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THE OFFICIAL MAGAZINE OF THE AMMONIA REFRIGERATION INDUSTRY ■ **MAY 2023**

# CONDENSER

## 2023 conference **roundup**

IIAR WELCOMES
1,700 IIAR MEMBERS
IN LONG BEACH

MAY 2023

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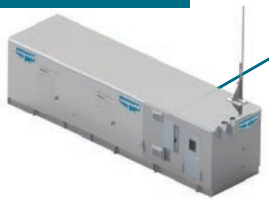

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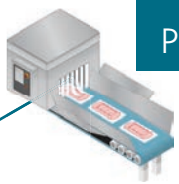

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# president's MESSAGE

BY GARY SCHRIFT

Our Annual Conference in Long Beach was a great success, and now that the flurry of committee meetings, networking events, and technical discussions have ended and we're all back at work, it's time to set some new goals and carry the momentum of our recent meeting into the rest of the year.

For the executive committee and your staff at headquarters, that means everyone is working hard to make sure our important initiatives continue to work for our members. From the AIM Act to the IIAR new membership & benefits program that began last year – to the many new projects our committees have started – we are continuing to develop and reach new milestones.

My priority this year is to carry those initiatives forward and make sure the growth of the industry and its use of natural refrigerants is well supported by your staff and our organization's leadership.

Under the leadership of our Board of Directors, our committees have seen one of their most productive years yet. Our education program is one of our most important member resources. The Academy of Natural Refrigerants and our educational video series I, II, & III, are serving as a vital educational resource within our industry – and are also laying the groundwork for powerful advocacy in the regulatory world.

Under the leadership of our Board of Directors, our committees have seen one of their most productive years yet. Our education program is one of our most important member resources. The Academy of Natural Refrigerants and our educational video series I, II, & III, are serving as a vital educational resource within our industry – and are also laying the groundwork for powerful advocacy in the regulatory world.

In the international arena, IIAR has established close ties with regions where ammonia refrigeration and the global cold chain are growing. We'll continue to foster communication with all our international partners while at the same time looking for new opportunities to grow as a presence on the global stage.

My priority this year will be to make sure that these programs continue to make gains in delivering the best collective knowledge and resources our industry has to offer, both internally, to our members, and externally, to any regulators, support personnel, industries that touch industrial refrigeration, and companies and organizations new to the use of natural refrigerants.

I hope you feel free to contribute with the new ideas and level of participation that has become the hallmark of this group.

While it's hard to turn our attention away from all the excitement of our most recent conference, it's time to start thinking about how to use that renewed enthusiasm in the coming year to strengthen IIAR's member presence and plan for our next event.

The 2024 IIAR Industrial Refrigeration Conference & Heavy Equipment Expo, will be held March 24 – 27 in Orlando, Florida.

If you have a Technical Paper or a workshop that you would like to present in California, please contact Eric Smith at IIAR headquarters to submit your abstract as soon as possible. Technical papers and session topics are the fabric of IIAR meetings and will be selected quickly to allow presenters plenty of time to prepare their presentations.

As members, your ongoing work and participation make all of our activities possible. Thank you for continuing to enrich our industry with your support.

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# chairman's MESSAGE

BY DAVE MALINAUSKAS

Conference time has come and gone, and there's a lot to look forward to this year.

For the executive committee and your staff at headquarters, that means everyone is working hard to make sure our recent initiatives – from the AIM Act to our focus on developing IIAR member benefits to the many new projects our committees have started – will put us in the best possible position.

As your new chairman, my priority this year is to carry those initiatives forward and make sure the growth of the industry is well supported by our organization's leadership.

As Trevor Hegg hands over the reins as IIAR Chairman, he's handing over a financially stable, productive organization that has weathered unprecedented times thanks to the solid foundation he and so many others have worked hard to build.

Under his leadership, our committees have seen one of their most productive years yet. In the international arena, IIAR has continued to establish close ties with regions where ammonia refrigeration and the global cold chain is growing. And on the regulatory front, IIAR's communication with the EPA could well impact the landscape for natural refrigerants for years to come.

Both Trevor and IIAR president Gary Schrift deserve huge thanks from all of us for their leadership in prudently managing our organization's finances and taking cost-cutting measures to keep our organization solvent.

My priority this year will be to make sure that our standards, educational and conference programs continue to make gains in delivering the best collective knowledge and resources our industry has to offer, both internally, to our members, and externally, to any regulators, support personnel or industries that touch industrial refrigeration.

Key to that effort is our new conference format. In addition to serving as a vital educational resource within our industry – it is also laying the groundwork for the future. Our virtual conference format – developed during the pandemic and continued for the second year this year – helps IIAR reach a broader swath of members, regulators, and international partners and is held in conjunction with our regular in-person meetings.

My priority this year will be to make sure that our standards, educational and conference programs continue to make gains in delivering the best collective knowledge and resources our industry has to offer, both internally, to our members, and externally, to any regulators, support personnel or industries that touch industrial refrigeration.

I view these projects and my tenure as your Chairman as a continuation of a new phase of IIAR leadership. As we begin this new membership year together, I hope you feel free to contribute with the new ideas and levels of participation that have become the hallmark of this group.

Speaking of participation, no introductory Chairman's column would be complete without giving recognition to the outpouring of support and involvement of IIAR members.

This year's conference was one of our best conferences yet. The packed technical paper sessions and workshops are the usual highlights of our annual meeting.

I'm looking forward to accomplishing several goals as your Chairman this year. As members, your ongoing work and participation make all of our activities possible. Thank you for continuing to enrich our industry with your support.

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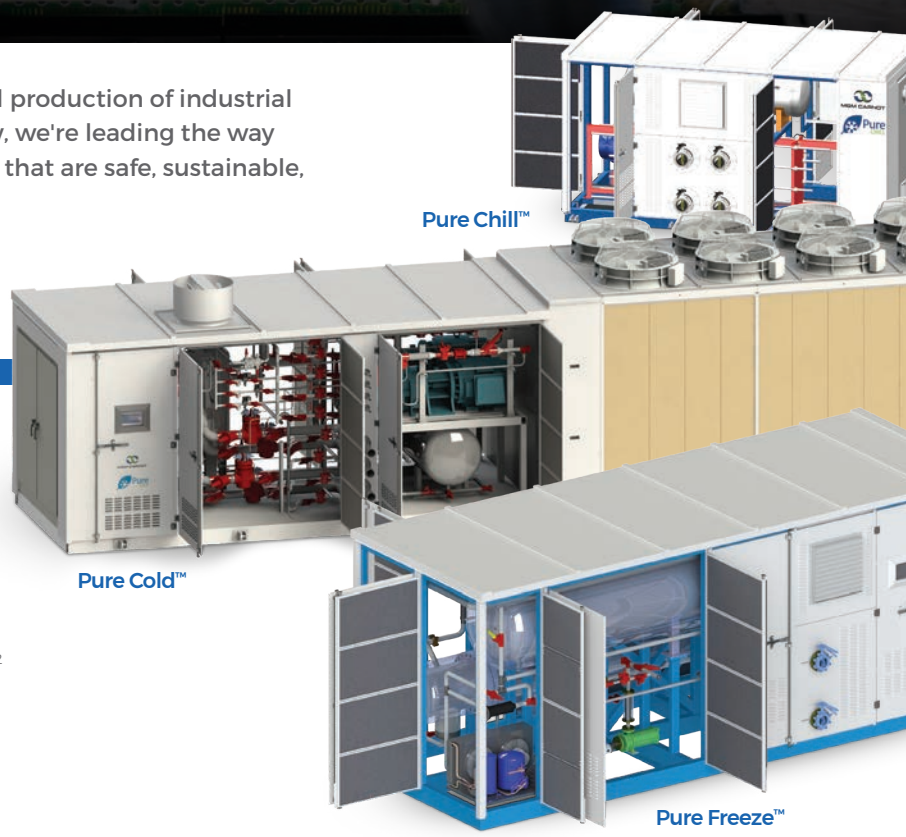

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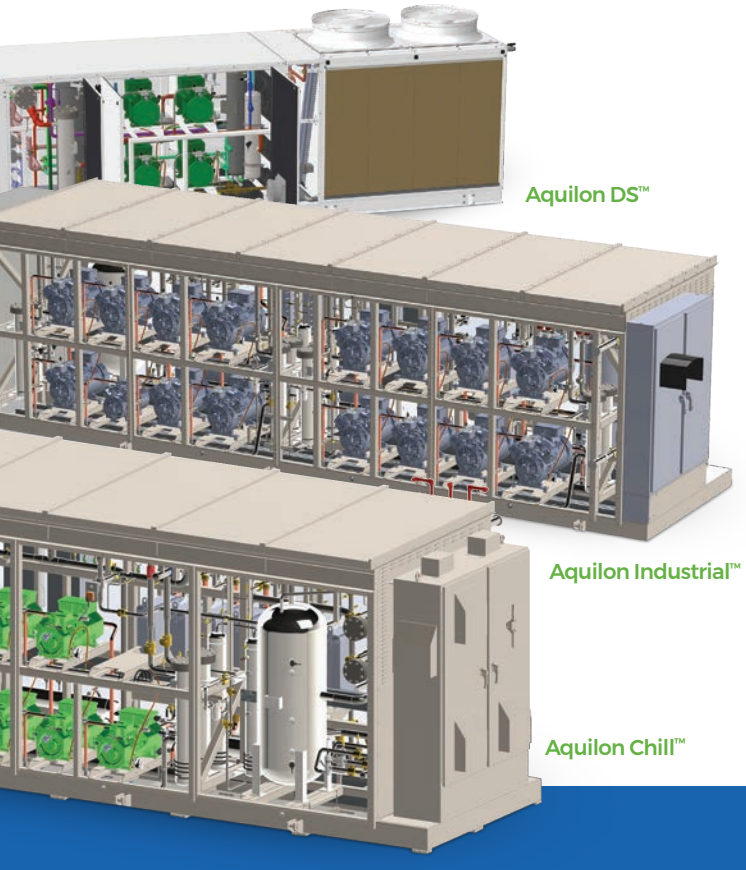

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# 2023 conference roundup

## IIAR WELCOMES 1,700 IIAR MEMBERS IN LONG BEACH

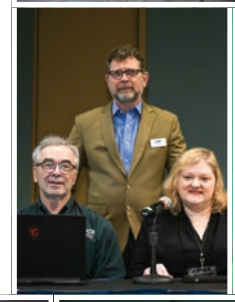
The International Institute of Ammonia Refrigeration 2023 Annual Natural Refrigeration Conference & Expo in Long Beach, California. The event provided four days of technical knowledge, networking, and industry-sponsored events for those involved in the natural refrigeration industry. Roughly 1,700 attendees took part in the show and IIAR set a new record with its exhibit space.

"There were a lot of manufacturers that had new things to show, especially with the push to phase down HFCs and expand the use of natural refrigerants," said Gary Schrift, IIAR's president.

Schrift said the AIM Act in the U.S., state action on HFC phasedowns and EU legislation to control F-gases are driving increased interest in natural refrigerants.













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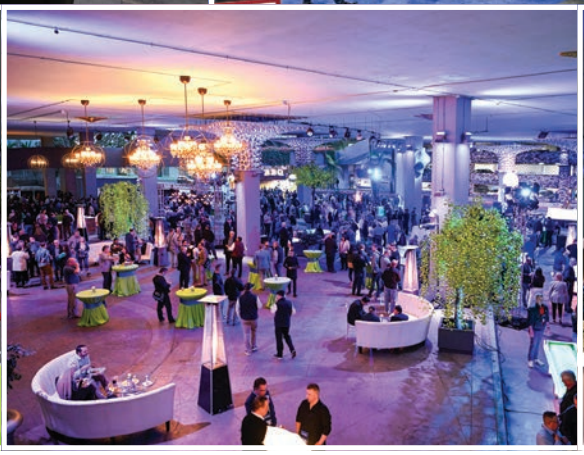

## OPPORTUNITIES FOR LEARNING

The meeting featured several learning opportunities, including technical paper presentations and technomercials. Schrift said the lineup of educational workshops was a highlight, and IIAR expanded on its technical workshop offerings by adding a panel on diversity, the technician shortage, and the AIM Act. "These had a broader appeal that attracted a lot of attendees," he said, adding that IIAR recorded several sessions, and the recordings will be available on the association's website.

## THE STATE OF THE ORGANIZATION

During the business meeting, Schrift provided an update on all IIAR has accomplished in the past year. "We continue to benefit and grow our global community with our advocacy, education, and standards for the safe and sustainable use of natural refrigerant systems," he said.

IIAR recently completed its first fiscal year with its new membership program, and membership has grown more than 14% to 3,194 members. Members have been granted free access to all of IIAR's standards via the association's digital publications provider and eReader service. Use of IIAR's online Academy and video series classes has increased dramatically as has monthly webinar attendance.

Schrift said IIAR's work with allied associations is resulting in significant results, including IIAR standards being adopted in Costa Rica along with the association's online training programs being used for their engineering certification program. IIAR is also publishing a new online Spanish version of the Condenser magazine called the Condenser Select and has helped create a stronger Safety Coalition with ASTI, RETA, and GCCA.

## TIME FOR FUN

Attendees were able to take part in several networking opportunities, including a reception on Sunday night and a "Block Party" on Monday night. "The Chairman's Reception on Sunday was packed and so was the Monday night event," Schrift said.

The conference also featured the Annual William E. Kahlert Golf Tournament to support the Natural Refrigeration Foundation (Ammonia Refrigeration Foundation) and the Founders' Scholarship Fund and the foundation's first-ever pickleball and cornhole tournament. "People want to do it again next year," Schrift said.

# Uriah Donaldson, Gabriel Gutierrez, Winners of the 2023 IIAR Award for Presentation Excellence

Uriah Donaldson, a process safety consultant and account manager for Resource Compliance, received IIAR's 2023 Award for Presentation Excellence for his outstanding description of "The Cost of Non-Compliance: An Objective Analysis of Federal EPA's Enforcement at Ammonia Facilities" during IIAR's 2023 Annual Conference in Long Beach, California.

Gabriel Gutierrez, a mechanical engineer and sales manager for Latin America for Colmac Coil, also received IIAR's 2023 Spanish Language Award for Presentation Excellence for his outstanding presentation "Mechanical Integrity of Evaporators."

"The IIAR Award for Presentation Excellence was created to acknowledge the crucial role that education and information sharing plays within our industry, and to provide acknowledgment of the hard work put forth by all of our volunteers who so generously donate their time and expertise to their peers," said Gary Schrift, president of IIAR.

Recipients of the award, previously IIAR's "Andy Ammonia Award," are chosen based on feedback provided by conference attendees.

# Natural Refrigeration Foundation Annual Golf Tournament a Success

The Natural Refrigeration Foundation has raised more than $73,000 at its annual golf tournament. The foundation promotes the climate-positive, safe, reliable, and efficient use of natural refrigerants through research and scholarships to develop industry talent, academic alliances, and outreach.

"Although there are other research projects in the works for the refrigeration industry, the scholarship program hits a nerve with many members out there," said Dennis Anderholm, ARF golf chairman.

The foundation awarded six scholarships this year. "Anytime we have an opportunity to help a student financially to get his or her degree, and they subsequently come on board in the industry, we are all a winner," Anderholm said.

New juniors receiving scholarships this year include Nicholas Keifer at Virginia Tech, Katelyn Rapp at Montana Technological University, Leah Rietz at the University of Wisconsin-Madison, and Cole Trautman at Cal Poly-SLO. New seniors receiving scholarships include Lily Chen at MIT and Erin Moss at Cal Poly-SLO.

Returning scholarship recipients Caden Matson (University of Florida) and Jordyn Vanevenhoven (University of Wisconsin-Platteville) attended the IIAR Conference in Long Beach and shares their experiences with the new group of awardees.

Past scholars are now employed at leading refrigeration companies, including Clauger, Bassett Mechanical, Wagner-Meinert, Mayekawa, General Refrigeration, and Evapco.

# Industrial Refrigeration Faces Significant Cybersecurity Risks

The use of technology in the industrial refrigeration industry continues to increase, and automation and internet control of facilities are becoming commonplace. The benefits of automation and control are massive, but there is also a downside. The systems can be vulnerable to attack, making cybersecurity measures essential to protect against cyber threats.

"Large refrigeration facilities do critical work, but a lot of them are underprepared from a cybersecurity standpoint," said Josh Symonds, lead information security engineer at CrossnoKaye and author of the technical paper Cybersecurity in Automated Industrial Systems. "The digital automation revolution is coming for us, but unfortunately we're not ready yet."

In today's operating environment, plants and grids that previously required manual oversight and teams of skilled engineers can now be controlled from hundreds of miles away by individuals or even automated systems. The concern is that bad actors will suborn industrial facilities and the processes used to control them, just as they do other Internet-connected applications.

## THE TYPES OF THREATS

Cybersecurity threats in the industrial refrigeration industry can take various forms, including hacking, malware attacks, phishing, and ransomware. The consequences of such attacks can be severe, leading to financial loss, damage to reputation, and even safety hazards.

Symonds said classes of attacks that were formerly exclusively the purview of Internet applications, such as Facebook or Twitter, could become commonplace in industrial infrastructure. "A lot of companies have poor cybersecurity. It is low-hanging fruit for attacks," he said.

Mike Lettman, cybersecurity advisor, Region IX, for the Cybersecurity and Infrastructure Security Agency, an agency of the United States Department of Homeland Security, said other countries pay people to launch cyberattacks. "They do it for data, information, trade secrets or they just hate you. The fab four are Russia, China, Iran, and North Korea," he said. "This is what your IT team is against, which is why it is difficult."

Multi-billion-dollar companies in the industrial sector have already experienced ransomware attacks on oil processing facilities, spear phishing on operators of electrical grids, and malware on industrial computer systems.

Multi-billion-dollar companies in the industrial sector have already experienced ransomware attacks on oil processing facilities, spear phishing on operators of electrical grids, and malware on industrial computer systems.

"The most obvious risk is losing money in some form or another. You lose control of your plant or your facility and they prevent refrigeration from happening and all of your food spoils," Symonds said. "There is personal information that can be leaked—addresses, phone numbers, social security numbers."

Losses due to cybersecurity breaches can be costly. Compromises of business emails cost about $3.5 billion every year and ransomware costs businesses about $7.5 billion annually. "You get malware on your computer that locks up your files and asks for money but there is no guarantee you'll get your files back even if you pay the ransom," Lettman said.

There are also overlooked costs due to business interruptions and lost revenue and opportunity costs. Attacks can also damage a company's brands. "People remember ransomware incidents and the media loves them," Symonds said.

Damages can even be devastating and about 65% of small businesses fail after a breach, Lettman said.

## SECURITY MEASURES

Controls in the industrial refrigeration space continue to move into computerization and people want to control all their hardware in one place, but there is no unifying vision for how controls should look. "Usually, the control vendor would sell software to control things in the facility. That was good enough for a long time because the computers weren't connected to the internet," Symonds said.

That method—called air gap—is being circumvented more and more and it wasn't that secure in the first place, Symonds explained.

Several privacy, control, and cybersecurity frameworks exist that are applicable to industrial refrigeration. Symonds recommends companies review the National Institute of Standards and Technologies Cybersecurity Framework. "It is long, but it covers all the bases," he said.

Other frameworks include NIST 800-53, IEC 62443, ISO 27001, SOC 2, and Purdue Enterprise Reference Architecture.

While there are no regulatory bodies specifically focused on compliance in industrial refrigeration systems, ever-evolving threats and a changing legal landscape mean following published cybersecurity, privacy, and control frameworks is the safest path forward, Symonds said.

It is also important to ensure that all devices connected to the networks are properly secured. These include not only computers and servers but also sensors, controllers, and monitoring systems.

One concern is that attacks will become more prevalent and system and software updates will have to happen sooner. "You'll want to make sure your facilities are using the most current

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versions," Symonds said. "Make sure you have a security team responsible for these types of things."

To be incident-ready, companies should also develop a response plan and create scenarios for common problems. "The pandemic was a great outage scenario. What happens if you can't get into the office? There should be plans in place. Have these things as policy," Symonds said.

Secure your internet connections. Use multi-factor authentication. If you have multi-factor in place, the odds of them getting around it are harder.

While cybersecurity may seem daunting, there are steps companies can take to mitigate risk.

"There are positive things we can do," Lettman said, adding that CISA has free resources available on CISA.gov. "Secure your internet connections. Use multi-factor authentication. If you have multifactor in place, the odds of them getting around it are harder."

Companies should also create backups of data that hackers can't alter or change. "Store them offsite at a cloud provider or a geographically different location," Symonds said. "If something gets ransomed, you'll lose all the data between the last backup and now, but you won't lose everything."

Symonds also suggests not reusing passwords, getting a password manager, and coming up with strong unique passwords. "People are, really, really bad at coming up with good passwords," he said, adding that the word 'password' is one of the most common passwords used in 2022.

Lettman said educating employees on how to identify and report suspicious emails and teaching them to avoid clicking on unknown links is critical. CISA offers a free tool for companies that want to run a phishing campaign that will get employees to try to click on links.

As an added safety step, Symonds suggests not loading email programs onto computers that don't need them. Other essential best practices include implementing regular security audits and vulnerability assessments to identify potential weaknesses in the system.

CISA also offers Cyber Resilience Review (CRR), an interview-based assessment to evaluate an organization's operational resilience and cybersecurity practices. "It looks at where you are running cyber risks," Lettman said.

### CREATE AWARENESS

Everyone in the company, including technicians, should be aware of cybersecurity risks, even in their personal lives, Symonds said.

"Doing just the basics will get you far and you can keep doing more and more," Symonds explained. "Most of the people who are likely to target you are doing it because it is easy and not because you were their particular target. Luckily for you, attackers are lazy. Don't be the low-hanging fruit."

# Heat Pumps Hold Potential in Household and Commercial Applications

Heat pumps can significantly reduce energy consumption and greenhouse gas emissions, and the adoption of heat pumps is continuing to increase in both household and industrial applications as technology advances.

"The biggest innovation in the heat pump space is the introduction of CO2 into the industrial sector. Because of the heat potential of CO2, heat reclaim has taken on a much bigger role in that space," said Andre Patenaude, director, solution strategy, cold chain, Emerson. "The pressures around decarbonization also help engineers to spend more time designing and looking at all the areas where heat could be used."

Heat pumps can be used in a wide range of applications, from heating and cooling buildings to powering industrial processes such as drying, evaporation, and distillation.

"The technology itself is quite simple. It is like your refrigerator. It gets cold inside and warm on the outside. We are just using the warm side of the refrigerator pump instead of the cold side to get useful heating out of it," said Kenneth Hoffmann, application manager for GEA Heating and Refrigeration Technologies.

Adam Shorey, director of sales engineering for Therm, said there is an age-old saying that there is no such thing as cold. There is just the removal of heat.

"Typically, ACs take the heat in a building and exit it to the atmosphere. Heat pumps take the heat and bring that into the building for HVAC, comfort cooling, or domestic hot water," Shorey said. "A heat pump is like a window air conditioner operating in reverse. It can take heat from the ground or other sources."

Shorey said heat pumps are more efficient than boilers or furnaces. "A furnace or boiler has a coefficient of performance (COP) of under one whereas heat pumps, depending on if it is air or ground, have a COP of two, three or four, so they are that much more efficient," he said.

Heat pumps use electricity, directly replacing a Scope 1 emission and replacing it with a Scope 2 emission, Shorey said. He added that when the grid is clean, it drops emissions further.

Hoffmann said the biggest benefit comes from applications that combine heating and cooling. "District heating, community heating, and campuses are looking to heat pumps for the heat source. If we can do combined heating and cooling that would be ideal for applications such as data centers, otherwise we need to find other heat sources like air, ground source water," he explained.

Manufacturing facilities often require heat and cooling. "There are a lot of refrigeration plants that have just sent heat outdoors to large evaporative condensers. Some of the smart ones are saying, 'We have megawatts of heat here and we need heat in this part of the system. Let's add heat exchangers to send the heat over here for this process,'" Patenaude said.

In food facilities, for example, the heat could be used to heat water for their wash down. "They have to clean the facility and typically need 140- or 160-degree water. You can get that easily from a CO2 system," Patenaude said. "Then the additional heat leftover can be used to heat the space."

Even if the heat pump doesn't cover all the heat needs, it could preheat a certain process and then be topped off with fossil fuels or electrical, Patenaude said.

GEA has delivered its first two low-charge ammonia/NH3(R717) industrial heat pumps—the RedGenium and the RedAstrum—in Canada and has orders for three heat pumps for a large multinational food company in Texas. "They are looking to decarbonize their facilities globally, so that is also why they are doing it in Texas," Hoffmann said.

Emerson recently held an open house in Quebec to show the CO2 heat pump it has been testing for two years. "We have 12,000 hours of run time on an industrial CO2 heat pump," Patenaude said, adding that Emerson has been working with a large electrical utility. "They have a vested stake in trying to satisfy some of the decarbonization needs in their province. Everywhere in the world is trying to decarbonize."

The North American market is playing a bit of catch-up compared to Europe. "We've been selling industrial heat pumps with ammonia in Europe for 15 years. We're just starting to see the first projects in the U.S.," Hoffmann said, adding that the U.S. sales team is getting a significant number of inquiries.

The focus on decarbonization is driving interest. "When we started 15 years ago, CO2 emissions were not an issue. Nobody was talking about that," Hoffmann said, explaining that people were interested in the cost savings heat pumps could provide.

Patenaude said there typically is a cost savings associated with CO2 heat pumps.

While some investors today are looking for a payback, others are interested even if costs end up beings slightly higher because of the environmental benefits, Hoffmann said.

## HEAT PUMP MARKET OPPORTUNITIES

Heat pump use can vary by region. "In Canada, you see a lot of the district heating. In the U.S., it is more process heating," Hoffmann said.

Some applications for heat pumps work better than others. "Heat pumps, once you're at a temp, are really good at maintaining that temp," Shorey said. "There is a lot less impact to leaving your heat pump on."

Hoffmann said heat pumps like to run smoothly. "You can get the heat instantly, but it takes a bit of time for them to start up or shut down," he said, adding that if there are big variations in loads, such as in a bath process, the systems can use a buffer tank of hot water that can heat up slowly.

Currently, the GEA's heat pump limit is 212 degrees Fahrenheit. "We're developing higher temperatures and running a trial next year," Hoffmann said, adding that the higher-temp units should be available commercially in about two years.

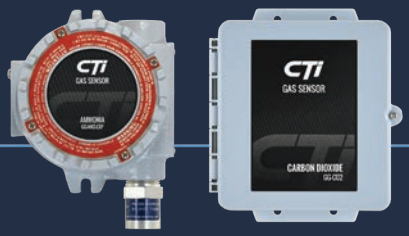
Fritz Troller, CEO and founder of Therm said costs of heat pumps can vary, especially between residential and commercial applications. "Our role is to reduce or eliminate any premium by doing the development, marketing, and sale of those carbon credits," he said, adding that Therm works with its customers to help obtain Refrigerant Carbon Credits™.

Troller explained that Therm can run calculations to help customers quantify the GWP gap and outline how carbon emissions can be avoided using environmentally friendly solutions. "We want to help bring down the GWP footprint of our customers while eliminating or reducing the premium between a not environmentally friendly decision or one that is energy efficient," he said.

As new technology develops, technicians will need to be trained on it, and Hoffmann said GEA is already looking at technician demand. "We can see the market is growing rapidly and we need to have a plan for that. You need to be a little ahead of the curve," he said. "We need to train them to have them available when the systems are being installed."

# GAS DETECTION SPECIALISTS


Controllers

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# Work Continues on IIAR Standards

The Standards Committee is continuing its work on revisions of several standards, which must be reviewed and revised a minimum of every five years by the American National Standards Institute (ANSI) for IIAR to remain as an accredited Standards Developing Organization (SDO). Updates for each standard were given during the IIAR Standards Committee Meeting at the IIAR 2023 Annual Conference in Long Beach.

"We had over 130 people at the meeting. That is a well-attend meeting," said Don Faust, chairman of the committee and training manager for Johnson Controls.

The Standards Committee is continuing its work on revisions of several standards, which must be reviewed and revised a minimum of every five years by the American National Standards Institute (ANSI) for IIAR to remain as an accredited Standards Developing Organization (SDO).

During the meeting, the committee updated its voting members and appointed a new vice chair of the committee, Mark Bazis, owner at Refrigeration Consultants Inc., Faust said.

The committee also voted to approve the ANSI Standards development procedures. "Largely the changes to the procedures were how we define IIAR. IIAR has a group for retired people and educators, but for ANSI we have to characterize people differently. We have manufacturers, contractors, end users, and others. Those are the only four," Faust said, adding that IIAR's voting members have to be a member of one of those four classes.

## REVIEWS OF STANDARDS

The committee is currently reviewing IIAR 5, IIAR 6, IIAR 7, and IIAR HC.

**IIAR 5 – Startup of Closed-Circuit Ammonia Refrigeration Systems:** Tony Lundell, IIAR senior director of standards and safety, said It is anticipated that the IIAR 5 public review of the first draft will be developed and ready to be reviewed and voted on by this fall. The target is to have the revision completed in 2024.

**IIAR 6 – Inspection, Testing, and Maintenance of Closed-Circuit Ammonia Refrigeration Systems:** The IIAR 6 subcommittee is meeting bi-weekly to discuss pre-public review questions and comments. A new section for "out of service" is being developed and added in IIAR 6.

"This will address when refrigeration equipment and/or systems are down for extended periods for when harvesting of fruits and vegetables is finished for the season or between fishing seasons," Lundell said.

An interactive brainstorming session of the "out of service" section was held with Trident Seafoods in Anchorage, Alaska, during a Trident Seafoods PSM Conference.

This section is intended to address seasonal shutdown facilities as they maintain proper Mechanical Integrity and Recognized and Generally Accepted Good Engineering Practices (RAGAGEP). For example, during the fishing season, many facilities have idle periods that can last months.

"The intent of the 'out of service' section is to get a clear directive on how to document and treat these facilities will continue to bolster their PSM and safety programs," Lundell said.

The IIAR 6 Subcommittee had a meeting with the internal relief valve manufacturers, which included Parker Hannifin, Danfoss, Hansen Technologies, and Cyrus Shank. No unsafe incidents were revealed that were caused by a failing—stuck open or stuck closed—internal relief valve.

"Since the manufacturers are unaware of where the design uses them or will use them, they cannot determine a frequency of testing or replacing them," Lundell said. "The discussion so far is that IIAR 6's next revision should replace ASME internal relief valves, just like the atmospheric relief valves are being replaced (if not bench tested to extend the life), and non-ASME internal relief valves, control valves, and/or check valves should be replaced when an operational indication occurs or when the frequency that is presented by the refrigeration system designer."

An operational indication is a situation where the pressure and/or temperatures are fluctuating, the equipment is making different noises or a combination of both. An operation indication is where a hydrostatic/internal overpressure protection device is possibly not operating correctly which may include surging and fluctuating pressures and temperatures, changes in equipment operating noise, or a combination of both. The operations could result in loss of equipment capacity and higher energy usage.

It is anticipated that the IIAR 6 public review of the first draft will be developed and ready to be reviewed and voted on by this fall. The goal is to have the revision completed in 2024.

**IIAR 7 – Developing Operating Procedures for Closed-Circuit Ammonia Refrigeration Systems:** The IIAR 7 Subcommittee is meeting bi-weekly to discuss pre-public review questions and comments. "Streamlining and determining what is normative versus what could be included to informatively help is being discussed," Lundell said.

It is anticipated that the IIAR 7 first draft for public review will be developed and ready to be reviewed and voted on by this fall or no later than year-end. The goal is to have the revision completed in 2024.

IIAR HC – Safety Standard for Closed-Circuit Refrigeration Systems

Utilizing Hydrocarbon Refrigerants: This standard is in Development. The IIAR HC Subcommittee has finished reviewing the pre-public review comments it received and IIAR staff has developed the IIAR HC public review first draft, which is being shared with the IIAR Standards Committee voting members and the IIAR board of directors prior to it going out for public review. The first public review is expected to take place in late June or early July, Lundell said. "Having this new standard in development fully completed in 2024 is the target," he explained.

### ADDITIONAL DISCUSSIONS

During the meeting, attendees also discussed IIAR 1 Definitions and Terminology Used in IIAR Standards, IIAR 2 Designing Safe Closed-Circuit Ammonia Refrigeration Systems), IIAR 3 Ammonia Refrigeration Valves, IIAR 4 Installation of Closed-Circuit Ammonia Refrigeration Systems, and IIAR 8 Decommissioning.

Additionally, an addendum to IIAR 9 Minimum System Safety Requirements for Existing Closed-Circuit Ammonia Refrigeration Systems is being discussed to address some interpretations that have developed since it was published. Any changes or modifications are expected to be complete by this summer with a first public review ready for the fall.

Lundell added that two separate Relief Valve Groups will continue to have discussions. One group is focusing on Internal Relief Valves and another group is focusing on Atmospheric Relief Valves. "Any highlights identified will be addressed in the next revisions IAR 2, IIAR 6, and IIAR 9," he said.

Lundell will provide an update on the IIAR Suite of Standards in November at the RETA 2023 Annual Conference in Jacksonville, Florida.

### GET INVOLVED

All IIAR members are invited to take part in the Standards Committee. "If you're in the industry, you've got some knowledge we can use. You can reach out to me or express your interest in IIAR," Faust said. "There is an old saying, 85% of success is showing up."

# IIAR Remembers Members for Their Service and Contributions

IIAR's success hinges on the involvement of its members, and the association would like to pay tribute to several members who have passed away. These members generously shared their time and expertise with IIAR and the industry, and they will be missed.

### Saul Beck

Saul Beck passed away on December 11th at the age of 106. Beck's obituary said his greatest passion was his job. He started working for a large publishing company Harcourt Brace Jovanovich on a publication called Quick Frozen Foods. He loved attending industry conventions and writing opinion pieces for the magazine. He became a distinguished member of the Frozen Food Industry, becoming a member of the Zerocrats, and eventually inducted into the "Frozen Food Hall of Fame."

When Beck turned 75, he acquired Quick Frozen Foods and founded Frozen Food Digest. He worked as a publisher his entire life, publishing his final issue in 2021.

### Thomas John Heisler

Thomas John Heisler passed away suddenly on January 15th. Heisler graduated from St. John's University in Collegeville, Minnesota, in 1982, with a degree in chemistry. He enjoyed a long and prosperous career at Evapco Inc., in Medford, Minnesota.

### Pega Hrnjak

Pega Hrnjak received a Ph.D. from the University of Belgrade in Yugoslavia, where he was also on the faculty, rising to the rank of Associate Professor. He emigrated to the U.S. in 1993, becoming a Stoecker Faculty Fellow and Distinguished Research Professor at the University of Illinois at Urbana-Champaign. He was also co-director and then director of the University's Air Conditioning and Refrigeration Center (ACRC).

He founded Creative Thermal Solutions (CTS), a research and consulting firm, in 2003. It grew to a state-of-the-art, 100,000 sq. ft. research facility. Throughout his career, Hrnjak was engaged in essential research on natural refrigerant projects, from low-charge ammonia to ejectors for transcritical CO2 to some of the early CO2 mobile air conditioning systems.

Hrnjak received several recognitions, including the Ritter von Rittinger Award, the IIR Gustav Lorentzen Medal, the J&E Hall Medal, and the ASHRAE Holladay Distinguished Fellow Award. He contributed to several industry groups and has written hundreds of papers and articles.

### Donald Niederer

Donald Harold Niederer passed away on June 4th at the age of 91. He graduated from Texas A&M University with a degree in mechanical engineering. He served in the U.S. Army as a Second Lieutenant.

His career path took him back to Chicago to his father's small compressor company. He worked there while attending the Chicago-Kent School of Law and earned his J.D. in 1957. Over the next 27 years, he grew his father's company to national prominence as a manufacturer of industrial refrigeration systems under the name Krack Corp.

Following the sale of Krack, Niederer acquired a struggling insulated panel plant, renaming it Metl-Span Corp. He guided its development as a turn-key supplier of refrigerated warehousing and food processing plants until he retired in 1996.

Niederer was named a Distinguished Graduate of the School of Engineering. He was a founding member of the Midwest Industrial Management Association and IIAR.

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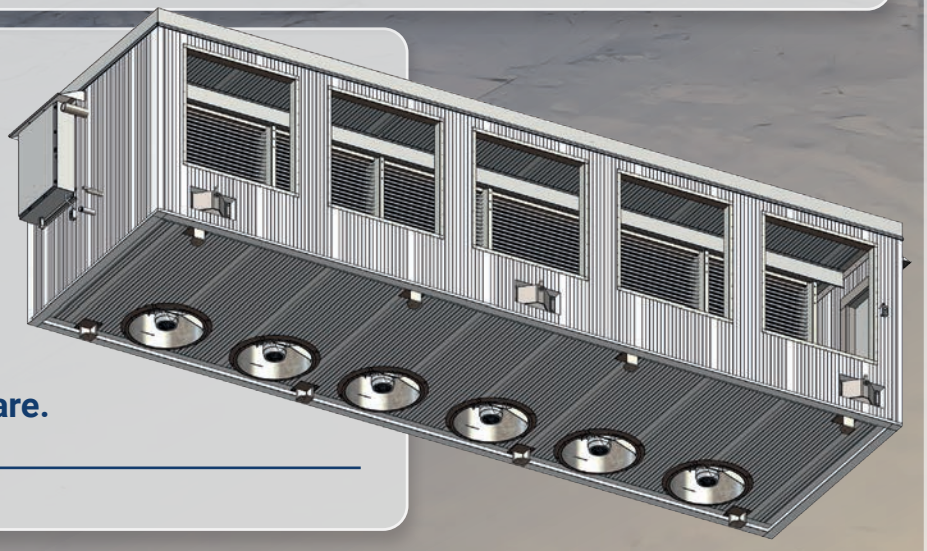

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# IIAR, RETA Work to Increase Diversity, Equity, and Inclusion in the Industry

Industrial refrigeration has long been a male-dominated industry with women being few and far between, whether it be at the end-user, contractor, or manufacturer level, but that is changing.

"There have been concerted efforts over the past several years focused on bringing women into the industry, and as an industry undergoing this shift, it's important to highlight the accomplishments of women," said Melissa Cassell, finance director, General Refrigeration Company.

Cassell worked closely with Yesenia Rector, meetings and international program director for IIAR, and Claudia Sanchez, executive director of ACAIRE Colombia, to put together the session "Diversity and Inclusion in Natural Refrigeration: A Women in Natural Refrigeration Workshop" at IIAR's annual conference. The session was a joint effort between IIAR and the Refrigerating Engineers & Technicians Association (RETA) to highlight the progress the industry has made as well as the challenges that remain.

"When the planning discussion started, it was primarily focused on women in the industry, but we did also want to touch on the broader stroke of diversity," Cassell said.

Ultimately, the panel, which Cassell moderated, included five speakers. Panelists included: Colleen Keyworth director of sales and marketing for Online-Access, an HVAC web marketing company; Lee Pyle, business unit director for the SCS Tracer division of SCS Engineers and a vice president of SCS Engineers; Tania Herrera Serna, a key account manager for Güntner and member of the Women in Natural Refrigeration Steering Committee; Ken Williams, a semi-retired consultant for Chemical Transfer; and Monika Witt, managing director of TH.

They discussed how to address challenges and opportunities in the workplace, and shared their experiences with women in the industry. They also discussed ways to increase diversity in the industry and how to continue breaking down barriers.

"It's important to the success of any company to incorporate different backgrounds and perspectives into its business operations," Cassell said. "Bringing different ideas to the table often helps companies to look outside the box to find innovative and forward-thinking solutions to an ever-changing landscape of issues that business face in today's world."

"Bringing different ideas to the table often helps companies to look outside the box to find innovative and forward-thinking solutions to an ever-changing landscape of issues that business face in today's world."

—Melissa Cassell, finance director, General Refrigeration Company

Following the panel, Sanchez presented findings from the Women in Cooling Worldwide Survey. According to the survey, just 6 percent of the members of national refrigeration associations, organizations, and institutions are women. Women reported several challenges, including a lack of career advancement opportunities, no other female colleagues in their organization, and limited training opportunities to develop their skills.

However, survey respondents said they are eager to support other women. More than half—53 percent—said they were directly involved in activities such as training, workshops, mentoring, or recruitment.

RETA's Women in Natural Refrigeration (WiNR) focuses on providing networking opportunities to support the education and empowerment of women in the industry. The group grew out of an informal get-together several years ago and has grown exponentially.

"What started in 2016 as a group of women at a RETA conference in Vegas, who just got together to go to dinner because there weren't many attending, has grown to a national movement/forum for a more inclusive and supportive industry across all boundaries," said Lois Stirewalt of RETA.

At the beginning of IIAR's annual meeting, WiNR held a reception, giving women in the industry the chance to network and meet new people. "The idea behind having the networking event at the beginning of the conference is to give women the opportunity to meet new people and to have a 'friendly face' throughout the conference," Cassell said.

Cassell said those interested in getting involved with WiNR or volunteering for the WiNR Steering Committee can email info@reta-ti.org for more information. To learn more about WiNR, visit the group's website at https://www.reta-ti.org/winr or LinkedIn page at https://www.linkedin.com/company/women-in-natural-refrigeration/.

# Keeping Up

**BY DR. JANET LAPP**

The increase in the volume of work resulting from regulatory changes is superimposed on a backset of a) unprecedented instability and b) an increasing and overwhelming number of decisions we are forced to make daily.

a) The 2022 Collins Dictionary word of the year 'permacrisis' means an 'extended period instability and insecurity.' The World Economic Forum's 2023 Global Risks Report defines a 'polycrisis' comprising global and local threats of "inflation, cost-of-living crises, trade wars, capital outflows from emerging markets, widespread social unrest, and geopolitical confrontation."

b) A 2023 Oracle Survey of 14,000 leaders in 17 countries found that 86% are less confident in making decisions, 85% suffer from decision distress and 72% have been paralyzed from making decisions at all.

Generative A.I. is compounding the overwhelm. The number of decisions every day has increased tenfold over the last three years (74%), 78% are bombarded with more data than ever, and 86% say the volume of data is making decisions much more complicated.

One of the top skills to navigate through this is to recognize and avoid decision distress and decision paralysis.

## DECISION DISTRESS

Brains are cognitive misers. They avoid decisions when they can because decision-making takes a high degree of energy. Willpower and decision-making ability deteriorate with the number and complexity of decisions. After a time, caution goes down and decisions become more impulsive. That's why impulse items are at grocery checkouts.

- The brain can tolerate just so much before it goes into a rest cycle.
- The demand for decision-making is increasing daily, but our capacity to make them is not.
- After we have peaked our capacity, more data only overwhelms us.

1. Make important decisions earlier in the day before brain fatigue sets in.
2. Cut down on unimportant decisions. Streamline your life to avoid low-level decision-making. Monitor and control the number of decisions you make daily.
3. Give your brain a rest. Get into nature. Go for a run. Take a shower. Meditate. Stare at a blank wall.
4. Think about doing less. If your brain is shouting that you're doing too much, you're doing too much.

## DECISION PARALYSIS

Decision fatigue at the individual level can blossom into group paralysis, with slower and less-efficient decisions despite the use of technology.

- Several meetings are devoted to the 'problem,' but nothing gets done.
- More data is continually being requested.
- Important decisions about products, markets, and technologies are not being made.
- Projects relating to what needs to be done become unfunded or withdrawn.
- Several layers of approval are needed before a decision is approved.

1. Are you working on the right problem? Dan Burrus advises to "take your biggest problem, and skip it." Move on - especially if you've determined sunk-cost fallacy is involved (we've put so much into it already, hate to let it go).
2. What level of decision is this?

   LEVEL 1 Hard trends are clear (preferable or probable futures). We're sure this future will happen. These decisions are usually made easily.

   LEVEL 2 Possible outcomes are clear, but it's hard to predict which one will happen. Most people get stuck in the uncertainty of LEVEL 2 and freeze. Instead, plot out the three most probable future scenarios and gather relevant information.

   LEVEL 3 An ambiguous future, almost impossible to predict. It might not even be possible to identify the relevant variables that will define the future. Save this area for your future scenario brainstorming time.
3. Are you managing the process?

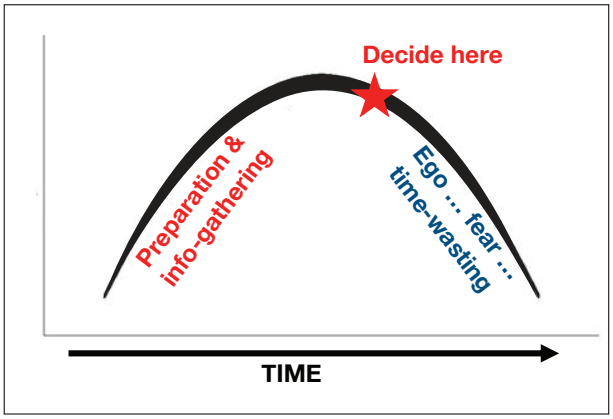
   Groups in paralysis lie on the right downward slope, having missed the optimal decision point. There is no payoff in spending time here other than to bolster egos and waste time.

Here are specific actions to take:

At the beginning of a project,

a. Describe what the project will look like when it's optimal.

b. Define who the project is for, and what their needs are. When will it be adequate?




c. Identify two trackers who can watch for this point.

d. Define how and when you'll know the project is successful after the decision is made.

f. Plan the steps you'll take to reverse or change the decision if it isn't working.

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**Dr Janet Lapp** *was the Keynote Speaker at the IIAR Annual Convention in Long Beach CA March 2023. She is a neuropsychologist, author, and keynote speaker and can be contacted at info@janetlapp.com.*

# OSHA Nears Completion of Final Rule on Injury and Illness Recordkeeping Requirements

iiar government RELATIONS

BY LOWELL RANDEL, IIAR GOVERNMENT RELATIONS DIRECTOR

On April 7, 2023, the Occupational Safety and Health Administration (OSHA) submitted its latest injury and illness recordkeeping proposal to the Office of Information and Regulatory Affairs (OIRA). Submission to OIRA usually marks the last step in the rulemaking process before a Final Rule is published. Injury and illness recordkeeping has been the subject of regulatory attention by the last three administrations. The Obama administration issued new reporting requirements and the Trump Administration moved to roll some of them back. Now, the Biden administration is seeking to restrengthen electronic reporting requirements.

Injury and illness recordkeeping has been the subject of regulatory attention by the last three administrations. The Obama administration issued new reporting requirements and the Trump Administration moved to roll some of them back. Now, the Biden administration is seeking to restrengthen electronic reporting requirements.

## CURRENT POLICY

OSHA's current regulations require employers with more than 10 employees in most industries to keep records of occupational injuries and illnesses at their establishments. Employers covered by the regulation must record each recordable employee injury and illness on an OSHA Form 300, which is the "Log of Work-Related Injuries and Illnesses." Employers must also prepare a supplementary OSHA Form 301 "Injury and Illness Incident Report" that provides additional details about each case recorded on the OSHA Form 300. At the end of each year, employers are required to prepare a summary report of all injuries and illnesses on the OSHA Form 300A, which is the "Summary of Work-Related Injuries and Illnesses," and post the form in a visible location in the workplace. The current recordkeeping regulation also requires certain employers to electronically submit injury and illness data to OSHA. Section 1904.41(a)(1) requires establishments with 250 or more employees in industries that are required to routinely keep OSHA injury and illness records to electronically submit information from the Form 300A summary to OSHA once a year. Establishments with 20-249 employees in certain designated industries to electronically submit information from their Form 300A summary to OSHA once a year.

## PROPOSED CHANGES

Under the latest OSHA proposed rule, establishments with 20 or more employees in certain designated industries (Appendix A of the rule) would continue to electronically submit information from their Form 300A annual summary to OSHA once a year. Designated industries of interest to IIAR members in Appendix A include: Construction, Manufacturing, Grocery Stores, and Warehousing and Storage. However, the proposed rule would eliminate the requirement for all establishments with 250 or more employees in industries that are required to routinely keep OSHA injury and illness records to electronically submit information from the Form 300A to OSHA. Instead, establishments with 100 or more employees in certain designated industries (Appendix B of the rule) would be required to electronically submit information from their OSHA Forms 300, 301, and 300A to OSHA once a year. Designated industries impacting IIAR members in Appendix B include: fruit and vegetable preserving and specialty food manufacturing, dairy product manufacturing, animal slaughtering and processing, seafood product preparation and packaging, bakeries and tortilla manufacturing, other food manufacturing, beverage manufacturing, grocery and related product merchant wholesalers, beer, wine, and distilled alcoholic beverage merchant wholesalers, grocery stores, and warehousing and storage. In addition, OSHA is proposing to require establishments to include their company name when making electronic submissions to OSHA.

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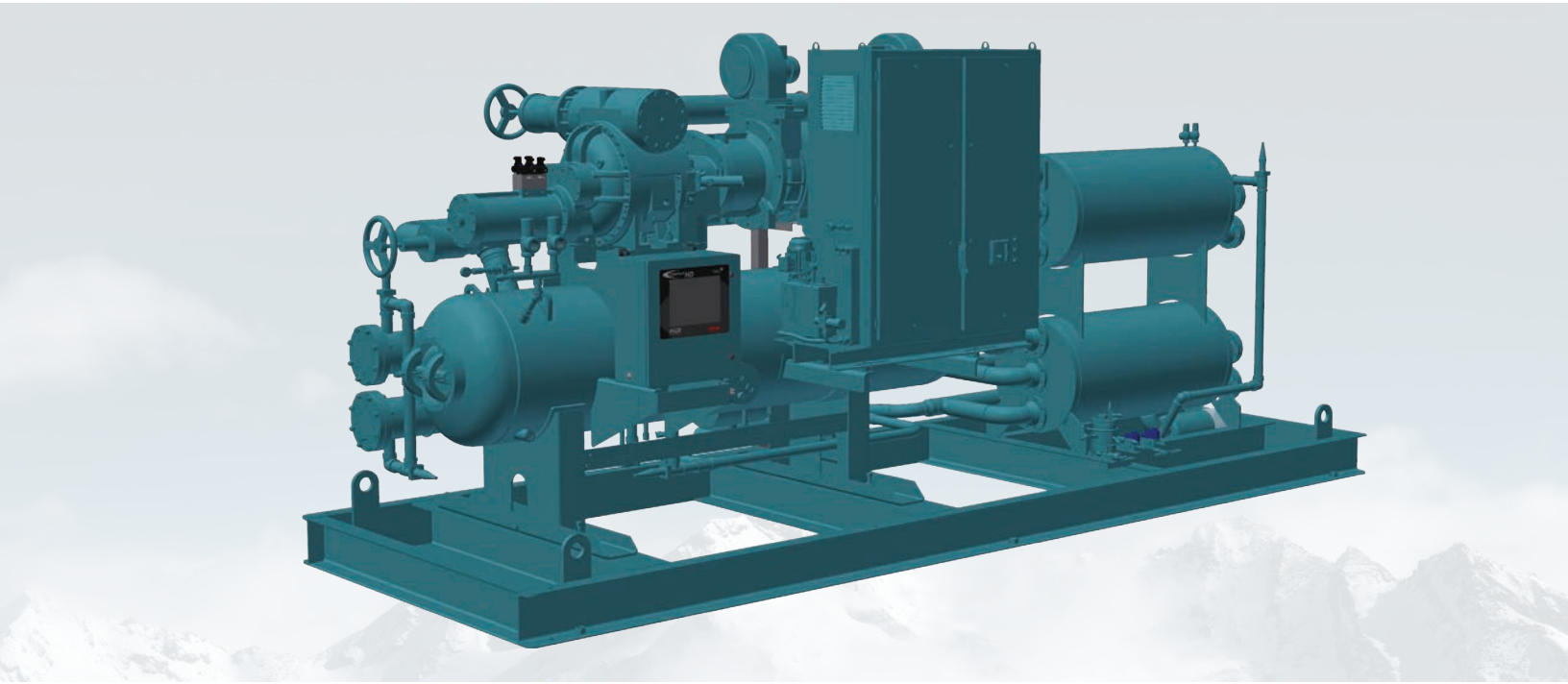

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The proposed requirement for establishments with 20 or more employees in certain designated industries to electronically submit information from their Form 300A to OSHA once a year is essentially the same as the current regulation. For establishments with 100 or more employees in certain designated industries, the proposed requirement to electronically submit information from their Forms 300 and 301 to OSHA on an annual basis represents a change from the current regulation. The proposed requirement would provide systematic access for OSHA to the establishment-specific, case-specific injury and illness information that these establishments are already required to collect.

Additionally, OSHA intends to post the collected establishment-specific, case-specific injury, and illness information online. OSHA has stated that the agency will seek to minimize the possibility that worker information, such as name and contact information, will be released. OSHA does not intend to include information that reasonably identifies individuals directly, such as employee name, contact information, and name of physician or health care professional, in the published information.

For establishments with 100 or more employees in certain designated industries, the proposed requirement to electronically submit information from their Forms 300 and 301 to OSHA on an annual basis represents a change from the current regulation.

OSHA believes the expanded public access to establishment-specific, case-specific injury and illness data would allow employers, employees, and other stakeholders to make informed decisions about workplace safety and health at a given establishment, and this accessibility will ultimately result in the reduction of occupational injuries and illnesses. OSHA asserts that the changes will allow OSHA to use its resources more effectively by better enabling the agency to identify workplaces where workers are at greatest risk from specific hazards and to target its compliance assistance and enforcement efforts accordingly. OSHA also argues the new policies will improve the ability of employers to compare their own injury and illness data on hazards with the data from similar establishments in the same industry.

OSHA has committed to complete the rulemaking process by June 2023. The agency made this commitment in response to a lawsuit brought in the U.S. Court of Appeals for the District of Columbia Circuit by organizations representing labor challenging the Trump administration's rollback of the Obama-era recordkeeping requirements. Once the final rule is published, IIAR members are encouraged to familiarize themselves with the new policies, understand which requirements apply to them, and make preparations to ensure they meet their compliance responsibilities for injury and illness reporting.

# Weighing the Choice between Taxable and Tax-Free Bonds


If you're considering the purchase of an individual bond or even a bond mutual fund, one of your first concerns will be its yield. However, when comparing various yields, you need to make sure you're not comparing apples to oranges. The yield on a tax-free bond may be lower than that paid by a taxable bond, but you'll need to look at its tax-equivalent yield to compare them accurately.

### WHAT'S TAXABLE? WHAT'S NOT?

The interest on corporate bonds is taxable by local, state, and federal governments. However, interest on bonds issued by state and local governments (called municipal bonds, or munis) generally is exempt from federal income tax. If you live in the state in which a specific muni is issued, it may be tax-free at the state or local level as well.

Unlike munis, the income from Treasury securities, which are issued by the U.S. government, is exempt from state and local taxes but not from federal taxes. The general principle is that federal and state/local governments can impose taxes on their level, but not at the other level; for example, states can tax securities of other states but not those of the federal government, and vice versa.

### THE IMPACT OF FREEDOM FROM TAXES

To attract investors, taxable bonds typically pay a higher interest rate than tax-exempt bonds. Why? Because of governmental bodies' taxing authority, investors often consider munis safer than corporate bonds and are more likely to accept a lower yield. Even more important is the associated tax exemption, which can account for a difference of several percentage points between a corporate bond's coupon rate — the annual percentage rate it pays bondholders — and that of a muni with an identical maturity period.

Still, depending on your tax bracket, a tax-free bond could provide a better net after-tax return. Generally, the higher your tax bracket, the higher the tax-equivalent yield of a muni bond will be.

### IT'S NOT WHAT YOU GET, IT'S WHAT YOU KEEP

To accurately evaluate how a tax-free bond compares to a taxable bond, you'll need to look at its tax-equivalent yield. To do that, you apply a simple formula that involves your federal marginal tax rate — the income tax rate you pay on the last dollar of your yearly income. The formula depends on whether you want to know the taxable equivalent of a tax-free bond or the tax-free equivalent of a taxable bond.

The table on the next page shows the tax-free equivalents of various taxable yields; the figures are determined by subtracting your marginal tax rate from 1, then multiplying the taxable bond's yield by the result. To calculate the taxable equivalent of a tax-free yield, subtract your marginal tax rate from 1, then divide the tax-free yield by the result.

If a taxable bond also is subject to state and local taxes and the tax-exempt one isn't, the tax-exempt bond's coupon rate could be even lower and still provide a higher tax-equivalent yield.

### MUNIS ARE TAX-FREE, EXCEPT WHEN THEY'RE NOT

As is true of almost anything related

| | TAX BRACKET | | | | | |
|---|---|---|---|---|---|---|
| | 12% | 22% | 24% | 32% | 35% | 37% |
| **Taxable Yield (%)** | **Equivalent Tax-Free Yield (%)** | | | | | |
| **2.0** | 1.76 | 1.56 | 1.52 | 1.36 | 1.30 | 1.26 |
| **2.5** | 2.20 | 1.95 | 1.90 | 1.70 | 1.63 | 1.58 |
| **3.0** | 2.64 | 2.34 | 2.28 | 2.04 | 1.95 | 1.89 |
| **3.5** | 3.08 | 2.73 | 2.66 | 2.38 | 2.28 | 2.21 |
| **4.0** | 3.52 | 3.12 | 3.04 | 2.72 | 2.60 | 2.52 |
| **4.5** | 3.96 | 3.51 | 3.42 | 3.06 | 2.93 | 2.84 |
| **5.0** | 4.40 | 3.90 | 3.80 | 3.40 | 3.25 | 3.15 |
| **5.5** | 4.84 | 4.29 | 4.18 | 3.74 | 3.58 | 3.47 |
| **6.0** | 5.28 | 4.68 | 4.56 | 4.08 | 3.90 | 3.78 |
| **6.5** | 5.72 | 5.07 | 4.94 | 4.42 | 4.23 | 4.10 |
| **7.0** | 6.16 | 5.46 | 5.32 | 4.76 | 4.55 | 4.41 |
| **7.5** | 6.60 | 5.85 | 5.70 | 5.10 | 4.88 | 4.73 |

Tip: The equivalent tax-free yield can be even lower if you are subject to an additional 3.8% Medicare contribution tax that applies to net investment income for individuals with an adjusted gross income of more than $200,000 ($250,000 for married couples filing jointly).

to taxes, munis can get complicated. A bond's tax-exempt status applies only to the interest paid on the bond; any increases in the bond's value are taxable if and when the bond is sold. You also may owe taxes when you sell shares of a muni bond mutual fund.

If you sell a municipal bond at a profit, you could incur capital gains taxes. Also, the principal value of bonds may fluctuate with market conditions. Bonds redeemed before maturity may be worth more or less than their original cost. And remember that municipal bond funds are subject to the same inflation, interest rate, and credit risks associated with their underlying bonds. As interest rates rise, bond prices typically fall, which can adversely affect a bond fund's performance.

Also, specific munis may be subject to federal income tax, depending on how the issuer will use the proceeds. If a bond finances a project that offers a substantial benefit to private interests, it is taxable at the federal level unless specifically exempted. For example, a new football stadium may serve a public purpose locally but provide little benefit to federal taxpayers. As a result, a muni bond that finances it is considered a so-called private-purpose bond. Other public projects whose bonds may be federally taxable include housing, student loans, industrial development, and airports.

Even though such bonds are subject to federal tax, they still can have some advantages. For example, they may be exempt from state or local taxes. And you may find that yields on such taxable municipal bonds are closer to those of corporate bonds than they are to tax-free bonds.

Agencies and GSEs (government-sponsored enterprises) vary in their tax status. Interest paid by Ginnie Mae, Fannie Mae, and Freddie Mac is taxable at federal, state, and local levels. The bonds of other GSEs, such as the Federal Farm Credit Banks, Federal Home Loan Banks, and the Resolution Funding Corp. (REFCO), are subject to federal tax but exempt from state and local taxes. Before buying an agency bond, verify the issuer's tax status.

## DON'T FORGET THE AMT

To even further complicate matters, the interest from private-purpose bonds may be specifically exempted from regular federal income tax but still may be considered when calculating whether the alternative minimum tax (AMT) applies to you. A tax professional can determine the likelihood that a bond will affect your AMT liability.

## PAY ATTENTION TO MUNI BOND FUNDS

Just because you've invested in a municipal bond fund doesn't mean the income you receive is automatically tax-free. Some muni funds invest in both public-purpose and private-purpose munis. Those that do must disclose on their yearly 1099 forms how much of the tax-free interest they pay is subject to AMT.

**Note:** *Before investing in a mutual fund, carefully consider its investment objectives, risks, fees, and expenses, which are in the prospectus available from the fund; read it carefully before investing.*

## USE YOUR TAX ADVANTAGE WHERE IT COUNTS

Be careful not to make a mistake that is common among people who invest through a tax-deferred account, such as an IRA. Because those accounts automatically provide a tax advantage, you receive no additional benefit by investing in tax-free bonds within them. By doing so, you may be needlessly forgoing a higher yield from a taxable bond. Tax-free munis are best held in taxable accounts.

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# Bad Decommissioning Mistake

KEM RUSSELL, P.E


I am sure that many of us have seen ammonia refrigeration systems that have operated for several decades, with equipment and system components functioning well past recommended operating life. This is a credit to manufacturers, installers, service technicians, and operators. Aging equipment and piping at some point will eventually require replacement. Or the system or portion of it may be decommissioned due to a business discussion. Due to various conditions, it may become necessary to decommission a system or portions of it, which is defined in ANSI/IIAR 8- 2020 – Decommissioning of Closed-Circuit Ammonia Refrigeration Systems as: "The permanent deactivation of a closed-circuit refrigeration system." ANSI/IIAR 8-2020 is a helpful guide when considering decommissioning some or all of an ammonia refrigeration system.

At some facilities equipment and piping may be abandoned in place for various reasons. This may occur due to the difficulty of removing the equipment and piping; the cost of removal is considered too high; or it may be abandoned in place because the unusable space taken up will not have an impact on the operation.

Whatever decommissioning is intended to be done many factors should be considered so the work is done safely. The slow decommissioning of two separate systems at a facility in Kamloops, BC actually began on December 21, 2015, when the equipment was shut down. On May 26, 2022, during the attempt to remove equipment associated with one of the systems, an accident occurred. It resulted in one fatality, ammonia ignition, 14 persons exposed to ammonia and 3 went to the hospital, a local evacuation, extended facility business shutdown, and an environmental response to the release.

The slow decommissioning of two separate systems at a facility in Kamloops, BC actually began on December 21, 2015, when the equipment was shut down. On May 26, 2022, during the attempt to remove equipment associated with one of the systems, an accident occurred. It resulted in one fatality, ammonia ignition, 14 persons exposed to ammonia and 3 went to the hospital, a local evacuation, extended facility business shutdown, and an environmental response to the release.

In the Technical Safety BC report of the incident, one could see that a major contributing factor to the incident was a lack of and breakdown in communication. Since this demolition occurred over several years this made the need for clear and accurate communication and documentation of what had and hadn't been done even more challenging. This is an important factor to consider if demolition will take months or years to get done.

The misunderstanding regarding the ammonia still being in the system occurred due to changes in personnel and their assigned responsibilities as well as a miscommunication of what work had been completed. The refrigeration mechanic familiar with the system had pumped down the two systems to their respective high-pressure receivers in 2016 before his retirement. He stated the ammonia was still in the system. The Distribution Manager also believed the ammonia was still in the system, however, the Plant Manager who had been relocated to another city thought it had been removed. It was not clearly communicated that the ammonia had not been removed from the system. From 2016 till May 25, 2022, it was incorrectly believed that there was no ammonia in either of the two systems.

The belief that there was no ammonia in either system should have been questioned when on May 25th a worker cut into an HPR pressurized ammonia line connection with a Sawzall. After this occurred the people involved supposedly reviewed the other system for indications of ammonia. Unfortunately, those doing the demolition did not understand what they didn't know and still held to the belief that all the ammonia had been removed, which was one of their strict criteria before removing systems or system components. It was assumed that the high-pressure receiver was empty because there was no liquid indicated in the liquid level sight glass, not realizing that the sight glass isolation valves were closed. They also believed that the system pressure gauges, that showed 0 psig meant the high-pressure receiver (HPR) must be empty. These

gauges did not indicate HPR pressure. It was believed that the ammonia vapor released from the first system was just residual and could be quickly purged to continue the demolition.

While looking at the HPR piping of the second system it was assumed that because they saw a pipe completely open with no shut-off valve between the open end and the vessel, the vessel must have been empty. A review and understanding of whatever system piping diagrams that might have been available, as suggested in ANSI/IIAR 8-2020 Appendix B. (Informative) Example of a Decommissioning Checklist could have prevented the fatality. They should also have had help from a trained refrigeration technician or licensed contractor, but the added cost was an issue.

Once it was discovered that there was ammonia pressure in the one system that should have raised a concern in the mind of those doing this work. The demolition at that point should have stopped. A licensed refrigeration contractor should have then been involved to determine the system condition(s). ANSI/IIAR 8-2020, Chapter 5 recommends: "5.2.3.5 Do not physically disconnect and remove system components until the components have been isolated and residual ammonia and lubrication oil have been drained from the components." Unfortunately, this was not done.

After the discovery of ammonia pressure in the first system those doing the work decided to purge what they thought was residual ammonia from the system. It is estimated that the purging process took approximately 16.5 hours and purged the entire system's ammonia operating charge, later estimated to be a maximum of 1,044 lbs.

On May 26 the removal of the second system components began. It was noticed that a valve stuck out past the support skid of the HPR so the assembly could not be laid on its side for removal from the room. The valve was a one-inch ¼ turn ball valve with no plug or cap in the exit of the valve. The valve was in the HPR liquid supply line and had an internal extension pipe that went to near the bottom of the HPR. The valve was turned ¼ turn which fully opened the line releasing pressurized liquid ammonia directly onto the person opening the valve and quickly filling the area with a dense cloud of ammonia. The other person was able to escape through a large front bay door, but the person hit by the ammonia moved further into the building. The dense cloud of ammonia came in contact with an ignition source and ignited. It was later estimated that 1,345 lbs. to 1,600 lbs. of ammonia had been released directly into the atmosphere.

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The machine room area ventilation system had previously been shut off due to the mistaken belief that all the ammonia had been removed from both systems. It was later estimated that even with a functioning ventilation system due to the large and sudden release the ignition of the ammonia would likely still have occurred.

In the post-investigation of the incident, it was discovered that the pressure relief valve on the HPR involved in this incident had at some time in the past been removed. On checking the integrity of the isolation valves associated with all connections to the HPR it was verified that all could be closed securely tight, and the vessel would hold pressure. It was estimated that the HPR held 1,600 lbs. of ammonia which was the manufacturer's recommended charge for that system. Fortunately, the ambient conditions never reached a temperature that would have expanded the ammonia contents of the HPR to cause a failure of the vessel, a connected line, or a valve.

Several factors contributed to this unfortunate incident. The misinterpretation and poor communication of whether the ammonia had already been removed from the system was a major factor. However, following the guidelines as given in ANSI/IIAR 8- 2020 – Decommissioning of Closed-Circuit Ammonia Refrigeration Systems would very likely have made this a non-event, saving someone's life. Don't make similar mistakes as occurred in this incident when decommissioning a system or equipment in a system.

TECHNICAL PAPER #4

# Benefit of Ammonia Heat Pump Implementation in the Industry and for District Heating

KENNETH HOFFMANN, APPLICATION MANAGER HEAT PUMPS,
GEA HEATING AND REFRIGERATION TECHNOLOGIES

## ABSTRACT

Over the last 15 years the market for high-temperature ammonia heat pumps has been growing in Europe and now it is also taking off in North America. That period in Europe has yielded many lessons as higher pressure and temperature present new challenges in refrigerant design. This paper explains where heat pump installation differs from refrigeration installation through three case studies of installations in Europe. The favorable thermodynamic properties of ammonia and good system design lead to high efficiency and short payback, which the three cases will describe. With many heat pumps being installed into the district heating market new challenges also arise regarding ammonia handling and safety as the installations are now closer to the public than traditional industrial settings for ammonia refrigeration systems. The paper will describe how these challenges have been overcome. With the phasedown of fluorinated greenhouse gases (F gases), incentives to go for natural refrigerants for these solutions have increased, and as this paper shows financial and environmental incentives to employ ammonia heat pumps are also large.

## INTRODUCTION

Industrial heat pump technology has been a known technology for more than 100 years and has been economically viable solution since the 1970s. Nonetheless the widespread uptake of heat pump solutions only started in the last decade. The reason is that burning fossil fuels like coal, oil, or gas is much easier than taking on the bigger investment in a heat pump to save cost in the long run. Most food factories have an abundance of waste heat available from the refrigeration system that can be upgraded with an add-on heat pump. Detailed analysis of the process requirements for heat and cold is necessary to apply the right size buffer tanks so the heat can be used in the process at low cost and high efficiency. Traditionally rejecting all this energy and then using boilers to provide the heating energy was preferred. However, as climate change continues to rise in importance on the global political agenda, major companies are looking to maximize carbon savings, which is where highly efficient heat pumps become an important replacement for boilers. If we can replace fossil fuel heating with heat pumps that only require a small percentage of the heating duty as renewable electricity to become carbon neutral, we will have taken a giant leap toward avoiding a climate crisis.

## AMMONIA HEAT PUMP MAIN COMPONENTS

### Compression Technology

Several compression technologies are currently available on the market, including reciprocating, scroll, centrifugal, and screw compressors. For ammonia applications, the industry typically uses reciprocating or screw compressors (Figure 1). Open-type compressors were preferred in years past, but more recently small screw compressors have also become available as semi-hermetic machines with integrated high- efficiency, copper-wound motors without a shaft seal for chiller applications. This development is just one reason natural refrigerants are becoming more accessible in commercial areas.

Each compression technology has strengths and weaknesses, so selecting the right compressor is important for getting optimal results from the heat pump installation. For heat pump applications, as for refrigeration applications, the specific running conditions for each project determines the preferred technology.

Reciprocating compressors have a smaller operating envelope relative to differential pressure. For example, high-temperature applications with a low source temperature require two-stage reciprocating compressors, whereas other applications require only a single screw compressor.

High-pressure reciprocating ammonia compressors are limited in capacity to around 580 ft3/min (1,000 m3/h), whereas some ammonia screw compressors in operation for heat pump applications have a capacity of more than 5,000 ft3/min (8,500 m3/h).

Also worth noting is that according to RTSelect, compressor selection software by GEA Heating & Refrigerating Technologies, reciprocating ammonia compressors increase in volumetric efficiency at heat pump conditions, while screw compressors' volumetric efficiency reduces at the higher evaporation and condensing temperature (Table 1).

The volumetric efficiency of the screw compressors reduces 6% in heat pump operation compared with chill operation, whereas the piston compressor increases 10% in volumetric efficiency at comparable conditions.

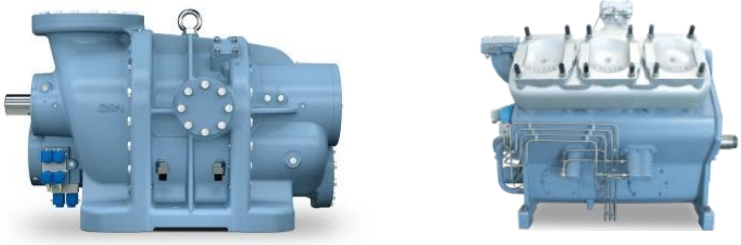
In the industry, reciprocating compressors do most heat recovery as they match the capacity and offer better performance than screw compressors. For district heating most cases use screw compressors due to the large capacities offered by this compressor type.

### Heat Exchangers

For ammonia heat pump applications delivering up to 203°F, heat exchangers with a minimum design pressure of 870 psi (60 bar[a]) are required. For refrigeration purposes, plate and frame heat exchangers are traditionally used, but availability of plate and frame heat exchangers for ammonia at the heat pump application design pressure is limited. The most common heat exchangers used on the heating side of an ammonia heat pump are shell-and-plate heat exchangers (Figure 2).

These are available in a wide range of capacities and pressures, and for ammonia heat pumps using multiple heat exchangers in the heating circuit to opti-

**Figure 1.**



To the left, an ammonia screw compressor and to the right an ammonia piston compressor.

**Table 1.**

| | | Screw compressor | | Piston compressor | |
|---|---|---|---|---|---|
| | | Chill | Heat | Chill | Heat |
| Evaporation/ Condensing temperature | °F | 14/ + 95 | + 91/ + 158 | 14/ + 95 | + 91/ + 158 |
| Actual ft³/min | ft³/min | 1,980 | 1,815 | 171 | 171 |
| Volumetric efficiency | % | 94.4 | 88.4 | 75.2 | 85.8 |

Source: Data from RTSelect, compressor selection software by GEA Heating & Refrigerating Technologies.

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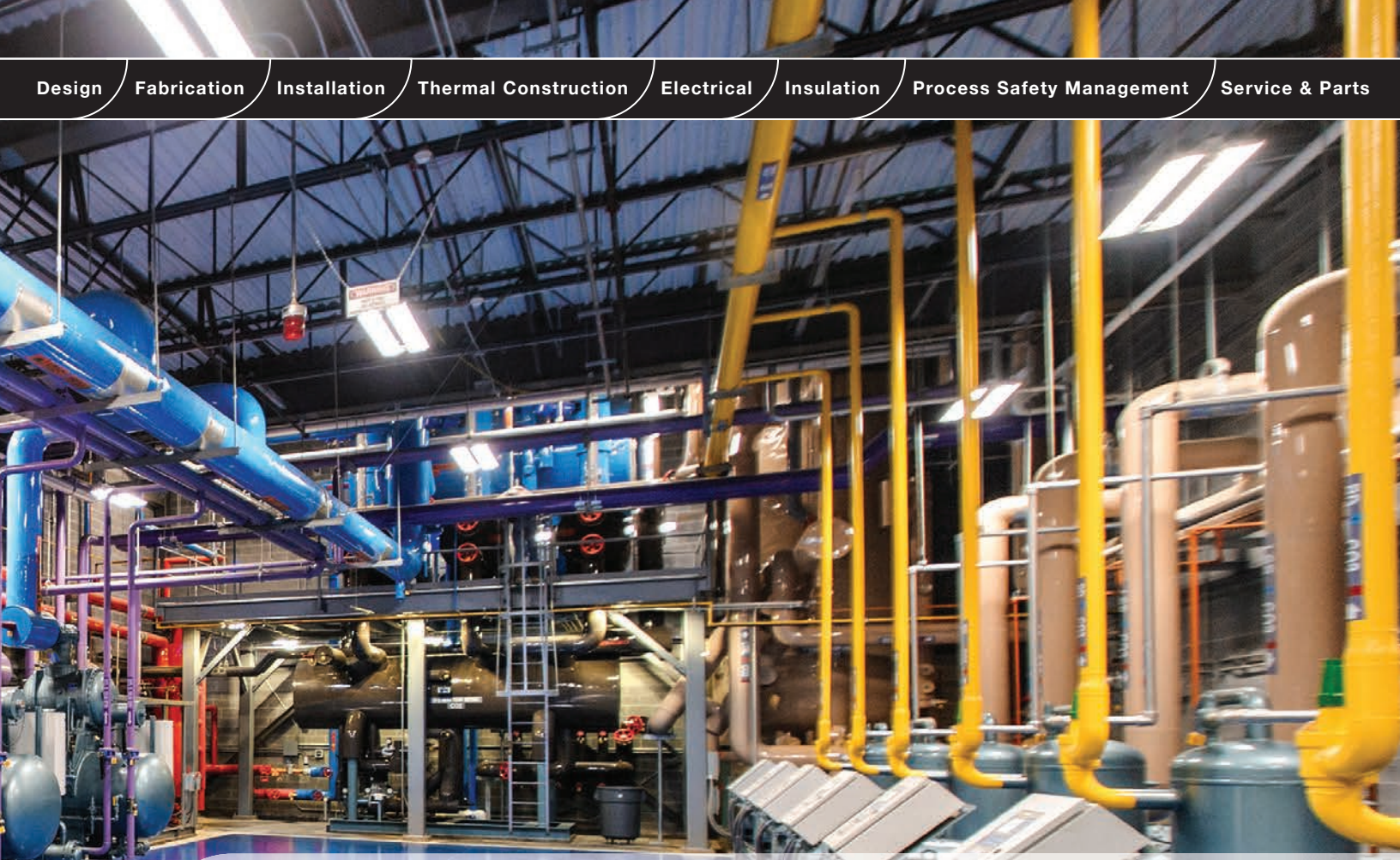

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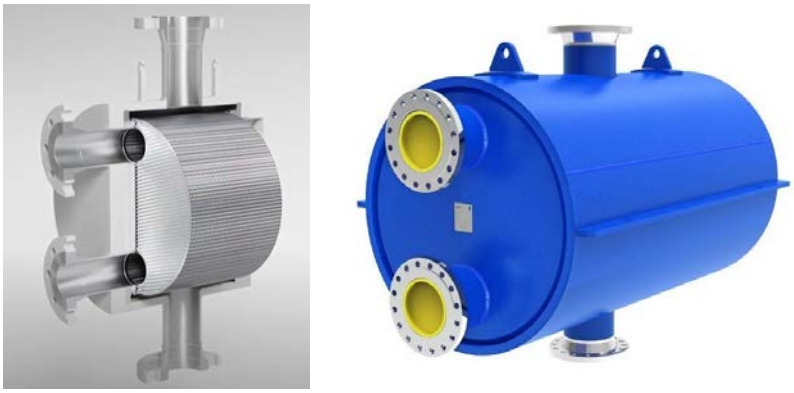
**Figure 2.**



A cut-through view of a plate-and-shell heat exchanger. It offers the high integrity of a fully welded heat exchanger (like shell and tube), but the small footprint and refrigerant charge of a plate heat exchanger.

**Figure 3.**

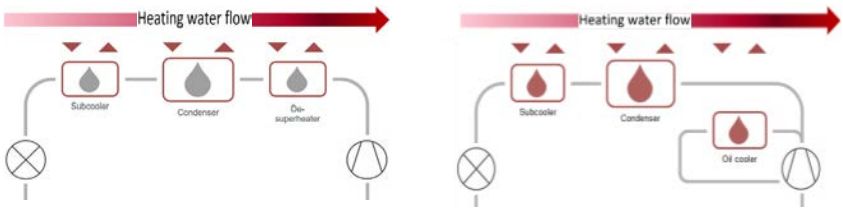
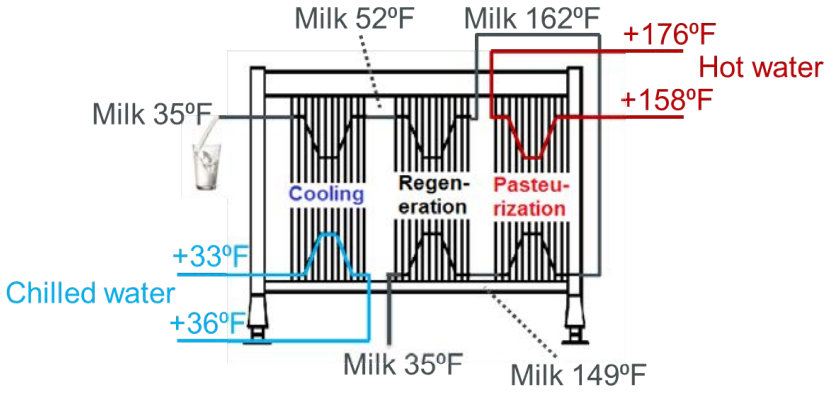



Figure 3. To the left is a typical heat exchanger setup for a reciprocating compressor heat pump, where a high discharge temperature greatly benefits a de-superheater but no oil cooling is available. To the right is a schematic of the water flow through the heat exchangers for a screw compressor heat pump, which features a lower discharge temperature and less superheat energy, but significant heat in the oil cooling circuit.

**Figure 4.**




A typical setup for pasteurization with a three-zoned heat exchanger. First the incoming milk is heated in a regeneration area, while the pasteurized milk cools, then the incoming milk is pasteurized with hot water to above 162°F (for fresh milk). After the regeneration area the milk is chilled to a holding temperature of around 35°F using chilled water.

mize efficiency is common. A typical ammonia heat pump has a de-superheater, a condenser, a sub cooler, and an oil cooler (for screw compressor heat pumps), so up to four high-pressure heat exchangers are employed to get maximum efficiency out of the system (Figure 3).

Shell-and-plate heat exchanger technology is not commonly known outside the ammonia refrigeration market. The tender specification for large heat pump projects often calls for use of shell-and-tube heat exchangers as this is predominantly the choice for F-gas heat pump manufacturers. Using shell-and-plate heat exchangers has clear benefits such as compactness, low charge, no requirement for service space for tube bundle extraction, etc. Customers must be informed about these benefits to accept alternative heat exchanger solutions.

On the cooling side of a heat pump the selection of heat exchanger depends on the heat source. Many heat pumps installed in the industry use the condenser heat from the refrigeration system as the heat source. For these applications having fully welded heat exchangers is preferable as it minimizes the risk of ammonia leakage out of the system.

For water source heat pumps the selection of evaporator is like refrigeration systems, where plate and frame are most commonly used. If there are particles in the water, shell and tube is preferable and if operating close to freezing a falling film evaporator is an option. These heat exchangers have no special requirements regarding the pressure as standard design pressure can be applied (230–360 psi).

## HEAT PUMPS IN DAIRIES IN THE UNITED KINGDOM AND IRELAND

In 2008, a dairy in Northeast England was looking to save costs on its fresh milk production line. Fresh milk is a low-margin, high-volume product, so a small savings per gallon can add up to high value. The dairy had installed a 398 TR (1,400kW) ammonia refrigeration plant for cooling down the milk after pasteurization, and it was using 3.14 MBtu/hr (920 kW) of steam (generated by gas boilers) to heat water to 176°F for the pasteurization process (Figure 4). This process is the same for almost all fresh milk dairies across the world.

For refrigeration 3 x GEA V1100 compressors were installed with evaporative condensers for heat rejection. At the UK average condensing temperature of 73°F

**Table 2. Cooling Coefficient of Performance (COP) of the Refrigeration Plant without the Heat Pump Installed**

| Compressor | Rpm | To (°F) | Tc (°F) | Qo (TR) | P (kW) | Qc (kW) | COP cooling |
|---|---|---|---|---|---|---|---|
| 3 x GEA V1100 | 734 | 23 | 73 | (1,400 kW) 398 | 203 | 1,603 | 6.9 |

Note that Table 2 indicates a cooling coefficient of performance (COP) of 6.9 for the compressors. The COP is defined as the cooling duty (Qo) in kW divided by the absorbed power (P) in kW. The same expression (COP) is used for heat pump installations. In this case the heating duty (Qc) in kW is divided by the absorbed power (P) in kW.

**Table 3. Cooling COP and Power Consumption of Refrigeration and Heat Pump System**

| Compressor | Rpm | To (°F) | Tc (°F) | Qo (TR) | P (kW) | Qc (kW) | COP cooling |
|---|---|---|---|---|---|---|---|
| 2 x GEA V1100 | 590 | 23 | 61 | 786 kW 224 | 87 | 1,603 | 6.9 |
| 1 x GEA V1100 | 1,191 | 23 | 109 | 684 kW 194 | 160 | 774 | 3.8 |
| 2 x GEA 65HP | 1,072 | 109 | 181 | 774 kW 220 | 146 | 920 | |

**Figure 5.**

Installation of 1,200 kW ammonia heat pump at Aurivo fresh milk dairy in Ireland.

the condenser heat rejection is 5.47 MBtu/hr (1,603 kW) at full load (Table 2).

When operating the dairy plant in a traditional way, the dairy uses 203 kW of electricity and 920 kW of steam. There are losses in the steam system (5%–50%), and industrial boiler efficiency is normally between 75% and 85%. For assessment of the site, we have assumed only 20% losses in the boiler and steam system. To get 920 kW of steam energy into the milk requires 1,150 kW of natural gas. Installing

a heat pump that uses the waste heat from the refrigeration process enables significant reductions of energy usage. To optimize the heat pump installation, one of the refrigeration compressors is dedicated as a heat source for the heat pump compressors (Table 3). Using this configuration enables us to minimize the heat pump compressors by increasing suction temperature and still have the refrigeration plant operate with floating head pressure for optimum efficiency throughout the year.

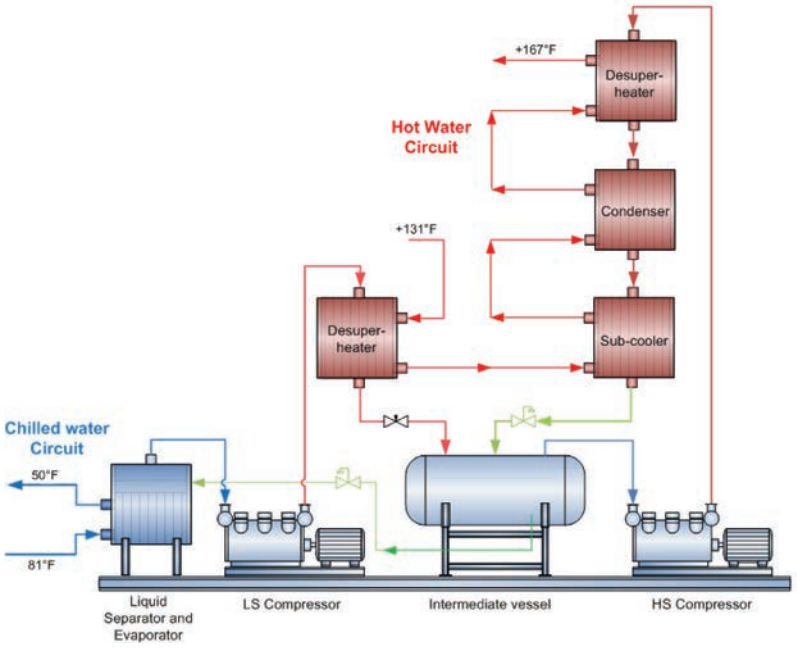
The two heat pump compressors were added to the system via an interstage vessel, so losses between the condensing temperature of the refrigeration compressor and the suction pressure of the heat pump compressor are minimal. The heat pump compressors deliver 180°F hot water (hence the condensing temperature of 181°F). An intermediate water circuit is between the 176 °F hot water going into the pasteurizer and the 181°F coming out of the heat pump, which ensures that any potential ammonia leak into the heating water will not contaminate the milk. Table 3 shows that the total electrical power has increased from 203 kW to 393 kW, so an extra 190 kW of electricity, but the customer has also saved 1,150 kW of gas usage. Based on a gas price of $0.052/kWh and an electricity price of $0.09/kWh and with the plant operating 7,488 hours per year the yearly savings are $307,500 per year (Unsworth, 2011). In addition the carbon savings are significant. When the plant was installed in 2008, the carbon intensity of electricity production in the United Kingdom was 1,190 lb/MWh and emissions from burning gas was 474 lb/MWh, at the time the dairy saved 1,083 tonnes of CO2 emissions per year. Today, 13 years after the installation, all coal-fired power plants have been decommissioned in the United Kingdom and a significant part of UK electricity is supplied by renewable sources, so the yearly average carbon intensity of electricity is now 400 lb/MWh (2020). As of this writing, the plant has reduced carbon emissions by 1,600 tonnes per year.

In 2019 Aurivo dairies in Ireland made a similar installation for their fresh milk pasteurization process in County Donegal (Figure 5), where they pack 120 million liters of fresh milk per year and are saving $402,500 per year and 400,000 lb of CO2 emissions per year (Dairy Reporter, 2020).

## LONDON UNDERGROUND HEAT PUMP

In 2016, Islington Council in Central London built the world's first heat pump to feed cheap low-carbon heat into a district heating network using the exhaust ventilation air from the London Underground as the heat source. The plan is to continue the development of district heating networks in London and eventually connect all the tower blocks and public buildings like schools, hospitals, and leisure centers. When the heat network has been established, the plan is to try to attract private and commercial owners to sign up to the network also. The heat network will be able to supply environmentally friendly heating at lower cost than burning gas and with zero NOx emissions, which cause around

**Figure 6.**




Simplified schematic of the ammonia and water circuit of a high-efficiency heat pump.

**Figure 7.**

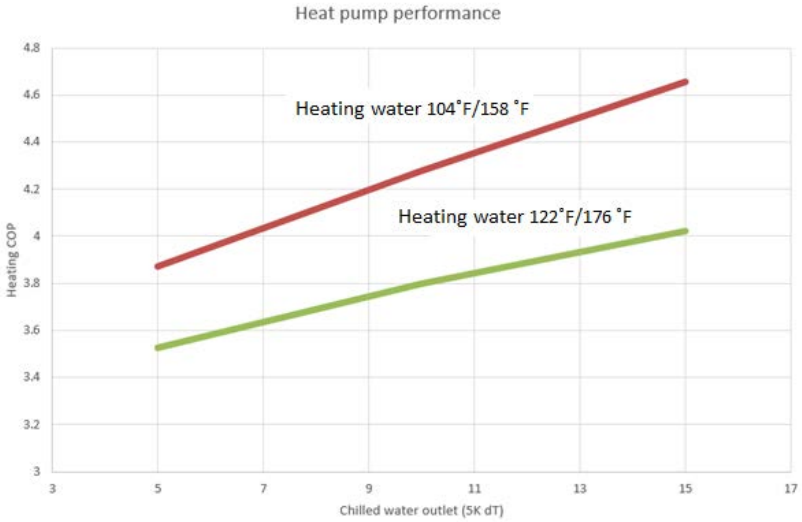



Illustration of the performance of the London Underground heat pump. The green line (122°F/176°F) is the performance at the time of installation. The council aim to optimize the heating network over time and lower the flow and return temperature and eventually achieve the performance illustrated by the red line (104°F/158°F).

4,000 deaths per year in central London (Imperial College London, 2020).

For this phase of the project (Bunhill 2), a 1,034 kW two-stage ammonia heat pump was installed. The ammonia charge is approximately 770 lb (Hoffmann, 2017). The heat pump consists of a combined evaporator/separator in a fully welded shell. Four heat exchangers are in series in the heating circuit to optimize the performance of the heat pump (Figure 6). First the district heating water cools the de-superheated gas from the low-stage compressor, and then the water is heated in series through the sub cooler, condenser, and de-superheater from the high-stage compressors.

The design criteria for the heat pump are based on heating water returning at 122°F and supplied at 167°F. The air cools from 75°F to 57°F in the cooling coil with water at 55°F/46°F. At these conditions, the total cooling duty is 222 TR (780 kW), the absorbed power of the three compressors is 369 BHP (275 kW), and the heating duty is 1,034 kW giving a heating COP of 3.7. The heat network needs a higher temperature in the peak of winter, so the heat pump is designed to supply heating water up to 176°F (Figure 7). On the cooling side the ventilation air coming out of the underground can also vary. In the peak of summer, it can be 86°F and in the winter, it can drop to 68°F. It rarely drops below 68°F. When the tube started operating in the 19th century it was cool underground, but due to inadequate cooling and ventilation, the generated heat from the people and friction from the train operation have heated up the whole network 18–25°F since it began operation.

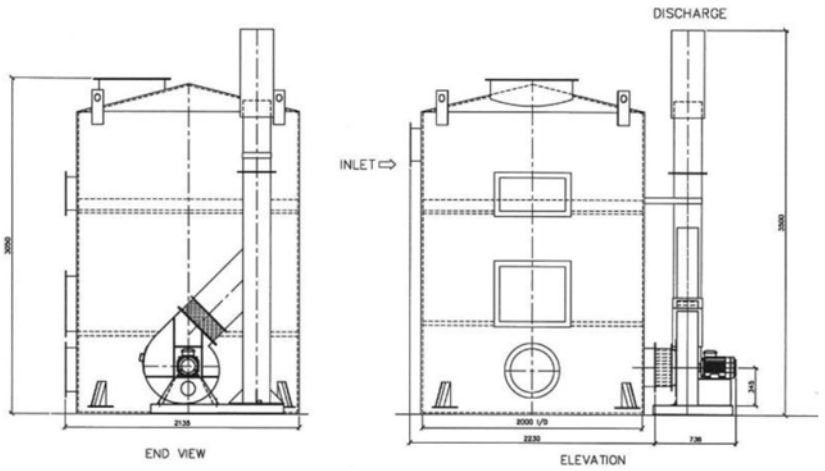
The heat pump has one low-stage piston compressor and two high-stage compressors.

The low-stage compressor provides enough cooling capacity to generate 1,000 kW heating capacity. The minimum part load of the system is 25% of the design capacity—both low-stage and high-stage compressors have VFD motors for optimised performance at part load.

## Heat Source

From other air source heat pumps, we are accustomed to the air-cooled evaporator blocking up with ice, which can be overcome by defrosting the coil. In this case defrost is unnecessary as the temperatures are much above 32°F, but an issue remains with the cooling coil blocking up. The air is extracted from the underground to ambient at ground level. A (780 kW) 222 tons of refrigeration water–cooled cooling coil is mounted in the airstream with a reversible fan extracting 70 m3/s. Most of the year the air from the London Underground will be cooled before being vented to atmosphere. On warm days, the airstream is reversed and chilled across the cooling coil before being vented into the underground tunnel. The London Underground has experience with this type of installation from other parts of London

**Figure 8.**




Drawing of the absorber vessel holding 17,600 lb of carbon pellets, through which the ventilation air passes.

where the air is chilled before venting to the underground tunnels. The air quality from street level differs significantly from air extracted from the underground. The underground air has a high metal content (Transport for London, 2014), whereas the air quality on busy London streets is mainly (around 80%) NOx and PM10 and PM2.5 from exhaust and brakes from cars, busses, and trucks (Chetan Lad, 2016). To avoid the coil being blocked by the pollutants, a wide fin spacing was chosen (four fins per in.). Based on the London Underground's experience from other sites and tests made with the cooling coil the coil will need to be cleaned every 6–12 months.

To avoid ammonia potentially leaking from the air-cooling coil and being vented into the underground, there is an intermediate water loop. The heat pump cools water that is circulated in the cooling coil in the ventilation shaft.

### Ammonia Absorber

The ammonia heat pump is installed at street level on the corner of a busy London street. To avoid any harm to people the extract air from the plant room will be rejected above the roof of the nearby 18-story block of flats during normal operation. When the plant is serviced (some ammonia smell can be expected) or an ammonia alarm is set off, all the ventilation air will be passed through a carbon filter, which absorbs all the ammonia leaving 0 ppm of ammonia in the air after filtration. We have investigated other options, but no other solution can offer 100% removal of the ammonia in the air. Water scrubbers and acid-based scrubbers reduce the ammonia content in the air below dangerous levels, but they do not completely remove the ammonia from the air, and with a large population in the area with no knowledge of ammonia safety levels, any prevailing ammonia smell could cause panic. Although the ventilation air is rejected at the highest level, taller buildings are under construction nearby, so having zero ammonia content in the ventilation air is important.

The absorption material used is a carbon-based pellet, with an additive to improve the ammonia absorption properties. In our test we found that that material can absorb up to 5.6% ammonia. For the project in London, the absorber quantity is selected based on 4.6% ammonia absorption capacity. Therefore, installation of 17,600 lb of absorbent material would be required to absorb the 770 lb of ammonia in the heat pump (Figure 8). This could have been mitigated by selecting a design with independent ammonia circuits for the low stage and high stage, which would have more than quartered the ammonia content per circuit to less than 150 lb, thereby reducing the size of the absorber equally.

## MALMÖ DISTRICT HEATING HEAT PUMPS

In a world of phrases such as "environmentally friendly," "sustainable," and "natural," Swedish district heating is using innovative technology to meet regulations and set quite high efficiency standards. In 1980, the Swedish town of Malmö installed its first district heating heat pump plant. However, in 2012 when the Montreal Protocol banned the synthetic refrigerant used in the plant (R22), the plant was decommissioned. In November 2017, the second generation was up and running after one year of preparation.

E.ON, one of the world's largest investor-owned electric utility service providers, installed four ammonia heat pumps, each with just more than 34 MBtu/h (10 MW) heating capacity next to the sewage treatment and waste incinerator plant in the Malmö harbor area (Figure 9). The heat pump system extracts nearly 8,500 TR (30 MW) of heat from the sewage water and adds 10 MW of electrical power to generate 136 MBtu/h (40 MW) of heating.

The sewage water temperature varies between 54°F and 64°F depending on the season. The cleaned sewage water was previously returned to the sea, but now it passes through the heat pump evaporator and is chilled 6K before being returned to the sea. By harvesting the heat from the wastewater, which has a higher average temperature, the plant is running with better efficiency than if it had been using sea water (-15% efficiency) or ground source water (-10% efficiency).

As the sewage water is not constant throughout the year (more after rainfall) or during the day (more in the morning), a large reservoir for the sewage water was built, which was ready a year after the heat pump was installed. By evening out the sewage water flow the yearly energy output from the heat pumps has increased from 110 GWh to 170 GWh.

Although the sewage water is taken at the end of the cleaning process, particles of organic material remain in the water. To avoid these blocking up the evaporator, a fine filter (2 mm) is installed, and the tubes in the shell-and-tube evaporator are cleaned daily, using a ball cleaning system, without stopping the heat pump. Efficiency improves 2%–3% after each ball cleaning of the tubes.

### Heat Network

The heat pump has been integrated into the district heating network to work with the nearby waste incinerator plant. The return water from the city comes to the waste incinerator plant at around 122°F, where the flue gas economizer heats it to around 131°F before it enters the heat pump where it is further heated to 151°F. The water then returns to the waste incinerator plant where it is further heated to the required temperature for the heating network, which can vary depending on

**Figure 9.**

Four 10 MW heat pumps installed in Malmö, Sweden.

**Figure 10.**

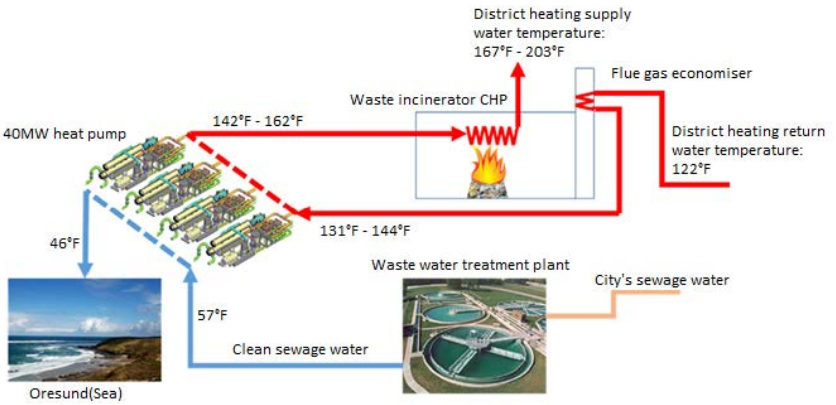



Figure 10. Schematic of the water flow through the heat pump. The sewage water is first cleaned before the heat pump and afterward pumped into the sea. The heating water comes back from the city and is heated in the flue gas economizer and then heated by the heat pump before it returns to the waste incinerator plant where it is heated further from the waste heat to the desired outgoing temperature.

the heating demand from 167°F to 203°F (Figure 10). The heat pump is designed to deliver heat up to 176°F, but will rarely deliver temperatures greater than 162°F.

By replacing heating traditionally done by gas boilers the district heating network saves more than 50,000 tons of CO2 per year. Many other cities aim to decarbonize their heating systems over the coming years and remove NOx from the local environment. Many other Nordic cities have already installed high-efficiency heat pumps to combat local and global pollution, and more will surely follow globally in the coming years. By using ammonia heat pumps, the City of Malmö is not only swapping from fossil fuel to electrically driven heating, it is also doing it in the most efficient way. Today delivering heat up to 203°F is possible (Ammonia21, 2021) with a heating COP greater than 3.0 using an ammonia heat pump, which is more than 20% better than F-gas competition.

In the future when all heating has moved from fossil fuel to electrically driven heat generation green electricity production will be unable to fulfill this growing demand.

To achieve a match between the available electricity and renewable heating installing the most efficient system today is important.

## CONCLUSION

Ammonia heat pumps are suitable for many applications. Industries with combined cooling and heating needs are the most obvious application because payback of the investment is the shortest. However, many other applications also exist such as in industries where there is no cooling demand but plenty of waste heat. Many cities are also looking into decarbonizing the heating of homes, as replacing fossil fuels not only reduces the carbon footprint, it also reduces NOx emissions, which are a major health problem in large cities.

Heat pump installations have also advanced from being purely based on payback, as demand for decarbonization is increasing, leading to ever increasing temperature demand. Many customers now ask for heat pump solutions up to 203°F hot water, which is possible with today's ammonia heat pumps.

As with refrigeration, ammonia is not competitive for small domestic systems, but the upper size of ammonia heat pumps has few limits. So far, the largest installed is 136 MBtu/hr (40 MW), but with modular design even larger ammonia heat pump installation are achievable.

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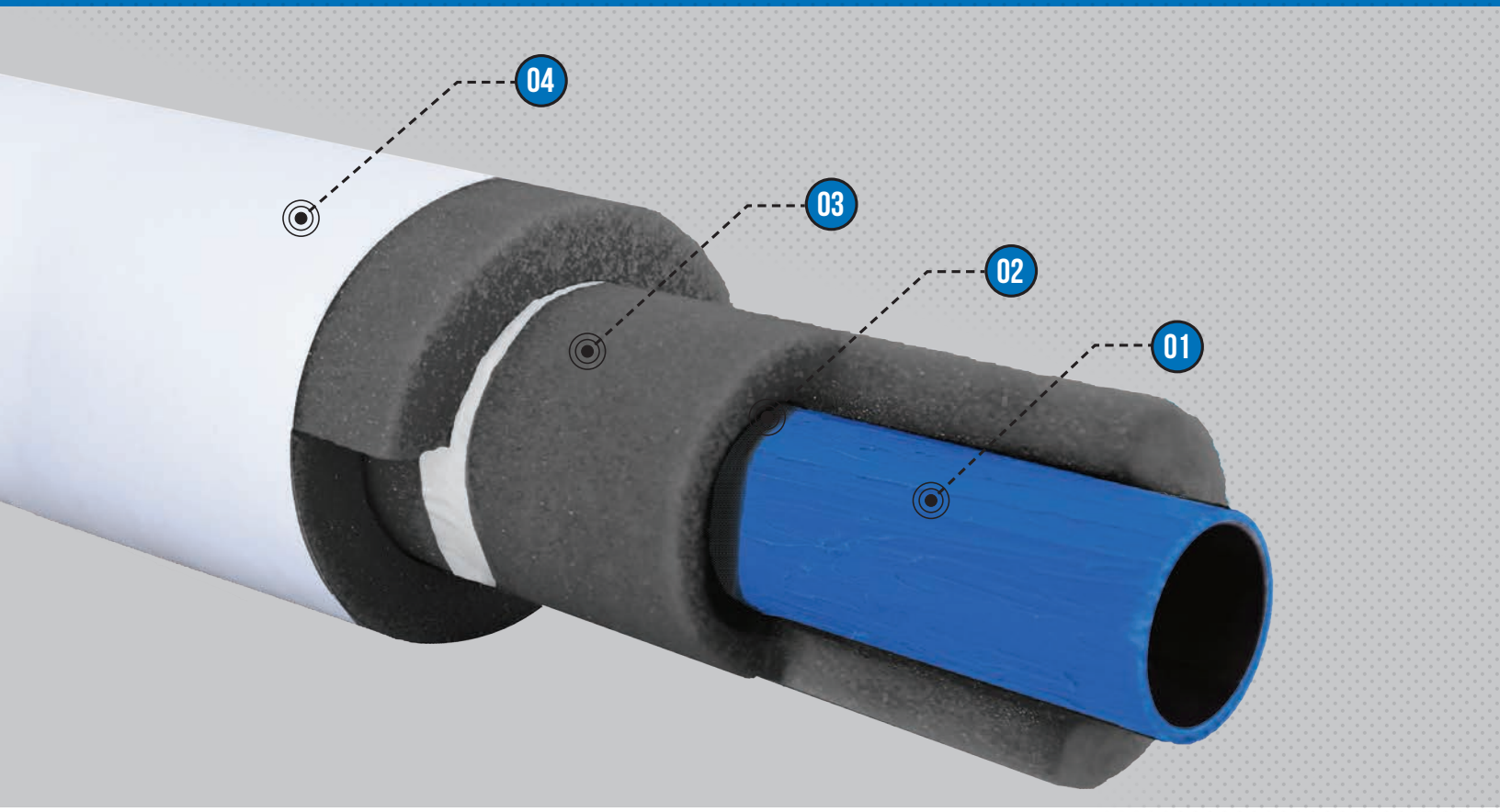


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