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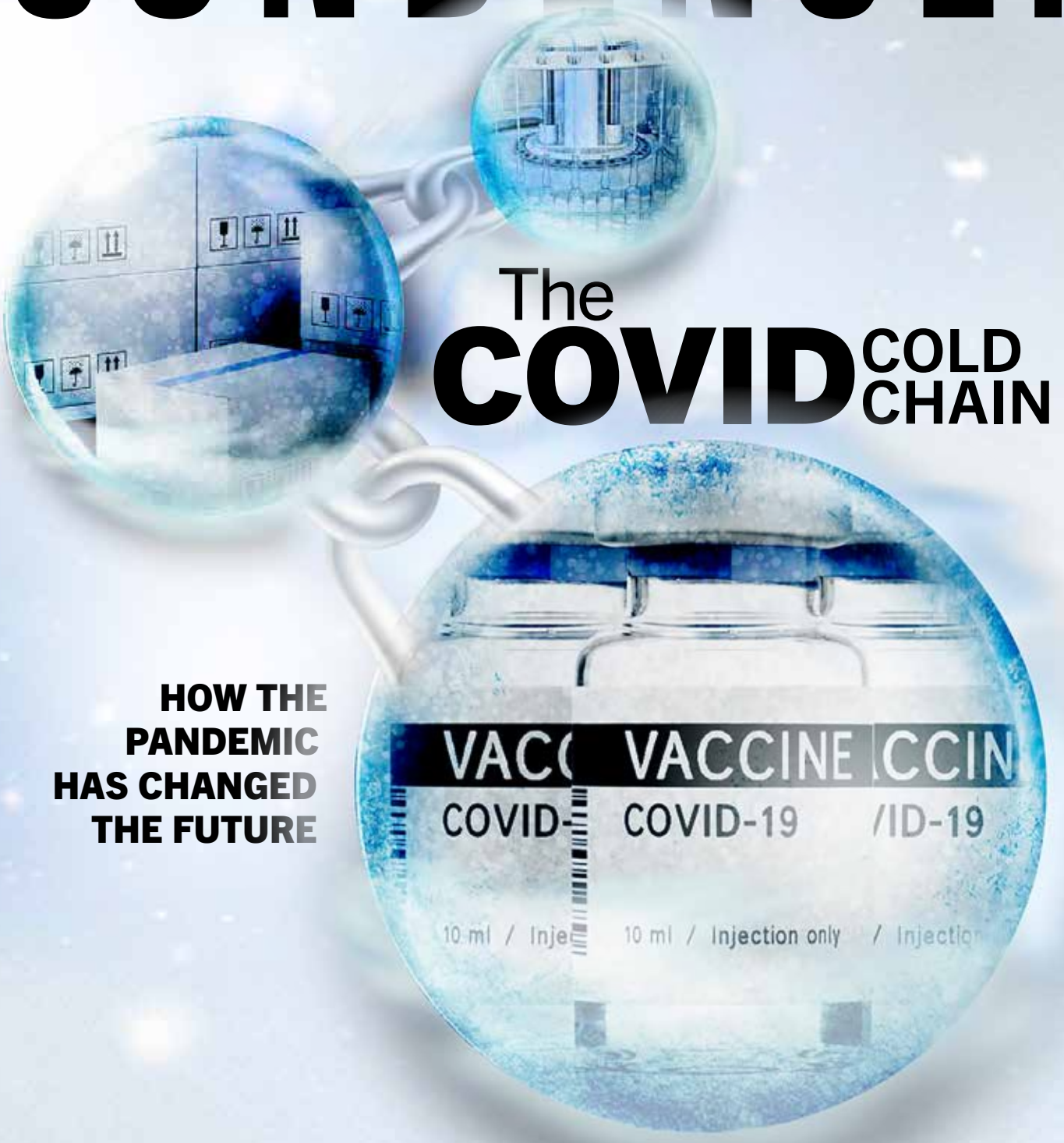

The COVID COLD CHAIN

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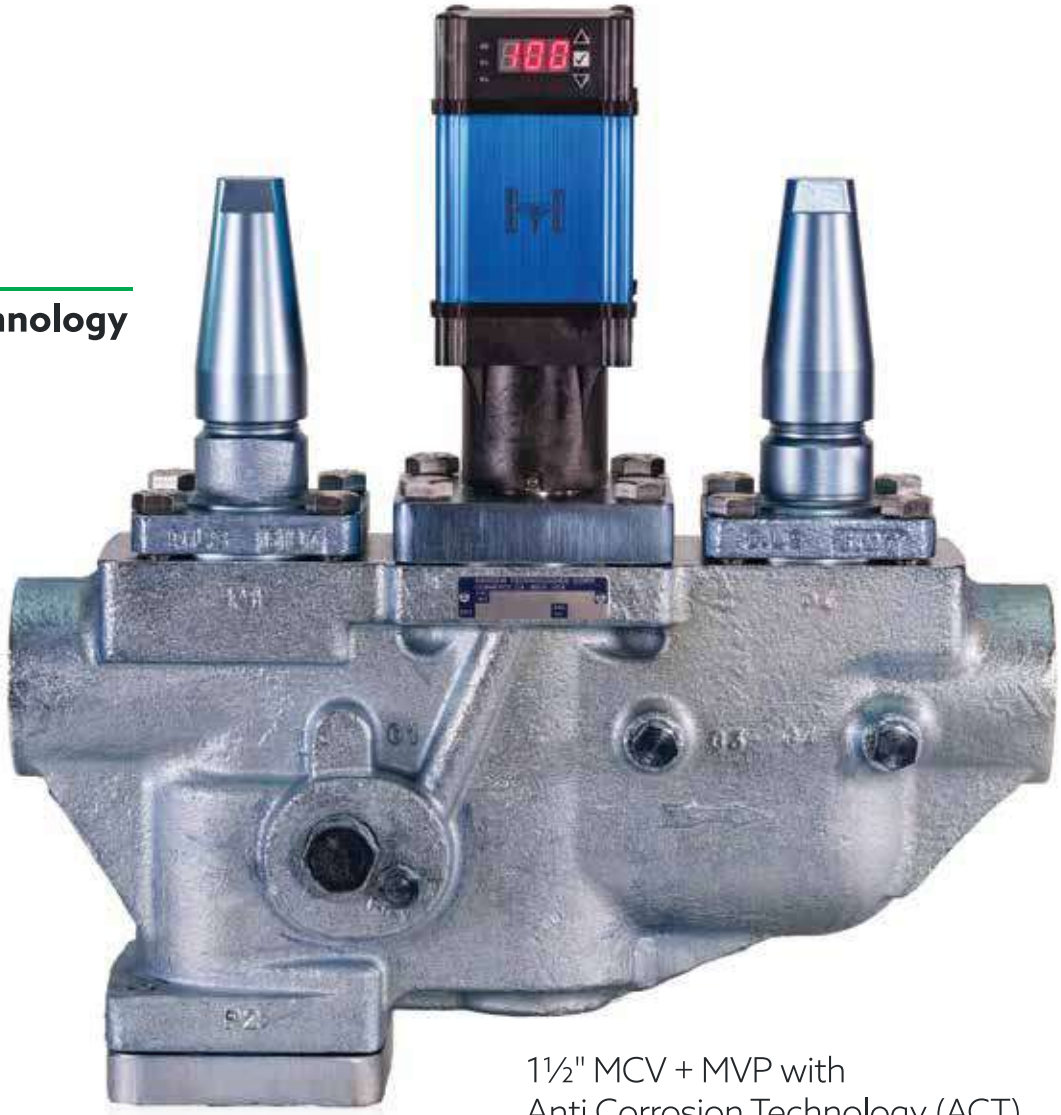

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FEBRUARY 2021

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Publisher
Gary Schrift

Editor-In-Chief
Andrea Fischer

Staff Writer
Mindy Long

Creative Director
Bill Ellis

V.P. Marketing and Sales
Eileen McKeown

V.P. and Technical Director
Eric Smith

International Institute of Ammonia Refrigeration
1001 North Fairfax Street, Suite 503
Alexandria, VA 22314
www.iiar.org
Phone: 703-312-4200
Fax: 703-312-0065

president's MESSAGE

BY GARY SCHRIFT

Exciting Times of Change

In this February 2021 Edition of our Condenser Magazine, you will read about progress made with the California Air Resources Board, completion of the ice arena for the upcoming 2022 Olympics, an overview of research projects, and ANSI standards development…..all initiatives conducted by IIAR volunteers, members, and the organization as a whole towards furthering our mission to provide advocacy, education, and standards for the benefit of the global community in the safe and sustainable design, installation, and operation of ammonia and other natural refrigerants.

In my August 2020 and November 2020 messages, I detailed the many other advocacy, educational, research, training, guideline, and standards initiatives, with results that continue to benefit our members and the world, and to show real value created from our/your organization!

I would be naïve to believe that IIAR is meeting the needs of everyone. Therefore, I continue to ask for input from members and non-members and ask again that you call, email, or text me to discuss any concerns or ideas to enhance or improve our organization.

In November we held our first Talk it Out virtual session, the topic was Membership Fees. This topic was suggested by one of our members and was received after a call for topics was sent to our email database. Over 20 participants provided very candid and sincere comments during an open forum and led the discussion attended by IIAR staff and some board members.

Since then, a Membership Taskforce has been formed of volunteers, staff, and Executive Board members with three goals 1) Create financial sustainability for IIAR where the organization does not have to rely on revenues from the annual conference to meet non-conference expenses 2) Create a membership structure and membership dues that promote financial sustainability while focusing on increasing membership and 3) Create member benefits that promote new memberships and retention of existing memberships.

These goals will not be easy to achieve and even more difficult to measure, and such efforts have certainly been conducted in the past 50 years of our organization. But I am excited to see the results and anticipate future actions that can benefit most existing members and increase our ranks.

We are entering exciting times for natural refrigerants as companies, governments, and code bodies worldwide revisit the use of ammonia and natural refrigerants for applications once left to the many medium and high GWP and ODP refrigerants, and as countries and the private sector explore the use of ammonia as a green fuel source. Buckle up….

We are entering exciting times for natural refrigerants as companies, governments, and code bodies worldwide revisit the use of ammonia and natural refrigerants for applications once left to the many medium and high GWP and ODP refrigerants, and as countries and the private sector explore the use of ammonia as a green fuel source. Buckle up….

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chairman's MESSAGE

BY DAVE SCHAEFER

It is with great regret that we have to cancel the face-to-face 2021 IIAR conference in Palm Springs, CA. However, we look forward to an exciting second virtual conference that will be as informative and widely watched as the fantastic first-ever 2020 All-Natural Refrigerant Virtual Conference.

Instead of dwelling on what could have been with the canceled face-to-face conference, I would like to focus on something that has been extremely positive and what makes our organization great. We are very fortunate to have a very hard working staff, generous contributors to the Ammonia Research Foundation, and many volunteers that have been bringing us educational materials and programs like the virtual conference, the Academy of Natural Refrigerants, safety videos and of course our standards that make our industry safer.

With this letter I would like to point out the contributions that our Standards Committee Chairman Mr. Robert Czarnecki has made to our industry as he steps away from the chairmanship, a position he has held for over nine years.

We would like to recognize Mr. Robert Czarnecki, Chairman of the International Institute of Ammonia Refrigeration (IIAR), Standards Committee, for his long-standing and tireless efforts in leading the committee for so many years. During his nine-year tenure as chair, and for many years prior, Bob has been a selfless contributor to the Institute. His leadership has enabled IIAR to develop a full suite of standards for the ammonia refrigeration industry. These standards are cited by numerous United States government agencies and several international governments as recognized and generally accepted good engineering practices. Several of them are also normative references in national building codes. Mr. Czarnecki has devoted countless uncompensated hours to the development of IIAR standards and has provided unwavering leadership, a fair and open forum for discussion and opinions, initiatives for research, and a great deal of engineering expertise in the field of industrial refrigeration engineering.

With this letter I would like to point out the contributions that our Standards Committee Chairman Mr. Robert Czarnecki has made to our industry as he steps away from the chairmanship, a position he has held for over nine years.

As we know, the United States Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) regulate the use of hazardous chemicals. In their process safety management and risk management enforcement programs, these agencies rely on industry-developed "recognized and generally accepted good engineering practices" (RAGAGEP), for practitioners to follow. IIAR standards are used as RAGEGEP for ammonia refrigeration and have been cited by OSHA in their definition of RAGAGEP in general – a testament to the quality and importance of the standards.

It can be observed that Mr. Czarnecki's contributions are not only important to the IIAR, but also the nation's and the world's safe supply of food and beverages. Mr. Czarnecki has been the chair of the committee during its most productive period in IIAR's 50-year history. During this time, of the nine published IIAR standards, six ANSI standards have been developed, three have undergone extensive revision, and several have been re-affirmed, all according to the ANSI Essential Requirements. The standards committee itself has also grown significantly, and Mr. Czarnecki has been instrumental in the management of over 40 particularly active members, and over 100 corresponding members. He has been recognized as IIAR Member of the Year, IIAR Life Member, and has represented the industry and the committee in numerous public forums.

Bob Czarnecki is truly deserving of recognition beyond his esteemed status with the industrial refrigeration community. His work has affected the public in general and the safety and health of thousands of practitioners who are made safer by the IIAR standards.

We also sincerely appreciate that Bob plans to stay on as a corresponding member of the Standards Committee.

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The COVID COLD CHAIN

HOW THE PANDEMIC HAS CHANGED THE FUTURE

Before COVID-19, the cold chain wasn't on most people's radar, but shifting consumer demands, concern over food supply and specific healthcare needs during a pandemic put it in the spotlight.

"It changed last spring when we started to see disruptions and challenges in the early days of the pandemic related to food," said Lowell Randel, director of government affairs for IIAR and senior vice president of government and legal affairs for the Global Cold Chain Alliance. "The attention around the cold chain got even more intense with the vaccines coming online."

Michael Golek, a spokesman for GEA Group Aktiengesellschaft, said the pandemic has placed a greater focus on the environmental health and safety discipline in the refrigeration industry. "This is reflected in the strict precautions and procedures put in place to ensure that our industry can remain operational in order to supply our food industry customers with the equipment and services needed for them to continue to operate," he said.

MEETING THE COUNTRY'S NEEDS

Throughout the pandemic, Randel has been in regular communication with the government. "I was saying, 'We've got a lot of capacity out there in the cold chain industry to provide temperature control logistics for whatever type of product needs to be stored," he said, adding that most of the needs were for food. "If there are significant gaps where there is a need to fill distribution and storage for vaccines, there are a lot of companies out there that are ready and willing to help if needed and called upon."

FOCUSING ON PHARMACEUTICALS

Randel said the recent focus on pharmaceuticals could provide new opportunities for some in the natural refrigerant industry. "All of the attention due to the vaccine is giving people the motivation to evaluate if it makes sense to get involved with pharmaceuticals," he said. "When you think about pharmaceuticals, you have security elements, liability considerations, insurance requirements and additional licensing. There are some complexities in dealing with pharmaceuticals."

Another consideration is that pharmaceuticals can't be stored in the same area as food. "You would need to have plans in place for the segregation of product," Randel said. "I think people are looking at what it would take to transition some of their operations to accommodate pharmaceuticals, but it is going to be a very individual assessment that companies will make to see how a transition to pharmaceuticals fits in their long-term plans."

Golek said, generally speaking, there is a trend in the cold chain away from the use of traditional cold stores and distribution centers that serve various companies. "The trend in some regions is toward processors developing their

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own storage and distribution logistics and not relying on others to store and ship their products. This has created less spare capacity among cold stores that serve multiple customers," he said, adding that natural refrigerants remain an excellent choice for large cold stores.

Golek said there are opportunities for ammonia and CO_2 to support the global pharmaceutical manufacturing and distribution supply chain. "As most industries, ours constantly strives to innovate and introduce ways to increase efficiency and reduce energy use. This benefit is twofold for our customers – lower operating expenses and reduced carbon footprints," he said.

Additionally, low-charge, high-efficiency ammonia chillers and semi-hermetic screw compressors for enhanced safety can improve ammonia's general efficiency in the pharmaceutical cold chain, Golek said.

The COVID-19 vaccines from Pfizer and Moderna both have unique temperature requirements. Pfizer's vaccine must be kept ultra-cold. "They recognized the -70-degree requirement was unique, and the conventional supply chain is not configured to reach those temperatures," Randel said. "They took a packaging solution to address the temperature control down to those low temps."

Pfizer utilizes dry ice to keep the vaccine cold. "You're seeing the use of specialized packaging, and in many cases, it is shipped directly from the point of manufacturing to the point of distribution. It isn't going to a third-party warehouse as you might see with food," Randel said. "With food, you have this established supply chain where inventories go from manufacturing to warehouses to distribution centers and then to the ultimate destination. Particularly with the Pfizer vaccine, they are not going through those multiple steps."

The Moderna vaccine is stored in more conventional temperatures. "Your average cold storage warehouse and traditional refrigerated transport can handle those temperature requirements," Randel said.

> **"You're seeing the use of specialized packaging, and in many cases, it is shipped directly from the point of manufacturing to the point of distribution. It isn't going to a third-party warehouse as you might see with food."**
>
> – Lowell Randel, director of government affairs for IIAR and senior vice president of government and legal affairs for the Global Cold Chain Alliance

ESTIMATING DEMAND

It may take two to three years to understand how the current COVID vaccines will affect demand. "Will the vaccine need to be administered annually like the flu shot? I don't think we really know that yet," Randel said.

However, the cold chain's overall demand will continue to grow, but it won't be limited to the pharmaceutical industry, Randel said. "We expect increased demand on the food side as well," he said. "The question of how much goes to pharmaceutical as opposed to food is a harder question to answer."

Despite the economic downturn in 2020 following the COVID-19 pandemic, new projects with both ammonia and CO_2 continued for Star Refrigeration, said Robert Lamb, group sales and marketing director for Star Refrigeration. "In fact, it has been a record year in terms of new equipment contract sales," he said, adding that many projects have included Star Refrigeration's Azanechiller and Azanefreezer projects, which offer low-charge ammonia and deliver a new benchmark in terms of energy efficiency.

The temperature-controlled distribution sector has seen particular investment in 2020, including new high bay cold storage facilities and traditional warehouse designs," Lamb said. "We've also been involved in retrofit projects, removing high GWP gases such as R404A for ammonia."

There have also been a number of Azanechiller orders for the pharmaceutical business, including three off 1MW chillers for a leading pharma business as part of a new construction project and three 1.2MW chillers for another customer, replacing old absorption equipment, Lamb said.

For chill temperature warehouses, Star Refrigeration has used its Azanechiller product to cool glycol to room coolers, Lamb said. "For cold storage applications, our Azanefreezer has been used, which uses low charge ammonia technology," Lamb said.

Caleb Nelson, vice president of business development for Azane, the U.S.-based division of Star Refrigeration, said there has also been an uptick in California's cold storage business, specifically in applications where product storage flexibility is needed. "This is partly due to COVID creating uncertainty in the demands of the consumer," he said. "One quarter a warehouse may need to store frozen product, and the next may need to transition part of the facility to chill storage to accept a specific crop of fresh produce, for example."

On the industrial beverage side, Azane is doing work with the Azanechiller, which is supporting existing facility expansions. "Simple increases in demand have required additional chiller capacity for production," he said.

WORKING TOGETHER

Randel said the pandemic has highlighted the adaptability of the cold supply chain and emphasized the importance of the industry. "I absolutely believe policymakers will look to us as an important partner," he said. "The cold chain is an important part of critical infrastructure. We are essential businesses. We play a critical function, and we want to partner to make sure people have access to safe, quality products," he said.

2022 Winter Olympics Embrace Natural Refrigerants, Set the Stage for the Future

For the first time, transcritical CO_2 refrigeration will be used to make ice at a Winter Olympics, which will be hosted by Beijing in 2022, with the International Olympic Committee deciding to use CO_2 refrigeration system for the most iconic venues for the Beijing Olympics. The decision, which the Beijing 2022 Organizing Committee announced as part of a joint alliance with the United Nations (UN) for the Climate Action framework agreement, led by the IOC, will decrease the overall carbon footprint of the Winter Olympic Games in Beijing.

"This is a landmark decision which could potentially help address the issue of climate change, both in China and even globally," said Juan Antonio Samaranch, chairman of the IOC Coordination Commission for the upcoming winter games. "We are pleased to see that the IOC's close collaboration with Beijing 2022 has resulted in such an important outcome."

Guy Evon Cloutier, CEO of the CTC Group and IIAR's regional vice chair for China and Asia, said the legacy and sustainability of the games as set by the IOC with the Beijing Organizing Committee Olympic Games is very ambitious and was a top priority. CTC is the strategic partner of CIMCO Refrigeration for the Olympic Projects in Beijing. The company has been active in China since 1999, ever since promoting and developing projects for ice and snow in Asia.

The decision to use natural refrigerants was made possible due to close collaboration between Beijing 2022, International Sports Federations and the IOC, which provided guidance and technical expertise on the topic.

Yumin Liu, general director for the venue planning and construction department of the Beijing 2022 Winter Olympics Organizing Committee (BOCOG), said there will be eight competition and non-competition venues, with nine pieces of ice. According to the IOC's website, CO_2 refrigerant, which has no impact on the environment, will be used in the Beijing 2022 speed skating venue and some of the training venues. Ammonia is being used for the sliding center for the bobsleigh and luge competitions.

"We all know the influence and legacy created by Olympic venues, and China is making a statement by using refrigerants in ways that have never been done before," said David Fauser, director of sales for CIMCO Refrigeration, a division of Toromont from Canada. "China is demonstrating real leadership here in terms of these games, showing that sustainability and performance can both be achieved and elevated without compromising each other. As we all look at what China has done, it can only create acceptance and awareness to what can be achieved, and that is how you make a worldwide change."

The National Speed Skating Stadium, also known as the "Ice Ribbon," is the only new ice competition venue in the Beijing Winter Olympics Park. The main stadium covers an area of about 80,000 square meters and can accommodate 12,000 spectators. The total ice surface can cover up to 12,000 square meters, almost equal to the size of a track and field. The National Speed Skating Oval's interior has adopted an all-ice surface that can meet the competition requirements of five major ice sports—speed skating, short track skating, figure skating, curling and ice hockey, as well as public skating and special events and performances. The multi-purpose design concept is a first in the world, no other speed oval has such configuration and capability, Cloutier said.

Beijing 2022 also joined the UN Sports for Climate Action framework, which UN Climate Change launched in December 2018. Its goal is to set a clear trajectory for the sports community to contribute to global climate goals. Beijing 2022 is one of almost 40 sports organizations that have agreed to the framework so far. Others include the Organizing Committees for the Olympic Games Tokyo 2020 and Paris 2024.

Xinrog Zhang, chairman of the Beijing Energy Society, said most refrigerants on the market contribute to the greenhouse effects and are detrimental to the ozone layer. "On the other hand, carbon dioxide is a natural and green refrigerant that is friendly to the environment," he said. "Liquid carbon dioxide absorbs heat as it evaporates, making refrigeration and ice-making possible. When it releases heat, we can recycle the heat."

Wayne Dilk, senior vice president of CIMCO and specialist of Olympic projects, said the Beijing Olympics could provide additional opportunities for natural refrigerants in the future. "This being the first transcritical oval in the world for the Olympics and will be a benchmark. The Beijing Olympic Committee should be acknowledged for their progressive big step forward in moving to CO_2 systems setting significant guidelines for natural refrigerants in the future in such a high-profile facility," Dilk said.

DEVELOPING THE REFRIGERATION SYSTEMS

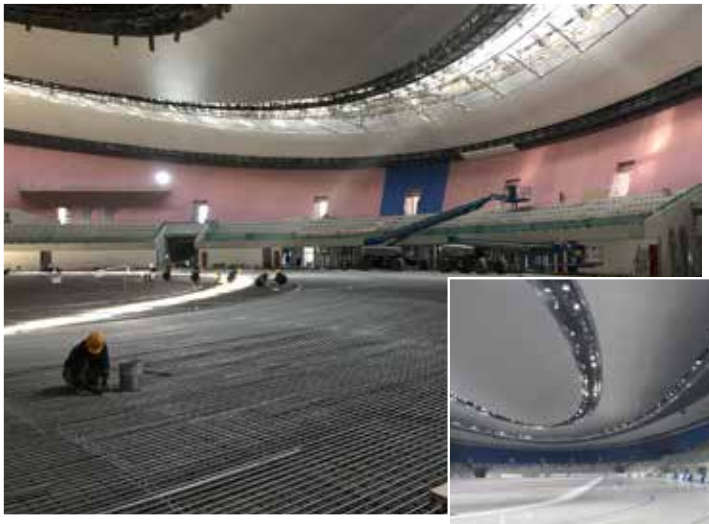
As part of a four-party consortium, CIMCO Refrigeration, was contracted to provide the ice rink consulting services for the project, which includes reviewing the conceptual system design, making recommendations and the modifications and

2022 Winter Olympics Embrace Natural Refrigerants, Set the Stage for the Future

final engineering to meet the design criteria, and developing and overseeing the project installation and the commissioning within the quality control parameters for an Olympic project.

The CO_2 transcritical system being used consists of a CO_2 system with a nominal capacity of 4000 KW (1,140 TR) at -18°C SST and 38°C SCT. The transcritical CO_2 includes six packages with each six compressors, six adiabatic gas coolers one for each system, and four CO_2 recirculation vessel packages each with 2 CO_2 pumps together connected to common suction and liquid supply manifolds.

The floor design consists of 10 separate refrigerated floor zones, including two speed skating tracks, one warm-up track and two ice rinks each with dedicated pumping systems. The other six zones are connected into two separate pumping systems, but with individual zone valves and temperature control. The floor network is constructed of stainless pipe of different sizes with stainless headers all sized to provide the optimal flow rates to maintain uniform temperature all over the ice surfaces.



Carrier is providing the CO_2 pre-fabricated refrigeration systems, manufactured by their Green & Cool division and imported from France. Carrier also has a joint venture in China with Haier established in 2001, providing local heating, ventilating and air conditioning, refrigeration, fire, security and building automation technologies for the China market.

In a statement, Carrier said a CO_2 transcritical for ice making is the most environmentally responsible technology in the world with direct carbon emissions close to zero, thanks to the low GWP of the refrigerant. What's more, the advanced technology can control ice temperature variances within 0.5 degrees. For post-Olympic operation, it can save nearly 2 million kWh of electricity each year, making the venue sustainable for the long term.

The refrigeration system designed for our speed skating oval will allow us to control the ice temperature to within 0.5°C (0.9°F). Xiaonan Wu, board chairman of the Beijing National Speed Skating company, said carbon dioxide refrigeration could help make the oval with the most possible even temperature across the ice.

The waste heat generated during the refrigeration process will be fully recycled and used for the stadium ambient heating, hot water for ice making process and showers, ice melting, and the efficient control of temperature and humidity all year around. The heat recovery system will save two million kilowatt-hours of electricity every year, Wu said.

Different sports require different temperatures of ice. "Curling ice operates at two degrees higher than hockey ice. Figure skating is different than speed skating because of the blades. For speed skating, the ice has to be as hard as hockey ice, but it can't be much harder because the blades are so long, they can't turn. If it is too soft, they have a real struggle," Dilk said.

The ability to maintain accurate temperatures should benefit athletes, Fauser said. "When it is transcritical, it really does create the best ice because there is no temperature difference across the floor," he said. "For an Olympic event where every millisecond matters, that could be the difference in winning gold or setting a new world record. With this type of system mixed with an experienced crew of ice makers, this ice will provide unbelievable consistency and glide potential, which could make it the highest quality fastest ice that the Olympics have ever seen."

The oil recovery on a CO_2 system is different than for ammonia, Dilk said. The oil recovery system is unique in that each skid has its own oil recovery system.

The IOC mandates that the ice surface is ready for international competition the winter before the Olympics, Dilk said. "That timeframe leaves timing a little bit more difficult because you have access a year earlier, and there is a lot of planning that goes into it," he said.

The speed skating oval was completed on Jan. 22 with the making of the first ice sheet. From April the ice will be permanently used and start to host pre-Olympic games competitions.

There have been some challenges with creating the new venues, including the global pandemic. "COVID-19 was by far the biggest challenge, with the restriction to bring to China some of our overseas experts," said Cloutier, who has lived in China since 2002 and has been involved in the Olympic projects in Beijing since the beginning.

Some unique design requirements by the organizing committee and operation team had issues to be addressed. For example, the Ice Ribbon has a fourth speed skating track. "That caused some piping design challenges. The final design allows for the whole surface of 12,000 square meters to be covered with ice, or different section independently as needed. This is the first time, no other speed oval speed oval in the world has this layout design, he says.

Automation has proved to be a challenge. Siemens Electric will provide the hardware for the automation, but Dilk said those involved are working on the operational aspect. "Our last scramble right now is to finalize the run logic of the automation system to run it," he said, adding that the technology will have to synchronize 48 compressors, 30 temperature sensors as well as heat recovery systems. "Everything is computerized and can be completely operated and coordinated for high-quality ice with the system from the control room."

The hardest part of building Olympic venues is they're only done every four years and experience is limited, but Dilk said CIMCO has an advantage because it has worked on Olympic venues in the past. CIMCO was involved with the engineering and supply of the ice surfaces for the Winter Olympic Games in Vancouver and Calgary in Canada, Dilk was involved in both projects.

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The ANSI-Approval Process: A Step-By-Step Guide

Well-developed standards are critical. They can empower and strengthen users with regard to marketplace position and even the global economy. They also ensure the safety of consumers and that the environment is protected.

"Knowing what is required by standardization saves both time and money," said Tony Lundell, senior director of standards and safety for IIAR. "Standards should ensure safety, and that may be the sole purpose of a single standard. Standards should also provide protection for people and for the environment, where applicable."

The American National Standards Institute was created to guide the development of all kinds of standards. However, ANSI does not write standards. "They establish the rules for standards development and ensure that the standards development process is fair, open, accessible, and responsive to the needs of affected stakeholders and interested parties," Lundell said.

IIAR is an ANSI-approved standards developer, also known as a standards development organization or SDO, and the association follows set standards development procedures to ensure a safe and efficient industrial refrigeration operating environment.

"The IIAR suite of standards is intended to be a single source for the refrigeration community so that they don't have to wade through multiple guidelines regarding the use of natural refrigerants," Lundell said. "Often there are multiple standards covering a single topic, and this can become confusing."

Eric Smith, technical director at IIAR, said IIAR has been able to influence the model code bodies due to the completeness of its suite of standards and the rigorous ANSI public review process used to develop them.

"We were able to get the model code bodies to directly reference our standards rather than promulgating their own requirements for ammonia refrigeration systems," Smith said. "That allows users to have a single reference point for their recognized and generally accepted good engineering practices (RAGAGEP) rather than performing a gap analysis every time a system is designed or modified."

One of the things that makes IIAR an ideal candidate as a standards developer is its collaborations with allied associations worldwide, including Columbia, Australia, Chile, Costa Rica, and with the Eurammon block of European organizations, Lundell said. "In addition, IIAR has strong ties to U.S.-based refrigeration and safety organizations such as the Global Cold Chain Alliance, ASHRAE, the Industrial Refrigeration Consortium, ASTI (Ammonia Safety Training Institute) and RETA, the Refrigerating Engineers and Technicians Association," he explained.

STARTING THE ANSI-APPROVAL PROCESS

Because IIAR standards are ANSI approved, they are subject to a rigorous public review process to ensure that they represent an industry consensus.

The standards process starts by recruiting stakeholders for a standards development committee. That committee is then divided into working groups that will address specific topics within the scope of the proposed standard, Lundell said.

Most standards begin with either the standards committee or the board identifying a standards project, which can be either a new standard or a revision to an existing standard, Smith said. "They file a project identification notification system with ANSI. That announces to the public IIAR is working on a standards project," he said.

Once ANSI approves the proposal, the standards development process can begin. ANSI standards start off as a board of standards review (BSR) document.

When the first draft is ready, the standards committee and the IIAR board of directors vote to publish the first public

IIAR Suite of Standards Under Periodic Maintenance

IIAR 1 – Definitions and Terminology Used in IIAR Standards

IIAR 2 – Safe Design of Closed-Circuit Ammonia Refrigeration Systems

IIAR 3 – Ammonia Refrigeration Valves

IIAR 4 – Installation of Closed-Circuit Ammonia Refrigeration Systems

IIAR 5 – Startup of Closed-Circuit Ammonia Refrigeration Systems

IIAR 6 – Inspection, Testing, and Maintenance of Closed-Circuit Ammonia Refrigeration Systems

IIAR 7 – Developing Operating Procedures for Closed-Circuit Ammonia Refrigeration Systems

IIAR 8 – Decommissioning of Closed-Circuit Ammonia Refrigeration Systems

IIAR 9 – Minimum System Safety Requirements for Existing Closed-Circuit Ammonia Refrigeration Systems

Non-Ammonia IIAR Standards in Development

IIAR CO_2 - Safety Standard for Closed-Circuit Carbon Dioxide (CO_2) Refrigeration Systems

IIAR HC – Safety Standard for Closed-Circuit Refrigeration Systems Utilizing Hydrocarbon Refrigerants

review draft, Smith said. Each standard can go through multiple public reviews. "Every public review comment must be addressed in one way or another. Every comment gets discussed. That is unlike the ISO process where only the people on the committees get to comment," Smith said, adding that the process can sometimes take years.

"Developed responses for each comment are tracked and shared with the originating commenters to work to a resolution/agreement and eventually voted on by the IIAR standard committee voting members," Lundell said.

Hallmarks of the ANSI process are that consensus must be reached by representatives of materially affected and interested parties and that the standards undergo a public review, Lundell said. "In addition, a consensus body must be assembled to verify the standard's content and verify that the ANSI process was met."

Also, the consensus body is invited to comment on the standard either before, during or after the public review, Smith said. "This is a group we solicit publicly through our website," he said. "It has been a steady group of people over the last couple of years."

At this time, IIAR has three consensus bodies and will be developing a fourth consensus body soon. The consensus body rosters can be viewed on the IIAR website.

Lundell said comments must be answered in good faith and an appeal process is required. "The consensus body is responsible not only for verifying a standard's content as mentioned, but also for verifying that all elements of the ANSI essential requirements have been met," he said. "The ANSI essential requirements include openness, balance, lack of dominance among stakeholder groups, consensus and due process."

Ultimately, the consensus body has to vote on whether to approve the standard and the standards committee has to vote for publication. "The board, standards committee and the consensus body are balanced," Smith said.

Smith said anybody who is an IIAR member can join the committee or be corresponding members to get involved and then become voting members.

MAINTAINING STANDARDS

There are different ways to maintain standards, Smith said. "IIAR chose five-year periodic maintenance," he explained.

IIAR has also updated several standards. IIAR 4 and 8 have been recently updated, Smith said. An update on IIAR 2 will be released in the next quarter. "IIAR 9 was published last year, and IIAR 5, 6 and 7 was published the year before," he said.

"IIAR 1 and IIAR 3 are now open for their five-year periodic maintenance review, and two other new standards are in development for CO_2 (carbon dioxide) and HC (Hydrocarbon) natural refrigerants," Lundell said.

KEEPING ACCREDITATION

IIAR is audited by ANSI every five years. "We have to prove that we've handled negative comments in an appropriate way," Smith said. "They audit IIAR against ANSI procedures. It is every bit as intensive as an annual financial audit."

"The ANSI audit includes project tracking for each standard shows each step taken when a standard is being developed," Lundell said.

IIAR Improves Safety and Operations with Ongoing Research and Standards

As the world›s leading advocate for the safe, reliable and efficient use of ammonia and other natural refrigerants, research is a critical component of IIAR's work. IIAR's ongoing research projects lead to improved safety and more efficient operations while also shaping industry standards.

CURRENT RESEARCH PROJECTS

The IIAR Research Committee currently has three active research projects, said Bruce Nelson, president of Colmac Coil Manufacturing and chairman of the Ammonia Refrigeration Foundation. "Each of these projects follows a well-defined work statement that was first developed and approved by the Research Committee, reviewed and approved for funding by the ARF Board of Directors, and then sent to prospective researchers soliciting their proposals to do the work," he said.

The research committee reviews each proposal and then selects the successful bidder. Each research project is managed by a project monitoring subcommittee appointed by the research committee chair, Nelson said. The current chair is Wayne Wehber.

The project monitoring subcommittees are made up of people on the research committee and anyone with a significant interest, said Eric Smith, technical director at IIAR. "I encourage people to get involved if they have a particular interest in a research project or a particular type of expertise that might be applicable."

Current research projects are:

Machinery Room Ventilation and Ammonia Release Computational Fluid Dynamics Study: The study aims to evaluate ventilation system designs and requirements for mitigating the chance of deflagration during accidental ammonia releases in machinery rooms. The research's potential benefits include reduced capital costs, improved safety, and greater consistency in design practice. The study is being performed by Gexcon US, with Dr. Scott Davis as the Principal Investigator. Work began in March 2020 and is expected to complete by June 2021.

A Step-by-Step Guide to Estimate Ammonia Releases and Reporting: The project deliverable is to generate an IIAR step-by-step guidance document and accompanying spreadsheet calculator that will aid end-users dealing with ammonia releases. This work is being conducted by Bent Wiencke and is due to be completed by June 2021.

"The idea is to provide an easy-to-use methodology and computer spreadsheet program to report ammonia releases," Smith said. "It will provide an easier way to estimate release amounts and guidance on what the report should contain."

Smith said the tool should also help companies avoid over-reporting. "Some people make a report out of an abundance of caution, so they aren't fined later, but the next thing you know, they're reporting all kinds of incidents that might unnecessarily raise a red flag to regulators. That isn't good either," he said.

Development of a Design Basis for the Avoidance of Hydraulic Shock in Ammonia Pipework Systems using State of the Art CFD Modeling: CFD modeling of ammonia suction lines at the moment of hot gas defrost initiation is being conducted to analyze condensate induced hydraulic shock (CIHS) phenomenon. The research is being undertaken by Chidambaram Narayanan, at AFRY in Switzerland.

Smith said it builds on an earlier ASHRAE research project on condensate induced hydraulic shock. Currently, Narayanan is validating the CFD model to confirm the results match work that was previously conducted through ASHRAE research at Georgia Tech on hydraulic shock in ammonia piping. The modeling program is also being verified against a well-documented incident involving CIHS.

Each IIAR Research Project Goes Through 13 Critical Steps:

All research at IIAR goes through a strategic process. Bruce Nelson, president of Colmac Coil Manufacturing and chairman of the Ammonia Refrigeration Foundation, identified these 13 steps that are part of every research project.

1. A new research topic is identified and forwarded to the research committee for discussion and development. These new topics can come from a number of sources, including individual members, IIAR committees, the IIAR board of directors, IIAR staff or other organizations.
2. The research committee evaluates and prioritizes these new topics within the overall long-range research plan.
3. A work statement describing the topic and deliverables is developed for the highest priority topics using a standard work statement template.
4. The research committee then votes to recommend approved work statements for funding by Ammonia Research Foundation.
5. The ARF board of directors reviews the work statements and requests for funding.
6. Work statements approved for funding are returned to the research committee and a proposal evaluation subcommittee (PES) is formed.
7. The research committee forwards the work statement to IIAR staff with a recommended list of bidders.
8. IIAR staff solicits proposals from researchers.
9. Proposals received are forwarded to the PES and evaluated.
10. The PES recommends a bidder to the Research Committee for approval and a project monitoring subcommittee (PMS) is formed.
11. The successful bidder's name is forwarded to IIAR staff, who then negotiate the contract for the research with the bidder.
12. Once the contract is signed, the PMS manages the project to completion.
13. Deliverables from the project are forwarded to IIAR staff for publication and distribution.

"Once the validation step is completed, the model will be used to characterize and identify pipe dimensions and operating conditions that produce hydraulic shock in ammonia piping. The deliverable from this project will be a set of design guidelines that help designers of ammonia refrigeration piping systems avoid hydraulic shock during hot gas defrosting," Nelson said.

These deliverables are expected to be incorporated in our ammonia training literature and the Piping Handbook.

RECENT RESEARCH PROJECTS

IIAR recently completed a project studying insulation installation techniques. "It resulted in a report by the researcher on appropriate practices for installing insulation to both preserve the integrity of the insulation and the integrity of the system itself," Smith said, adding that the report has been crafted in a soon-to-be-published guideline on the installation of the most common insulation systems. "The point is to protect owners' investments and ensure the quality of insulation systems.

Smith added that the guideline provides the installation techniques as well as quality-control methodology and basic guidance on maintenance.

Additionally, recent ARF-funded research on pressure drop in wet suction risers resulted in revised design calculations and tools, which were published in the recently revised ammonia Piping Handbook.

RESEARCH FUNDING

All of the research is funded by the Ammonia Refrigeration Foundation. "The ARF exists to fund education through scholarships and research projects of importance to IIAR members," Nelson said. "ARF is funded entirely by donations from individuals, companies, and other foundations."

Nelson said every research project put forward for funding must have well-defined deliverables that are of compelling and urgent importance to the IIAR membership. "Deliverables can take a number of forms including important new design data for our handbooks, new science-based justification for changes to our safety standards, tools to help our end-user members with compliance issues, energy efficiency analysis and guidance, etc.," he said.

An ARF research project's cost can exceed $150,000, said Joe Mandato, chairman of the ARF board of trustees. "Annual budgeting for research projects is based on the amount of funds available," he said. "These funds are generated from the Foundation's investment income and donations received."

Donations include pledge payments from existing trustees who are in the process of fulfilling their $50,000 pledges, initial pledge payments from new trustees, funds from foundations and individual contributions, Mandato said. "As a result, it is important to add new trustees each year to increase the funds available for the foundation to expand its research program in terms of the number of approved projects and/or the complexity of the projects approved."

Mandato said the COVID-19 pandemic adversely impacted ARF fundraising efforts in 2020. "Since July 1st, we have added only one new ARF trustee," he said. "I'm hopeful companies are in a better position to join the ARF Trustees now that COVID-19 vaccine distribution has begun.

All IIAR member companies can support the foundation by becoming ARF trustees and designating their donations be used for research or by funding specific research projects, Mandato said.

Call For Applicants: Foundation Scholarships

Another important Foundation service is the Foundation's scholarship program, which has recently received a generous $45,000 donation from the Kahlert Foundation for fiscal year 2000 – 2021. This year, the Foundation funded eight scholarships for engineering students currently pursuing an engineering or related technical degree leading to a career in the refrigeration field.

The ARF Founders Scholarship is now accepting Applications! Click here ARF Scholarship Application Form (iiar.org) to submit your application.

Colmac Coil Manufacturing Announces Leadership Change

Colmac Coil Manufacturing has announced that Joe Fazzari, P.E., has been promoted to the position of President, Colmac Coil Manufacturing, effective January 1st, 2021. Fazzari succeeds immediate former President Bruce Nelson, P.E. who has transitioned to a new role as Director of Innovation of Colmac Coil Manufacturing. Fazzari will have the oversight of all operations and strategic direction of Colmac Coil.

"I am excited to take on this new challenge with our focus being to continue Colmac Coil's growth with new, innovative products for the industrial heat transfer industry."

said Joe Fazzari, President of Colmac Coil.

Fazzari has been with Colmac Coil since 2002, serving as Vice President for 13 years. He has played an active role in helping guide the Company's strategic plan over the past 16 years. Joe is a licensed Professional Engineer in the State of Washington and is actively involved in the International Institute of Ammonia Refrigeration community. He also holds a B.S. in Mechanical Engineering from Washington State University. Fazzari has been instrumental in Colmac Coil's growth.

"I have found that the best way to grow our company is to listen closely when customers speak and work to develop new products and new product features that solve problems for our customers," said Fazzari. "If you listen to your customers carefully, they will tell you what direction to go in order to better serve them."

Bruce Nelson, former Colmac Coil President of 24 years, will continue to serve as Director of Innovation. Nelson led Colmac Coil through decades of growth and helped make Colmac Coil a leader in the industrial heat transfer industry.

"It is very gratifying for me to have seen Joe grow and mature as an engineer and as an executive manager at the company," said Nelson "He knows our industry well and is well known by many in our industry having served for several years on the Board of Directors of IIAR. Joe is well suited and well prepared to lead the company going forward and will keep our customer-focused culture going strong."

CARB Moves Forward on Low-GWP Requirements for California Ice Rinks

At the December meeting of the California Air Resources Board, the board voted to approve the proposed regulation on hydrofluorocarbons that established a 150 GWP limit for new ice rinks and other types of large refrigeration systems in locations such as cold storage warehousing.

Based on the vote, the proposed regulation will be finalized mostly in its current form. Any changes CARB makes will have to be limited in scope and are called "15-day changes" which are tweaks to the proposed rule that will come out for a final 15-day public notice and comment period.

Christina Starr, EIA senior policy analyst, said she expects any 15-day changes on this HFC rulemaking to be unrelated to the ice rink sector and more focused on the air conditioning sector for manufacturers that are seeking an additional two-year time delay for making a refrigerant transition.

"The biggest takeaway is that the more than 80 percent of ice rinks that already use ammonia or CO_2 would be smart to continue opting for these truly climate-friendly alternatives," Starr said. "CARB's decision signals that only refrigerants under 150 GWP should be considered 'future-proof' from a climate regulation perspective."

Under the new regulation, the 150 GWP limit applies to new ice rinks, while a 750 GWP limit applies to existing rinks. Starr said it's quite likely future regulations will expand this to existing rinks as well. "CARB was very clear in the hearing that this distinction is only because there are some very few counties where it could be more challenging for an existing rink that uses a higher-GWP refrigerant to switch to ammonia due to local permitting challenges," Starr said.

Gary Schrift, president of IIAR, said any regulation in California that requires and promotes the use of natural refrigerants is a gain for our industry and will most likely expand the use of natural refrigerants.

"We all know that often when California creates a regulation, other states follow, and often manufacturers and suppliers follow with their products designed to meet California requirements so that one does not have to have a California version and an 'all other states' version,"

Schrift said he was on a call with some Latin American IIAR chapter representatives recently who stated 'we do what the USA does.' "The USA often follows what California does, so it only seems likely that this decision will expand in the USA and Internationally," he said.

There was some pushback from HFO-HFC blend manufacturers against the 150 GWP limit for new rinks. One manufacturer voiced concern that some CO_2 and ammonia refrigeration system designs are patented. "However, those patents do not limit the numerous design possibilities," Schrift said, adding that the manufacturer expressing concern produces a patented refrigerant that can only be purchased or licensed from that company.

Starr said CARB's staff responses to any concerns indicated the board stands by the technical feasibility of the proposal CARB approved. "There was also a strong showing by a number of industry stakeholders that support the 150 GWP limit," she said. "There was no indication they plan to revisit this part of the regulation, though it's still a slim possibility."

Several proponents of low GWP refrigerants shared their thoughts during the meeting. "It was really encouraging at the hearing to see so much of the industry come out strongly in support of more ambitious yet feasible climate regulations that will reward the innovation and entrepreneurship of the companies that have made the most sustainable choices," Starr said.

During the December meeting, Mary Nichols, then administrator of CARB, said HFCs are synthetic chemicals that are very powerful short-lived climate pollutants and present an immediate threat to the atmosphere.

"Refrigerants in particular are an overwhelming problem at this point. The growth and use of these chemicals is extraordinary around the world as developing countries improve their standard of living," Nichols said. "Fortunately, there is a transition underway around the world to more climate-friendly refrigerants. It is important those of us in California do our part as we also move ahead with other chemicals as well.

"The growth and use of [refrigerants] is extraordinary around the world as developing countries improve their standard of living. Fortunately, there is a transition underway around the world to more climate-friendly refrigerants. It is important those of us in California do our part as we also move ahead with other chemicals as well."

—Mary Nichols, then administrator of CARB

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Energy Performance Benchmarking: Considering the Efficiency of an Ammonia Refrigeration Installation

STEFAN JENSEN, SCANTEC

The number of countries ratifying the Kigali Amendment to the Montreal Protocol is steadily growing.

In 2016 in Kigali, Rwanda it was agreed to phase down hydrofluorocarbon (HFC) refrigerants for environmental reasons. The amended Montreal Protocol is the instrument that will make this happen.

In November 2016, the Paris Agreement entered into force. The Paris Agreement is a legally binding international treaty on climate change. At the time of writing, 190 Parties out of 197 Parties to the Convention are Parties to the Paris Agreement.

The goal of the Paris Agreement is to limit global warming to well below 2°C (3.6F), preferably to 1.5°C (2.7F), compared to pre-industrial levels.

The science and the politics that have led to these agreements are therefore obviously considered conclusive. Within polities across the world, legislation and regulations are or have been evolving that reflect the above two global initiatives.

For practitioners within the refrigeration industry, the time for questioning what has led us all to this point has passed. It is now necessary to focus our combined efforts and expertise on the responses to the new regulatory and legislative environments that either are or will be realities soon.

The ammonia refrigeration industry, which already uses one of the most energy-efficient and environmentally benign refrigerants available, does not have to concern itself with too many of these energy conservation initiatives, right? Wrong.

Is this as good as it gets? Is the ammonia refrigeration industry as energy efficient as it can be? If not, how is the energy conservation potential of ammonia refrigeration plant generally (existing as well as new) quantified, and how is this potential realized?

Ammonia refrigeration plants are employed in a variety of different applications. To shed light on some of the questions raised above, mixed refrigerated warehouses have been used as a sample application in the following.

Refrigerated warehouses have been the subject of numerous energy performance analyses by many researchers over several decades. There are not many analyses, however, that mainly focus on ammonia refrigeration plant.

Secondly, the results of the published analyses have, with few exceptions, been grouped to show designers and users average energy performance practice as opposed to best practice energy performance.

If users and designers examine their key performance indicators and determine that they fall within the average industry practice bracket, it is tempting to conclude that the plant they possess is indeed as good as it gets.

It is, however, the difference between average industry practice and

best practice energy performance that will provide a measure for the energy conservation potential of a particular application.

So, what is the best practice energy performance for an ammonia refrigeration system servicing a refrigerated facility?

Generally, the energy performance of a refrigerated warehouse is measured in kWh per unit refrigerated volume per year or kWh·m^{-3}·year^{-1} (kWh·ft^{-3}·year^{-1}). This is also referred to as Specific Energy Consumption (SEC). Figure 1 provides examples of recorded SEC-values.

The color-coding of the performance values is self-explanatory. The systems represented by the yellow dots are highly energy-optimized, dual-stage ammonia refrigeration plants with screw compressors and liquid overfeed. These systems were designed and constructed between 1999 and 2013 by one refrigeration contractor for one client.

What is noteworthy in relation to Fig. 1 is the spread between the SEC-values. Some of this spread is of course explained by differences in peripheral conditions and differences in the ways the individual warehouses are operated.

What is also evident is that the SEC-values of certain plant types form a significantly closer and more predictable cluster than others. This is the case for the systems represented by the green dots.

The green dots characterize refrigeration plants with a significant focus on superior part load energy efficiency. This translates into multiple smaller compressors, extensive use of rotational speed control, and detailed optimization of the operating envelopes of the individual heat exchangers throughout the systems.

The plants represented by the green dots are also not penalized by the presence of relatively heavy liquefied refrigerant in the suction lines/risers. Particularly at part load, the presence of liquefied refrigerant in suction lines and risers can cause very significant line pressure drops and serious energy performance penalties.

Within Fig. 2 is illustrated an achievable best practice energy performance benchmark. The benchmark is based on recorded SEC-values of ammonia refrigeration plants operating in the field.

The graph for the best practice energy performance benchmark is SEC=16,000V-0.61 kW·h$^{-0.61}$ m^{-3}·year^{-1} where the refrigerated volume V is inserted in m^3. The blue graph SEC=78,673V$^{-0.631}$ represents average practice for the facilities recorded in this example.

The vertical distance between the two graphs represents the energy conservation

Generally, the energy performance of a refrigerated warehouse is measured in kWh per unit refrigerated volume per year or kWh·m-^{3}·year-1 (kWh·ft-3·year-1). This is also referred to as Specific Energy Consumption (SEC). Figure 1 provides examples of recorded SEC-values.

Figure 1. Typical SEC-values for refrigerated warehouses

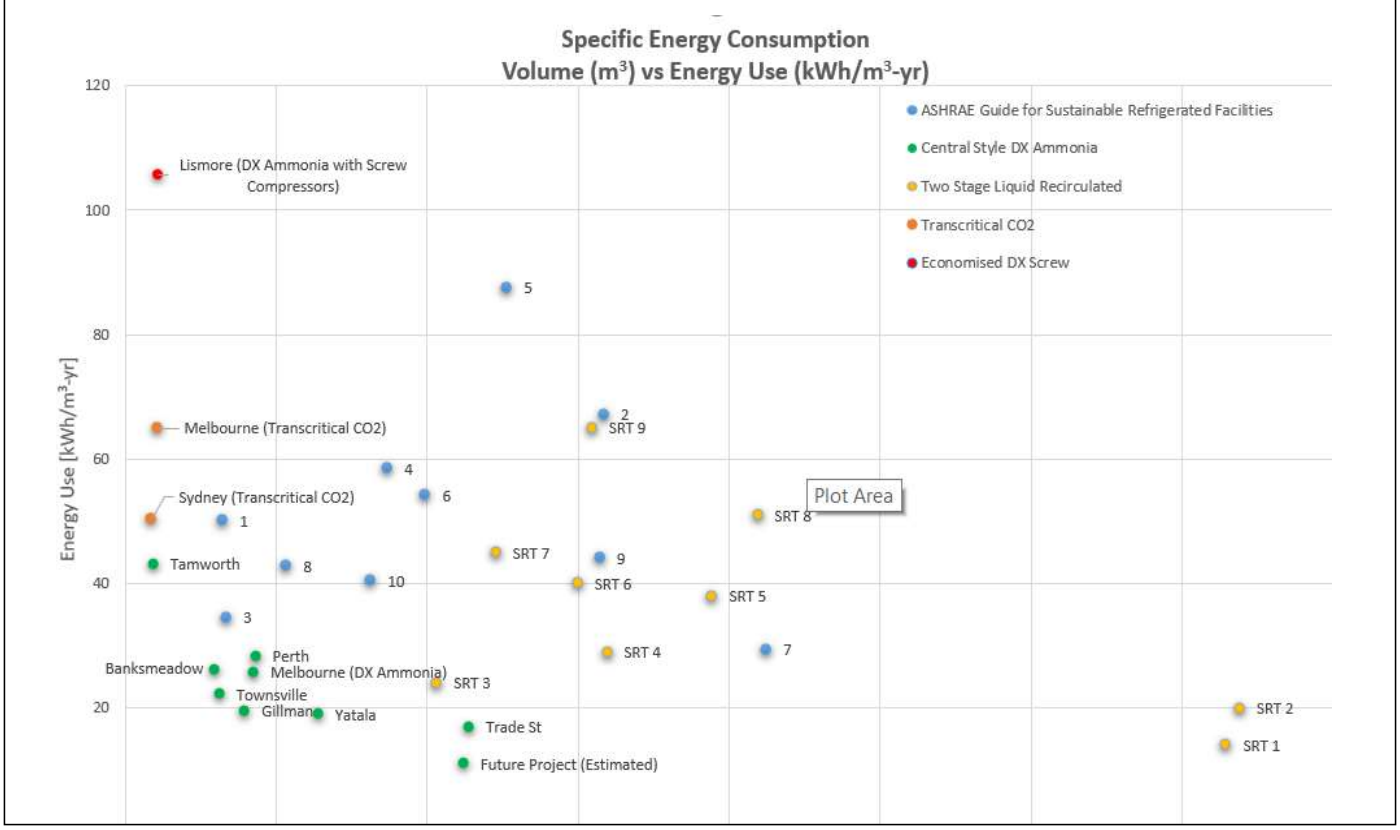
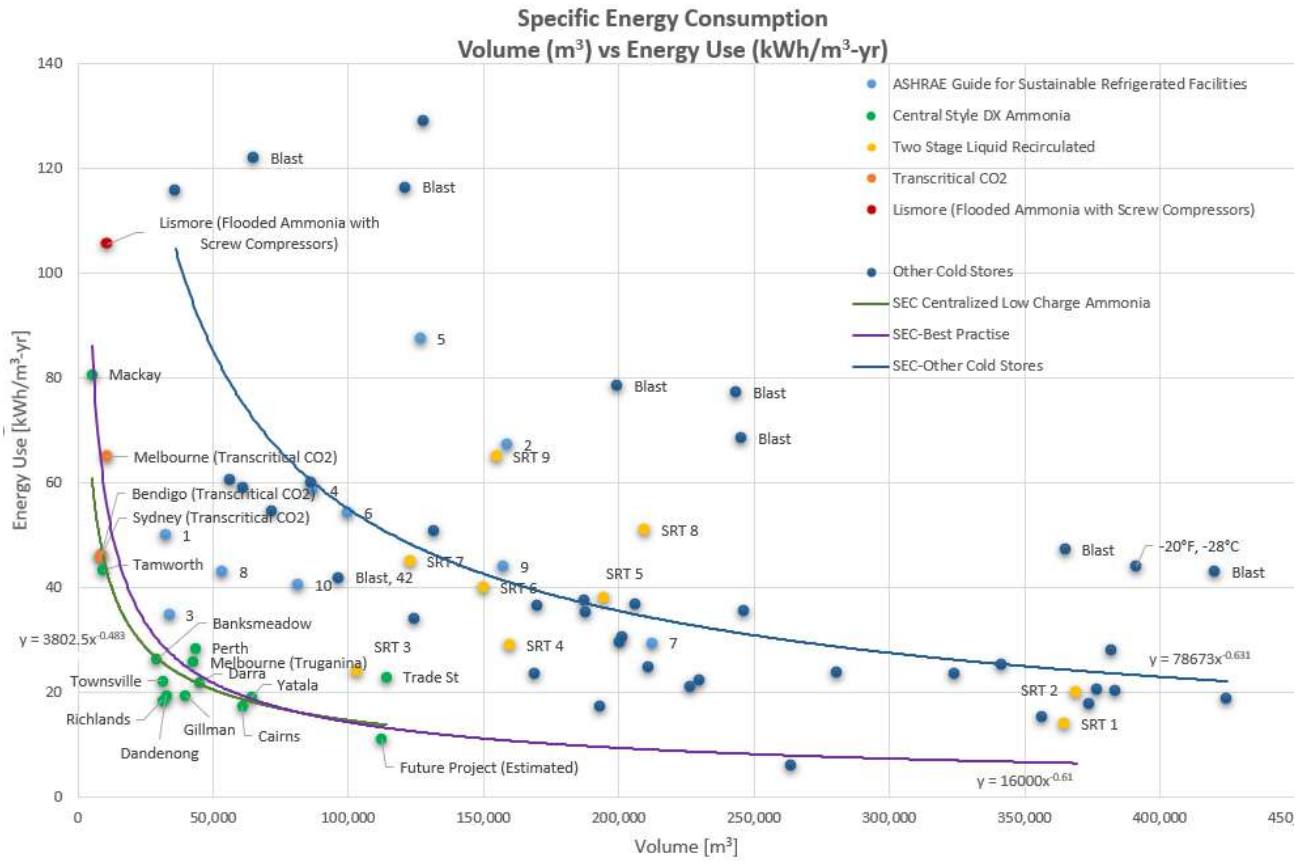


Figure 2. Best and average practice energy performances



potential. For a 100,000 m³ (3,531,467 ft³) warehouse, the energy conservation potential is 55-14.3=40.7 kWh/m³*a (1.15 kWh/ft³*a) or a 74% reduction.

So, what explains the recorded spread in SEC-values aside from variations in peripheral conditions?

This can be answered in one sentence – lack of attention to overall system energy performance at partial load.

Let us have a look at some practical examples.

The first one is a conversion of a small 5.250 m³ (185,400 ft³) refrigerated food service facility from air cooled, single stage R404A based condensing units with electric defrost to a dual stage centralized, low charge NH_3 plant with hot gas defrost and evaporative condenser.

The recorded reduction in SEC is 57 to 71% depending on the time of year and plant control settings.

The second example is the replacement of an existing NH_3 plant with two single stage economized screw compressors, gravity flooded refrigerant feed, hot gas defrost and evaporative condenser with a dual stage, centralized, low charge NH_3 plant with reciprocating compressors and hot gas defrost – refrigerated volume 10,000 m³ (350,000 ft³).

The before/after annual operating expenses (sum of energy and maintenance costs) are $275,000 and $83,000 respectively. The simple pay-back is five years.

The third example is a 60,000 m³ (2,119,000 ft³) refrigerated distribution facility with 300 tons/week blast freezing capacity. Based on the first electricity account after commissioning, the new facility features 57% lower annual energy costs ($370,000 versus $865,000/year) than the almost identical neighboring facility serviced by a conventional liquid overfeed NH_3 plant.

It is anticipated that this initial energy performance advantage recorded for the third example will increase further as steady state conditions are established within the new facility.

The tasks that lie in front of us all are clear, but not necessarily easy. Collectively, we need to examine our past performances within the area of energy efficiency engineering as applied to industrial refrigeration, identify shortcomings, and improve.

This will no doubt challenge some well-established conventions, but there is not anyone better at challenging what we do than ourselves. Collectively, we clearly have what it takes to do this job. In IIAR we have an excellent forum for information exchange. We must start this journey now. The time is right.

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Emergency Series Part 2: Emergency Shutdown and Response

JEN ALLEN, ALLEN SAFETY LLC

This article has been updated from a previous version to distinguish the differences between a nuisance leak response and a HAZMAT response.

Emergency response or responding to emergencies means a response effort by employees from outside the immediate release area or by other designated responders (i.e., mutual aid groups, local fire departments, etc.) to an occurrence which results, or is likely to result, in an uncontrolled release of a hazardous substance. Responses to incidental releases of hazardous substances where the substance can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel are not considered to be emergency responses within the scope of this standard. Responses to releases of hazardous substances where there is no potential safety or health hazard (i.e., fire, explosion, or chemical exposure) are not considered to be emergency responses.

We saw in part one of our Emergency Series covering Pre-Emergency Planning (November 2020 Condenser, page 25) that, as an industry, we are having to reframe how we look at ammonia leaks. From employee turnover creating less experience in our engine rooms to aging equipment, we are finding that HAZMAT scenarios have become part of the business. We have also found that, based on the safeguards an organization puts in place to address these leaks, ammonia leak management can be simple. In this second article, we will take you step-by-step through the emergency response process. From initial leak identification through releasing the area back to normal operations, we will provide you with tools and strategies to ensure any leak at your location is well-coordinated and well managed.

WHAT CAUSES A LEAK, AND WHEN IS IT HAZMAT?

When we think about what can cause an ammonia leak, several scenarios come to mind: construction, line break, repair and maintenance, weather, mechanical integrity, wear and tear, wrong parts, sanitation chemical corrosion, and power industrial trucks to name a few. But how do we recognize if the leak is a "nuisance leak" or if a HAZMAT scenario is occurring? To make this determination, we may need to reframe how we view HAZMAT responses. Often the term "HAZMAT" brings to mind an outside agency response and level A suits, but it may be beneficial to view HAZMAT responses with a more modern lens where we define a HAZMAT response as a response to an unexpected ammonia leak at or above a facility's pre-determined evacuation levels, in which responding operators or technicians match the level of PPE worn to the leak's severity. To aid in this, the following questions can be helpful:

- Is the presence of released ammonia unexpected, and not the result of planned repairs/maintenance?
- Is the concentration of ammonia in the technician's breathing zone where they would stand to make the adjustments/repair greater than the facility's pre-determined evacuation levels for ammonia?
- Is the concentration of ammonia rapidly increasing?
- Per the facility's emergency programs, would the operator or technician be required to either don additional PPE to fix the leak or evacuate the area?
- If operators or technicians answer yes to the questions above, then the scenario would likely require a HAZMAT response.

OSHA's HAZMAT and Emergency Response standard, 1910.120, outlines emergency responses as those where a group of responders, either internal or third party, comes from "outside the immediate release area" to address a leak that has a good chance of becoming uncontrolled or significant in size. Within this standard OSHA allows employees to address the release without classifying it as a HAZMAT response if:

1. They are within the immediate leak area
2. They feel the release can be easily controlled and/or managed
3. There are no safety hazards present at the time of occurrence

The complete standard can be found at https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.120

In any case, a facility should establish protocols for a leak investigation, what situations constitute safety hazards, and when HAZMAT responses should be initiated. Operators and technicians should be familiar with these protocols.

THE RELEASE

Once it is established that a HAZMAT response will be required, a facility has two choices. If there is a trained internal HAZMAT team at the facility, a trained Incident Commander- someone with a current HAZMAT Technician Certification *as well as* a current Incident Command Certification- will need to take over the scene. Alternatively, if the facility does not have a trained HAZMAT team on-site, they will need to call a third-party HAZMAT team

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to respond. This can include a fire department or a hired response company. The facility will then stand down, not making entry into the hot zone regardless of victim or leak status, and upon the arrival of the third-party responders, the facility's role will be to advise and support from the cold zone.

If the facility has an internal HAZMAT team, the Incident Commander will need to determine what PPE Level and response style is required. To accomplish this, additional leak investigation may be needed using the investigation protocols created during emergency pre-planning. These protocols outline the number of participants, what meter will be used, and when to don respiratory equipment. Based on the information the investigation yields, the Incident Commander can determine the following:

- Is the quantity of ammonia lost small or large?
- Do any local, state, and federal agencies require leak notification?
- Are shelter in place or evacuation orders necessary for the facility itself, surrounding businesses, or residential neighbors?
- What Level of PPE is required?
- Does the team have the training and medical qualification to respond at that Level, and in that PPE?
- Is the required PPE on hand, in good working order, and in sufficient amounts for each participant?
- Are there enough trained personnel present on-site to safely respond?
- Is an offensive response (to include victim rescue and leak shutdown), or defensive response (emergency stop button is pushed) required?
- Is your team trained to perform offensive or defensive leak responses?

Upon answering these questions, the Incident Commander will begin putting a response plan into place. If the Incident Commander determines a facility

evacuation is required, trained location evacuation coordinators will begin evacuating personnel to pre-identified locations up-wind of the leak while the Incident Commander is conferring with location refrigeration technicians to develop a plan to address the leak or any life safety/victim concerns. It would be typical that law enforcement and fire support aid in the evacuation notifications for any neighboring businesses or residential areas.

PPE SELECTION

With site evacuation coordinators and local agencies managing shelter in place or evacuation needs, the Incident Commander can turn their focus on outlining specific plans for addressing victim management, where the leak is occurring, the size of the leak, how long the leak has been active, options for shutting down the leak, and PPM of ammonia in the areas where victims and/or valves for shutdown are located. For PPE determination there are two options. If the leak is known to be under IDLH in areas the entry team will need to access, a response in APRs and ammonia gloves paired with a standard work uniform, Level B suit, or rain suit- often called a "Stage 2 HAZMAT Response" or "Limited HAZMAT Response"- is sufficient. If significant time has gone by since the initial investigation, Levels are at or above IDLH, or if leak concentrations are unknown, a "Stage 3" or "Level A HAZMAT Response" is required. While in the past facilities trained using Level B for ammonia leak responses that were just over IDLH, viewing them as a "less risky" PPE option, we have found in live applications this concept is not practical. This is due to many Level B manufacturers not providing a max PPM concentration for Level B use. That coupled with the possibility of finding the leak is both liquid and vapor, a mixture of ammonia and other chemicals, or exceeds their location's Level B threshold all make a response in Level B undesirable. This is because these scenarios all require the entry team to return to the cold zone where entry and backup teams must change to Level A, with entry teams re-entering the hot zone 20+ minutes later to manage a leak that has increased in size and duration, adding unnecessary risk for entrants.

If significant time has gone by since the initial investigation, Levels are at or above IDLH, or if leak concentrations are unknown, a "Stage 3" or "Level A HAZMAT Response" is required. While in the past facilities trained using Level B for ammonia leak responses that were just over IDLH, viewing them as a "less risky" PPE option, we have found in live applications this concept is not practical.

BRIEFING AND GOALS

Once the team has determined PPE Levels, the Incident Commander will begin verifying last dates of training, training Levels, and that physicals and fit testing are within the last 12 months. (Even during a pandemic, training and medical questionnaires/evaluations should be within 12 months). Officer roles will be assigned according to the style of response chosen. If a Stage 2 or APR response is required, two entry, two backup, and an on-site Incident Commander will begin the briefing session. For a Stage 3 or Level A response, the Incident Commander will instruct the 2-person entry team and a 2-person backup team to begin having their pre-entry vitals taken by the Medical Officer and begin dressing in Level A. A Decontamination (Decon) Officer would begin setting up a three-stage wet decontamination zone prior to entry, allowing the team to be immediately decontaminated upon their arrival to decon regardless of what is identified in the hot zone. This could include victim management, heat stress recovery, a mixture of chemicals or oil, or a liquid leak. This versatility makes wet decon preferential to a dry decon, which can only be used for ammonia vapor. Once decon is staged, the team member would have their pre-entry vitals taken by the Medical Officer, and dress in Level B. Based on the number of additional team members available, the roles of Entry Team Officer, Safety Officer, Logger, and Security Officer roles may also be assigned.

Once the team is ready to make entry, the Incident Commander will review the goals of the entry with the goals of Life Safety (remove and treat victims), Scene Stabilization (leak shutdown or hitting the emergency stop), and Property/Product Conservation in mind, in that order. For entry teams performing refrigeration tasks, it is important that a trained and qualified operator perform the refrigeration tasks. The roles of the second entrant, backup team, or for an entry team that is only removing victims can be filled by anyone that is current on their technician training and medical qualifications. This is something that can be extremely relevant for responses where there are limited operators that can pass vitals, where multiple entry teams are required, or for off-shift,

weekend, or holiday responses when team members called back are slow to arrive at the location.

Communication methods and expectations should be covered, including who on the entry team will communicate with the Incident Commander, as well as specific parameters for exiting the hot zone. For a Stage 2 entry, expectations to exit the hot zone would include meter readings nearing 250PPM (immediately dangerous to life and health, IDLH, for ammonia is 300PPM). For a Stage 3 Level A entry, a typical expectation might be when the SCBA "bell" beings ringing, or when there are approximately 10-15 minutes of air remaining in the tank. For either stage response, entrants should exit the hot zone if conditions inside the hot zone are different than expected or change, rendering the initial plan unsafe to complete, unachievable, or ineffective.

The emergency portion of the location's SOP should be reviewed and then followed by the entry team, providing the team with specific detailed information on how to shut down and isolate a leak for each specific piece of equipment at that site, based on that unique system. Support documents such as accurate P&IDs and block flow diagrams can be extremely helpful for refrigeration operators and PSM coordinators when locating what valves should be closed, the order in which they should be closed, if any pump-out lines exist, and any drain time required to avoid trapping ammonia. If the team determines that the pre-determined site-specific emergency shutdown procedures written into the SOPs- that receive an annual review by operators- cannot be followed for any reason during the response, it is highly recommended that the Incident Commander or logger document during the briefing the reason these procedures cannot be followed. The team will also need to document what procedures were followed instead, and why a different method was utilized.

THE RESPONSE

Once the entry team departs the cold zone, the Incident Commander will have frequent check-ins with the entry team, with the entry team providing updates on their location, meter readings, what step of the plan they are completing, and when they are returning to Command or Decontamination. This accomplishes two goals. One, it allows the IC to track the specific location of the entry team in case backup must be activated. Two, it allows the IC to verify conditions inside the hot zone and determine the goals and plans for the next entry team. If any of the pre-determined scenarios for immediate departure of the hot zone arise (meter readings, conditions, elapsed time), the entry team will return to Command. If for any reason the IC loses communication with the entry team, or if the entry team does not return within the expected timeframe, backup will be sent to retrieve the entrants.

VICTIMS AND DECONTAMINATION:

If victims are removed from the hot zone, there are two options based on a team's training level. If the team is a Stage 3 Level A trained team, the team can begin treatment of victims immediately by providing a wet decontamination as victims arrive at the decontamination zone. Decon and Medical Officers will coordinate with ambulance crews for victim medical management once initially decontaminated. If the facility has no HAZMAT team, or, a Stage 2 or Limited Response HAZMAT team, the facility would work with the area fire department or ambulance crew to decontaminate and treat any victims removed from the hot zone. Once victims are being treated- or if there were no victims removed- the entry team will be deconned, swabbed to ensure there are no residual contaminants, and return to the cold zone where PPE is removed and post-entry vitals are taken.

RELEASING THE AREA:

The entry, decontamination, re-entry cycle may continue several times based on if there were victims, leak size, duration, location, valve accessibility, number of leaks, mechanical integrity in the area where the leak was shut down/isolated, and the accuracy and effectiveness of the location's SOPs. Once the final entry is made and the Incident Commander has verified the shutdown was successful and the area is ventilating, the team can begin focusing on returning to normal operations. This includes:

- Collection of any logger notes
- Obtaining written statements from all participants
- Lock/tag any required valves and secure rooms
- Contact a hazardous waste hauler to neutralize and remove any contaminated items
- Schedule any required repairs
- Completion of an event critique
- The final step includes the completion of an incident investigation addressing how and why the leak occurred, with a written action plan including responsible parties and estimated completion dates to prevent re-occurrence.

LASTING EFFECTS:

HAZMAT response timelines can range from 15 minutes to 8+ hours, but with proper pre-emergency planning and emergency response safeguards, a facility can take back control of what historically was viewed as an uncontrolled event. The impact this planning has on risk reduction for responders, response time to victims, and length and severity of the leak, all also directly affect a facility's bottom line through production downtime and product loss. This makes thoughtful and detailed emergency management programs not only the right and responsible thing to do for employees and neighbors but also a benefit financially to every location.

Jen Allen is the Vice President for Allen Safety LLC, which specializes in confined space rescue training, HAZMAT training, and customized Safety & PSM audits.

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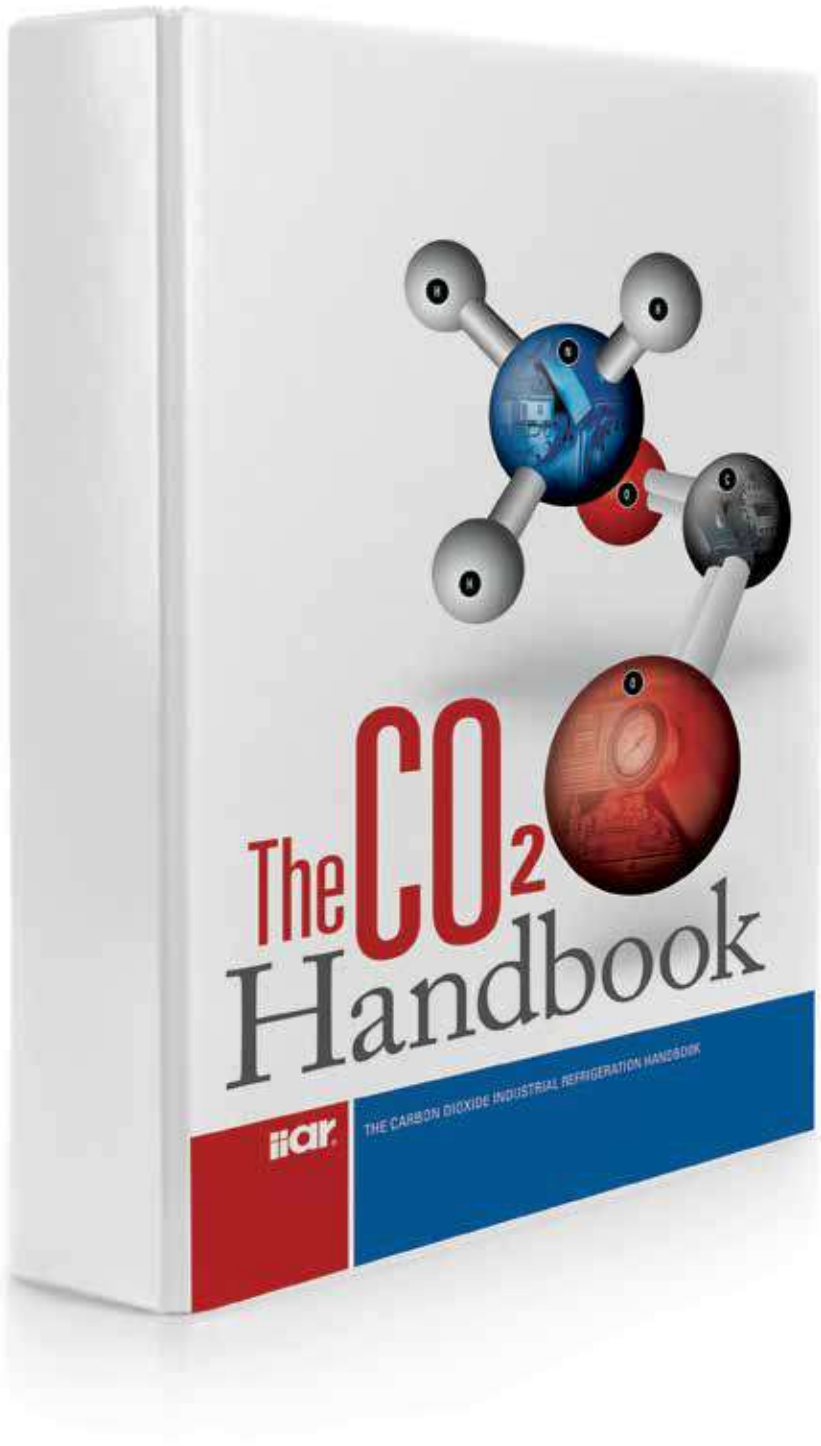

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Unknowns

BY KEM RUSSELL

Participating in IIAR conferences, webinars, committees, and sub-committees has certainly increased my knowledge and my access to information. I have listened to and worked with very knowledgeable people from many backgrounds. Even after being involved in the ammonia refrigeration industry, and specifically IIAR for many decades, I am still learning. This reminds me of a famous statement I read in a book by Donald Rumsfeld, who served as George W. Bush's secretary of defense. Rumsfeld said:

"As we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say, we know there are some things we do not know. But there are also unknown unknowns—the ones we don't know we don't know."

The part of this quote that still surprises me today is how many times I experience "unknown unknowns."

I am not going to get into the details of some of the "unknown unknowns" that I have run into, but generally describe three examples of things I recently "didn't know I didn't know."

In doing maintenance of ammonia equipment and piping one primary concern is that the work is done safely. A lot of thought has gone into what should be done to be safe, yet still, be able to perform the intended activity.

One example, where I have been surprised at what I didn't know, is entering an evaporative condenser. I have been inside of many evaporative condensers. Before entering a unit certain precautions are taken, such as: verifying that the fans and water pump(s) have been shut down and locked out; and visually looking inside the unit for possible interior hazards. Before I knew of such a thing as Legionnaires' disease, I, and everyone I knew, just went inside the condenser. I have not heard of someone catching Legionnaires' disease from entering an evaporative condenser, but it does seem to be a potential area that could have the bacteria. Now wearing some type of breathing protection seems like good advice.

Does the interior of an evaporative condenser qualify as a confined space? I didn't really give this much thought, however in conversations with knowledgeable people on this topic, evaporative condensers do fit the requirement of a "Permit Required Confined Space" (PRCS). As I mentioned, decades ago I never saw an evaporative condenser with signage identifying the space as a "Confined Space." It wasn't until about the last 10 – 15 years that I started seeing some units with a sign, and the few I saw had a sign saying something like, "No-permit required Confined Space", which from what I have understood would not be appropriate signage.

If the interior of a condenser is PRCS, what does that mean? Here I have run into "unknown unknowns", and this issue is still being discussed by knowledgeable people participating in the IIAR Safety Committee. One of the challenges with entering an evaporative condenser is the ammonia in the coil. If there is even a "potential" of a release of a hazardous substance, then certain actions, according to OSHA, must be taken. The ammonia must be removed from the coil. That's easier said than done, but assume there is a safe way to do that. The next hurdle is isolation of the coil from the system. There are three methods for doing this, however, no evaporative condenser installation I have seen can be isolated using one of those methods. How we match up what we have (design and procedures) with what the OSHA regulations apparently require, is a challenge. Hopefully, over the next several months, a reasonable recommended approach will be determined.

Another example: Air purifying respirators. Early in my ammonia refrigeration career, I was at times assigned to assist a refrigeration technician as work was done changing piping and control valves on an active ammonia system. During the 1960's I had no knowledge of PPM levels, I just knew ammonia made my eyes water, breathing difficult, and I wanted to leave the space. However, when ammonia became too irritating we wore a canister style full-face respirator, the kind with the elephant hose from the mask to the canister. I also did not know there was such a thing as "fit testing", nor did the people I worked with. All we knew at the time was that if the face seal was good, we didn't experience effects on our eyes or breathing due to the ammonia.

At that time I didn't know there might be devices that could measure the PPM of the ammonia. I'm not sure that such measuring devices were even generally available to purchase. What PPM levels we were working in was unknown. We now know the levels should be measured and monitored. It was also not known that ammonia within a fairly narrow range of concentrations in air, and in an enclosed space could possibly ignite. We now know this. I did see flame erupt out of cut lines, but at the time we thought that was just the residual oil, not realizing that ammonia vapor might have been part of the flaming action. We also heard some scary sounds inside of a few pressure vessels. All the time doing work I know I was never in a concentration that was high enough to result in a possible ignition. I was never in a hazy ammonia atmosphere, but this was due to luck, not knowledge. At the time the only testing means we had was that if you started to feel stinging it was time to leave.

Even if you didn't feel stinging, the canister would eventually reach a saturation level (you started smelling ammonia in the mask), which told you it was time to change the canister.

As time has gone by, more and more people started using cartridge-style instead of canister-style full-faced ammonia masks. Presently a large percentage of air purifying respirator (APR)

masks are cartridge style. What I didn't know until fairly recently is there is a difference in the specifications NIOSH uses for masks. A cartridge-style meets the specifications for a 23C, which is good for PPM levels up to, but not over 300 PPM, the IDLH for ammonia. The canister-style mask is a 14G, which is also good for 300 PPM. However, while wearing the 14G a person could accidentally be in a higher PPM level due to a sudden release and they can justifiably escape, they just cannot go back in the above 300 PPM environment. So, with the 23C a person never goes above 300 PPM, but with a 14G style, you could be above 300 PPM and escape. This for me was an unknown unknown, and I am still studying this one.

One more example of an unknown is a term I never thought of that now applies to something I know a fair amount about, which is ammonia. I have seen liquid ammonia many times. If you were upwind and the pool has stabilized, you might first think it was water. After a first few seconds, you should notice visible vapor forming and disappearing just above the liquid surface, like wisps of smoke. Ammonia is a clear and very cold liquid at atmospheric pressure.

Not too many months ago, while on a conference call I heard the term "Green ammonia." What is that? Even though I am Red/Green colorblind, I know ammonia is most often clear (other impurities such as oils, etc. might change the color). The term actually doesn't apply to the color, but to the energy source used to produce it. In this case, ammonia is being produced using solar or wind power generating methods. Thus ammonia is called green because it's being produced using a renewable energy source.

There are many unknowns, and even unknown unknowns, even within our industrial ammonia refrigeration industry. As we stay involved, listen, and learn, we can, over time, change many of these unknowns into knowns, which can improve designs, operation and maintenance, and overall safety for all.

Choosing Between Traditional and Roth IRA's

Each year, individuals with earned income may decide to put $6,000 ($7,000 if age 50 or older) into an IRA to save for retirement. The decision to contribute to a traditional IRA versus a Roth IRA has several key considerations, such as eligibility, tax-deductibility, and current versus future tax rate. The below chart outlines some features of each type of IRA to aid in the important decision of which IRA to fund annually.

	Traditional IRA	Roth IRA
Tax-deductible contributions	Yes[1]	No
Tax-deferred growth on earnings	Yes	No
Tax-free growth on earnings	No	Yes
Tax-free distribution of earnings	No	Yes[2]
Contributions allowed at any age	Yes[3]	Yes[3]
Required minimum distributions (RMDs) at age 72	Yes	No
Contribution eligibility depends on income	No	Yes
Contributions may be withdrawn at any time tax-free	No4	Yes

[1] Dependent on tax filing status, retirement plan coverage, and adjusted gross income (AGI)
[2] Five years from first Roth IRA funding and age 59½, first-time homebuyer, death, or disability
[3] Must have earned income
[4] Non-deductible contributions may be withdrawn tax-free, but subject to the pro rata rule

Five Important Questions to Ask:

Do I need a tax deduction, and am I eligible for it?

- If you are covered by a workplace retirement plan and are a single filer, adjusted gross income (AGI) under $66,000 will allow for a full tax deduction on a traditional IRA contribution.
- If you are covered by a workplace retirement plan and are married filing jointly, AGI under $105,000 will allow for a full tax deduction on a traditional IRA contribution.
- If you (and your spouse if married) are not covered by a workplace retirement plan, you can have any AGI level and fully deduct your traditional IRA contribution.

Am I eligible to make a Roth IRA contribution?

- If a single filer and have AGI under $125,000, you may make the full $6,000 ($7,000 if age 50+) Roth IRA contribution.
- If married filing jointly and have AGI under $198,000, you may make the full $6,000 ($7,000 if age 50+) Roth IRA contribution.

Is my tax rate going to be higher now or higher in the future?

- If you believe your tax rate is going to be the same or higher in the future, a Roth IRA is more beneficial, as those assets will be tax-free after five years and age 59½.

Are my beneficiaries in high tax brackets?

- Under the SECURE Act's 10-year rule, non-spouse beneficiaries must have inherited IRAs depleted over 10 years instead of taking minimum distributions each year over a life expectancy.
- If beneficiaries are in a high tax bracket, inheriting tax-free Roth IRA money does not get taxed at the beneficiary's high rate.

How long do I have until retirement or needing access to this money?

- The younger the investor, the longer time horizon he or she has to compound earnings in an IRA.
- Since Roth IRA earnings will eventually be tax-free, Roth IRAs become more appealing for younger investors.

Bonus question: Do I have a larger concentration of pre-tax or Roth IRAs and retirement plans?

- By having a large concentration of only pre-tax IRAs and retirement plans, you are subject to RMDs and must start paying taxes on this money at age 72.
- By having a tax-diversified portfolio with some pre-tax and some Roth IRAs, you have the flexibility to draw from both account types to minimize tax liability.

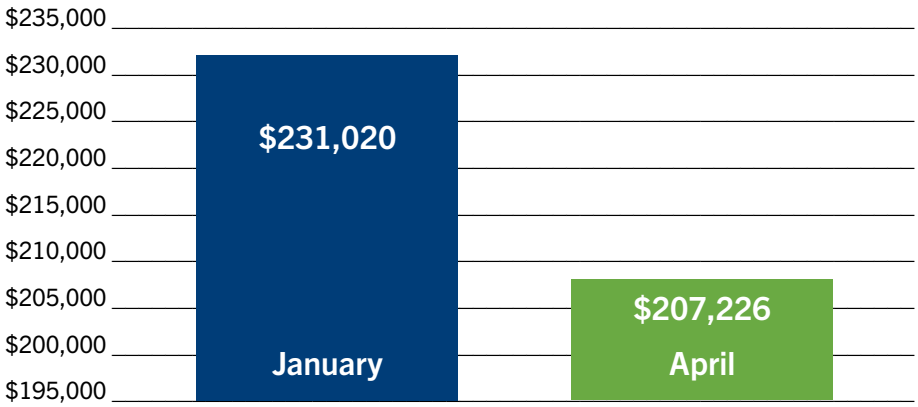
As you can see in the chart below, by waiting just 15 months, the cost could be $23,794. By making IRA contributions earlier in the year, the account's value has more time to grow and compound earnings.

Final round: Why contributing early in the year matters IRA owners can make IRA contributions for 2021 from January 1, 2021 – April 15, 2022, so why does it pay off to contribute early?

Over the course of 20 years, a $6,000 contribution invested in January of each tax year versus on April 15 of the following year can make a significant difference:

As you can see in the chart to the right, by waiting just 15 months, the cost could be $23,794. By making IRA contributions earlier in the year, the account's value has more time to grow and compound earnings.

The IIAR and ARF reserve investment funds are currently managed by Stifel Financial Services under the investment policy established by their respective board of directors. Members of IIAR may use the services of Stifel for personal and business investments and take advantage of the reduced rate structure offered with IIAR membership. For additional wealth planning assistance, contact your Stifel representative: Jeff Howard or Jim Lenaghan at (251) 340-5044.



Assumes: 6% rate of return, compounded monthly. This is a hypothetical illustration only and does not reflect actual performance of any particular investment.

Biden Administration Takes Early Action on Regulatory Policy and Climate Change

iiar government RELATIONS

BY LOWELL RANDEL, IIAR GOVERNMENT RELATIONS DIRECTOR

Joe Biden began his presidency on January 20th by signing a series of Executive Orders impacting a wide range of policy issues. In just the first 10 days of his Administration, Biden took 42 individual executive actions, many of which reversed policies instituted by former President Trump. Regulatory review and climate change are among the major actions that will have an impact on the natural refrigerants industry.

REGULATORY REVIEW AND FREEZE OF TRUMP ACTIONS

It is customary for incoming Presidents to freeze late term actions of the previous administration. The Biden Administration is following this practice by pausing the implementation of rules finalized in the last days of the Trump administration. In a memo to agencies, the Biden administration has directed that agencies not propose or issue rules in any manner until a department or agency head appointed or designated by Biden reviews and approves the rule. Rules that have already been sent to the Federal Register, but not published, shall be immediately withdrawn for review and approval. Effective dates for rules that have been published in the Federal Register, or otherwise issued, but have not taken effect shall be postponed for 60 days to allow for review.

In addition to reviewing late term Trump regulations, the Biden administration has issued a memo on modernizing the regulatory review process. The modernization calls for concrete suggestions on how the regulatory review process can promote public health and safety, economic growth, social welfare, racial justice, environmental stewardship, human dignity, equity, and the interests of future generations. The recommendations should also include proposals that would ensure that regulatory review serves as a tool to affirmatively promote regulations that advance these values. The memo also calls for the development of procedures that account for distributional consequences of regulations, including as part of any quantitative or qualitative analysis of the costs and benefits of regulations. These changes to the review process are likely to shift how cost benefit analysis is viewed and lead to a more aggressive regulatory agenda. The policies articulated in the memo are a strong indication that agencies are likely to be very active in increasing the role of regulations in advancing the Biden administration's priorities.

ADDRESSING CLIMATE CHANGE

Joe Biden stressed the need to act on climate change during the campaign. He has pledged that the US will reach net-zero greenhouse gas emissions by 2050 and has proposed investment of $1.7 trillion in clean energy and green jobs, ending fossil fuel subsidies and banning new oil and gas permits on public lands. Some of Biden's first actions as President have focused on combating climate change. The Executive Order on Tackling the Climate Crisis at Home and Abroad sets the stage for climate to be at the center of US foreign policy and national security.

Making good on his campaign promise, Biden is moving to have the U.S. rejoin the Paris Climate Agreement and is committed to playing a greater role in multilateral climate efforts. Examples of increased global engagement include hosting a Leaders' Climate Summit on Earth Day, April 22, 2021; reconvening the Major Economies Forum and creating a new position, the Special Presidential Envoy for Climate, which will have a seat on the National Security Council. The order initiates the process of developing the United States' "nationally determined contribution" (emissions reduction targets) under the Paris Agreement.

In addition to the Paris Agreement, Biden has signed an Executive Order regarding the Kigali Amendment to phase down HFCs. The order directs the Secretary of State to prepare, within 60 days, a transmittal package seeking the Senate's advice and consent to ratification of the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer. The U.S. signed the Kigali Amendment during the Obama Administration, but the Trump Administration did not take any steps to further its ratification. The Kigali Amendment has been ratified by 112 countries, but the three largest users of HFCs, the U.S., China and India, have yet to ratify. Should the U.S. complete ratification, that could encourage China and India to follow suit.

Ratification of Kigali would also build on recent Congressional action to pass the American Innovation and Manufacturing Act (AIM Act), which was included in the Omnibus Appropriations and COVID relief bill passed in December 2020. The AIM Act provides EPA with regulatory authority to phase down HFCs, something the courts had ruled the agency did not have previously when the Obama Administration attempted to use the Significant New Alternatives Policy (SNAP) Program to restrict HFC use.

Under the AIM Act, EPA will administer an allowance system reducing the permitted amount of HFCs that can be consumed (i.e. produced or imported) in the U.S. by 85% at the end of 2035. The bill gives EPA a mechanism by which it can meet Kigali Amendment targets and authorizes prohibitions or restrictions on HFC use by sector or subsector. The AIM Act includes provisions to improve the management of refrigerants to "minimize release" by regulating servicing, repair, disposal, or installation of equipment and reclamation.

The Biden Administration's efforts on regulations and climate change represent both opportunities and challenges for the industrial refrigeration industry. An increased focus on regulatory enforcement and potential efforts to revise programs such as Process Safety Management and the Risk Management Program could add to regulatory burdens. IIAR will work closely with government and industry partners to promote and protect the industry as these policies evolve.

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Pressure Relief Design Considerations From a PSM Compliance Standpoint (Part One)

BILL LAPE, SCS ENGINEERS

Pressure relief design documentation is often the most misunderstood portion of the Process Safety Information required under 29 CFR 1910.119(d)(3)(i)(D) and 40 CFR Part 68.65(d)(1)(iv). The two regulations state that the relief system design AND design basis shall be included in the process safety information pertaining to the equipment in the process.

The word "design" is fairly straightforward. The Cambridge Dictionary defines the word design, when used as a noun, as "a drawing or set of drawings showing how a … product is to be made and how it will work and look" or "the way in which something is planned and made." Sounds simple, right? We need to have the technical specifications and physical arrangement of the relief design documented. Easily done.

Hold that thought for a moment. Before we dive into the pitfalls associated with the documentation of the physical arrangement and technical specifications for the relief system, let's consider what the regulation means by the "design basis." In the strict sense, the "design basis" of a design is the set of codes and standards that were used to determine the design. For instance, a facility with a relief vent header that was constructed in 1997 would likely have followed ASHRAE15, 1994 Edition. If the facility modified their vent header in 2016, the header design basis would be updated to IIAR2, 2014 edition. These design bases need to be listed in the design documentation.

Circling back to the design documentation, the ASME Boiler & Pressure Vessel Code (B&PVC) requires that the user "conduct a detailed analysis to identify and examine all potential overpressure scenarios." It goes on to say that the causes of overpressure as described in API 521, Pressure Relieving and Depressurizing Systems, shall be considered, but that "other standards or recommended practices that are more appropriate to the specific application may also be considered." Some of the scenarios listed in API 521 that can be relevant to ammonia refrigeration systems include closed outlets on vessels, cooling water failure to condenser, accumulation of non-condensables, overfilling of a storage or surge vessel, failure of automatic control, abnormal heat or vapor input, a heat exchanger leak, hydraulic expansion, exterior fire, and a power failure.

We need to start by documenting the required relief capacity for each piece of equipment for each relevant scenario as determined by the facility's Process Hazard Analysis (PHA). Bear in mind that a scenario is not irrelevant if we deem them to be improbable due to the engineering (e.g. high pressure alarms and cutouts) and administrative (e.g. periodic inspections and operating procedures) safeguards that are in place at our facility. The two scenarios of overpressure that are most commonly identified for ammonia refrigeration equipment include an exterior fire or an abnormal heat or vapor generation, perhaps due to a closed valve, with exterior fire generation being the scenario that is most often documented in the relief design. We'll look at each one individually to illustrate some of the pitfalls associated with determining the required relief capacity.

Let's start by looking at how the relief capacity is determined for an exterior fire. The formula to calculate this relief capacity for a vessel or pipe is:

$$C_{required} = f \times D \times L$$

Where:

$C_{required}$	=	required discharge capacity rate (lbair/min)
f	=	0.5 (1.25 if combustible materials are within 20ft of protected equipment)
D	=	vessel or pipe diameter (ft)
L	=	vessel or pipe length (ft)

Let's say that we have a shell and tube heat exchanger. The heat exchanger has a diameter of 2 ft and a length of 5 ft. Let's assume for the sake of argument that there are no combustibles within 20 ft. The required relief capacity using the formula would be:

$$C_{required,HEX} = 0.5 \times 2 \times 5 = 5 lb_{air}/min$$

What if the unit is outdoors and is insulated and jacketed with an aluminum jacket? The reduced likelihood of a fire around the unit due to its location, together with the reduction in heat load due to the reflective properties of the insulation jacket along with the F factor of the insulation, need to be considered. While a mathematical treatise on how to determine an appropriate reduction factor in required capacity due to insulation and location is outside the scope of this article, it is important to be aware of these factors as they will occasionally make a huge difference in the cost of the relief system for certain pieces of equipment. For the purposes of this exercise, let's say that this heat exchanger is located indoors, so we are going to assume that there is no attenuation of the heat load presented by a fire around the equipment.

Let's take the external fire scenario a step further. For the purposes of illustration, assume that the heat exchanger has 8 ft of 6" diameter piping attached directly to the suction outlet of the heat exchanger prior to the suction isolation valve. The required relief capacity for this pipe must be included in our calculation as it is part of the protected equipment. The required relief capacity of the pipe is:

$$C_{required,pipe} = 0.5 \times 0.5 \times 8 = 2 lb_{air}/min$$

The total required relief capacity for this equipment would then be:

$$C_{required,total} = C_{required,pipe} + C_{required,HEX}$$

$$C_{required,total} = 2lb_{air}/min + 5lb_{air}/min = 7lb_{air}/min$$

While the change to the required relief capacity in this illustration would be unlikely to change the selected relief valve, consider a product tank with a flooded ammonia refrigeration jacket. In order to properly calculate the total required relief capacity, not only does the surge drum need to be included, but the tank jacket, the liquid drop leg, and the jacket suction return piping to the surge drum also need to be included in the total required relief capacity. Often these additional pieces of equipment within the envelope of relief valve protection are omitted from the calculations.

Another area that is often overlooked is the potential relief scenarios due to **internal** heat loads. While internal heat loads are unlikely for most pressure vessels in an ammonia refrigeration system, they are a consideration for heat exchangers. If a heat exchanger will be exposed to a fluid that is above the saturation temperature of ammonia that corresponds to the set pressure of the relief valves that are installed to protect it, then the internal heat loads must also be considered. For instance, if the set pressure of a surge drum on a product tank is 150psig, the corresponding saturation temperature is roughly 85°F. Most clean-in-place (CIP) systems for product tanks will have a high temperature cutout for their wash cycles between 140°F and 180°F, depending on the application. This temperature is well above the saturation temperature of the ammonia at 150 psig, and, as such, the internal heat load must be considered. It is outside the scope of this article to dive into the math behind the internal heat load calculations, but the following example provides illustration of how the internal heat load can often be the true factor in determining the required relief capacity of equipment.

Let's say that we have a product tank that, while not flooded, is built to the ASME B&PVC, so it must be protected with relief valves. Its refrigeration jacket is 5 ft high and the tank is 10 ft in diameter. It is rated for 150 psig Maximum Allowable Working Pressure (MAWP). To be conservative, no attenuation factor will be used for heat loads due to external fire, even though it is insulated and located outdoors. There are no combustibles within 20 ft of the tank. The required capacity for the external heat load is:

$$C_{required,External} = 0.5 \times 10 \times 5 = 25lb_{air}/min$$

However, the tank is cleaned by a CIP system that washes the tank with a maximum flow rate of 125 gallons per minute of wash solution. The high temperature cutout on the CIP system is 180°F. The required relief capacity due to internal heat load would be:

$$C_{required,Internal} = 49.58lb_{air}/min$$

As you can see, the required relief capacity due to internal heat load is the relief capacity scenario that determines the capacity of the installed relief valves on this equipment. As an end user with an ammonia refrigeration system, is important to be mindful of these internal heat loads and their impact on relief capacity, as this particular scenario has often been overlooked when the relief system design is documented.

Another parameter that is often omitted from relief designs is an analysis of inlet losses between the protected equipment and the relief valve. In a nutshell, the piping between the protected equipment and the relief valve will cause a pressure drop between them. The effect of this pressure drop is to de-rate the capacity of the relief valve. Section UG-135(b)(1) of the ASME B&PVC requires that "…The characteristics of the upstream [pressure relief] system shall be such that the pressure drop will not reduce the relieving capacity below that required or adversely affect the proper operation of the pressure relief valve." So, in order to comply with the ASME B&PVC, two things must be true of the inlet losses:

The required relief capacity must be less than the de-rated capacity of the pressure relief valve due to the inlet pressure loss.

The inlet pressure loss must be less than the blowdown pressure of the relief valve or the relief valve will chatter during operation, reducing its flow.

Let's look again at our product tank example. We determined that the required relief capacity is 49.58 lb_{air}/min. The tank has no nozzle on it dedicated for relief, but let's say that its jacket suction outlet connection is 1-1/2." We cannot install a relief connection greater than 1-1/2," but ½" or even ¾" is undesirable due to its relative lack of strength and potential for breakage. So, we choose a 1" nozzle to connect the relief valve inlet piping to the tank suction line. Let's say that a commercial refrigeration relief valve is chosen with an inlet port size of 1" and a relief capacity of 53.8 lb_{air}/min.

Since there is an isolation valve in this suction line within a foot of the jacket nozzle on the tank, the connection must be made within six inches of the tank suction outlet. However, the alcove of this tank where the operator inspects it and makes connections to pump product in and out of the tank is on the second floor of the facility, so the tank is mounted on a steel framework, putting this nozzle out of reach of the refrigeration operators. So, upon installing this tank, the operators decide to extend the relief valve inlet piping up to the roof to facilitate the inspection and maintenance of the relief valves. They install 25 ft of 1" piping, with one 90° elbow, and a three way valve with a Cv of 13.95 gpm/psi. When we calculate the de-rating of the relief valve capacity, we find that the adjusted capacity is 43.44 lbair/min, which is inadequate to cover our required relief capacity.

One might argue that such a piping arrangement for the inlets of relief valves is unusual. Admittedly, it is. However, it serves to illustrate how important it is to evaluate the inlet piping and its effect on the relief valve capacity.

The purpose of this article was to highlight some of the factors that affect the relief capacity of a relief system that are often overlooked. In the next article, we will discuss some of the pitfalls associated with internally relieving relief valves.

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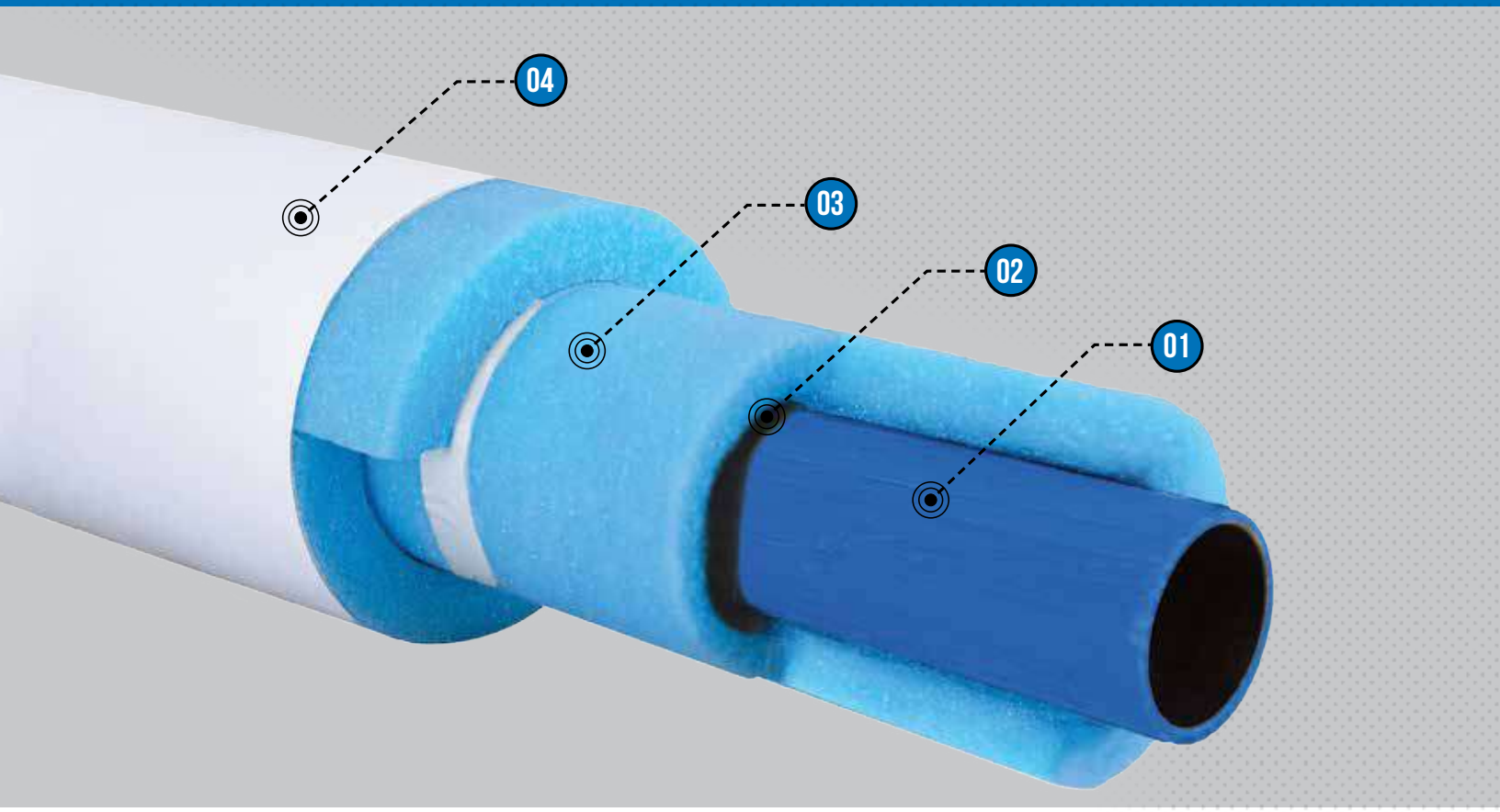

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