LH_2 System Examples)

Cold costs money, and insulation saves money

Insulation also makes possible the practical control and operation of cryogenic systems. It is the first line of defense in beating the heat and meeting the challenges of conveying liquid hydrogen (LH_2) for mobility, energy storage, and industry. This includes a wide range of electrical power equipment, aircraft, ships, spacecraft, trucks, tractors, and other heavy machinery being developed in the clean energy transition currently underway.

In Part 1 of this series, the needs and motivations for different cryogenic insulation applications, key parameters and definitions, calculations, and the basics of cryostat testing were introduced. Part 2 provided cryostat test data for key examples of thermal insulation systems and thermophysical data for structural-thermal materials used in cryogenic systems. The "cold triangle design" approach was also reviewed. Concluding this series, Part 3 examines engineered system examples of different LH_2 tanks and piping, including a breakdown of the components of total heat transmission.

Five examples of cryogenic systems—three tanks and two piping systems—are shown in Figure 1. In each case, the optimum approach involves a unique combination of materials; for simplicity and comparison, uniform hot and cold surfaces are assumed. The cold vacuum pressure (CVP), ranging from high vacuum (<0.1 μ), to normal vacuum (~1 μ), to moderate vacuum (~10 μ), to soft vacuum (~100 μ), to no vacuum (760,000 μ), is also uniquely representative of actual working systems in each case. (Note: 1 millitorr = 1 μ = 0.0013 mb.)

Comparative Analysis of Example Systems

The first example is a 125-m^3 horizontal cylindrical SST tank with a carbon steel outer jacket and a 200-mm annular space. This factory-built, medium-sized tank includes an 80-layer MLI system for high vacuum, four G10 pad supports, several piping penetrations, and a 0.6-m diameter manway for internal access and multiple instrumentation feedthroughs. Extensive boiloff testing was performed using both LN_2 and liquid hydrogen (LH_2).

The second example is a 3,200-m^3 spherical 304 SST tank (30-mm thickness) with a carbon steel outer jacket (17-mm thickness) and a 1,200-mm annular space. This tank includes 40 vertical SST support rods connecting the inner vessel to the outer jacket, four piping penetrations on the bottom, and a 0.5-m diameter manway for internal access. The specified boiloff rate is 0.075% per day (LH_2) with the original perlite powder insulation. In this example, the insulation system is glass bubbles, which provides an estimated 46% reduction in boiloff, compared to perlite, at a moderate vacuum level of 10 millitorr, based on field test data. Construction of an even larger LH_2 storage sphere (4,700 m^3), including the glass bubbles insulation system, was completed at NASA's Kennedy Space Center in 2022.

The third tank example is a 100-liter carbon composite tank in a 4:1 cylindrical geometry with an SST outer jacket and an annular space of 23-mm thickness. The LCI system is designed for a soft vacuum of 100 μ for low cost and to avoid vacuum maintenance. Three polyimide aerogel rings support and isolate the inner vessel, and a single 12.7-mm diameter piping penetration is also included, as depicted for this generalized mobility tank concept.

In addition to the three tanks, two piping systems are analyzed. Example four is a $DN_2$5x80-mm all-SST vacuum-jacketed (VJ) pipe segment with an 18.3-m length. The ends are thermally guarded with LN_2 to achieve an absolute boiloff test. The insulation consists of 20 layers of MLI (aluminized Mylar and paper) with a CVP in the normal vacuum range of approximately 1 μ.

Finally, example five is a $DN_2$50x300-mm, double-walled field joint connection (1-m overall length) between two VJ pipe segments. The ends, with 425-mm length cones, act as supports, while a straight middle portion is 150 mm in length. The insulation system is a complete bulk-fill using aerogel particles (1-mm nominal diameter) in the sealed annular space, designed for non-vacuum. The space is optionally backfilled with CO_2 to enhance performance at a cryo-pumped soft vacuum (~100 μ) under cold operating conditions.

Breakdowns of the heat leaks for the five example systems are summarized in Table 1. The Q total is the sum of four parts: Qi is the heat leak for the insulation; Qs is the heat leak attributed to the supports; Qp is the heat leak due to the piping penetrations; and the additional Q_{IQF} is the heat leak associated with the installation quality factor (IQF). The total system thermal conductivity (ks), as defined in ASTM C1774, is also calculated for each case.

The best thermal insulation system under idealized laboratory conditions is not always the best one to use in practice. In the example of the field joint, the majority of the

▶ continues on page 84

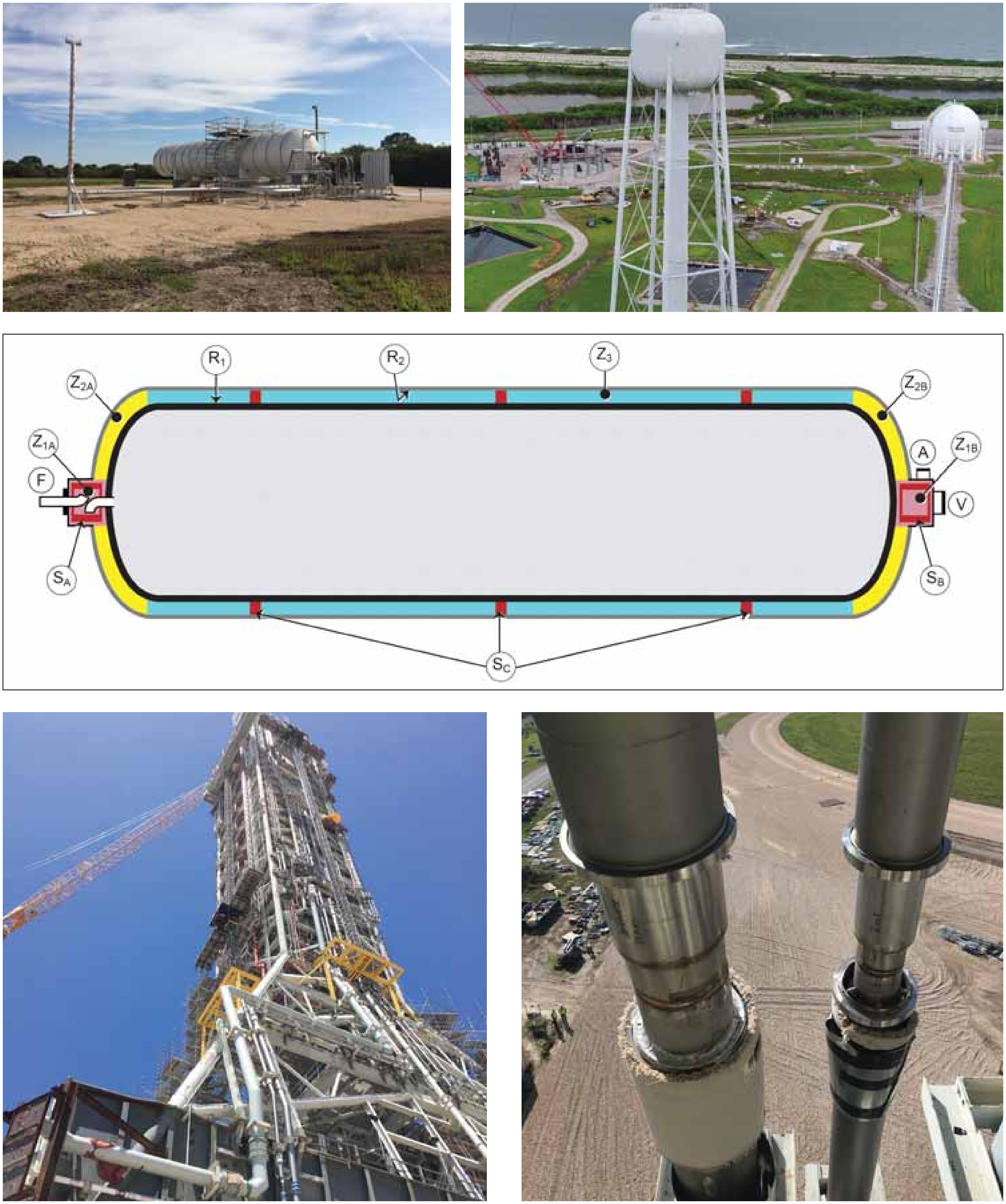


Figure 1. Cryogenic system examples: 1) cylindrical tank (upper left), 2) large spherical tank (upper right), 3) small composite automotive tank (middle), 4) launch tower transfer piping (lower left), 5) piping field joint (lower right). *Credit: J. Fesmire*

Table 1. Total heat flow rate analysis for different examples of cryogenic systems

Case	*Cryogenic System Description*	*Thermal Insulation System*	*CVP*	Dimensions		Components of Q_{total}								Q_{total}	*q*	†k_s
				t	*A_e	Q_i		Q_s		Q_p		Q_{IQF}				
			μ	mm	m²	W	%	W	%	W	%	W	%	W	W/m²	mW/m-K
1	Medium tank, VJ, factory built (125-m³ capacity)	MLI (80 layers) for high vacuum	<0.1	250	229	101	33.7	50	17	130	43.3	19	6.3	300	1.3	1.5
2	Large tank, VJ, site-built (3,200-m³ capacity)	Bulk-fill glass bubbles for moderate vacuum	10	1200	1194	178	74.1	31	12.9	31	12.9	0	0.0	240	0.2	1.1
3	Small composite tank, VJ, conceptual (0.1-m³ capacity)	LCI for soft vacuum	100	23	1.6	10	68.9	3	21	1.5	10.4	?	?	14.4	9.0	1.0
4	Piping System, DN25x80-mm, VJ, with two bayonet joints, factory built (18.3-m length)	MLI (20 layers) for normal vacuum	1	26	3.2	2.5	12.0	3.2	15	8	38.3	7.2	34.4	20.9	6.5	0.8
5	Piping Field Joint, DN250x300-mm, double-wall, field fabricated (1-m length)	Bulk-fill aerogel for non-vacuum (optional CO2 cryopumped)	760000	50	0.88	26.5	54.1	13	27	9.5	19	0	0.0	49.0	55.7	12.9

*Effective surface area between inner and outer shells (log-mean area) †ΔT = 293 K - 78 K = 215 K

Note: 1 millitorr = 1 μ = 0.0013 mb

heat leak is fixed by solid conduction (75% of Q total), and the annular space is mostly inaccessible for wrapping with multilayer insulation (MLI). Added to the geometric constraints are the challenges related to field fabrication, for which achieving a long-term high vacuum in the annular space is not a reasonable expectation. With the option of adding a CO_2 backfill to achieve the effect of cryopumping to a soft vacuum, the Q total drops to 30.6 W, and the ks drops to 8.1 mW/m-K, making it comparable to a high-vacuum MLI system in this case.

These cases represent idealized solutions for each situation. The Q_{IQF} ranges from zero to 34% of the total. In many real cases, the Q_{IQF} can be as high as or higher than the Qi. For example, a small single penetration (12-mm diameter) through an MLI blanket results in a Q_{IQF} that is one to five times the Qi. Even in bulk fill systems—where the two examples given show zero IQF—there can still be issues. Two identical design 3,200-m³ VJ LH_2 storage tanks were built at Kennedy Space Center in 1965, but one ended up with more than triple the heat leak of the other (3.8 versus 1.1 m³ per day boiloff losses). The problem was eventually traced to a large void within the perlite annular space filling. Therefore, the Q_{IQF} is not just a deviation from the ideal or a degradation of the insulation material that can be mitigated; it represents a substantial heat leak potential that must be addressed up front in the design process.

The elements are highly interdependent, showing that the analysis of the total heat leak is an iterative process. A practical methodology for designing cryogenic thermal insulation systems is based on a "cold triangle" approach of insulation, supports, and piping, as well as the insulation quality factor (IQF). The total heat leak of the end product is what matters, but to minimize this heat leak cost-effectively, the calculations, testing, and materials data must be covered, and the thermal performance understood as a summation of its parts. The approach also provides a basis for evaluating the performance benefits of new materials and analyzing cost-effectiveness in overall system design. Examples of different cryogenic storage tanks and piping systems show the relative importance of both insulation and structural materials in achieving designs with the highest energy efficiency. The right design approach depends on the shape, size, operational duty cycle, and, of course, the thermo-economic objectives.

References:

[1] Fesmire, J., & Swanger, A. (2019). Advanced cryogenic insulation systems. *25th IIR International Congress of Refrigeration*, Montreal, Canada, IIR No. 1732.

[2] Demko, C., Fesmire, J., & Shu, H. (2022). *Cryogenic Heat Management: Technology and Applications for Science and Industry*. CRC Press, imprint of Taylor & Francis Group.

[3] Fesmire, J., Swanger, A., Jacobson, J., & Notardonato, W. (2021, July). Energy efficient large-scale storage of liquid hydrogen. *Advances in Cryogenic Engineering*, Cryogenic Engineering Conference.

[4] Notardonato, B., Swanger, A., Fesmire, J., Jumper, K., Johnson, W., & Tomsik, T. (2017). Final test results for the ground operations demonstration unit for liquid hydrogen. *Cryogenics*, 88, 147–155.

Stirling Cryogenics' World Tour

by Francesco Dioguardi, Stirling Cryogenics

Given the theme of this issue of *Cold Facts*, Stirling Cryogenics would like to take you on a tour of our 70-year history, telling about our recent and vintage cryogenerators and systems all around the world.

Universities worldwide have been our customers from the very beginning, cheering in the 1950s that they could now produce their own LN_2. In South America, proud examples include systems at the Universidad de Chile since 1964 and IVIC in Venezuela where the old Philips Cryogenerator was replaced with a new system after 45 years of operation. The University of Buenos Aires in Argentina has several systems in operation of which the oldest cryogenerator was installed in 1958 providing 66 years of service!

A high-level LN_2 system worth mentioning is the one installed at Atacama Large Millimeter Array (ALMA) of ESO at Paranal in the Atacama Desert in Chile, at an altitude of 2635 meters above sea level.

Moving from South America to Africa, here the two main types of applications are the preservation of biological materials and production of fruit juices and water. Throughout Africa there are institutes that carry out research on viruses, for example, which are preserved in LN_2. As these often are in remote locations, they depend on Stirling LN_2 generators.

Renowned beverage companies making drinks often use Stirling systems to provide LN_2 for their nitrodosers, injecting a drop of liquid nitrogen into a bottle of juice, water or oil. The rapidly evaporating liquid nitrogen will disperse the oxygen from the bottle, extending its shelf life without preservatives and increasing compressive strength of bottles required during packaging and transportation.

Crossing the Middle East with many systems at universities, we land in India. Beyond a large number of closed loop cooling systems in many of India's renowned science and technical institutes and universities,

Stirling Cryogenics' dedicated team at Hysytech's 20th anniversary and inauguration of its new headquarters in Orbassano, Italy. *Credit: Stirling*

Onsite liquid nitrogen for storage and preserving semen for artificial insemination. *Credit: Stirling*

India is also home to a large number of LN_2 systems for artificial insemination. These are used to preserve semen for breeding livestock and assuring milk production, for which many centers are in the countryside.

India is by far the country with the largest number of Stirling systems, many of which date back to the 1990s and are still in operation, for example systems at IIT Kharagpur installed in 1994 and at NEHU where our LN_2 system was installed in 1999.

Moving further east, we find again more systems for AI all over Asia and closed loop systems for superconductivity in Korea and Japan. Crossing the ocean brings us to North America. Here too we have LN_2 systems at universities in the US and a large customer base concentrated in the east of Canada.

▶ *continues on page 88*


technifab PRODUCTS
CRANE
Vacuum Jacketed Piping Systems | Cryogenic Transfer Hoses | Phase Separators | Automatic Fill Stations | Manual + Actuated VJ Valves | OEM & Private Label Manufacturing
COMPLETE CRYOGENIC SOLUTIONS FOR ALL APPLICATIONS
www.technifab.com | 812.442.0520 | sales@technifab.com


SAFETY KITS and SAFETY KITS PLUS
FOR COMMERCIAL CRYOGENIC APPLICATIONS
TEMPSHIELD®
CRYO-PROTECTION®
CRYO-PROTECTION® SAFETY KITS - FOR LABORATORY APPLICATIONS
Kits contain:
Mid-arm or elbow gloves
42" or 48" apron
Fully adjustable face shield
One-size gaiters* fit most
(*for Plus kits)
CRYO-INDUSTRIAL® SAFETY KITS - FOR HEAVIER-DUTY APPLICATIONS
CE CAT. III + CAT. II**
**face shield
info@tempshield.com
207-667-9696
TEMPSHIELD.COM


CPC-Cryolab
TRUSTED SINCE THE BEGINNING
CPC-Cryolab valves have powered advancements in cryogenics for generations, setting new benchmarks in low-temperature applications. From cryo tanks to distribution systems, trust our products ensure safety, efficiency, and reliability, custom tailored to your specific needs.
Rockwood Swendeman
Also try simplifying installation, cut costs, and enhance safety through versatile applications in liquid and gaseous cryogenic systems with our Rockwood-Swendeman safety relief valves.
(813) 644 - 3764
sales@cpc-cryolab.com
www.cpc-cryolab.com

Stirling Cryogenics... Continued from page 86

With numerous scientific institutes and innovative companies, closed loop systems can be found in many of the states. Our deepest system is at the Sanford Underground Research Facility, located at a depth of 1,500 meters in South-Dakota. Aiming higher are our systems supporting space research at NASA and Georgia Tech. Another application which we support widely is superconductivity, with 25 K systems at CAPS in Florida and ComEd in Chicago for their HTS cable in use since 2021.

If we cross the Atlantic again, we come close to home with the 22 K GHe loop cooling system for the Reactor Institute Delft in the Netherlands, making sure their neutron moderator existing of a bath of LH_2 will always be kept at the right pressure.

Similar systems are being built to cool superconducting electric motors that are now under development in Europe, paving the way for carbon-free and sustainable aviation.

Stirling Cryogenics liquid nitrogen system at Universidad de Buenos Aires - Argentine dated 1958. *Credit: Stirling*

Sustainability is a relatively new but growing market which is supported by Stirling, providing cryogenerators and systems to convert bio-mass into bio-LNG, which can be used as a CO_2 neutral fuel for trucks. By the end of 2024, the collective of our LNG liquefiers across Europe will be producing over 150 tonnes per day of bio-LNG, replacing diesel and fossil LNG, with more projects being developed in the coming years.

The latest application we support is the emerging market of liquid hydrogen, providing systems to produce LH_2 on site, as well as manage boiloff by reliquefaction, for which in fact we have been building cryogenerators since the late 1960s.

In the spirit of “Cryogenics around the World,” the final application we would like to showcase is our seaworthy version of cryogenerators for reliquefaction of LNG on ships, as these quite literally move around the world.

We at Stirling Cryogenics hope this tale of the use of cryogenics and cryogenerators around the world and through time has given you an insight into Stirling’s past, present and future. Obviously not all systems and applications have been mentioned. For any inquiries on these or other possibilities, please contact us. **www.stirlingcryogenics.com**

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.

ICEoxford

Cryogen-Free (Dry Cryogenics) System

A cryogen-free (or DRY) system achieves cryogenic cooling without liquid cryogens such as liquid nitrogen or helium. Instead, these systems use a coldhead to lower temperatures, liquefying helium to 4 K; pressure reduction enables cooling to below 1 K. Cryogen-free systems offer several advantages: they're often more compact and eliminate the need for costly cryogenic liquids and safety measures related to vapor boiloff. Ideal for fields like material or medical research, these systems allow researchers to focus on their work without needing specialized cryogenic training. In space applications, cryogen-free systems also eliminate liquid handling and boiloff venting, making mission duration dependent on cryocooler reliability rather than cryogen volume. ICEoxford manufactures reliable cryogen-free superconducting magnets and systems, supporting research institutions worldwide with expert knowledge and dependable technology. **www.iceoxford.com**

ACME Cryogenics

XL Bore Vacuum Jacketed Piping

ACME Cryogenics, part of OPW Clean Energy Solutions, has launched its XL Bore Vacuum Jacketed Piping (VJP), designed to enhance cryogenic liquid transfer by reducing heat leaks and maintaining extremely cold temperatures. Unlike foam-insulated piping, this VJP uses a multilayer insulation (MLI) system with metallic coatings that block radiative heat transfer, making it more durable and maintenance-free for over 20 years. Available in larger configurations—16" x 18", 20" x 24" and 24" x 28"—the XL Bore VJP ensures efficient handling of cryogenic liquids such as LNG, LH_2, LOX, CO_2 and helium. Built in 40-foot segments, the piping system supports high-volume cryogenics applications, offering improved flow rates, enhanced cooling efficiency and cost-effectiveness compared to traditional methods. This robust design delivers superior insulation, higher flow rates and customizability to meet diverse industry needs in sectors like space exploration and fuel transport. **www.opwglobal.com**

STAR Cryoelectronics

Modular Four-Channel Quad SQUID and Quad Array Sensor Assemblies

STAR Cryoelectronics now offers two versions of a connectorized and modular four-channel SQUID sensor assembly with Nb shield and optional mu-metal shield that can be configured with four Series SQUID Array (SSA) sensors, four single SQUID sensors, or four two-stage SQUID amplifier sensor assemblies. The connectorized SQUID sensor packages simplify replacement in the field or changing SQUID type. Hermetic feedthroughs and mating cryocables are available with optional integrated heat sinks for installation in a variety of cryogenic systems, as well as input cables with superconducting shielding and superconducting twisted pairs. The Quad SQUID and Quad Array sensor assemblies can be read out using STAR Cryoelectronics single- or multichannel pcSQUID™ electronics. **www.starcryo.com**

Imtek Cryogenics

CNPECO-1

The CNPECO-1 is the game-changer in liquid nitrogen production. With an impressive output of over 240 liters/day and industry-leading nitrogen purity at >99%, this compact powerhouse is built for efficiency. Consuming just 13 kW of energy, it redefines eco-friendly operations while slashing costs. Designed for simplicity, the plug-and-play setup and one-button operation make the CNPECO-1 as user-friendly as it is powerful. Its advanced cold-head technology ensures seamless, reliable performance, backed by a robust design and low-maintenance intervals of 8,000 hours. Perfect for medical, research and industrial applications, the CNPECO-1 fits effortlessly into any workspace with its compact size and low noise output (<65 dBA). The CNPECO-1 is the ultimate solution for liquid nitrogen generation—efficient, reliable and ready to deliver. Power your operations smarter, not harder. **www.imtekcryogenics.com**

Stirling

Cryogenerators and Systems

Stirling Cryogenerators and systems are designed for a long life. Due to the robust design, some of our customers have been able to operate the Stirling Cryogenerator for more than 60 years. The only maintenance required is an annual inspection and cleaning. Once every 35,000 operating hours maintenance is required, which includes the preventive replacement of some parts. This maintenance is always caried out on-site by one of our service engineers. There is no need to ship components back to the factory for maintenance or repair, which means less downtime and transport costs. In addition, Stirling systems are equipped with a device that enables remote access to the control box. With this feature, we have the possibility to remotely support the customer in case of operational and maintenance issues. Stirling Cryogenics also offers service contracts, which cover a period of 6 years and include all annual maintenance. **www.stirlingcryogenics.com**

CO2Meter

Oxygen Deficiency Safety Alarm

The Oxygen Deficiency Safety Alarm is a 0-23% room oxygen monitor designed to protect staff from oxygen depletion. This device is designed to be mounted near nitrogen, argon, helium or other inert gas sources. It can also be used in walk-in refrigerators or freezers with temperatures as low as -50°C.Our Oxygen Deficiency Safety Alarm is used in laboratories, pharmaceuticals, cryogenics, process cooling, freezers, manufacturing and research facilities. **www.co2meter.com**

People & Companies in Cryogenics

Gas Equipment Company is excited to announce that **Christopher White** has joined our team as the new Sales Director for Industrial Gas and Cryogenics. Chris' new role encompasses coordinating sales strategies across GEC's industrial gases and cryogenics division, with a focus on expanding product lines, enhancing client relationships and driving growth for the company. With a wealth of sales experience under his belt, Chris is eager and ready to take on his new role.

Christopher White. Credit: Gas Equipment Company

……………………………………

Leon Cooper, Nobel-winning physicist and neuroscientist whose groundbreaking contributions reshaped the industry's understanding of superconductivity and neural networks, passed away at the age of 94. He co-developed the BCS theory, which explained how "Cooper pairs" enable resistance-free electricity in supercooled materials, earning the 1972 Nobel Prize in Physics. Later, he turned to neuroscience, co-creating the BCM theory, which modeled how brain activity adapts during learning, leaving a lasting impact on cognitive science and machine learning. A long-time professor at Brown University, Cooper's interdisciplinary work showcased the vital role of imagination in advancing physics, neuroscience and philosophy.

Leon Cooper. Credit: Keystone Press/Alamy

……………………………………

Image provided by Web Industries Inc.

Web Industries Inc., a composite materials converter and outsource manufacturer serving the aerospace, wire and cable, medical, home care and industrial markets, has named **Suzanne Rotherham** chief operating officer. Rotherham brings to Web Industries more than 25 years of business experience working with domestic and global companies. Her leadership roles span supply chain, information technology and general management. She has led several transformative initiatives, including ERP implementation. Rotherham joins Web Industries from Hollingsworth & Vose, where she served most recently as vice president and managing director for the Americas region. Prior to that, she spent six years at Johns Manville in a series of progressive leadership roles.

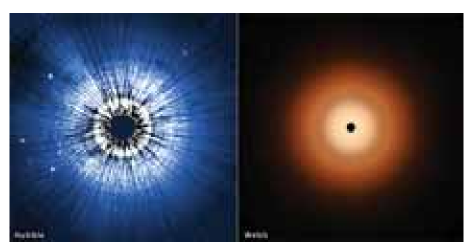
……………………………………

Bluefors officially opened an expanded facility in Syracuse, New York, increasing production capacity for Cryomech cryocoolers and enabling the manufacture of Bluefors Dilution Refrigerators directly in the USA. The expansion increases capacity by 45% and doubles throughput to support the quantum sector and provide the cooling power needed in academia and industries such as medical and life sciences. The expanded facility also opens a new spare parts hub to serve customers in North America and lays the groundwork for the future growth of Bluefors operations in the USA.

Bluefors Syracuse, NY opening. Credit: Bluefors

……………………………………

A team of **University of Arizona** astronomers has unveiled new details about the nearly 100-billion-mile debris disk surrounding Vega, using **NASA's Hubble and James Webb space telescopes**. The observations reveal a remarkably smooth disk of particles, with no evidence of large planets disrupting the structure. Webb detects warm, sand-sized grains close to the star, while Hubble captures smaller particles in an outer halo. The findings shed light on how dust dynamics vary across circumstellar disks and offer clues to planet formation. Vega's unique system contrasts with similar stars like Fomalhaut, raising questions about planetary system diversity and evolution.



New details about debris disk surrounding Vega. Credit: NASA, ESA, CSA, STScI, S. Wolff (University of Arizona), K. Su (University of Arizona), A. Gáspár (University of Arizona)

Meetings & Events

CCA 2025: International Workshop on Coated Conductors for Applications
March 11-13, 2025
Geneva, Switzerland
https://indico.cern.ch/event/1347361/

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

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

Index of Advertisers

Join CSA and start receiving ***Cold Facts***!

Rates: circle $ amount

In US: Individual $85 • Student or retiree: $40

Outside US: Individual $130 • Student or retiree $80

Corporate, in US, number of employees:
1-10, $495 • 11-25, $695 • 16-50, $915 • 51-100, $1,355
101-500, $2,460 • 501-1,000, $5,515 • 1,000+, $7,720

Corporate, outside of US, number of employees:
1-10, $555 • 11-25, $765 • 16-50, $990 • 51-100, $1,400
101-500, $2,580 • 501-1,000, $5,725 • 1,000+, $8,000

Government/Non-profit: $475

Outside the US, please remit in US $ on US bank. No bank transfers.

Charge your membership

__Discovery __Visa __MasterCard __AmEx

Account number

Expiration

Security code

Signature

Please print

Name

Title

Company

Address

City

State/Country

Zip + 4

Email

Website

Phone

Fax

Send to:

New Memberships • Cryogenic Society of America
800 Roosevelt Rd. Suite 312-C • Glen Ellyn, IL 60137
Fax: 630-790-3095

Join CSA online!

www.cryogenicsociety.org/membership

Cold Facts **is the official technical magazine of The Cryogenic Society of America, Inc.** 800 Roosevelt Rd. Suite 312-C • Glen Ellyn, IL 60137
Phone: 630-858-7337 Ext. 8765 • Fax: 630-790-3095
Email: membership@cryogenicsociety.org • Web: cryogenicsociety.org
A non-profit technical society serving all those interested in any phase of cryogenics
SSN 1085-5262 • January 2025
Printed in USA

OmegaFlex®

Cryogenic / Vacuum Jacketed Hose Assemblies

Keep Cryogenic Liquids Cold • Safety Containment

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.

OmegaFlex welders and OmegaFlex welding procedures are qualified to Section IX of the ASME Boiler and Pressure Vessel Code. OmegaFlex hose assemblies are tested in accordance with ISO- 10380:2012.

Omegaflex Cryogenic / Vacuum Jacketed Hose Assemblies

- 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

Contact OmegaFlex with your specification and we will engineer a custom jacketed hose assembly for you.

omegaflex.com

OmegaFlex®

Omega Flex, Inc.
451 Creamery Way
Exton, PA 19341
1-800-671-8622
ISO 9001 Registered Company
IND-673 Rev 1223