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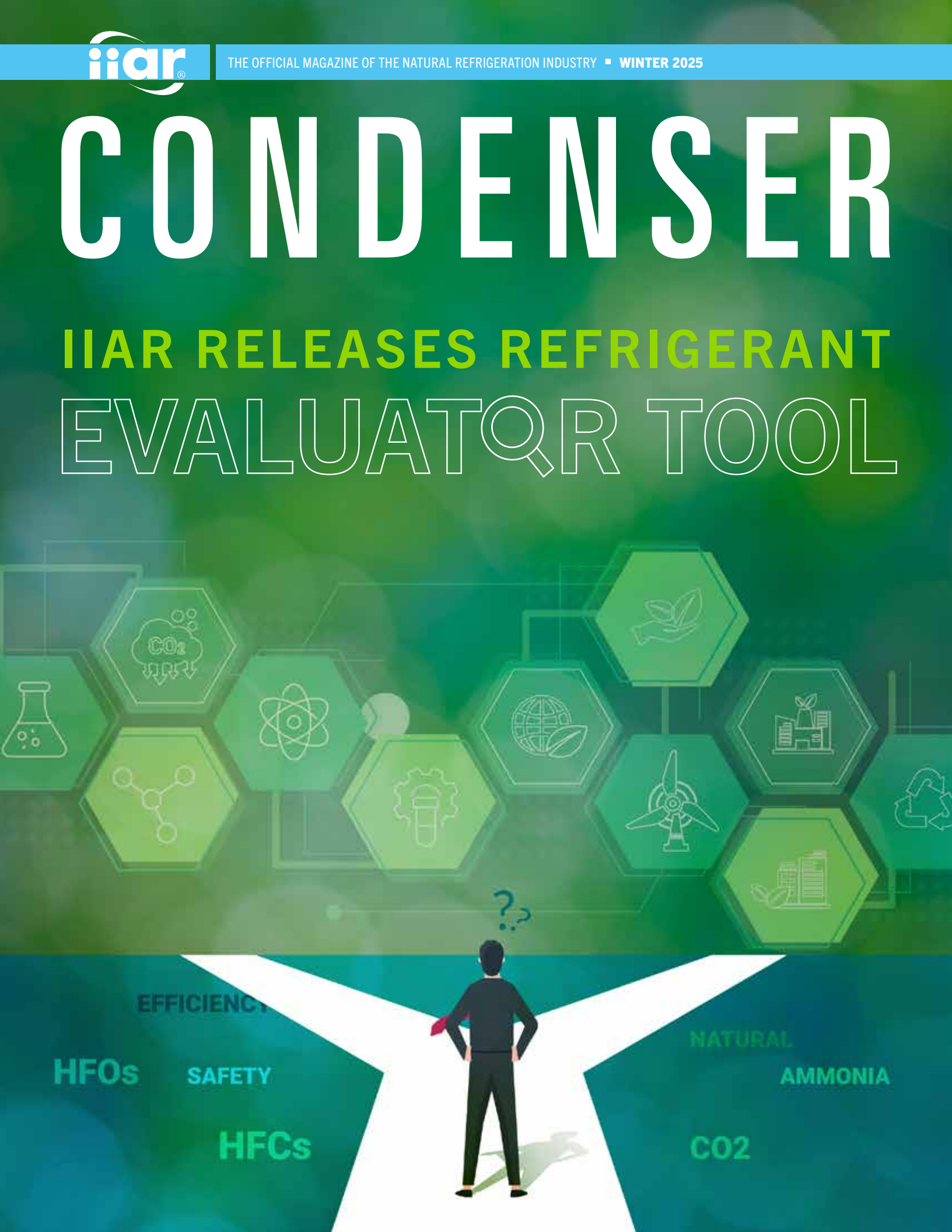
THE OFFICIAL MAGAZINE OF THE NATURAL REFRIGERATION INDUSTRY ▪ **WINTER 2025**

CONDENSER

IIAR RELEASES REFRIGERANT EVALUATOR TOOL



WINTER 2025

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08 COVER story

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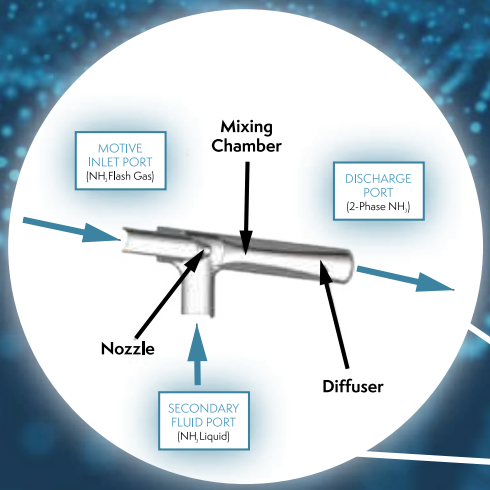

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A MESSAGE FROM OUR CONFERENCE CHAIR

Welcome to Phoenix and the 2025 IIAR Industrial Refrigeration Conference & Heavy Equipment Expo!

I'm excited to welcome you to Phoenix as part of the 47th IIAR conference. It's hard to believe that our organization recently blew past five decades of work on behalf of this industry! Much of that work happens at our annual conference, so welcoming you this year is more than just a hello, it's a call to dig in, get involved, network, and help your colleagues carry on this awesome tradition of advancing natural refrigerants here and around the world.

Now is a truly global moment for our industry. The legacy of the movement that began in 1970 with a small group of engineers who wanted to shape standards — is here. Walking through the halls of IIAR conferences in the last few years, I've noticed how we've grown into our mission. I see faces from all over the world, from different countries, ethnicities and genders. With that in mind, it's my pleasure to mark this milestone by introducing myself as your first female conference chair.

Diversity in thought, development and discussion is our great strength. As we hurtle into the next chapter — of environmental challenges, economic changes, and the need for ever more efficient and advanced technologies — our industry will be well prepared to compete.

This year, our keynote speaker, Robert Bilott, will be on hand to speak about his 20-year fight to expose the dangers of PFAS or "forever chemicals." His epic legal battle against DuPont consumed his life and exposed the worst case of corporate coverup and environmental contamination in modern history. It's a story I think we can all draw strength from as we work to advance natural refrigerants to meet the environmental needs of our planet.

Again this year, IIAR is also broadening the scope of our technical program. For the first time, we've introduced tracks to better organize our technical discussions and meet a broader range of educational needs. These new educational tracks represent a deeper dive into our subject matter and include: System Design; System Safety; Carbon Tracking/ Decarbonization; Facility Management; Heat Pumps and Intro to Refrigeration.

I'm also excited to announce that this year's conference will feature many activities designed for fun and relaxation, including an NRF-sponsored bingo tournament and the new NRF lounge where you can go Sunday through Tuesday to get some down time with colleagues, catch up on email or grab a cup of coffee.

As always, please join me in thanking your hardworking IIAR staff for completing another successful event. And if you're new here, don't hesitate to reach out, get involved and find the IIAR committee or volunteer work that makes the best use of your talent! Welcome to Phoenix and enjoy the conference.

Best Regards,

Jeanna Emmons, 2025 Conference Chair

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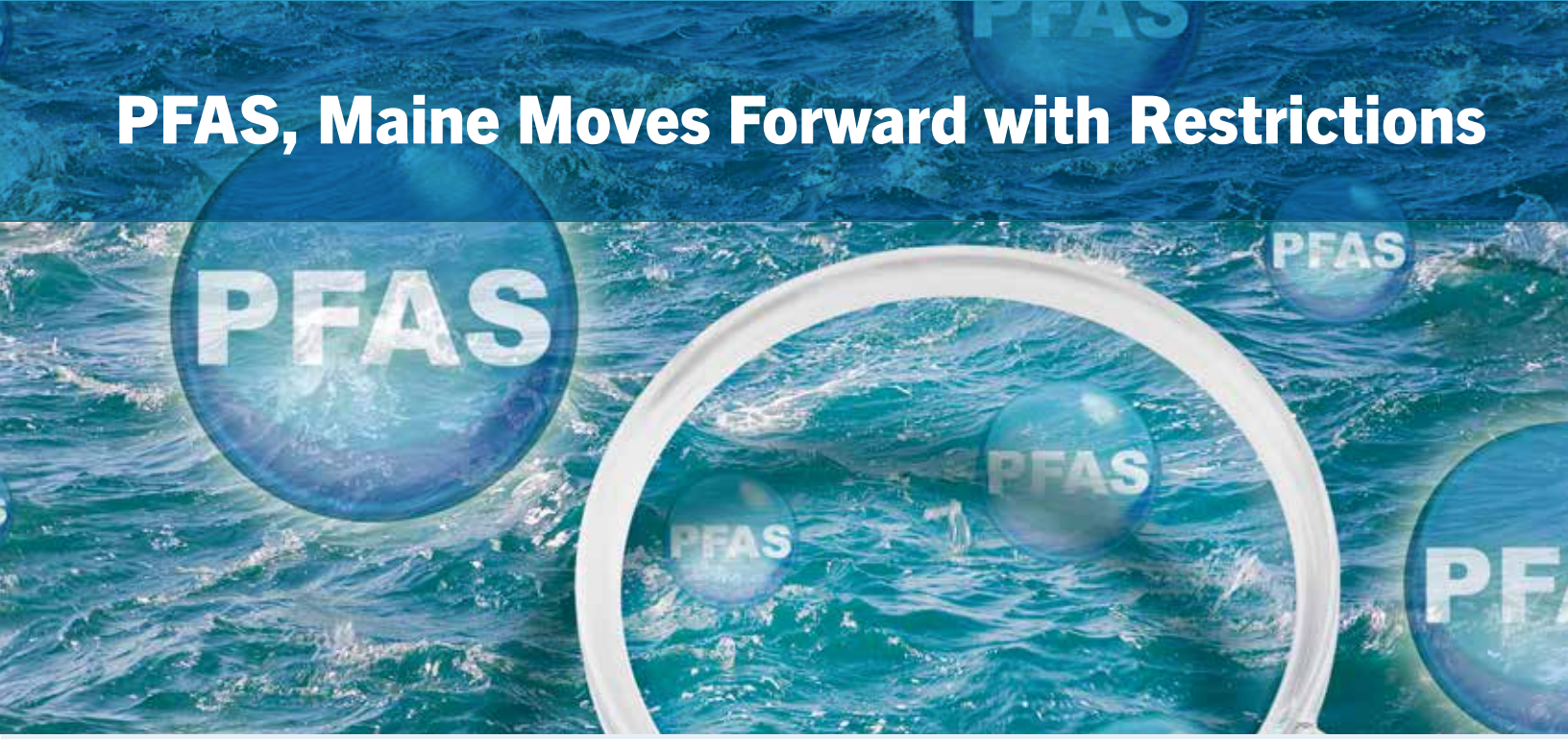

As awareness of health-related concerns surrounding per- and polyfluoroalkyl substances (PFAS) increases, more and more states are taking action to limit the use of the substances, which are often referred to as forever chemicals.

"PFAS generally, as a classification of substances, continues to draw a lot of attention and concern. How it will be addressed is to be determined, but the states are looking into it," said Tristam Coffin, co-founder, and president of sustainability, policy, and technical services, êffecterra.

Coffin said there are already options that allow end-users to avoid PFAS in refrigerants. "There is a pretty clear discussion that there are viable alternatives for every possible end use for refrigerants in particular," Coffin said. "Are there other tradeoffs involved? Yes. There are certain applications when utilizing natural refrigerants that might be more efficient than others."

STATE ACTION

The state of Maine has been at the forefront of addressing PFAS contamination. It has enacted legislation to ban the sale of certain products containing intentionally added PFAS, including specific refrigerants, foams, aerosol propellants, and heating, ventilation, air-conditioning and refrigeration equipment beginning Jan. 1, 2040.

Minnesota first passed laws restricting PFAS in 2023 and is developing a process to assess the use of PFAS in refrigerants. The state has set reporting requirements for remaining PFAS uses beginning in 2026. By 2032, Minnesota intends to ban non-essential uses of PFAS in new products, which may include certain refrigerants.

Maine and Minnesota are among several states that classify f-gases or their degradation product, trifluoroacetic acid, as PFAS. More states are expected to continue restricting the use of PFAS in various products, including refrigerants, especially if the federal government doesn't issue regulatory guidance.

NATIONAL AND GLOBAL CONSIDERATIONS

At the federal level, the U.S. Environmental Protection Agency does not classify f-gases or trifluoroacetic acid as PFAS. Additionally, the EPA has not yet proposed specific regulations concerning the use of PFAS in refrigerants, but the agency has published its "PFAS Strategic Roadmap." The roadmap outlines the schedule for conducting specific measures regarding these chemicals.

“Coffin said the European Union is still looking at PFAS in relation to refrigerants. “It will be in the next round of end-use and sector-specific reviews,” Coffin said. “They are systematically reviewing the potential impacts and cost benefits.”

COMPLYING WITH MAINE’S RESTRICTIONS

While there is plenty of time to comply with Maine's 2040 deadline banning PFAS in refrigerants, there are several ways manufacturers and end users can prepare to meet the state’s regulatory requirements. These include:

- **Assess Product Lines:** Identify products that contain intentionally added PFAS and determine the necessity of these substances in their applications.
- **Explore Alternatives:** Research and develop alternative substances or technologies that do not rely on PFAS and ensure they meet safety and performance standards.
- **Staying Informed:** Reviewing Maine DEP's guidelines and staying current on PFAS regulations can help companies comply with evolving requirements.
- **Engage with Regulatory Processes:** If a product's use of PFAS is deemed currently unavoidable, manufacturers can apply for an exemption through the DEP's "Currently Unavoidable Use" (CUU) designation. This process involves demonstrating the lack of safer alternatives and the essential nature of PFAS in the product.

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IIAR Releases Refrigerant Evaluator Tool

The International Institute of All-Natural Refrigeration has released a "Refrigerant Evaluator Tool" to help IIAR members and others assess their refrigerant choices and evaluate their options as the Environmental Protection Agency phases out high global warming potential refrigerants.

The International Institute of All-Natural Refrigeration has released a "Refrigerant Evaluator Tool" to help IIAR members and others assess their refrigerant choices and evaluate their options as the Environmental Protection Agency phases out high global warming potential refrigerants.

"End users are facing new regulations that will limit their choices for refrigerants, and the refrigerants that they are familiar with may not be an available option for them anymore," said John Flynn, the chair of the IIAR Education Committee, the committee responsible for the creation of the new tool. "The side-by-side evaluation tool can be a powerfully helpful tool for them as they compare refrigerant properties and characteristics to find the right choice for their operation."

Refrigerant choices outside of the world of natural refrigerants have gotten more complex as a result of regulatory phaseouts, making IIAR's newly released comparison tool a valuable resource for anyone trying to compare the performance and efficiency of different refrigerants.

"For us in the industrial refrigeration business, most of our customers use naturals, but some use synthetics and those customers will have to find new refrigerants," Flynn said. "The purpose of this tool is for those people to find new refrigerants and to help them evaluate their options."

End-users who aren't familiar with natural refrigerants often have concerns over safety and regulatory costs. "Many of these have been mitigated through the work of this organization and its members," Flynn said. "The concern or fear for these unknowns has largely been offset by the breadth of materials which IIAR has created for training, technical information, and design standards."

Plus, non-natural refrigerants share flammability and safety ratings now, and the regulatory gap between natural and non-natural refrigerants has largely closed.

IMPROVING DECISION MAKING

The tool allows anyone to look at a side-by-side comparison of natural and synthetic refrigerants and determine which refrigerants have the best qualities for any given installation. It provides a lot of fact-based information to help end users and contractors quickly evaluate one refrigerant

against another and includes information on natural refrigerants like ammonia, CO2, propane and other hydrocarbons alongside synthetic refrigerants.

"Having a tool that can start to direct you, even if it is just for certain applications, is brilliant. If nothing else, it starts the thought process," said Tristam Coffin, co-founder and president of sustainability, policy, and technical services, êffecterra.

The tool is designed to not only enhance end users' comparisons of refrigerants that they are choosing among but also allows them to compare those refrigerants to the refrigerant that they are already familiar with to give them context for the characteristics.

The tool displays refrigerant information across two screens. The first screen displays information for individual refrigerants, while the second screen allows a side-by-side comparison of up to three refrigerants. The format helps a facility owner make decisions like comparing safety system costs and installation costs or performing an evaluation of the full costs of installing and running a refrigeration system with a particular refrigerant.

Coffin said there are a lot of nuances between different refrigeration solutions. "When it comes to emerging technologies, there are a lot of considerations," he said. "There is a paradigm/infrastructure shift that you have to take into account."

For example, in some applications, a HFC system can be replaced with a CO2 system. "It is effectively like for like," Coffin said. "I think, in that regard, that is why you've seen the refrigeration industry make significant strides as compared to the HVAC industry, where those like-for-like applications are much less common."

HIGHLIGHTING CRITICAL DIFFERENCES

A lot of the things those in the world of natural refrigerants are accustomed to, such as ventilation, safety and venting, are things that prior synthetics did not have as concerns when they were classified as A1 refrigerants.

To get below the EPA-mandated 150 GWP limit, synthetic refrigerant blends now carry an A2L classification, which puts them in the same B2L flammability category as ammonia because of their similar flammability characteristics.

That means that "if you're using new synthetics, you have to adhere to the safety code requirements such as ventilation and refrigerant detection that are similar to the requirements that ammonia has always had," Flynn explained.

Part of the purpose and beauty of the tool is that it helps anyone who is not familiar with these requirements take them into account as they compare all the different factors that go into making a refrigerant decision. "The information the tool displays is built upon a database of information that is readily available but not all in one place, so this tool helps owners find all that information in one place," Flynn said.

The tool's information sources include the standards ASHRAE 15 and ASHRAE 34, different chapters of the ASHRAE Handbook, information from the U.S. EPA, NIST and other sources that are outlined in a fact sheet that accompanies the tool.

"With the focus on our climate and the impact refrigerants can have, this is an important time for facility owners to recognize that leaks from their systems can harm the environment," Flynn said. "Because of the steps the EPA is taking to manage releases, a time of change is coming. This tool gives everyone the information needed to help navigate that time of change and make the most informed decisions."

UNDERSTANDING THE CHALLENGES WITH SYNTHETICS

HFOs have been chemically engineered to lower the global warming potential of refrigerants using HFO components in anticipation of these climate-related regulations. "The lower GWP comes with an unfortunate cost, though, and that is flammability," Flynn said.

Most of the new refrigerants are blends of HFOs to lower GWP and HFCs to lower flammability. "However, an unanticipated consequence of HFOs is that they readily degrade into TFAs and other PFAS chemicals in the atmosphere, usually within just a few weeks of release," Flynn explained, adding that the result is these chemicals are absorbed into precipitation and contaminate our water supplies.

"One thing that we know is that on a level playing field, natural refrigerants compare favorably to other refrigerants in most applications," Flynn said. "As the regulations for safety on A2L refrigerants are shown to be similar to the requirements for ammonia, end users are more likely to base their decisions on efficiency comparisons which often favor natural refrigerants."

Owners being forced to change refrigerants because of new environmental regulatory factors may increase the weight of the likelihood of future regulations to avoid the painful process in the future in their decision-making process. Natural refrigerants are often referred to as future-proof refrigerants specifically because the probability of these refrigerants being banned or curtailed is so minuscule.

For those considering which refrigerants to use, Flynn recommends they undertake a thorough analysis and consider safety, regulatory as well as energy efficiency and other operating costs of the refrigerant. "Once all the facts are understood, the choice is usually a straightforward one," he said.

IIAR's Education Committee task force responsible for developing the refrigerant evaluator tool was led by Jose Mergolhoa and includes Caden Matson, Josh Isely, Wayne Borrowman, Chris Savage and Flynn as well as IIAR staff members Tony Lundell and Eric Smith.

The IIAR Refrigerant Evaluator Tool can be found at: https://refrigerantcomparison.com/

If you're using new synthetics, you have to adhere to the safety code requirements such as ventilation and refrigerant detection that are similar to the requirements that ammonia has always had.

Shifting Regulations and Sustainability Goals Drive Equipment Demand

The demand for industrial refrigeration equipment using natural refrigerants remains strong, driven by increased demand for cold storage capacity, regulatory requirements and corporate sustainability goals. The post-COVID supply chain challenges have eased, but lead times could increase amid uncertainties around tariffs, geopolitical disruptions, and supply and demand.

“We see both contractors and end users nervous about what tariffs will do to pricing on equipment parts and availability,” said Erik McMillan, CEO of Genemco Inc.

Harold Streicher, principal innovation officer at Hansen Technologies Corp., said lead times for equipment, compressors and valves have largely returned to normal. “Over the last three years or more, there has been a recovery,” he said, adding that while equipment is available, it may cost more.

McMillan noted that equipment prices have been on an upward trend since the COVID-19 pandemic. He added that extended lead times continue to impact certain equipment, including screw compressors, evaporative condensers, ice machines, and evaporators.

MONITORING DEMAND

In the U.S. market, CO2 equipment is ramping up fast in areas where people want an alternative to ammonia, said Monika Witt, managing director of special projects for WITT.

"The phase-out of synthetic refrigerants is just a matter of time, and, meanwhile, prices of synthetic refrigerants will increase significantly," Witt said. "It is becoming more economical to use CO2 not only because the refrigerant is cheap, but system technology has improved, and more and more technicians have learned to handle CO2 properly.”

Today, the European market is dominated by equipment for natural refrigerants. “Since refrigerants with high GWP are becoming extremely expensive and unavailable and HFOs are threatened by the PFAS regulations, only equipment for ammonia, carbon dioxide and hydrocarbons will be of interest,” Witt explained.

Witt added that she doesn't foresee an equipment shortage, but the availability of CO2 equipment could become an issue if demand explodes. “Equipment for ammonia should not be a problem since enough reliable suppliers are available for decades,” she said.

TRACKING TRENDS

In the U.S. market, McMillan has observed a shift among end users replacing reciprocating compressors with screw compressors. “Many clients prefer to retain some reciprocating compressors because they offer greater flexibility in ramping capacity up and down, whereas screw compressors require more stability,” he explained.

Another key trend is the move away from halocarbons and Freon-based refrigerants in industrial engine rooms, with many companies transitioning to ammonia. However, McMillan pointed out that regulatory restrictions or long approval times for ammonia systems can sometimes limit this transition. “I’m also seeing increased PSI requirements for evaporators and vessels as regulations evolve to enforce higher safety and testing limits,” he added.

Additionally, more companies are open to sourcing equipment from China. “This trend is particularly pronounced in Central and South America due to cost considerations, but we’re also beginning to see more U.S. projects incorporate Chinese equipment,” McMillan noted. “However, this could shift if new tariffs on Chinese imports to the U.S. are enacted.”

TAPPING INTO THE SECONDARY MARKET

When faced with long equipment lead times, end users and contractors often turn to used equipment as an immediate solution. “Purchasing second-hand or refurbished equipment—whether removed from an operational plant or rebuilt with a warranty—can be a great way to get back up and running quickly,” McMillan said.

Recently, McMillan has observed a growing trend of companies utilizing used evaporative condensers to replace units with leaks or failures in the field. However, he noted that the key challenges include quickly locating a suitable replacement, ensuring timely delivery, and confirming that the unit will perform as required for the application.

To address these challenges, Genemco is developing a priority spares program, maintaining mission-critical, rebuilt equipment in stock for rapid shipment when needed. “If you have $10 million in inventory that needs to stay frozen, why take the risk of losing product due to a compressor failure?” McMillan said.

Witt said that ammonia equipment should be available second-hand without any issues. However, since carbon dioxide is relatively new to the U.S. market, used equipment is most likely difficult to get.

In Europe, users can utilize rental equipment during unexpected downtimes or short remodeling periods of the system. However, rental costs are fairly high. "A permanent, good-designed system should pay off within a short period of time," Witt added.

QUICK TIPS FOR ACCESSING USED EQUIPMENT

When new equipment is difficult to source, used equipment can provide a faster solution to keep operations running. Erik McMillan, CEO of Genemco Inc., shared key strategies for securing the right used equipment quickly.

- **Buy refurbished, rebuilt, and tested used equipment with a warranty or guarantee.** Installing a quality used option can get operations back online quickly.
- If possible, repair and rebuild the failed equipment to have it delivered as a backup, ensuring redundancy in case of future failures.
- Use a phased replacement approach. Install a used unit to restore operations while waiting for new equipment to arrive. Once the new equipment is available, replace the used unit and either:
  - > Retain the used equipment for redundancy or deploy it in another facility, or
  - > Sell or trade the used equipment if no longer needed.
- Consider short-term rental agreements. If the need for temporary equipment is time-sensitive, work with a used equipment provider to establish a rental agreement, including shipping and pickup logistics.

These strategies help mitigate downtime, provide backup solutions, and offer flexibility in managing equipment transitions.

New York State Finalizes Rules Limiting HFCs

The New York State Department of Environmental Conservation (DEC) has finalized regulations required by the Climate Leadership and Community Protection Act to reduce emissions from hydrofluorocarbons (HFCs) and sulfur hexafluoride (SF6).

"New York has aligned with, but in a lot of respects, also gone above and beyond California and Washington. It isn't that New York is necessarily ahead of California, but they moved similar rules forward largely in one fell swoop, given the precedent California set over a longer period of time," said Tristam Coffin, co-founder and president sustainability, policy, and technical services, êffecterra.

The new requirements are designed to help phase down the use of HFCs and SF6 over time and bolster the use of alternatives that are better for public health and the environment and more cost-effective for impacted businesses, said Sean Mahar, interim commissioner of the DEC.

> The New York state refrigerant regulation is the most complex refrigerant regulation in the country.

HFC STANDARDS

The amendment to HFC Standards and Reporting under Part 494 of the New York Codes, Rules, and Regulations introduces stringent prohibitions, usage restrictions, and reporting requirements for HFC refrigerants.

The New York DEC said the amendments are based in part on the U.S. Environmental Protection Agency's regulations implementing the American Innovation and Manufacturing Act, as well as recommendations in New York State that support establishing a GWP threshold for refrigerants, as well as reducing HFC emissions from equipment leakage.

"The New York state refrigerant regulation is the most complex refrigerant regulation in the country," said Keilly Witman, department lead of the Refrigerant Management Solutions Group at DC Engineering.

Some aspects of the final rule caught the industry by surprise, including the sales prohibition. "From a language and application perspective, they borrowed from the State of California, including even referencing California Health & Safety Code," Coffin said.

The final rule issued phaseout schedules based on the type of equipment and substances charged. HFCs with higher global warming potential and systems with larger charge capacities had prohibition dates ranging from "the effective date" of the rule—Dec. 23, 2024—through 2034. The rule also stated that the charging of HFCs and installation of any systems that utilize regulated substances are prohibited as of the prohibition date.

Some of the compliance dates were stricter than expected. Witman said one of the most important things for those in the industry to know is that they already need to be in compliance. "Our industry is used to final regulations coming out six months to a year

prior to compliance deadlines. We found out about this regulation on Dec. 23, 2024, and compliance began on Jan. 9, 2025.

Such tight deadlines created concerns within the industry and for end users. "Even the companies that are trying to do the right thing still need access to certain refrigerants to run their business. Potentially not having access to them as a result of a sales prohibition that goes into effect very abruptly creates challenges," Coffin said, adding that the DEC recently issued an Enforcement Discretion letter effectively pushing the prohibition dates out, which aligns with their overall intent to support the industry with these changes.

The amended regulation does not require the replacement of existing equipment prior to the end of its useful life. However, it does outline leak inspection frequency and methodology, and, as of Dec. 23, 2024, equipment with a charge capacity greater than 1,500 pounds requires monthly leak inspections. It also includes registration and labeling requirements beginning on June 1, 2025.

Witman said some of the requirements in the regulations are already requirements under the federal regulations, so complying with those shouldn't be an issue. "Other requirements are things that any responsible refrigerant end-user was already trying to do," she added. "For instance, I don't know anybody who can afford to just let their appliances leak for any number of days."

It's the parts of the regulation that are completely new that will be problematic to accomplish within the time frames of the regulation. "The requirement to label existing equipment by June 1, 2025, or June 1, 2026, depending on the full charge, is going to be very challenging given the technician shortage," she said. "Also challenging is the fact that retailers will need lists of each appliance's specified components for the respective registration deadlines."

Most retailers don't have lists of their condensing units, condensers, compressors, evaporator units, and evaporators for each appliance, so Witman said technicians will be very busy gathering all of that data. "Unfortunately, all the time that technicians are out there labeling all that existing equipment and creating lists of specified components is time that is not spent on leak repair, inspections, and carrying out best practices," she added.

To help small businesses comply with the phaseout, DEC is finalizing the development of a new grant program. Grant availability and additional details will be provided later this year.

"With these regulations, New York State is sending clear market signals that will drive industries away from these climate super pollutants and towards alternatives that are compatible with a stable climate future," said Richie Kaur, senior super pollutant reduction advocate at the Natural Resources Defense Council. "These regulations would largely phase out the use of hydrofluorocarbons and sulfur hexafluoride over the next two decades, in alignment with New York's ambitious climate targets, making them a prime example of what decisive climate action looks like."

CONTINUED STATE ACTION

Coffin said there is a general consensus that there is a tremendous opportunity to reduce harmful emissions from refrigerants. In late 2024, êffecterra looked at state-level action, including building codes related to refrigerants. "There has been a ton of movement. Not to the extent New York has moved, but they are moving forward," Coffin explained.

State-level action may increase if the federal government is paring back its oversight and intent to address climate change. "If the refrigerants are being phased down, and they are, proper management is critical," Coffin said.

Differing state and federal requirements can make it difficult for end users to know what avenue to pursue. "Creating a patchwork of regulatory action is bad for business but necessary in the absence of federal leadership," Coffin said.

GOVERNMENT RELATIONS

BY LOWELL RANDEL, IIAR GOVERNMENT RELATIONS DIRECTOR

TRUMP STARTS SECOND TERM
with Flurry of Executive Orders

PUTTING AMERICA FIRST IN INTERNATIONAL ENVIRONMENTAL AGREEMENTS

Similar to Trump's first term, he has taken action to withdraw the United States from international environmental agreements. This order directed the immediate withdrawal from the Paris Agreement under the United Nations Framework Convention on Climate Change. It also calls for withdrawal from any agreement, pact, accord, or similar commitment made under the United Nations Framework Convention on Climate Change.

It is unclear at this point whether the Trump Administration will move to roll back actions taken under the AIM Act to phase down HFCs, consistent with the Kigali Amendment to the Montreal Protocol. The Aim Act had bipartisan support when it passed Congress, and several key rules, such as the Technology Transitions Rule, have been finalized for some time. However, a recently enacted rule entitled Management of Certain HFCs and Their Substitutes Under the AIM Act is still currently in the window for potential cancellation under the Congressional Review Act (CRA). The CRA is a tool that allows Congress to cancel regulations finalized within a certain timeframe. Passage requires a simple majority in the House and Senate and presidential signature. CRA's use has historically come after a change in administration, such as the current situation.

REGULATORY FREEZE AND UNLEASHING PROSPERITY THROUGH DEREGULATION

As is typical of incoming administrations, Trump has placed a temporary freeze on rulemaking activity. He has directed agencies not to propose or issue any rule in any manner until a department or agency head appointed or designated by the President reviews and approves the rule. Any rules sent to the Federal Register under the Biden Administration but not published were Immediately withdrawn for review. Any rules published but that had not taken effect were postponed to review any questions of fact, law, and policy that the rules may raise.

In addition to a temporary freeze, Trump issued an order stating that it is the policy of his Administration to significantly reduce the private expenditures required to comply with Federal regulations to secure America's economic prosperity and national security and the highest possible quality of life for each citizen. To that end, it will be the policy of the Trump Administration that for each new regulation issued, at least 10 prior regulations be identified for elimination. The new practice is intended to ensure that the cost of planned regulations is responsibly managed and controlled through a rigorous regulatory budgeting process. Going forward, whenever an agency publicly proposes a new regulation, it shall identify at least 10 existing regulations to be repealed. Further, heads of all agencies have been directed to ensure that the total incremental cost of all new regulations, including repealed regulations, being finalized this year, shall be significantly less than zero, as determined by the Office of Management and Budget. The new policy may be used by agencies such as EPA to roll back regulations instituted during the Biden Administration, such as the Safer Communities by Chemical Accident Prevention, which amended the Risk Management Program.

DEPARTMENT OF GOVERNMENT EFFICIENCY

Trump has created a new Department of Government Efficiency (DOGE), led by Elon Musk, to identify ways to make the government more efficient and reduce federal expenditures. DOGE is placing personnel in all federal Departments and

It is unclear at this point whether the Trump Administration will move to roll back actions taken under the AIM Act to phase down HFCs, consistent with the Kigali Amendment to the Montreal Protocol.

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The Phoenix Convention Center, Phoenix, Arizona March 2-5, 2025

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- M&M Carnot CO_2 presentation 10:55 a.m. to 11:20 a.m.

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 (continued from page 14)

reviews of spending are currently underway. Trump placed a blanket freeze on federal programs, which was challenged in court and subsequently withdrawn. However, some programs remain frozen and DOGE has already identified a significant number of programs for cancellation.

HIRING FREEZE, RETURN TO WORK AND REDUCTION IN FEDERAL WORKFORCE

The Trump Administration is taking aggressive steps to transform the federal workforce beginning with a hiring freeze and mandating that all workers return to the office in-person. Heads of all departments and agencies in the executive branch of Government are directed to take all necessary steps to terminate remote work arrangements and require employees to return to work in-person at their respective duty stations on a full-time basis.

In an effort to reduce the federal workforce, the Office of Personnel Management sent federal employees a buyout offer allowing them to resign immediately and retain their pay and benefits through September 30, 2025. It has been reported that approximately 75,000 employees (roughly 3% of the federal workforce) accepted the offer. Once the offer closed, agencies began to implement "reductions in force," starting with probationary employees. The total number of employees being targeted for reduction is not clear at this time, but Administration officials have indicated that further efforts to reduce the workforce are expected. Once the hiring freeze is lifted, agencies will be permitted to hire no more than one employee for every four employees that depart. Changes to the federal workforce could impact how regulatory agencies conduct enforcement and engage with industry.

TARIFFS

Another policy area that has been subject to numerous executive actions is the use of tariffs. During the campaign, Trump indicated his intention to utilize tariffs to achieve policy goals as well as rebalance what he sees as unfair trade relationships. Trump has ordered 25 percent tariffs on Canada and Mexico to pressure them to focus more resources on border security and addressing fentanyl trafficking. Those tariffs were paused for 30 days as both countries committed to dedicating additional resources to the border. China has also been hit with an additional 10 percent tariff on imports, citing its role in the production and movement of fentanyl. New 25 percent tariffs have also been placed on all aluminum and steel imports, similar to a move Trump made during his first term. Trump is also taking action to implement reciprocal tariffs on countries that are currently placing tariffs on American goods. Depending on the duration of the tariffs and expected retaliatory measures taken by trading partners, it is expected that inflationary pressures will mount. This could impact food prices, materials needed for construction, and a variety of other goods.

While it is too early to know the longer-term impacts of Trump's early executive actions, it is clear that his administration is working to transform how the federal government does business. IIAR will continue to keep members updated as policies and actions evolve.

Financial Tech Tip

Charitable giving can take many forms. Whether you gift on an annual basis or you are planning to make a one-time gift, make sure you are maximizing the tax benefits associated with your gift. One way to do this is to compare gifting cash versus stock.

Most people donate to charity in the form of cash. This can be a huge mistake, especially if they hold securities with unrealized long-term gains. Donating appreciated stock is a cashless transaction that yields additional tax benefits to the donor. First, the donor receives an itemized deduction equal to the fair market value (FMV) of the stock. FMV is calculated as the high-low average of the stock price on the day contributed. This deduction is limited to 30% of the donor's adjusted gross income (AGI) for gifts to public charities. Any amount over the 30% AGI limitation can be carried forward for a maximum of five years. Second, the donor does not have to realize the gain on appreciation of the securities. That is a savings of up to 20% in capital gains tax and another 3.8% in net investment income tax. Remember, this is for stock with a long-term holding period.

Below is a side-by-side comparison showing the benefits of donating appreciated stock.

	DONATE CASH	SELL STOCK TO DONATE CASH	DONATE STOCK
Adjusted Gross Income (AGI)	$750, 000	$750,000	$750,000
Fair Market Value (FMV) of Gift[1]	$25,000	$25,000	$25,000
AGI Limit	60%	60%	30%
Charitable Deduction	$25,000	$21,430[2]	$25,000
Cash Required	$25,000	$0	$0
Capital Gains Tax	$0	$3,570[3]	$0

[1] Assume 1,000 shares with a cost basis of $10 and a high-low average on the day of contribution of $25.

[2] Assume that cash remaining after taxes are paid has been donated. See footnote three below. ($25,000 - $3,570)

[3] Tax is computed based on the maximum capital gains rate of 20% plus the 3.8% net investment income tax ($15,000* 23.8%).

It's clear that donating long-term appreciated securities is a more tax-efficient way to donate to charity, yet very few taxpayers utilize this strategy. It may be because donors do not realize they can contribute securities to charity or because they want to continue to maintain their current holdings. If you wish to continue to own the stock of a particular company, you can utilize the cash that you would otherwise be donating to charity to repurchase the stock at the current FMV. This effectively generates a charitable deduction and avoids a taxable event, yet allows you to reestablish your desired position at a higher cost basis, allowing you to continue participating in growth and dividends.

IMPORTANT DISCLOSURES

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

Stifel does not provide legal or tax advice. You should consult with your legal and tax advisors regarding your particular situation.

These materials are provided for general information and educational purposes based upon publicly available information from sources believed to be reliable — we cannot assure the accuracy or completeness of these materials. The information in these materials may change at any time and without notice.

IIAR Takes its Training on the Road for Trident Seafoods

IIAR serves as a valuable resource for education and training for its members, and took its training on the road, sharing information on IIAR, codes, standards, guidelines, and operational, testing and maintenance situations with end users from Trident Seafoods in Alaska.

Tony Lundell, senior director of standards and safety for IIAR, traveled to Wrangell, Alaska, to lead the training, which took place Oct. 1 through 3.

Bill Jensen, division manager of refrigeration for Trident Seafoods, said Alaska's remote location could make it difficult for employees to attend the IIAR conference, so remote workshops give team members the proper exposure to new standards and in-person interaction with industry experts.

Lundell discussed a range of topics, including an update on the IIAR Suite of Standards that covered the nine Ammonia Refrigeration Standards, the Safety Standard for Carbon Dioxide, and the Safety Standard for Closed-Circuit Refrigeration Systems Utilizing Hydrocarbon Refrigerants. He also discussed the General Duty Clause and enforcement awareness, the differences between PSM and RMP requirements, ammonia transfer and permanent hoses, and mechanical integrity, inspection, testing, and maintenance.

As part of the session, Lundell also presented a summary of Natural Refrigerant Codes and Standards that went in depth pertaining to a Road Map, Significant New Alternatives Policy (SNAP) Team purpose to EPA, and the details of the IIAR HC Standard in Development for Propane (R290), Butane/N-Butane (R600), and Isobutane (R600a) for using in systems larger than listed equipment and appliances.

"We also did a tour of the Wrangell facility, machinery room, and practice for applying ITM tasks," Lundell said.

ONGOING EDUCATIONAL OPPORTUNITIES

The refrigeration industry has different levels of operators, different levels of technicians, different levels of Process Safety Management (PSM) coordinators, different levels and types of engineers, and different levels of Environmental, Health and Safety (EHS) employees that benefit from the information and teachings provided in the different standards, certificate classes, and webinars.

IIAR members can take advantage of several useful resources from IIAR to aid in their education and training efforts, including self-taught and self-paced training programs that are available online through the online Academy of Natural Refrigerants (ANR) certificate courses and online video series classes. IIAR also offers technical programs at conferences, online webinars and, at times, in-person onsite training.

IIAR considers in-person training opportunities if members have a developed program and could use the support of IIAR as part of their program. Participation is dependent on staff members' expertise and availability and members cover the costs for IIAR staff travel and living expenses.

IIAR STANDARDS UPDATE

BY TONY LUNDELL, CIRO, PMP, IIAR SENIOR DIRECTOR OF STANDARDS AND SAFETY

IIAR 1: ANSI/IIAR 1-2022 Standard for Definitions and Terminology Used in IIAR Standards is presently in effect. It will be opened up for review starting in mid-2026 for its next revision with a targeted completion with ANSI approval in 2027. Jake Denison serves as the IIAR 1 subcommittee chair and Tony Lundell, senior director of standards and safety at IIAR, is the IIAR staff facilitator. An IIAR 1 future revision considerations (FRC) list has captured suggestions and considerations for its next revision.

IIAR 2: ANSI/IIAR 2-2021 Standard for Design of Safe Closed-Circuit Ammonia Refrigeration Systems is presently in effect. It will be opened up for review in late 2024 for its next revision with a targeted completion with ANSI approval in 2027. Mark Bazis Jr. is the IIAR 2 subcommittee chair, Eric Smith is vice president and technical director at IIAR, and Matt Chojnacki, Tony Lundell, and Eric Smith are the IIAR staff facilitators. An IIAR 2 FRC list has captured suggestions and considerations for its next revision. The IIAR 2 Subcommittee is starting a meeting to review the captured suggestions and considerations to develop responses and make changes if determined are needed.

IIAR 3: ANSI/IIAR 3-2022 Ammonia Refrigeration Valves is presently in effect. It will be opened up for review starting in mid-2026 for its next revision with a targeted completion with ANSI approval in 2027. Michael Trumbower is presently the IIAR 3 subcommittee chair, and Lundell is the IIAR staff facilitator. This standard provides minimum "performance criteria" requirements for ammonia refrigeration valves and strainers that are used in closed-circuit ammonia refrigeration systems. AN IIAR 3 FRC list has captured suggestions and considerations for its next revision.

IIAR 4: ANSI/IIAR 4-2020 Standard for the Installation of Closed Circuit Ammonia Refrigeration Systems is presently in effect. It will be opened up for review starting in early 2025 for its next revision with a targeted completion with ANSI approval within 2025. Brian Alleman is the IIAR 4 Subcommittee Chair. Lundell is the IIAR staff facilitator. An IIAR 4 FRC list has captured suggestions and considerations for its next revision. IIAR 4 will be opened up for its next revision after IIAR 5, IIAR 6, & IIAR 7 2025 revisions are completed.

IIAR 5: ANSI/IIAR 5-2019 Standard for the Startup of Closed-Circuit Ammonia Refrigeration Systems is presently under revision. The IIAR 5 Subcommittee reviewed the comments and questions that were received in the pre-public review. The second (2nd) Public Review ended on October 25, 2024, receiving comments that are being reviewed. A third public review is targeted to occur in late 2024/ early 2025. The IIAR 5 revision is targeted for its completion with ANSI approval in early 2025. Nick Nechay serves as the IIAR 5 subcommittee chair, and Lundell is the IIAR staff facilitator. The revision addresses the standard to harmonize items with IIAR 2, IIAR 4, IIAR 6, and IIAR 7. The third (3rd) public review (less than ½ a page) started on February 21, 2025, and ends on March 23, 2025. The target is to submit IIAR 5, as well as IIAR 6 & IIAR 7, at the same time for approvals to all be 2025 revisions.

IIAR 6: ANSI/IIAR 6-2019 Standard for Inspection, Testing, and Maintenance of Closed-Circuit Ammonia Refrigeration Systems is presently under revision. The IIAR 6 Subcommittee reviewed the comments and questions that were received in the pre-public review. "Functional Testing" of equipment, components, and/ or devices to clarify expected results was included, and an "out of service" section was added to sustain the minimum requirements of IIAR 6 while a closed-circuit ammonia refrigeration system is shut down for an off-season, such as down/off seasons for fruit and/or vegetable harvesting or for down/off seasons for fish catching (seafood). The second public review ended on October 25, 2024, and comments were received that are being reviewed. A third public review is targeted to occur in late 2024/ early 2025. The IIAR 6 revision is targeted for its completion with ANSI approval in early 2025. Jeff Sutton is the IIAR 6 subcommittee chair, and Lundell is the IIAR staff facilitator. The revision addresses the standard to harmonize items with IIAR 2, IIAR 4, IIAR 5, and IIAR 7. The third (3rd) public review (less than five pages) started on February 7, 2025, and ends on March 9, 2025. The target is to submit IIAR 6, as well as IIAR 5 & IIAR 7, at the same time for approvals to all be 2025 revisions.

IIAR 7: ANSI/IIAR 7-2019 Standard for Developing Operating Procedures for Closed-Circuit Ammonia Refrigeration Systems is presently under revision. The IIAR 7 Subcommittee reviewed the comments and questions that were received in the pre-public review. Several discussions have occurred to address regulated (i.e., PSM/RMP systems, larger systems with 10,000 lbs. or more) and non-regulated (i.e., General Duty Clause, smaller systems with less than 10,000 lbs.) sized closed-circuit ammonia refrigeration systems and addressed normative material versus informative/explanatory material. The first public review is targeted to be completed by yearend in 2024, and the ANSI Approval is targeted for completion by early-to-mid 2025. Lesley Schafer is the IIAR 7 subcommittee chair, and Lundell is the IIAR staff facilitator. The revision addresses the standard to harmonize items with IIAR 2, IIAR 5, and IIAR 6. The target is to submit IIAR 7, as well as IIAR 6 & IIAR 7, at the same time for approvals to all be 2025 revisions.

IIAR 8: ANSI/IIAR 8-2020 Standard for Decommissioning of Closed-Circuit Ammonia Refrigeration Systems is presently in effect. It will be opened up for review starting in early 2025 for its next revision with a targeted completion with ANSI approval within 2025. Lesley Schafer is presently the IIAR 4 subcommittee chair, and Lundell is the IIAR staff facilitator. AN IIAR 8 FRC list has captured suggestions

and considerations for its next revision. IIAR 8 will be opened up for its next revision after IIAR 5, IIAR 6, & IIAR 7 2025 revisions are completed.

IIAR 9: ANSI/IIAR 9-2020 Standard for Minimum System Safety Requirements for Existing Closed-Circuit Ammonia Refrigeration Systems recently had an Addendum A developed to address a scope change and an interpretation, provide a clear compliance deadline, address some simple edits, and provide an informative flow chart. Also, an IIAR 9 Checklist was developed as a tool. It will be opened up for its next revision with a targeted ANSI approval within 2025. Eric Johnston is the IIAR 9 subcommittee chair, and Lundell is the IIAR staff facilitator. IIAR 9 will be opened up for its next revision after IIAR 5, IIAR 6, & IIAR 7 2025 revisions are completed.

CARBON DIOXIDE (IIAR STANDARD):

IIAR CO2: ANSI/IIAR CO2-2021 Safety Standard for Closed-Circuit Carbon Dioxide Refrigeration Systems is presently in effect. Presently, an **IIAR CO2 Addendum** is under consideration for Relief Device Capacity by a Task Group. The Task Group has been meeting weekly and is considering that it may be most appropriate to propose a hybrid approach toward defining "Mair" requirements. The sections pertaining to the Relief Device Capacity are in Chapter 11, and the informative material is in Appendix A. At this time, the latest material for the Addendum's proposed approach for consideration is being targeted to be presented at the upcoming Standards Committee Meeting in Phoenix, AZ, on March 2, 2025, during the IIAR 2025 Conference.

After the Addendum consideration is address, the IIAR CO2 Standard will be opened up in mid-2025 for its next full review and full revision. John Collins is the IIAR CO2 subcommittee chair and Lundell is the IIAR staff facilitator.

HYDROCARBONS (STANDARD IN DEVELOPMENT):

IIAR HC: IIAR HC-202x Safety Standard for Closed-Circuit Refrigeration Systems Utilizing Hydrocarbon Refrigerants is a standard presently in development. This standard pertains to utilizing "natural" hydrocarbon refrigerants that have zero ozone-depleting potential and ultra-low global warming potential. The committee reviewed and developed responses to one hundred-sixty-one (161) comments received during the first public review. Joseph Pillis is the IIAR HC subcommittee chair, and Lundell is the IIAR staff facilitator. The IIAR HC's second public review started on October 25, 2024, and ended on December 9, 2024, which received fifteen (15) comments. Responses to the comments were developed, with nine (9) being "Resolved" on the first pass. Six (6) developed responses that pertain to two commenters are under discussion. Once all fifteen (15) public review #2 comments are resolved/addressed, a third (3rd) IIAR HC public review will occur, showing substantive changes resulting from the second (2nd) public review, which is anticipated to be out in early-to-mid 2025. This standard in development is targeted for ANSI Approval within 2025.

IIAR Marked Notable Accomplishments Throughout 2024

IIAR staff and IIAR's many volunteer committees were hard at work throughout 2024 and have strengthened the membership offerings, provided valuable education, and furthered the organization's mission through advocacy, work with regulatory agencies and new partnerships.

INDUSTRY OUTREACH

Gary Schrift, president of IIAR, said the association has been focused on outreach. "We've been taking the tools that we developed, standards, our guidelines and our training programs and making them broader and more well known to the industry, both within the U.S. and abroad," he said. "We have also been focused on making connections with other organizations, including those in academia and government, and the hope is that we can bring all groups even closer together."

As part of that outreach, IIAR has entered into memorandums of understanding with several agencies, including the Instituto Nacional de Tecnología, Normalización y Metrología (INTN) in Paraguay, the International Institute of Refrigeration in Paris, France, and the North American Sustainable Refrigeration Council in the U.S.

The number of scholarships IIAR offered for the 2024-2025 fiscal year increased, connecting more students with the industry. IIAR issued 12 new and seven returning scholarships.

MEMBERSHIP ENHANCEMENTS

Staff continued their focus on creating value for members. Membership enhancements included adding more videos and classes. Plus, IIAR offered 12 webinars in 2024, took part in three Latin American educational conferences and exhibitions and offered in-person IIAR ANR Certificate Course Training at RETA.

The association launched the Refrigerant Evaluator Tool to allow users to compare different refrigerants. "The Refrigerant Evaluator Tool was done in record time by several committees—the Education Committee, Research Committee, the Marketing Committee, and others. It's online for the world to see," Schrift said.

Staff also updated the Natural Refrigerant Directory website. The directory now includes an advanced search function, making it easier for someone to locate a natural refrigerant expert by location, product or service, or type of company. "We're working to provide more member value without any increases in costs," Schrift said.

CONFERENCE CHANGES

Education is a top priority for IIAR, and the association has made several changes to its conference, doubling the number of session programs and creating tracks, including a basic natural refrigeration track for end users and students who are not experts in the field.

"With the conference enhancements, we listened to our surveys and made changes based on the feedback we've gotten," Schrift said.

IIAR Welcomes New Board Members

IIAR has welcomed new members to its board of directors and the executive committee for the 2025-2026 term. The IIAR board plays a critical role in strategic planning and advancing the association's initiatives.

Wayne Webber with Vilter Manufacturing will serve as chairman. "Wayne has been an integral part of IIAR forever. He has spent a lot of time as chairman of the Research Committee, which is one of our most active committees and is crucial to supporting our Natural Refrigeration Foundation," said Gary Schrift, president of IIAR.

Mike McGinnis with Innovative Refrigeration has finished his term as chairman and will serve as the immediate past chair and will serve as chair of the Natural Refrigeration Foundation. Jeanna Emmons of PSM RMP Solutions has moved into the chair-elect position, while Lesley Schafer of C&S Wholesale Grocery will serve as vice chair. Miguel Garrido of Gunter U.S. has been appointed treasurer, rounding out the executive committee.

Schrift said many of IIAR's 18 board members also serve as committee chairs. "Committee chairs are moving a lot of the work forward. They're having monthly committee meetings, deciding on initiatives, and getting those initiatives underway," he explained.

IIAR'S 2025-2026 EXECUTIVE COMMITTEE AT A GLANCE

Chair: Wayne Webber, Vilter Manufacturing

Immediate Past Chair: Michael McGinnis, Innovative Refrigeration

Chair-Elect: Jeanna Emmons, PSM RMP Solutions

Vice Chair: Lesley Schafer, C&S Wholesale Grocery

Treasurer: Miguel Garrido, Guntner U.S.

President: IIAR: Gary Schrift

IIAR'S 2025-2026 BOARD MEMBERS AT A GLANCE

David Blackhurst, Star Refrigeration

Glen Heron, Tyson Foods Inc.

Kurt Liebendorfer, Evapco Inc.

Jeff Sutton, Mr. Ammonia Refrigeration Inc.

Mark Bazis, Jr., Refrigeration Consultants Inc.

Mark Wisniewski, Target Corp.

Gary Elk, Western Precooling Systems

Michael Lynch, United States Cold Storage Inc.

Nick Nechay, Independent Refrigeration Service Inc.

John Flynn, General Refrigeration

Joe Fazzari, Colmac Coil

Peter Thomas, Resource Compliance Inc.

Don Faust, Frick Industrial Refrigeration

Doug Scott, Claudius Lynn

Stephanie Smith, Risk Management Professionals Inc.

Todd Jekel, University of Wisconsin-Madison

Maxime Girot, Clauger, Mexico

David Fauser, CIMCO Refrigeration

TECHNICAL PAPER #5

Cues and Confirmation Your Piping is in Jeopardy:

A Comparison of 20+ Years of NDT Data with Field Observations

SUZY VOHSEN, DIRECTOR, MARKETING AND CLIENT SERVICES
LIXI, INC., AND GAMMA GRAPHICS SERVICES (GGS)

ABSTRACT

Ammonia refrigeration system managers are looking for more useful information regarding risk mitigation and compliance because they need to determine whether components are fit for service or vulnerable to damage, and when to act. Insulated piping is subject to corrosion under insulation (CUI), but some piping is more vulnerable depending on location, orientation, and/or function. A simple and affordable approach to regularly monitor the state of piping would be a useful tool for large industrial refrigeration facilities.

Refrigeration piping data from 20+ years of non-destructive testing (NDT) were directly compared with documented field observations, and specific physical characteristics were considered to identify patterns and validate evidence of weakness based on common factors. This quantitative information enabled the verification of primary CUI breeding locations and the presence of corrosion on bare and insulated piping.

Introduction

This paper discusses how corrosion presents on piping; common areas of susceptibility; general prevention measures; and classification and management of vulnerable areas. Armed with this material, system managers can conduct more effective assessments, make informed decisions related to prioritization and allocating funds, and avoid factors that induce corrosion. This paper will discuss the following issues:

- How CUI manifests and how to prevent it
- How to identify typical areas of susceptibility
- How to identify whether CUI is present
- How to identify whether CUI is likely to occur
- How to classify and prioritize vulnerable areas

The Greatest Threat to Piping is Corrosion

Corrosion under insulation (CUI), or external corrosion, is the primary damage mechanism that affects the integrity of ammonia piping. Moisture enters the insulation and becomes trapped against the pipe, vessel wall, or valve, and then corrosion forms on the surface. Corrosion does not exist for every instance of trapped moisture, but over time it can manifest and spread if not addressed. If left unattended, the developing corrosion gradually degrades the exterior wall of the piping, thinning the metal to the point of failure.

There is no universal solution for determining how much moisture will infiltrate the insulation or how quickly it will corrode the pipe. While some coastal regions experience higher levels of moisture contamination because of the environment, the upper and lower limits of the threat level and resulting damage varies based on many factors.

Corrosion has several predictable behaviors, including its occurrence in common areas and environments. However, biological growth on the jacketing or insulation and excessive ice build-up, which are visual indications that corrosion may be present, do not always occur. Corrosion often initiates without visual indications and persists for significant lengths of time before indications can appear, fully concealed by the jacketing and insulation that propagate it.

Moisture is usually introduced where insulation has deteriorated, at breaks in the insulation, where caulking has failed, or where damage has occurred as a result of impact, service operations, or weathering. Notably, all piping in an ammonia refrigeration system is subject to degradation, and preserving the vapor retarder is essential.

On average, 20% of aging ammonia refrigeration systems contain some level of rogue moisture in the piping insulation, but no systems exhibited moisture in 100% of the piping insulation, as seen in Figure 1. Protective measures to combat rogue moisture in the insulation have been partially effective, considering that these figures continue to decline (down from 30% in 2015). Furthermore, the lowest recorded percentage of water trapped in the ammonia piping insulation evaluated by visual inspection between June 2022 and May 2023 was ~10%, for ~40% of the systems, and the highest percentage of wet insulation was ~55%, for ~5% of the systems.

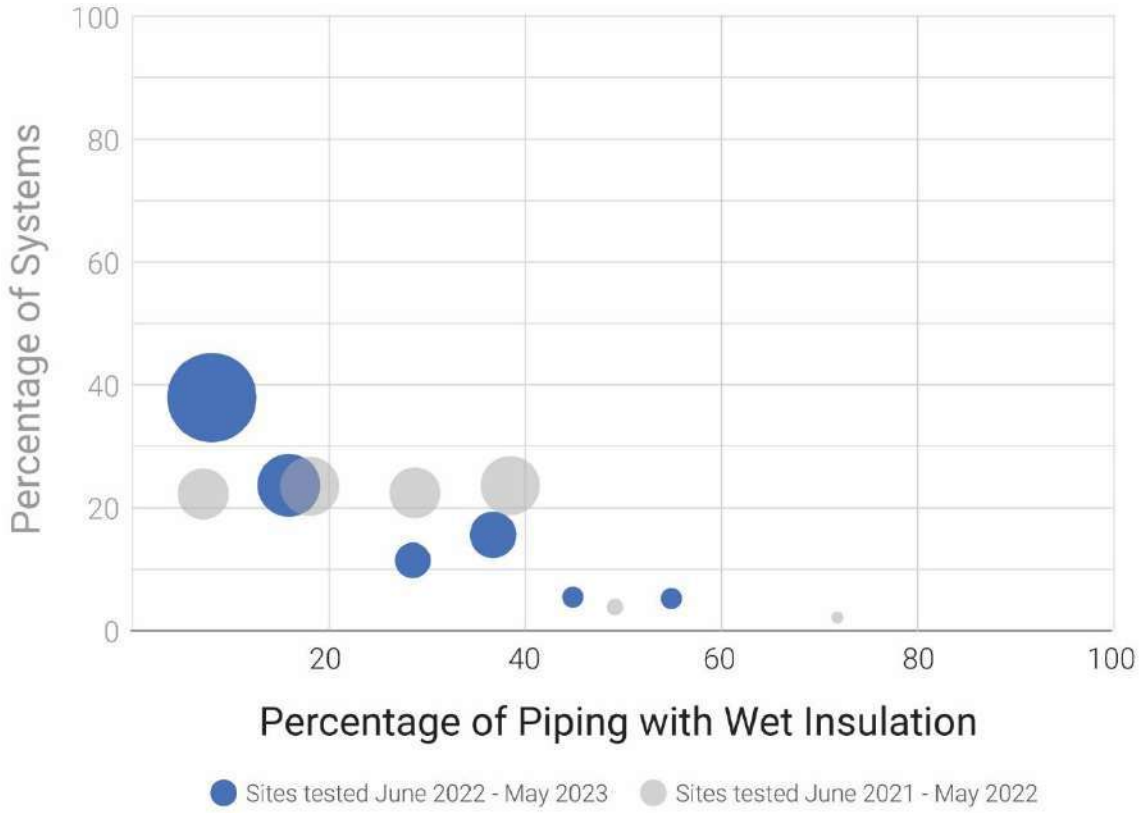

Figure 1. Based on a study of systems evaluated in the U.S. between June 2022 and May 2023.

Where CUI Degrades the Surface of the Pipe

Owing to the numerous factors involved, the progression time from moisture entering the insulation to the point of pipe failure varies widely across systems. Therefore, the rate at which external corrosion thins the pipe wall in an ammonia refrigeration system is not definitive. In particular, the ambient temperature and humidity are not constant or typically controlled. These variables also make it impossible to determine the distribution of corrosion around the circumference of the pipe. Frequently, moisture collects in concentrated areas on the pipe. Moreover, fully soaked insulation often leads to corrosion that forms evenly around the pipe, especially on vertical runs.

These conditions typically occur in thermal cycling areas, such as the section from the defrost condensate tee to the suction line, any other lines that are or will be above freezing, such as hot gas defrost lines, and equipment that is operated periodically. It is common to assume that suction lines are not susceptible because they are constantly operating below freezing. However, it only takes a few days above freezing for the ice to thaw and introduce moisture that begins to corrode the pipe. Furthermore, when these lines refreeze, they swell, and the corrosion and cracking are more destructive.

As seen in Figure 2, for example, pipe wall loss can be as high as 71% on low-temperature suction lines. In aggregate, 81% of systems exhibited pipe wall loss due to CUI on a suction line at the time of testing. Overall, 43% of the evaluated systems were reported to have areas with pipe wall loss of over 50%. The highest recorded loss, not including leaks that occurred as a result of complete metal integrity failure due to corrosion, peaked at 82% wall loss (or 18% remaining wall thickness).

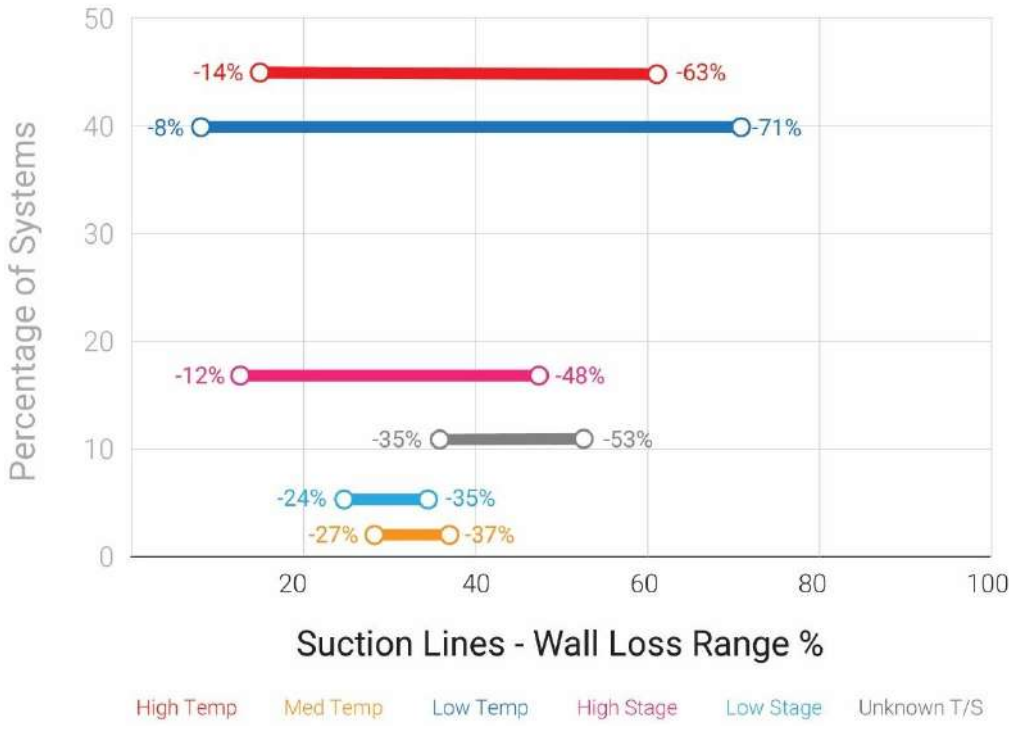

Figure 2. Based on a study of systems evaluated in the U.S. from June 2022 to May 2023.

Areas of Susceptibility

By employing practices to prevent and manage degradation, and with regular inspections, it is possible to predict the primary CUI breeding locations and detect where corrosion is present or may soon be present in the system.

Cues that the Piping is Compromised

Insulation conditions, such as damaged or missing components of the vapor retarder, can vary. Any damage can allow moisture through the vapor retarder, which is considered irreversible. The following cues should be regularly considered:

1. Jacketing separation (see Figure 3)
2. Holes in the insulation
3. Hail damage
4. Split seams
5. Crushing from physical damage
6. Weld strikes or other electrical damage that penetrate the jacketing

Figure 3. Jacketing separation and split seam

In addition to damage, which is a common catalyst for CUI, the areas where piping is most vulnerable are:

- The intersection of a pipe segment and major pieces of equipment
- Before and after pipe direction changes (e.g., elbows, tees, and reducers)
- Wall and roof penetrations
- Insulation terminations (e.g., valve groups and end caps)

The location of a component or structure can make it challenging to ensure piping integrity. It is necessary to regularly inspect:

1. Piping near condensers or a cooling tower area. This equipment can produce chemical and mineral-rich mists that are especially damaging to pipe jacketing and bare piping (see Figure 4). This mist can leave mineral deposits on metal surfaces, which are prone to corrosion unless cleaned and coated regularly. This is especially detrimental for piping that is not properly protected, like in areas where piping penetrates the walkways, or when the design does not allow for enough room to thoroughly inspect or properly maintain coatings.

2. Gravitational pooling also requires for consideration, specifically related to pump outs and roof penetrations (see Figure 5). Pump outs are commonly installed in the bottom of piping for proper function. However, this positions the piping precisely in the area that collects water after being compromised. Water collects in the lowest area, beneath the piping or in dips of the roof.

3. Any area where piping penetrates a boundary, such as a roof or wall, is difficult to inspect and maintain. Additionally, the piping is often uninsulated, leaving the bare piping exposed to moisture. In many systems, these areas are unprotected because they pass through a boundary. Integrity depends entirely on a secure adhesive or sealant, such as caulk, to provide weatherproofing.

4. Congested roof drains. Drains that are not regularly cleared can trap moisture and promote the growth of organic materials.

Figure 4. Chemically induced corrosion on bare piping.

Figure 5. Water pooling at the base of insulated ammonia piping at pump out.

Improper design, poor installation or maintenance, and use of the wrong materials can be equally devastating to piping and other components in ammonia systems. Look for:

1. Weak or missing gutters that are not properly channeling rain runoff away from the piping.
2. Poor or unmaintained caulking at insulation caps.
3. Screws in the jacketing.
4. Design configurations that collect or hold water such as insulated hand valves or other vertically oriented features. Although it may look good aesthetically, it may be destructive.
5. Be aware of how overlapping jacketing seams may allow water to collect. Seams placed on top of the piping, while quite common, invite water into the system.
6. Insulated-to-bare piping transitions at valve groups put stress on the unprotected bare piping, as well as the sealing. If not well maintained, the paint or coating can flake, and visible rust and corrosion soon follow.

7. Fiberglass and elastomeric foam insulation, commonly used for residential air conditioning and plumbing, are prone to waterlogging and should not be used (see Figure 6). Furthermore, elastomeric foam insulation is commonly glued tc the surface of the pipe with no outer protection from the elements, which is a sign of imminent damage.

8. Improper pipe supports are hotspots for corrosion and mechanical wear on piping. Thermal piping expansion/contraction in ammonia refrigeration can create wear points on piping if not properly protected from the support itself. T threat is magnified if the bracket design does not allow for proper maintenance and coating of the piping.

9. Brackets covered by jacketing. Although it may look nice, it is another area where water is allowed to enter the system. Over time, thermal cycling causes enormous stress on the jacketing, which does not expand but separates at the seams.

Figure 6. Elastomeric foam insulation on ammonia piping.

Confirmation that the Piping is Compromised

Unfortunately, CUI does not always present itself visually and is commonly hidden. Non-destructive testing (NDT) is recommended to evaluate common areas of failure and locate the wet insulation and corrosion.

Conversely, when the corrosion has advanced, the system shows indications that the piping is compromised. Visible cues reveal that moisture is trapped in the insulation or corrosion is present on insulated piping. Look for:

1. Moisture dripping or ice forming around the pipes. This is a sign that the insulation is saturated, exceeding the containment of the jacketing. Ice build-up on insulation typically occurs when water has penetrated the vapor retarder, resulting in ice formations from the surface of the pipe to outside the insulation jacketing, all the way through the saturated insulation.
2. Biological indicators, such as algae, moss, or plants, growing on the insulation (see Figure 7).
3. Rust stains on the insulation jacketing. Rust staining or rust-colored water from within the jacketing occurs as a result of degradation in the piping or components contained inside the jacketing and insulation.
4. Rust stains on the floor of engine rooms. Often, this is found near valve groups where the defrosting process produces excessive water exposure.
5. Sagging areas on a long run of pipe.
6. Painted corrosion. If the surface is not cleaned of all rust before coating, the paint shields the active corrosion and exacerbates the issue.

Figure 7. Algae on the ammonia pipe jacketing.

Building a Framework for Corrosion Intervention

Considering that multiple variables cannot be determined, there is no reliable formula for deriving how much corrosion can occur or how quickly it will advance. Quantitative data reveals that piping exhibiting any of the aforementioned characteristics should be regularly monitored because the formation of CUI and thinning of pipe walls is imminent if not corrected.

Daily system walk-downs and mechanical inspections should be routinely performed to document the suspected areas. Further investigation, maintenance, or replacement of vulnerable or compromised piping in the system should be prioritized based on level of severity. Because CUI does not always have visual indicators, further testing should be conducted at common areas of failure.

Classifying Severity

The first priority should be given to piping where leaks or fumes are present. Ammonia fumes are usually due to poor packing on the stems of solenoid valves that are actuated; tightening the packing nuts should resolve these leaks.

Where corrosion is present, the remaining pipe wall must be measured to make an accurate assessment of the severity, which is related to the level of priority. Corrosion on bare piping and CUI take on multiple forms and vary in terms of how aggressively they advance. Generally, blister rust is the most concerning form (Figure 8). If the piping shows layers of peeling rust (or blistering), the corrosion is advanced, and the remaining wall thickness is likely not suitable for operation. The general rule of thumb for companies that exercise a conservative approach is to immediately replace piping that exceeds 50% wall loss.

Figure 8. Blister rust/corrosion.

Pitting corrosion is the most common form of corrosion found in refrigeration systems (Figure 9). Pitting is usually a slow process that causes isolated, scattered pits over a localized area. Contrary to blister rust, pitting and swelling rust (Figure 10) both look severe, though oftentimes the piping can remain in service. Where piping has suffered wall loss in the range of 30%–50%, the pipe needs to be cleaned of all corrosion and coated to protect it from moisture.

Figure 9. Pitting rust/corrosion.

Figure 10. Swelling rust/corrosion.

Areas of wet insulation on piping with low wall loss (less than 30%) should be monitored for advancing corrosion. When replaced, a vapor retarder should be applied directly to the pipe surface, prior to installing the new insulation, to provide a water barrier and protect against infiltration.

Damaged and split jacketing, failed caulking, compromised sealing points, and improperly oriented seams should be addressed promptly. Replace any wet insulation and clean the piping in these areas so that the joints and sealants do not trap existing moisture in the jacketing.

Finally, other vulnerable areas of the system, as a result of proximity or design, should be resolved and inspected regularly to prevent degradation.

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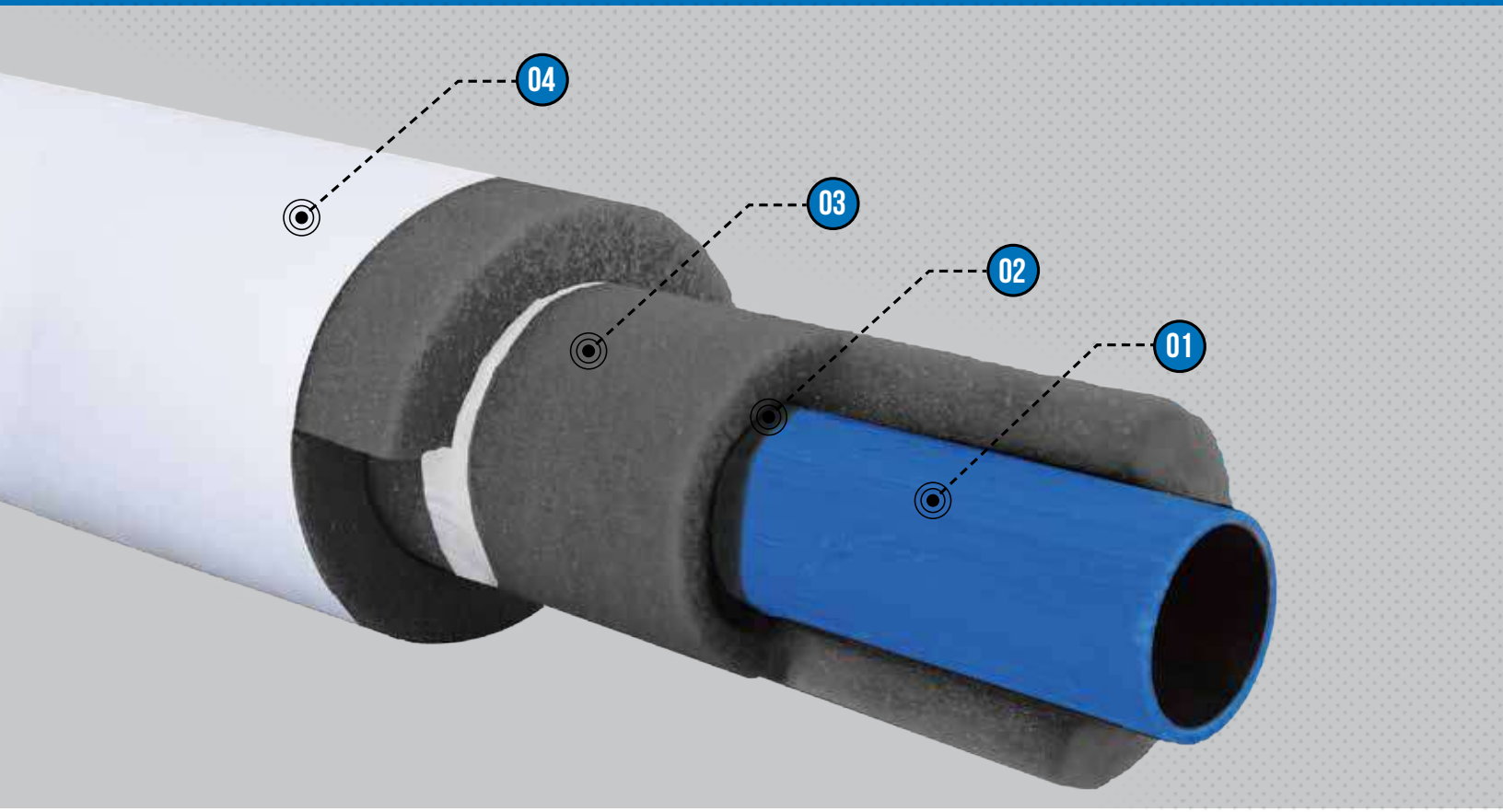

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