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IIAR Approves Consensus Body Replacements

IIAR approved 18 Consensus Body replacements on its three consensus bodies for IIAR standards. The replacements are routine maintenance required by the American National Standards Institute (ANSI) and are completed a minimum of every five years or when individuals are no longer participating.

IIAR maintains three consensus bodies, 1357, 24689 and CO2&HC. The bodies are the near-final stage of approval for IIAR standards 1,3,5, and 7, and 2,4,6,8, and 9, respectively. The CO2&HC body manages CO2 and hydrocarbons (HC).

Replacements to the consensus bodies can be done anytime, but the recent round of replacements were part of an overall periodic maintenance effort to meet IIAR's *"Procedures for the Development of IIAR Standards" and ANSI's "Essential Requirements."*

Tony Lundell, IIAR's Senior Director of Standards and Safety said IIARs replacements were recently completed in preparation for an upcoming Consensus Ballot Vote for a CO2 Addendum and the IIAR HC Standard in development, and to prepare for an upcoming regular ANSI audit in May 2027. "These replacements were required so that our new consensus body members could continue to participate through 2028 at a minimum," said Lundell.

Lundell said serving on one of IIAR's consensus bodies is an opportunity for IIAR members to get directly involved in confirming the work that occurs when developing standards. "Our consensus body members really want to be involved because they can take a direct interest in the standards they're responsible for by keeping abreast of their development and ensuring the procedures are followed." The consensus body members may also participate in development of specific content during public reviews.

Lundell added that the experience and professional visibility IIAR members can gain from working on standards is invaluable. "Serving on a consensus body is important because it allows members to directly know that standards are generally appropriate and have been developed in a fair, open, and balanced way.

ANSI has a set of requirements that essentially require a cognizant body of people to be convened to approve a standard, said Eric Smith, IIAR's Vice President of Technology, Advocacy, Research and Publications.

"In many standards development organizations, there is a committee in charge of developing and approving standards, and the detail work is done by subcommittees. When a subcommittee finishes their work, it gets passed to the main committee, which is the consensus body. IIAR takes this a step further by establishing independent consensus bodies."

Smith said IIAR's consensus bodies are open to participation by end users, manufacturers, consultants, contractors, and general interest stakeholders.

IIAR formed consensus bodies about 18 years ago when the current method of standards development was started by ANSI.

"Around 2008, ANSI changed the way that their essential requirements for the development of standards are done. Part of these requirements required that every standard had to be approved by a consensus body," said Smith.

"In IIAR's case, it was felt that the standards committee was, at the time, a somewhat smaller group of people and that the result of such an insular group was that our standards wouldn't necessarily get objective outside opinions from other stakeholders."

At the time, IIAR worked with ANSI to decide that in addition to the IIAR Standards Committee that develops the standards, there should be a somewhat uninvolved group that should not only review standards' concepts, but should also review that the process of development is fair and balanced such that all views and considerations are taken into account, said Smith.

IIAR invites consensus body members to provide specific comment as standards are being developed but will also ask them to review evidence of procedural compliance once the standard has been developed, said Smith. "There are many groups involved in standards development, including the subcommittees who work on the standard, public commenters, the overall Standards Committee, the Board of Directors and the Consensus Body. With all of these layers of review and approval, the industry can be assured that standards are well developed.

When a subcommittee finishes their work, it gets passed to the main committee, which is the consensus body.

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IIAR 2026 Conference Shatters Attendance Records

Over 2,000 attendees participated in the International Institute of All-Natural Refrigeration's Natural Refrigeration Conference & Heavy Equipment Expo in San Antonio, Texas. The event focused on networking, equipment exhibition, and a technical education track that featured industry trends and practical discussion of operational processes and details.

"Overall, the conference was better attended than ever before in years past, said Yesenia Rector, IIAR's Vice President – Education, Outreach and Events. "This was the first time we've broken the 2,000-attendee mark, so it's a big goal met for IIAR." Rector added that the San Antonio conference also saw the highest-ever exhibitor participation. "We broke records in a lot of key areas," she said.

At a time when so many external forces are influencing the industrial refrigeration industry, the IIAR conference serves as a common point of reference for members to gain a broad understanding of the policy, regulatory, and economic forces shaping their daily operations.

"There are quite a few areas where people who work in our industry want to know what's happening that will impact their operations," said Rector. "This is the perfect venue for finding out what's happening in your industry and your business."

This year's meeting featured thirty-one sessions comprising six educational tracks and expanded exhibit hall hours.

Eric Smith, IIAR's vice president and technical director, said while each IIAR conference is unique, this year's conference had a wide range of practical information on offer, from code discussions to overlooked operational details that may warrant closer attention.

"We want end users to gain practical information when they come to our conference, and this year was a great example of how detailed and valuable that information can get," said Smith. "Facility operations are just as significant a concern as the higher-level trends that shape our industry."

"There is a large subset of our membership that comes to our conference for practical knowledge. Code is one of those areas, and in particular, regulatory compliance is another of those areas where practical knowledge can really make a difference."

Smith said several subjects discussed at the recent conference helped members navigate specific issues.

"One of the most practical tech papers this year focused on forklift protection," said Smith. "Marty Timm delivered a good analysis of forklift safety issues." The paper, Forklift Safety in Refrigerated Facilities will be available online later this year.

Other sessions, like the regulatory update and a panel focused on IIAR's current research projects, were good examples of this year's actionable information, said Smith.

"While we cannot know the end results of current regulatory maneuvers, understanding what might be coming and what the implications are definitely helps our industry prepare for the changes that might be coming," he said.

The same holds true for the research IIAR is currently doing, said Smith. "What IIAR and NRF research is accomplishing doesn't have an immediate effect on our members, but it could in the long run."

Smith cited two research projects discussed at the recent conference. "One will help us determine if it's okay to discharge a relief valve into the header for CO2 relief systems,

and the second project will determine when or whether relief valves discharging back into the system need to be replaced."

"These are all projects that are getting answers to real problems, and that means they could lead to real changes that affect how we operate."

Another session, practical for end users, outlined the benefits of developing emergency action plans that facilities can put in place to address minor releases.

"There has been a long-term assumption that an emergency action for minor releases doesn't necessarily warrant proactive focus because facilities need not respond in any way except reporting the release and initiating evacuation," said Smith.

"But in order to be able to do any of that, facilities need to have good plans in place, even for minor releases. The panel session discussed a newly revised guideline that will help facilities prepare to legally and responsibly react [to minor releases]."

Dayna Martinez, IIAR Education Programs Manager, agreed with Smith that practical advice on implementing many of the processes industry decision makers deal with every day made up this year's most popular sessions.

Among the highest-ranked in IIAR's follow-up survey were a workshop focused on PSM: PSM Scorecards - The Real Score; and a Spanish-language tech paper focused on emergency prevention for ammonia systems: Prevención de emergencias en sistemas de refrigeración con amoníaco: la clave está en la normativa.

Rector emphasized that IIAR members should claim their continuing (PDH) credits online if they haven't already and reminded members that all education sessions are available online for those who attended the conference.

While many education sessions focused on practical information, several also served as opportunities for IIAR members to learn about association initiatives like partnerships with other industry groups.

"One session this year highlighted our work with Eurammon," said Rector. "We're gearing up for several events we've planned through that partnership, starting with a networking event in June in Germany where we'll be giving the keynote speech."

Overall, IIAR's 2026 conference saw more engagement than ever in the education programming, social events and all-around positive energy that has developed into a hallmark of the event, said Mike Chapman, IIAR's Vice President of Operations, adding that one addition to this year's program, the addition of a "white paper" track to the educational program seemed popular.

"Between the white papers, the tech papers and the workshops, our goal was to maintain balanced content but also address the different information needs of all our different types of members, and I think we were able to meet that goal," said Chapman.

"The biggest thing that stood out to me is that it seemed like everyone was on top of their game – from staff working so well together, to committees, to the efforts of our members who delivered presentations – it all went very smoothly this year."

IIAR Gives 2026 Awards for Presentation Excellence

Each year, IIAR recognizes the best technical paper presentations offered at the annual Natural Refrigeration Conference. This year's event took place March 15 – 18 in San Antonio, Texas.

The IIAR Award for Presentation Excellence, offered to the top English and non-English language technical papers and previously named the "Andy Ammonia Award," was created to acknowledge the crucial role that education and information-sharing plays within the natural refrigeration industry, and to provide acknowledgment of the expertise that is generously shared by association volunteers.

Award recipients receive a free registration for next year's conference, and perhaps most importantly, the acknowledgment from their peers for a job well done. Award selection is based on attendee evaluations, and scores are weighted based on attendance.

The 2026 Natural Refrigeration Conference featured many outstanding technical papers and presentations, but after extended consideration, the two 2026 winners (English language and non-English language) were:

- **Giacomo Pisano** received the 2026 award for the technical paper presentation that focused on ***Superheat Control in CO2 Transcritical Systems: Mastering the Challenges During Full-Load and Part-Load Operation.***
- **Catalina Aragón Azofeifa** received the 2026 award for the technical paper presentation that focused on ***Prevención de emergencias en sistemas de refrigeración con amoníaco: la clave está en la normative***.

IIAR acknowledged the participation of international natural refrigeration professionals who contribute non-English papers to the program, noting that it wouldn't be an international organization without the dedication of these industry experts.

Giacomo Pisano

Catalina Aragón Azofeifa

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IIAR Task Force to Propose PSM/RMP Changes

IIAR's newest task force has completed a gap analysis to assess OSHA and EPA's 30-year-old PSM/RMP programs. The "NH3 Overdue Regulation Modernization," or NORM, task force will ask regulators to remove regulatory burdens that overlap across agencies or defer to IIAR standards when the standards and regulations overlap. The task force's long-term effort will be to shift some funding and enforcement from federal regulators to state and local authorities.

The NORM task force was formed to operate in a rare federal environment in which the Trump administration has opened the door to regulatory reform through Executive Order 14192, which requires agencies to take 10 deregulatory actions for every new regulation.

IIAR president Gary Schrift said the organization formed the task force initially to respond to EPA's reconsideration of the AIM Act, which may raise a phaseout limit to allow 700GWP refrigerants for cold storages until 2032.

While that seemed like an initial setback given the industry's efforts to communicate the goals of the AIM Act, in the bigger picture, it was also an opportunity to accomplish some longstanding IIAR goals.

"We want to promote natural refrigerants, we're not trying to eliminate other [refrigerants] in this current administration, so we started asking…how do we make lemonade out of this lemon?" said Schrift.

"Right away, we hit on over-burdensome regulatory requirements as one of the biggest things preventing natural refrigerants from getting used. Paperwork is a major barrier to entry for natural refrigerants."

"At this point, you have to be a compliance specialist to understand what OSHA and EPA require. So, we decided to form a task force and use this current administration's desire to get rid of overburdensome or duplicative regulations to benefit our industry," said Schrift.

As the new task force began working through the details to perform IIAR's gap analysis — which put OSHA and EPA standards and IIAR regulations side-by-side — it quickly became apparent that "80% of our regulatory tasks require the same stuff for all three: EPA, OSHA, and IIAR standards," said NORM Task Force Chair Kurt Liebendorfer.

> "We want to engage our membership to support this effort because this affects everyone."

"The light bulb went off, and we started asking — why are these two agencies imposing the same things but then changing the specifics of the requirements independently of each other? It creates a maze of duplication."

"The compliance people on the NORM task force were really the ones who highlighted this first because they already navigate this day in and day out," said Liebendorfer. "But for the non-compliance people, it was a real eye opener, and it reinforced our idea that one agency duplicating the requirements and then independently changing them is very confusing to the industry."

From a policy standpoint, the NORM task force's work is an effort to engage IIAR's membership not only in the specific regulatory changes that IIAR will eventually propose, but also in raising the bar on compliance.

"We want to engage our membership to support this effort because this affects everyone," said Liebendorfer.

The NORM task force evaluated 18 topics across EPA and OSHA, including 17 specific RMP items and 14 specific PSM items. Of those, 13 sections have duplication or overlap between PSM and RMP, and 11 sections also overlap with IIAR standards, showing that IIAR already provides coverage across many of these areas.

Now that NORM has identified the areas of duplication, the task force will work to finalize a specific "ask list" of proposed changes as phase one of the task force's goals.

"The first opportunity in this phase-one part of our work is already here," said Liebendorfer. "There's an opening created by the EPA because they're already working through a proposed change to RMP — so we have this window of opportunity to move faster to get a quick win."

Liebendorfer said NORM plans to submit a formal request list to EPA this summer to enter any rulemaking cycle.

As for the specifics of that "ask list," IIAR is mainly asking EPA not to duplicate requirements that OSHA already imposes, and to defer to IIAR for compliance functions that the industry already mandates through IIAR codes and standards.

"Many of these requests are based on anecdotal reports we've gotten on duplicative enforcement activities," said Schrift, citing an example scenario "where one facility gets fined, then inspectors go out to the other facilities owned by the same company to look for the same violation without giving the company time to correct the original violation across the board."

"This is the kind of thing that's burdensome and dissuades people from choosing ammonia," said Schrift.

In addition to streamlining enforcement and fine structures that are paperwork-related to reduce the administrative burden on the industry, the NORM task force is considering three other avenues to reduce the amount of regulation the industry faces: defaulting to IIAR standards, modernizing the EPA and OSHA's approach to the general duty clause, and shifting funding from the federal enforcement level to local training, education, and inspection.

The NORM task force said it hopes to show EPA that ASHRAE has defaulted to IIAR for ammonia codes and to ask whether EPA would do something similar when IIAR standards overlap.

Second on the task force's ask list is modernizing the EPA approach to General Duty Clause enforcement by deferring to IIAR codes for safe design and operational practices for NH3 Refrigeration Systems, rather than referencing an EPA General Duty Clause guidance document, which only creates more confusion.

The third major ask being planned by NORM is to shift EPA federal enforcement funding to state-level work to support industry training, education, and inspection review.

IIAR's Schrift said the organization will soon begin a wide-ranging research project that will use industry data to quantify many of the issues behind the requests the NORM task force plans to make.

"We're pursuing a new project to dig into our industry data to see what trends are there," said Schrift. "We're hoping that some of the data can point to trends that will help our case with government regulators."

One statistic, for example, might look at the total number of incidents that cause injury to determine which occurred because IIAR safety standards weren't followed versus which were the result of other factors.

"IIAR and the industrial refrigeration industry stands to do a much better job of mitigating and preventing maintenance problems, far more than any PSM or RMP can help when it comes to mechanical integrity," said Liebendorfer. "Our task is to demonstrate to the federal government that the education of our industry through best practices is a more effective place to put resources than the surveillance of people who are already working hard to do their best on safety. That's the important point we're trying to make."

IIAR also hopes to find evidence in the industry data of how current regulations can obscure the industry's actual safety picture.

Liebendorfer pointed to a 2020 IIAR tech paper, *Case History: A Study of Incidents in the Ammonia Refrigeration Industry*, which outlines the problem of overreporting of minor releases. Page 8 of that tech paper outlines how the EPA's 15-minute release reporting requirement has led to overreporting of minor releases that can't be quantified within that timeframe.

"We believe in many cases the industry routinely reports releases that do not meet the 100 lb reporting threshold because they don't know in the moment what the actual release quantity is, and they can't quantify it in 15 minutes because systems are large and working to stop or mitigate a leak should be the first priority," said Liebendorfer.

"What led to that is EPA's really aggressive reporting requirements, so this is an example of where we might use our data to advocate for that 15-minute window to be longer."

After NORM's data collection research project and initial effort with the EPA this summer, the task force is eyeing a more comprehensive plan to find ways to get regulators to shift money from enforcement efforts to local education, inspection and response.

"We're hoping to convince EPA and OSHA — instead of spending time and money on PSM/RMP and General Duty Clause enforcement pertaining to ammonia refrigeration systems— to find a way to shift resources to local enforcement bodies using IIAR standards," said Schrift.

"That approach will be less burdensome than a federal-level organization coming in with untrained inspectors and huge fines who know little about ammonia. Involving a local authority in enforcement activities is more beneficial for everyone because those are the people who are more apt to work directly with businesses in their community."

For now, that effort will look more like a future business plan developed by NORM after the immediate steps to streamline regulations are underway.

"We want to simplify the regulatory criteria as it exists now first, by eliminating unnecessary duplication, before we advocate for big changes in how regulations are enforced," said Liebendorfer.

GOVERNMENT RELATIONS

BY LOWELL RANDEL, IIAR GOVERNMENT RELATIONS DIRECTOR

EPA Adopts "Compliance First" Policy for Enforcement Activities

In December 2025, Craig J. Pritzlaff, Acting Assistant Administrator for the Office of Enforcement and Compliance Assurance (OECA), issued a memorandum that reinforces a "compliance first" orientation as the guiding principle for the U.S. Environmental Protection Agency (EPA). The policy prioritizes environmental compliance "in the most efficient, most economical, and swiftest means possible, while ensuring that our actions align with the clearest, most defensible interpretations of statutory and regulatory mandates".

The policy reflects priorities details by President Trump's Executive Orders related to regulation and EPA Zeldin's agenda for the "Powering the Great American Comeback" Initiative. According to the memo, all EPA personnel responsible for civil judicial and administrative enforcement and compliance assurance activities must prioritize ensuring compliance when addressing potential noncompliance with federal environmental laws. The memo notes that at times EPA has followed a posture of pursuing enforcement that included findings of violation or orders that exceeded statutory or regulatory requirements. Such a posture can prolong negotiations and potentially delay actual compliance.

Under the new approach, enforcement should be tailored to achieve compliance quickly so that matters can be timely resolved and achieve compliance more quickly. Rather than beginning with what penalties should be applied, the policy reinforces that when confronting compliance issues, EPA should begin by asking how compliance can be achieved in the most efficient and quickest means possible.

The following six factors outline the foundation for our compliance-first operating framework:

1. Compliance Assistance Toolkit. Enforcement is an important tool for maintaining programmatic integrity, ensuring proper deterrence, and reducing pollution caused by noncompliance. However, it is not the only means of achieving compliance. The agency's enforcement program should prioritize deployment of compliance assistance tools— including providing proactive outreach, technical assistance, and training to the regulated community—to facilitate compliance and increase understanding. Voluntary compliance through self-reporting and voluntary audits should be encouraged to move regulated entities to proactively identify and correct compliance concerns.

2. State Partner Coordination. Congress has established a framework of cooperative federalism for most federal environmental laws. As such, EPA's enforcement efforts must be based on a clear federal interest. Authorized states have primary jurisdiction over many programs, and EPA activities should provide proper deference and support to state leads in most compliance and enforcement work. OECA shall work cooperatively with co-regulators to ensure consistency in compliance determinations and in enforcement of federal environmental law. EPA will provide technical assistance, training, and collaborative tools to strengthen co-regulator capacity, align performance standards to prioritize compliance, and foster information exchange.

3. Open Communication. The EPA's compliance-first approach emphasizes a "no surprises" framework based on transparent, two-way communication between regulatory bodies and entities to foster trust and accelerate compliance. By prioritizing collaboration and open dialogue, this strategy is intended to reduce duplicative efforts, avoid disputes, and allow for tailored solutions that are more effective and economically feasible.

Under the new approach, enforcement should be tailored to achieve compliance quickly so that matters can be timely resolved and achieve compliance more quickly.

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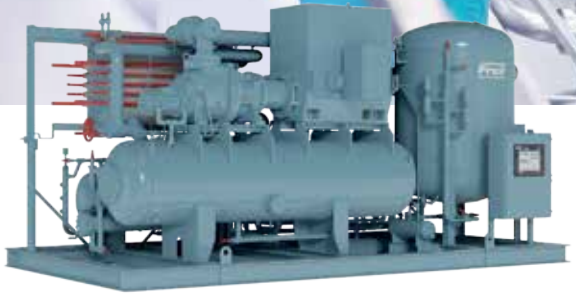

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 (continued from page 13)

4. Finding of Violation. The EPA is strengthening its enforcement strategy by requiring that findings of noncompliance adhere to the "best reading" of regulations to ensure clarity, consistency, and fairness. To eliminate ambiguity, the agency will develop a consolidated guidance document to unify violation categories across all programs, while requiring immediate escalation of legal uncertainties to national leadership.

5. Compliance Requirements and Injunctive Relief. The EPA's enforcement strategy now prioritizes rapid, cost-effective compliance through strictly tailored injunctive relief that is firmly rooted in legal requirements and directly linked to specific violations. By rescinding the 2021 memorandum on expansive remedies, the policy curtails excessive monitoring, restricts third-party audits to authorized cases, and halts the use of Supplemental Environmental Projects (SEPs). This approach aims to reduce regulatory uncertainty by limiting remedies to those that are defensible, necessary, and approved by the OECA Assistant Administrator for significant issues.

6. Reasoned Decision Making. Decisions on noncompliance determinations and the appropriate means for achieving compliance must be based on rational, transparent, and logical decision making. Going forward, EPA will follow the LEAPS model for enforcement decisions:

FIVE-FACTOR DECISION MODEL (LEAPS):

- Law: Actions be grounded in the most defensible legal interpretations.
- Evidence: Supported by unequivocal facts and "gold standard" science.
- Analysis: Rational, transparent, and defensible analysis.
- Programmatic Impact: Programmatic impacts must be considered to prevent "mission creep" and broader regulatory expansion.
- Stakeholder Impact: Assessment of effects on regulated entities and the community.

By applying these criteria, EPA intends to deliver sound, predictable decisions that will protect its regulatory integrity and proactively address potential issues like abusive third-party litigation.

The policy went into effect immediately and applies to all civil enforcement staff and all ongoing and future enforcement and compliance assurance matters. EPA has directed that the policy be integrated into all operations, compliance assurance activities, and enforcement cases.

In March, a group of 13 Democratic Attorneys General sent a letter to EPA expressing concerns with the new compliance policy. The group claims the policy puts the interests of businesses over the environment and public health. They further assert that without strong enforcement, regulated entities have less incentive to comply with environmental regulations.

Also in March, EPA Administrator released enforcement and compliance assurance results for Fiscal Year 2025. Zeldin was quoted as saying, "The days of using EPA's enforcement arm to pursue overzealous prosecution and partisan agendas are over. The Trump EPA is bringing common sense and the rule of law back to environmental enforcement and compliance. We know we can both protect human health and the environment while also providing the certainty and stability needed to Power the Great American Comeback."

It is still early in the implementation of the new policy and too soon to tell the full impacts of how "Compliance First" may change the experience of regulated entities undergoing inspections and enforcement actions.

The days of using EPA's enforcement arm to pursue overzealous prosecution and partisan agendas are over.

IIAR Introduces Legacy 100 Club Members

The International Institute of All-Natural Refrigeration posted remembrance videos for each of its seven inductees into the Natural Refrigeration Foundation's Legacy 100 Club.

Each inductee to the Legacy 100 Club represents an impactful contribution to the advancement of natural refrigerants, said Mike Chapman, IIAR's Vice President of Operations. "This is a chance for us to collectively name and acknowledge individuals for their contributions to our industry so that everyone is aware of the history of contributions that have helped to shape what our industry has become today."

Chapman said each inductee's contributions are showcased online with a video biography posted on the NRF website along with information regarding their contributions to the natural refrigeration industry.

IIAR's Chapman said the Legacy 100 Club is a key program for NRF, which hopes to increase the sustainability of its fundraising as an investment in the future talent of the industry through scholarships and the advancement of its science through research.

"A big part of investing in our future is our ability to award scholarships annually to recruit skilled and talented students into the natural refrigeration industry. It's exciting that we get to do that by using these incredible stories of our past to invest in our future."

Each of the seven inaugural Legacy 100 Club Members featured on NRF's site have in their own way advanced natural refrigerants, said Chapman.

"Each of these club members was a 'great' in terms of what they contributed to our industry and what they made possible for future generations. It's an honor to introduce them as part of this program."

IIAR INTRODUCES LEGACY 100 CLUB MEMBERS

Club Member William "Bill" E. Kahlert

Evapco

William "Bill" E. Kahlert led each day of his life with a compassionate heart and a giving spirit, and he used those gifts to make a difference in the communities where he lived and worked.

As a co-founder of EVAPCO, Inc., an industry-leading manufacturing company with global resources and solutions for worldwide heat transfer applications, Bill believed in the power of innovation and teamwork.

Club Member John Engalitcheff, Jr.

Baltimore Aircoil Company

John Engalitcheff, Jr. was an engineer, entrepreneur, and philanthropist who transformed the HVAC and refrigeration industries.

A Russian immigrant and Johns Hopkins graduate, he founded Baltimore Aircoil Company in 1938, growing it into a global leader. Holding 47 patents, he advanced sustainable cooling, earned recognition from President Reagan, and was inducted into the ASHRAE Hall of Fame.

Club Member Wilson E. Bradley

Evapco

Wilson E. Bradley, Chairman Emeritus of EVAPCO, co-founded the company in 1976 with Bill Kahlert.

His engineering expertise and leadership grew EVAPCO into a global heat transfer leader. He holds 35 U.S. patents and 200+ international patents and served IIAR as Standards Review Chair, Chairman, Honorary Life Member, and NRF Trustee.

"Each of these club members was a 'great' in terms of what they contributed to our industry and what they made possible for future generations. It's an honor to introduce them as part of this program."

IIAR INTRODUCES LEGACY 100 CLUB MEMBERS

Club Member Henry (Hank) Saye Sr.
Republic Refrigeration

Henry (Hank) Saye Sr. built his career on excellence and integrity, founding Republic Refrigeration, Inc. in 1983.

He earned national respect for delivering high-quality industrial refrigeration design, installation, and service. Hank served on the IIAR Board and led the IIAR Code Committee.

Club Member Art Marshall
AAIM Controls

Art Marshall entered industrial refrigeration in 1979, helping pioneer microprocessor-based controls and sensor systems.

From 2003–2022, he served as President and owner of AAIM Controls. After 43 years in the industry, he retired in 2022 and remains active in RETA and IIAR.

Club Member Rudy Nechay
Industrial Refrigeration Service

Rudy Nechay began his refrigeration career in 1970 as an apprentice, rising to pipefitter, welder, and service mechanic.

In 1978, he co-founded Industrial Refrigeration Service and led multiple companies. A licensed Master, he served on the Boards of IIAR, NRF, MCA, and RETA and was IIAR Member of the Year in 2010.

Club Member John Payne
Refrigeration Design & Service

John Payne founded RD&S – Refrigeration Design & Service in Pennsylvania, building it into an internationally respected company.

He served 30 years on the IIAR Piping Committee, six years as NRF Treasurer, and remains a Natural Refrigeration Foundation Trustee.

"A big part of investing in our future is our ability to award scholarships annually to recruit skilled and talented students into the natural refrigeration industry. It's exciting that we get to do that by using these incredible stories of our past to invest in our future."

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COLMAC COIL Manufacturing Inc.

Colmac Coil's Hygienic Air Handlers are custom engineered to help food processors maintain high quality and to meet the strict requirements of the USDA. A high level of food quality and safety can be achieved by controlling the process room air temperature, pressure, humidity, and cleanliness.

The HygenAir™ A+H Hygienic Air Handler Improves hygiene in the food processing environment by:

- Providing adequate cooling (and optional reheat for dehumidification)
- Limiting air migration
- Managing condensation
- Filtering out contaminants

FEATURES:

Available for all Refrigeration System Types

- Coils are designed and manufactured by Colmac Coil, as per the requirements of ASME B31.5
- Standard stainless-steel tube/aluminum fin construction. Other fin/tube materials are available to meet the requirements of every application.

Industrial Grade Construction

- Fully welded steel frame with a fully insulated base
- Standard G235 galvanized steel interior and exterior walls - option to upgrade to 304 stainless steel interior
- Standard stainless steel drain pans, optionally fully welded with varying hygienic weld finish levels

Filtration System

- Excellent performance in difficult operating conditions
- Fully resistant to corrosive environments
- Varying MERV and HEPA pre and final filter levels to exceed hygienic requirements.

Fans and Controls

- Electronically commutated (EC) exhaust air fan for units up to 40,000 CFM
- Plenum supply air fans with direct drive motors, including full VFD control
- Allen Bradley CompactLogix™ Controls System with a 6-inch user-friendly PanelView™ Plus 7 interface

Contact your local Colmac Coil Sales Representative or visit www.colmaccoil.com to learn more

IIAR STANDARDS UPDATE

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

Safe Work Practices (SWPs) for End User Operators & Technicians of Closed-Circuit Ammonia Refrigeration Systems

Safe Work Practices(s) are critical for operating and maintaining closed-circuit ammonia refrigeration systems. Developing safe working practices is not just good for workers' well-being, it is also good for business. The loss of systems' functionality because of accidents, and the loss of employees' skills because of injury is costly. It is far more fruitful to spend time to develop and practice safe work than to recover from accidents. Further, the development and engagement of safe work practices is a legal requirement in many jurisdictions and is broadly required in some countries.

In the United States, the federal government's Department of Labor requires safe work practices (SWP) to be included as part of Process Safety Management (PSM) programs for facilities with significant amounts of toxic or flammable materials. But regardless of system size or location, the concepts of SWP should be implemented. Following are some requirements from the US Dept of Labor Occupational of Safety and Health Administration (OSHA) PSM regulations.

OPERATING PROCEDURES:

SWPs must be provided for control of stored energy using lockout/tagout programs; confined space entry; opening process equipment or piping; and control over entrance into a facility by maintenance, contractor, laboratory, or other support personnel. These practices both to employees and to contractor employees.

TRAINING:

The implementation of an effective training program is one of the most important steps that an employer can take to enhance employee safety. Accordingly, PSM requires that each employee involved in operating a process or is newly assigned to a process must be initially trained in an overview of the process and its operating procedures. The training must emphasize the specific safety and health hazards of the process, emergency operations such as shutdown, and other procedures that apply to employees' job tasks. Employers must certify in writing that employees have the required knowledge, skills, and abilities to safely carry out the duties and responsibilities specified in the operating procedures.

OTHER EMPLOYER RESPONSIBILITIES:

When selecting a contractor, the employer must obtain and evaluate information regarding the contract employer's safety performance and programs. The employer also must inform contract employers of the known potential fire, explosion, or toxic release hazards related to the contractor's work and the process; explain to contract employers the applicable provisions of the emergency action plan; develop and implement SWPs to control the presence, entrance, and exit of contract employers and contract employees in covered process areas; periodically evaluate the performance of contract employers in fulfilling their obligations; and maintain a contract employee injury and illness log related to the contractor's work in the process areas.

CONTRACT EMPLOYER RESPONSIBILITIES:

The contract employer must:

- Ensure that contract employees are trained in the work practices necessary to perform their jobs safely;
- Ensure that contract employees are instructed in the known potential fire, explosion, or toxic release hazards related to their jobs and the process, and in the applicable provisions of the emergency action plan;
- Document that each contract employee has received and understood the training required by the standard by preparing a record that contains the identity of the contract employee, the date of training, and the means used to verify that the employee understood the training;
- Ensure that each contract employee follows the safety rules of the facility including the SWPs required;
- Advise the employer of any unique hazards presented by the contract employer's work.

IIAR WEBINARS FOR SAFE WORK PRACTICES (SWPS):

IIAR has presented the following IIAR Webinars pertaining to SWPs, which are reviewed for accuracy and current practices. These are helpful to inform end user operators and technicians, as well as others responsible for ammonia refrigeration systems.

- Operating Procedures for Ammonia Refrigeration Systems
- Qualifying Ammonia Refrigeration Contractors
- Hot Work Permits for Ammonia Refrigeration Systems
- Heat Stress & Cold Stress Prevention
- Permit to Work: Lockout/Tagout Procedure
- Permit to Work: Confined Space Entry
- Permit to Work: Line Opening Procedures
- Permit to Work: Hot Work Permits
- Permit to Work: Electrical Safety & Arc Flask Protection
- Permit to Work: Working at Height
- Permit to Work: Ground Disturbance

IIAR WEBINAR DEVELOPMENT:

IIAR welcomes suggestions and presenters for our webinar education series. If you have ideas for SWPs, other safety topics, or technical topics that apply to the natural refrigeration industry please contact Tony Lundell, Senior Director of Standards and Safety at tony_lundell@iiar.org.

The Importance of Awareness

BY KEM RUSSELL

Are you aware of changes that happen around you? When a smell changes, or a sound changes, etc. are you so focused on your work or another activity that you don't even notice?

There are five primary senses. Smell, hearing, sight, taste, and touch. However, we actually have considerably more. Researchers have identified approximately 22 to 33 different senses. These additional senses are internal and specialized senses like balance, temperature, pain, proprioception, etc. As we become more aware of the many inputs we have we can be better equipped to make good decisions. Unfortunately, many times people tune out the primary senses. This is one reason you should not text and drive. When we do tasks such as this it is sometimes referred to as "tunnel vision", although it is not a problem with the eyes, it is a mind issue.

Our minds can switch between tasks but not do two tasks simultaneously. When we are focused on a task, information coming to us that may be important is most often ignored. We all should be more aware of changes. The following is an example of a lack of awareness that lead to an ammonia release.

It likely started with a small vibration as a composite blade on multi-fan evaporator fan motor cracked. Why the fan blade began to fail is unknown. Composite blades (glass reinforced polypropylene) are used on thousands and thousands of evaporators, with an extremely low rate of failure. They are very reliable.

The personnel working in this particular storage room were focused on their task of driving forklifts as they loaded produce into a room. The evaporator fans were already noisy, and the forklift drivers apparently did not notice a change in sound. How long the crack in the blade had been growing is unknown but eventually the blade completely failed, meaning it separated from the hub of the fan assembly that was attached to the fan motor shaft.

When this happened the 3-blade fan was out of balance which caused additional stress on the other two fan blades. Eventually a second blade failed, which definitely would have been a noticeable sound change. Now the unit had serious vibration that affected not only the fan motor and its base, but the entire evaporator. How long this condition went on is also unknown, but the forklift drivers either didn't notice or didn't realize this was significant and the refrigeration operator(s) should have been notified.

The refrigeration operators, during their daily rounds, should also have noticed this change in both sound and vibration but did not.

It may have been possible for the crack in the blade to be seen during the annual evaporator inspection, but this didn't happen. Any slight change in the sound of the unit during operation would, due to a slight crack in a blade, likely not have been noticed, especially with several other noisy fan motors operating on this same unit. With two blades missing, the sound change was very noticeable.

With the failure of the second blade, still no one noticed the difference in sound of the fan nor the sound of the entire evaporator which was now vibrating. The movement of the unit was so significant that the vibration traveled up the ammonia refrigerating piping to the surge drum located above the roof in a small room, called a "doghouse". This vibration may have been going on for days, weeks, or longer. It was later seen that the vibration had caused a crack in the motor mounting base of the fan.

A much more significant impact happened in the doghouse. The surge drum relief connection came out of the center of the head of the horizontal vessel. The relief line was piped out through the vessel insulation and turned 90 degrees and extended a few inches to connect to the 3-way relief valve. The outlets of the associated relief valves joined together to extend outside of the doghouse. It was and typically is a screwed connection into a 3-way valve.

As time passed and the vibration continued, the pipe coming into the 3-way valve not only cracked but completely separated from the 3-way valve. When this occurred, there was a ½" schedule 80 pipe releasing ammonia vapor inside the doghouse. The leak started in the early morning hours.

The facility had a computerized control and alarming system for the refrigeration. The first alarm notified the refrigeration operator(s) that the system had shutdown due to a high liquid level in the suction accumulator. A second alarm occurred due to ammonia getting into the room below the doghouse. On arriving the two refrigeration operators that responded first checked the machine room. They noticed that the float switch arm was away from the float head column, indicating that no liquid was present at the float activation level. Not seeing any problems in the

As we become more aware of the many inputs we have we can be better equipped to make good decisions.

machine room, they headed to the roof of the facility. As they approached the access ladder to the roof level where several doghouses were located, they started to smell ammonia.

They decided to return to the machine room and close the manual king valve as a further precaution even though there was an electric solenoid (King solenoid) that had already closed due to the high liquid level alarm. They then returned to the roof.

As they got close to the doghouse they heard a loud noise caused by ammonia vapor releasing through the sheared ½" relief pipe. They wisely decided to remain outside of the doghouse and after a short time noticed the sound starting to dissipate. When the sound stopped they carefully opened the doghouse door to allow the small doghouse to better vent.

As these events were happening another very important action for an ammonia release was taking place. When the ammonia alarm was received one of the refrigeration operators called their supervisor alerting him to the ammonia alarm. He headed to the facility and while on the way called the National Response Center (NRC) and reported that they had a release going on of ammonia, and at that time, it was an unknown amount; also, that no one was injured. He next called the State. The State was already aware of the incident having been alerted by the NRC, but he still made a similar report of the event. He also tried contacting the Local Emergency Planning Committee (LEPC) but due to the time being well before 8 am he left a voice mail. He also called the Fire Department just to inform them. The Fire Department decided to send an engine to the facility as a precaution.

The Chemical Safety Board (CSB) was also supposed to have been notified within 30-minutes of contacting the NRC. This was actually done later in the day but there was no additional information the facility could report. Whether the loss of product was significant or not would not be determined until many days later.

The result was that there was a significant loss of product due to the contaminated ammonia vapor in the room. The amount of ammonia released was a few times over the 100 pounds in 24-hours, so it was appropriate and good protocol to contact the NRC, CSB, State, LEPC, and the Fire Department. Repairs were made and the system put back in operation.

It is likely that this whole incident could have been avoided if someone had noticed the change in sound of the evaporator and appropriate actions had been taken. The refrigeration operators need to be made aware of changes in sounds, smells, vibrations, etc. in their system(s) from other personnel who notice such changes or due to their own observations. People working in facilities should also be aware and know who to contact, so an issue can be addressed before it becomes an incident. We all need to be more aware of what is happening around us and not miss the cognizance that something significant may be occurring.

IIAR Scholars Attend 2026 Conference

IIAR's annual conference this year showcased the organization's growing scholarship program, which saw twelve new IIAR scholarships awarded. The 2026 scholars attended IIAR's annual conference as part of a fast-growing mentorship effort led by the Natural Refrigeration Foundation.

NRF has continuously increased the number of scholars each year, said John Flynn, Chairman of the IIAR Education Committee. The recipients get the benefit of a scholarship which helps defer the cost of their education, but IIAR also covers the cost of travel to the annual conference.

"We also bring them to our conference and pair each student with a guide or mentor to introduce them to our industry," said Flynn. "That experience of our conference and the networking that happens here is probably more valuable than many experiences they have at the beginning of their career."

Flynn said NRF scholars are paired with NRF trustees and member companies who engage them with discussions and questions about their knowledge of the industry. "We introduce each scholar to different people involved in different areas of our industry at the conference. They can get an idea of the equipment used in our industry, what it does and where the technology is going so they can relate that to what they're learning in the classroom."

Dayna Martinez, IIAR Education Programs Manager, said the NRF scholarship program gives students a foundation for natural refrigerants, especially through their participation at the IIAR conference.

"They get a real taste of what natural refrigerants are and how this industry can be a resource for them," said Martinez. "I think the need for this program to recruit new talent to our industry is very big. We're a niche industry and not a lot of people outside our industry know about what we do. This program raises awareness. It's always important to have young talent join us to diversify our industry. Diversity is the future of the industry, literally."

Martinez said the NRF scholarships are growing in popularity with 84 total applications received by NRF. Of those, 12 scholarships were awarded for 2026.

"Each year we're making this experience better and better," said Flynn. "We've gotten great feedback from our scholars this year."

"I think the scholarship program is extremely valuable to the natural refrigerant industry because the scholarship links interested students with great refrigeration companies who are always looking for new talent," said Zach Laser, a NRF scholarship alum and refrigeration sales engineer for Bassett Mechanical. "The IIAR conference provides the perfect opportunity for students to have face-to-face interactions with industry professionals who are looking to hire them."

"For me, the scholarship helped with tuition, but it also directly introduced me to the industry I would become a part of by bringing me to the IIAR conference," said Laser. "Attending the conference let me appreciate the scale of equipment firsthand which further sparked my curiosity, and I quickly found that companies at the conference are eager to hire students that express an interest in the natural refrigeration industry. I have no idea where my career would have gone had I not attended the IIAR conference and I'm glad I did."

NRF's scholarship is awarded annually to collegiate juniors exhibiting exceptional character and interest in pursuing an engineering or related technical degree leading to a career in the refrigeration field. Awards provide $4,000 to students during their junior year and $9,000 in their senior year for those who attended IIAR's Annual Natural Refrigeration Conference and Expo during the spring of their junior year.

A big advantage of the scholarship program is that it introduces new engineers to natural refrigeration at a time in their lives when they're making big decisions about where to invest their talent and start their careers, said Flynn.

The industrial refrigeration industry is a multidisciplinary field that offers exciting job opportunities in virtually all engineering fields of study. Engineers working in the industrial refrigeration industry have the opportunity to help address the urgent issue of climate change and reduce greenhouse gas emissions by applying environmentally friendly natural refrigerants in energy efficient refrigeration and heat pump systems.

As new technology develops that puts natural refrigerants at the center of a global push towards sustainability and draws attention to the global cold chain as the vital infrastructure that feeds the world's poorest populations, many students find purpose in their involvement with IIAR.

"The annual conference is really an opportunity to pair these students with industry veterans and show them firsthand our pride in our ability to have a career in this industry," said Flynn.

A big advantage of the scholarship program is that it introduces new engineers to natural refrigeration at a time in their lives when they're making big decisions about where to invest their talent and start their careers.

BIGGER THAN THE BALANCE SHEET

Can natural refrigerants save us from PFAS?

In the mid-2000's, when PFAS "forever chemicals" were first classified by the United Nations Environmental Programme, they were just beginning to be understood as dangerous pollutants. As the evidence mounted for their role in cancer and other health problems, regulators and activists began to outlaw PFAS sources, chief among them, many pesticides commonly used in agriculture.

Now, nearly two decades later, a new industrial PFAS contaminant is looming . . . hydrofluoroolefin, or HFO, refrigerants. HFO refrigerants – used anywhere industrial refrigeration is needed, from cold storage to data centers – release into the atmosphere, where they break apart to form trifluoroacetic acid, or TFA. TFA is a short-chain PFAS that falls back to Earth near the site of the release, continually accumulating in the water and soil of the nearby communities.

Without rapid intervention, TFA concentrations in water are projected to rise by 10-to 100-fold by 2040, exceeding existing safety thresholds. PFAS contamination is fast approaching what scientists call a "planetary boundary threat," beyond which the ability of natural systems to support human survival is uncertain.

That threat is addressed in the new IIAR white paper: Environmental and Health Risks of Synthetic PFAS Refrigerants.

"There's a threshold where we can't go back [from HFO contamination], so this message has to get to the mainstream now," said Tim Cook, IIAR member and one of the four authors of the paper. "This is a little different than climate change, where some people can't see the visible signs of environmental degradation because they live in places that aren't visibly affected. These [refrigeration] plants are everywhere in the world. This impacts people wherever they are. Industrial refrigeration is present in every community in the US. And every community in the US will face this risk."

Cook, along with authors Stephanie Smith and John Flynn, used the paper to lay out the environmental risks posed by HFOs.

"This paper is important because of the message it sends, and that message is that right now is the time to do the work of educating the public on this risk," said Smith, adding that IIAR has taken on that work because it aligns closely with the organization's mission.

"The general public does not know about this particular area, which is a potentially huge exposure. It's very important to start those discussions now, before the worst contamination can happen," said Smith. "We don't have widespread HFO-generated contamination yet, but if HFO's are widely adopted due to the impending phaseouts [of HFC's], we will. This is a silent threat creeping up on us."

The three authors said one of the most important goals IIAR hopes to accomplish with the whitepaper is to communicate that the world is at a crucial threshold regarding the threat posed by synthetic refrigerants.

Like the first generation of PFAS contaminants, HFO refrigerants are widely used. But unlike in agriculture, the industrial refrigeration industry already has PFAS-free alternatives that have been in use for a century.

IIAR said one purpose of the paper is to give members a reference point as they advise customers, end users, and even regulators on the benefits of choosing natural refrigerants instead of HFOs.

This education will be especially important as HFC phaseouts push refrigeration users

to decide to adopt HFOs or switch to natural refrigerants. And the rate at which HFOs are adopted to replace HFCs will determine whether the worst contamination can be avoided.

The timing of this refrigerant choice will be pivotal, said Smith. The 15-year EPA-mandated phasedown of HFCs began in 2022, and synthetic refrigerant manufacturers are already positioning the new generation of HFO refrigerants as drop-in replacements for the phased-out HFCs.

Nevertheless, the change in flammability classification that new synthetic refrigerants carry may present an opportunity to sway end users to choose natural refrigerants instead.

Historically, the difference between ammonia, which is classified as a mildly flammable B2L refrigerant, and the older generation HFCs, which were classified as A1 refrigerants, presented a price differential. More flammable refrigerants were simply more expensive to use, making synthetic refrigerants the least expensive choice.

However, the new generation of HFOs are now classified as mildly flammable A2L refrigerants, similar to ammonia's B2L classification.

"It really levels the playing field now that these new refrigerants have A2L classifications," said Flynn. "Ammonia detection or mitigation could add thousands of dollars to the cost of a system, so many owners chose A1 refrigerants to save on that expense. But now HFOs will face similar requirements for detection and mitigation."

Another factor working in favor of natural refrigerants may be the regulatory uncertainty that synthetic refrigerants carry. Much like HFCs when they were new, said Flynn, there's currently not much knowledge about the environmental risks posed by HFOs.

"As I work with our clients, many of them are facing changes in regulatory requirements, and many are facing decisions about which refrigerant they're going with. There's a lot of confusion on which refrigerants will be accepted long-term and which won't."

"When HCFCs were found to be ozone-depleting, the chemical industry came out with HFCs, only to find that there was a different environmental impact, called global warming. And now we're at that same point again with HFOs and PFAS contamination."

Realistically, synthetic refrigerants will never be entirely off the market. "But if companies, designers, and others in our industry can make the decision to use natural refrigerants instead, we go a long way towards doing our part to prevent this contamination," said Smith. "That's the point IIAR is trying to make, that there are already these good options on the table with natural refrigerants."

"Right now, PFAS toxicity levels are relatively low, but they're growing fast. So, we have this brief window of time where we can really do something. There isn't a lot of room for mistakes or saying, 'we'll get to it later," said Smith.

Fortunately, Europe has already become the model the US could follow for implementing PFAS source limits.

With widespread contamination, ongoing sources of TFA contamination, and concerns about toxicity, there is a strong call for action within the EU and its regulatory bodies. Recent studies show TFA in 94% of EU drinking water samples, with concentrations generally higher than those of other PFAS.

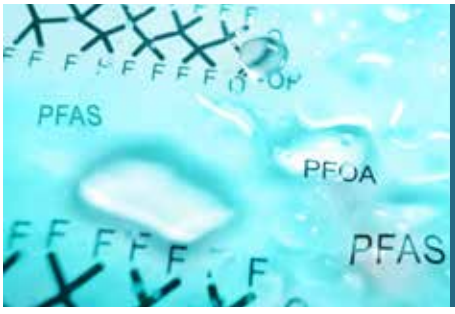
The outlook for EU regulation indicates that the EU is moving toward a universal restriction on PFAS, with a decision expected after 2025. If successful, this would likely include phased bans and some exceptions for essential uses. While TFA is not specifically regulated, it is under increasing scrutiny due to its environmental persistence, widespread presence, and emerging evidence of toxicity.

The US can start to address the problem by following Europe's lead, said Cook. But as with anything, the effort begins with awareness.

"Europe is way further down the line in outlawing PFAS sources and looking at the health risks posed by PFAS because their limits are much stricter. This is an area where we need to catch up with the rest of the world – and quickly," said Cook. "And with natural refrigerants as alternatives – why wouldn't you?"

One answer, said Smith, is that people don't really know that HFO-contributed PFAS is such a big risk, or what they can do about it.

"This is one of the reasons IIAR published this paper. IIAR should be educating refrigeration users as they decide if synthetic refrigerants are really the good long-term solution for their needs. Dollars and cents decisions are one thing, but if you have a plant where you, or your employees, live nearby, and you're introducing this kind of environmental risk, the decision becomes bigger than the balance sheet," said Cook.



"Right now, PFAS toxicity levels are relatively low, but they're growing fast. So, we have this brief window of time where we can really do something."

IIAR Releases Greenpaper

The International Institute of All-Natural Refrigeration released a new IIAR Greenpaper, a member resource for natural refrigerants. The Greenpaper, which is available on IIAR's newly launched Resource Center, is an industry reference document that outlines the basics of natural refrigerants and the direction the industry's technology is taking.

IIAR's marketing committee has taken the initiative to ensure the Greenpaper is always updated as a resource for members, said IIAR Marketing Committee Chair Stephanie Smith, adding that IIAR's goal is to have information on natural refrigerants available for members to use as needed.

"This Greenpaper is our guide to the latest information on these refrigerants," said Smith. The idea behind the paper is to provide well-substantiated arguments for natural refrigerants that everyone, from designers to end users, can use to explain how these refrigerants are the most sustainable choice.

"We are always saying that natural refrigerants are the best choice," said Smith. "Now this paper can provide the argument and data to go with that discussion. Or, if you're a student, this is a great place to get a foundation on natural refrigerants, like what they are, how they're used, and what's next for our industry."

Smith said the Greenpaper, as a product, is not new to IIAR but has recently been revamped to include new information relevant to the industry.

"This paper has evolved over time. It was originally an argument for natural refrigerants," said Smith. "Then it became more of a position paper as natural refrigerants expanded and became more of an important alternative to synthetic refrigerants."

The paper is also meant to provide a brief overview of the history of natural refrigerants for people who may not be familiar with the industry, said Smith. "Being able to read this paper and get a lot of different information in one place – on how natural refrigerants have evolved, how they are responding to current environmental needs, how the technology is changing – is valuable."

"For this Greenpaper, I think the updates on hydrocarbons and further discussion on CO2 rounds out the paper, as well as the discussion of future applications of natural refrigerants that are starting to see development now," said Smith. "It's interesting to see how much has changed from five to seven years ago when we last updated the paper, to now."

Smith said readers may find the discussion of the expansion of natural refrigerant use, as well as the potential outlined in the paper for smaller installations, interesting.

"I think there's huge potential for smaller installation usage in our industry, and this paper looks at that trend. Perhaps right now we're seeing a delay in these systems taking hold because the cost to change over to smaller systems is a barrier, but there is huge potential for growth there."

Another big trend in the coming years will be the growing number of green initiatives within private companies, which will push decision-makers towards natural refrigerants. Along with those initiatives, the industry may see increased funding for capital projects or new initiatives from government agencies interested in helping facilitate a shift to natural refrigerants.

"Hopefully, these changes will happen in response to the phaseouts that are doing away with banned refrigerants. I think places like Europe are pushing more and expanding faster towards natural refrigerants, which is a big opportunity for them. Everyone is looking at countries in Europe that have already built these strategies and asking can we do the same things?"

IIAR GREENPAPER SUMMARY

Industrial food production around the globe depends on natural refrigerants. Ammonia (NH_3), carbon dioxide (CO_2), and hydrocarbons such as propane (R290) make up the foundation of the technologies that support the global cold chain.

Often called one of the world's "century-proof" technologies, natural refrigerants have been used for over 100 years and continue to outperform synthetic alternatives in terms of energy efficiency and environmental impact.

And in a rapidly warming world, the low Global Warming Potential (GWP) and zero Ozone Depletion Potential (ODP) of natural refrigerants pose the only truly climate-neutral solution for the technical systems and infrastructure required to feed the world's population.

For the countries that have adopted HFC phase-down mandates, natural refrigerants promise certain climate gains without the drawbacks and PFAS pollution risk that synthetic replacements present.

This technical versatility has pushed natural refrigerants past traditional uses like refrigeration – and they now support complex climate control systems in data centers, contribute to waste heat recovery in district energy networks, and improve thermal management across industrial manufacturing processes.

Natural refrigerants play a vital role in keeping global food supply accessible. By converting energy savings into lower operating costs, natural refrigerants keep food available to consumers and make food relief feasible in the world's poorest places.

ENERGY AND THE ENVIRONMENT

In the 1980's and 1990's, as regulators began to recognize the science behind climate change, ozone degradation and warming, governments around the world joined coalitions and partnerships to identify the causes.

Chief among them were chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). Introduced in the 1930's, CFC's were fully halogenated hydrocarbons, mostly replaced in the late 1980's by HCFCs, their partially halogenated successors.

While HCFCs were meant to be used as transitional replacements for CFCs – because they break down more readily in the lower atmosphere and therefore have lower ozone-depleting potential – they are currently being phased out in favor of a class of unsaturated fluorinated organic compounds called hydrofluoroolefins, or HFOs.

The advent of HFO's, far from safely solving refrigerant-based ozone depletion, has introduced perhaps the most dangerous risk posed by synthetic refrigerants so far, widespread PFAS pollution. Chemically, HFO's are olefins meaning they contain a carbon–carbon double bond (C=C). This structural feature makes them far more reactive in the lower atmosphere than CFCs, HCFCs, or HFCs.

And while that reactivity means they break apart before they reach the upper atmosphere, the PFAS chemical they degrade into, called trifluoroacetic acid, or TFA, is now one of the most pervasive PFAS in the environment, worldwide. TFA is an ultrashort-chain PFAS that forms as a breakdown product of fluorinated refrigerants and other substances. It disperses back into the environment, posing widespread unknown riskto human and environmental health.

Unlike their synthetic refrigerant counterparts, ammonia, CO_2 and other natural refrigerants do not impact atmospheric ozone or contribute to climate change, and they pose no risk of PFAS pollution. Industry momentum has so far built powerful policy frameworks to meet climate goals by phasing out synthetic refrigerants. The Kigali Amendment to the Montreal Protocol is the primary HFC phase-down initiative.

Now, natural refrigerants are poised for expanded deployment across industrial and commercial sectors, fueled by both technological progress and regulatory alignment. However, the coming potential widespread adoption of HFO's to replace HCFC's represents the next major environmental threat. The natural refrigeration industry, together with regulatory bodies and global governments, must meet this challenge with the same focus and purpose that created the original phase-outs of earlier generations of synthetic refrigerants.

TECHNOLOGY AND INDUSTRY RESOURCES

Because natural refrigerants pose no long-term environmental risk, or the risk of an eventual regulatory phaseout, the technology and equipment supporting their use has boomed in recent years.

End users and industry sectors are switching from synthetic to natural refrigerants, and the technologies that support natural refrigerants are growing. Carbon dioxide (CO_2) has re-emerged as a popular option. It is non-toxic, non-flammable, and efficient because of new system design innovations.

Modern CO_2 systems now overcome the high operating pressures and temperature constraints that limited early adoption, enabling technologies that rival or exceed the performance of synthetic alternatives from an environmental perspective.

Significant advances have been made in the manufacture of compressors, heat exchangers, and control systems, and natural refrigerants are increasingly integrated into high-efficiency applications, from supermarket refrigeration and cold chain logistics to heat pumps and energy recovery systems.

The International Institute of All-Natural Refrigeration has compiled industry resources, including comprehensive training and safety standards, to support these rapid advances. In addition to IIAR's standards, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has, for the first time in recent years, formally recognized natural refrigerants alongside synthetic options.

FUTURE USES OF AMMONIA

Thanks to the rapidly growing global energy transition, ammonia is receiving renewed attention from industries, where its properties as a carbon-free energy carrier and potential fuel offer opportunities in sectors beyond refrigeration.

Remembering Mike Laucks

Mike Laucks, remembered by many of his colleagues and friends in the ammonia refrigeration industry for his quick wit and welcoming spirit, passed away peacefully on April 11, 2026. Laucks retired as vice president of engineering at GEA Refrigeration in 2006, where he spent his career in industrial refrigeration.

Mike was the former Chairman of IIAR and focused on developing many of IIAR's standards. He also worked closely with code development to advance natural refrigerants at a time when that effort was just beginning for IIAR.

"I remember Mike as being extremely smart. He did extensive work on oil viscosity and oil management. He was known as an expert in that area. He was always able to find the right oil for the right refrigerants," said John Bowman, Director Application Engineering – Skids for GEA.

"Mike was always working directly on code and updates; he spent a lot of time on standards for our industry.

"I started at FES in 1990. Mike was head of engineering at the time before he retired, and I worked in his department my entire career," said Bowman. "He was a very respected individual. When Mike spoke, we listened."

Bowman remembered Laucks as someone who was eager to mentor others and to set the direction and provide guidance for his company as well as IIAR.

IIAR president Gary Schrift said Mike will be remembered as a leader who had a formative role in the development of IIAR. "It's always hard to lose one of IIAR's early leaders. It's because of them that our organization has grown into what it is today."

According to a family remembrance, Foster Michael Laucks was born in York on September 27, 1939, to Foster Martin Laucks and Carrie Miller Laucks. He is survived by his devoted wife and best friend of 63 years, Nora, and their daughter, Elizabeth Laucks of Baltimore, MD.

Mike graduated from Red Lion High School in 1957, then earned a bachelor's degree in mechanical engineering from Lehigh University (where he was a member of Chi Phi) in 1961 and a master's degree in business administration from Temple University in 1970.

He dedicated his career to serving as an engineer and executive with several companies in the industrial refrigeration industry. He began his career at York International and continued as vice president of engineering at Frick Co. in Waynesboro, PA.

Mike cherished his family above all and was known as a generous, loving husband and father. He was deeply respected and admired by colleagues and friends alike. Though his dedication to work was well known, Mike's passions extended far beyond his profession. He traveled internationally with his wife, biked the York County Heritage Trail, embarked on home improvement projects, enjoyed listening to big band and jazz music, and was an avid reader. He relished weekends at his hunting cabin with childhood friends, cherished time with family at their Ocean City, Maryland, summer home, and spent the winter months in St. Petersburg, Florida, with his wife following his retirement.

Bowman remembered Laucks as someone who was eager to mentor others and to set the direction and provide guidance for his company as well as IIAR.

2020 TECHNICAL PAPER #7

CASE HISTORY: A Study of Incidents in the Ammonia Refrigeration Industry

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ABSTRACT

In June of 2005, the author initiated a project to collect data related to ammonia incidents using information from publicly available sources. For the past 14 years, the data have been input into an Excel spreadsheet every day. This information was analyzed and compared with historical incident data available from the U.S. Environmental Protection Agency's Risk Management Plan database and a 2008 IIAR survey. The hope is that analyzing these incidents will highlight industry policies and practices that can prevent and/or mitigate the consequences of future incidents in the ammonia refrigeration industry, thereby improving overall industry safety.

Introduction

The Occupational Safety and Health Administration (OSHA) published the Process Safety Management (PSM) standard, 29 CFR 1910.119, as a Final Rule on February 24, 1992. The U.S. Environmental Protection Agency (EPA) issued the Risk Management Program (RMP), 40 CFR Part 68, as a Final Rule on January 31, 1994. The purpose of these regulations is to prevent accidental releases of chemicals that could pose a threat to human health and the environment.

IIAR members have struggled to answer some basic industry-related questions since the earliest days of the PSM standard and the RMP rule. For example,

1. How many incidents occur in the ammonia refrigeration industry?
2. What are the consequences of these incidents?
3. What are the most common causes of the incidents?
4. What can be done to prevent and/or minimize the consequences of these incidents?

This paper focuses on the efforts made to answer these questions.

EPA RMP Database

In 2004, IIAR formed an Ammonia Release Task Force. The mission of the task force was to collect and compile information on all ammonia releases throughout the industry (IIAR 2004). The data collected would be used to identify the areas of greatest need for attention to help the industry reduce the number of releases.

One of the first actions this task force accomplished was to collaborate with the U.S. Chemical Safety and Hazard Investigation Board (CSB) to review five-year accident history data contained in EPA's RMP database. Facilities are required to report accidental releases from covered processes that have significant on-site or off-site impacts in the five-year accident history section (Section 6) of the RMPs submitted to the EPA. Significant on-site and off-site impacts are defined as accidental releases that result in on-site deaths, injuries, or significant property damage; or known off-site deaths, injuries, evacuations, sheltering in place, property damage, or environmental damage.

CSB provided the IIAR Ammonia Release Task Force a spreadsheet that included more than 600 ammonia refrigeration incidents contained in RMPs submitted between 1994 and 2004 (CSB 2004). Based on analysis of these incidents, the task force came to the following conclusions:

1. The following industry sectors had the most incidents reported in the five-year accident history database:

    a. Red meat and poultry processing facilities,

    b. Cold storage facilities,

    c. Frozen food facilities, and

    d. Dairies and related facilities.

2. Facilities may have been unsure of the five-year accident history requirements and may thus have overreported ammonia incidents to the EPA. Almost half of the five-year incidents reported to the EPA during this period had no on-site or off-site impacts listed in Section 6.9 (On-Site Impacts) or Section 6.10 (Known Off-Site Impacts) of their RMP submissions. If an incident had no on-site or off-site impacts, it should not have been reported in the five-year accident history.

3. Approximately half of the releases were reported to be from valves and piping.

4. Approximately half of the reported incidents were related to equipment failure and approximately half were related to human error. Contributing factors related to equipment failure included overpressure scenarios, process design failures, and unsuitable equipment. Contributing factors related to human error were maintenance activities, improper procedures, and management error.

The information provided by EPA and CSB proved valuable, but it was only a first step. Based on a review of RMP five-year accident histories, ammonia incidents were clearly occurring, but the root causes of these incidents were not immediately identifiable. The task force felt that additional work was needed.

IIAR Industry Section Meeting

The next step taken by IIAR's Ammonia Release Task Force was to obtain ammonia incident data directly from industry representatives. In June of 2006, the task force set up a meeting in Arkansas with representatives from five companies in the poultry processing sector. During this meeting, the following ground rules were established:

1. All participating companies were to benefit from this meeting because the goal was to identify industry-specific recommendations designed to reduce the number of ammonia incidents occurring at industrial ammonia refrigeration facilities.

2. No information was to be documented that would identify the company associated with any ammonia incident.

3. No marketing was to occur in Arkansas; the task force had nothing to "sell" except safety.

4. The poultry processing sector was to be the first of at least five industry sector meetings to be conducted.

The hope was that the meeting participants would be free to discuss actual incidents that occurred at their facilities. Specifically, the task force would attempt to determine the following information:

- What were the root causes of these ammonia incidents?
- What were the consequences of these ammonia incidents?
- What recommendations were made/can be made to prevent future incidents?

IIAR's Ammonia Release Task Force assumed that industry representatives would be willing to discuss ammonia incidents at their facilities openly provided that the incident information was de-identified. Five ammonia incidents were discussed

with five poultry processers during the initial meeting, in which the task force promised neither to take notes nor to release the results of these discussions due to the sensitive nature of the incident data. However, because no information was recorded or analyzed, the main goals of the meeting were not accomplished. After additional attempts to overcome this shortcoming, the task force abandoned the idea of obtaining ammonia incident data during industry sector meetings, recognizing that any data obtained during these meetings was too sensitive to be released to the industry at large.

IIAR Ammonia Incident Survey

In May of 2008, IIAR tried a different approach to collecting ammonia incident data, sending a questionnaire to all IIAR members. The stated intention of the questionnaire was to obtain ammonia incident information to assist IIAR members in the proper and safe handling of ammonia as a refrigerant. Also noted on the questionnaire was that all collected information would remain anonymous.

The questionnaire included the following 12 questions (IIAR 2008):

- What organization does your facility belong to?
- What region is your facility located?
- Which category does your facility fall under? More than 10,000 pounds of ammonia? Less than 10,000 pounds of ammonia?
- Which of the following best describes your facility (i.e. Cold Storage Facility, Dairy Facility, Frozen Food Production, etc.)?
- Based on your experience, where in the system do most of the ammonia releases occur?
- What are the areas where most ammonia releases occur (not included in question #5)?
- Based on your experience, what are the most common causes of ammonia releases?

- What are the most common causes of ammonia releases (not included in question #7)?
- During the past five years, how many ammonia releases amounting to at least 100 pounds has your facility experienced?
- What type of response resulted from the ammonia releases?
- What factors most commonly lead to ammonia releases?
- Which areas should the IIAR focus on?

IIAR summarized the ammonia incident survey results in October 2009. More than 500 facilities in the ammonia refrigeration industry provided ammonia incident information. Approximately 80% of the responses came from facilities housing more than 10,000 lb of ammonia and thus most likely subject to OSHA's PSM Standard and EPA's RMP Rule. More than 20% of the responses were from facilities storing less than 10,000 lb of ammonia and thus were most likely subject to OSHA and EPA General Duty Clauses. The greatest number of responses came from cold storage facilities (33%), frozen food production facilities (16%), and meat processing facilities (11%).

Figure 1 shows that more than two-thirds of the facilities responding to the survey had no ammonia releases of at least 100 lb during the five years preceding the survey. Thirty-one facilities (6%) had three or more releases of at least 100 lb during this same period, and nine facilities reported that they had experienced 10 or more incidents during the preceding five years in which more than 100 lb of ammonia was released.

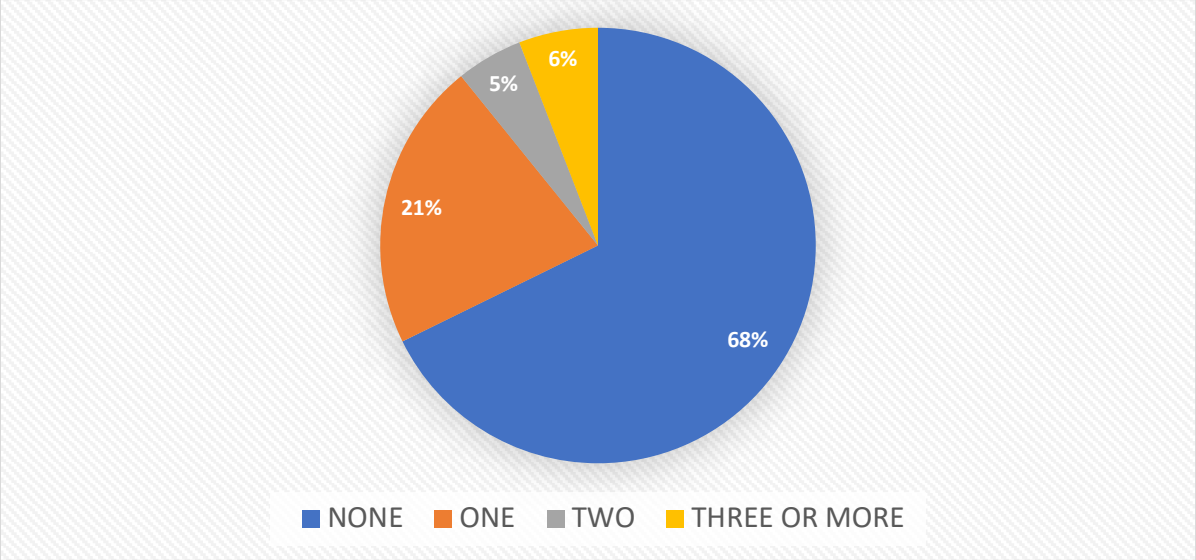

Figure 1. IIAR survey: Releases greater than 100 lb.

Figure 2 summarizes the consequences of the releases reported in the IIAR survey. Facilities were evacuated in approximately one-quarter of the releases, and off-site consequences occurred in 10% of the releases. Only 3% of the releases resulted in injuries.

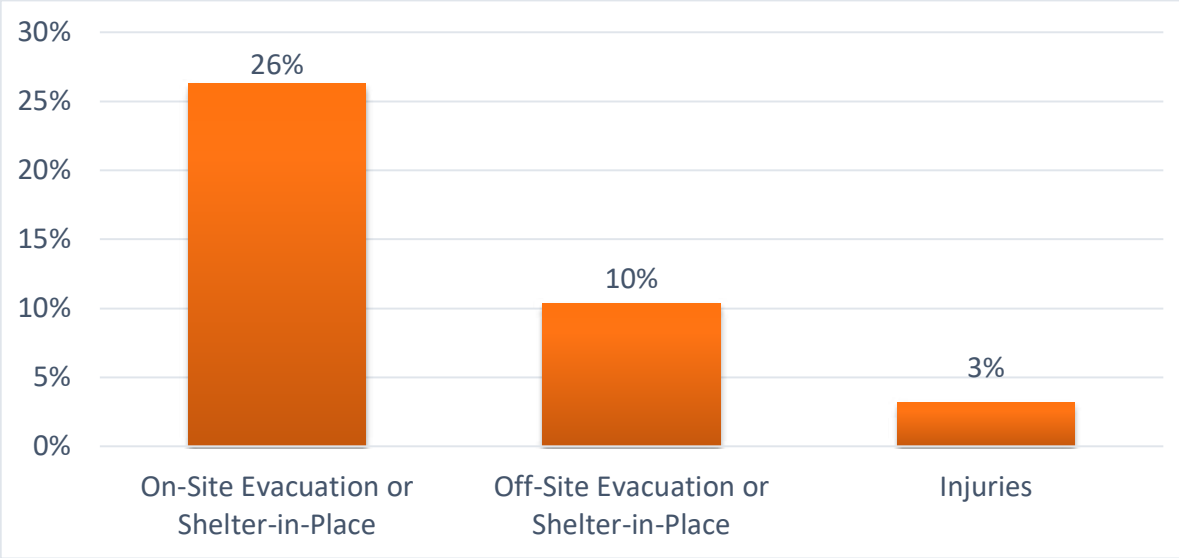

Figure 2. IIAR survey: Percentage of facilities experiencing a consequence of release.

Questionnaire respondents indicated that equipment failure caused approximately 60% of the reported incidents. The top five reported causes of equipment failure related to

- Leaks from mechanical seals,
- Corrosion,
- Relief valve opening prematurely,
- Hydraulic or thermal shock, and
- Failure of safety cutout.

Questionnaire respondents reported that human error caused 37% of the incidents. The top five reported causes of human error related to

- Improper training,
- Improper maintenance procedures,
- Oil draining procedures,
- Line opening procedures, and
- Improper valve opened or closed.

Ammonia Incident Database

To discover the root causes of the incidents described in RMPs submitted between 1994 and 2004, an effort was begun in June of 2005 to collect in an Excel spreadsheet the ammonia incident data reported via publicly available sources. The vast majority of the information contained in this "Ammonia Incident Database" was obtained via Google Alerts. Google Alerts is a content-change detection and notification service offered by the search engine company Google. The service sends emails to users when it finds new results—such as web pages, newspaper articles, blogs, or scientific research—that match a user's search term (Wikipedia 2019). The search term used to generate the Ammonia Incident Database was "ammonia."

Additional information in the Ammonia Incident Database was obtained from incident reports posted on the Chemical Safety Board's website. A conscious decision was made not to supplement the Ammonia Incident Database with information obtained from any other source, including first-hand knowledge of any incident, to enable analysis of "raw" data obtained from consistent sources.

Each day, the publicly reported ammonia incidents were reviewed and entered into the Ammonia Incident Database along with the following information:

1. Source of the information;
2. Date and time of the incident;
3. Company involved, including location;
4. Amount of ammonia released;
5. Release duration;
6. Off-site response personnel involvement;
7. Consequences of the release;
8. Release location; and
9. Cause of the release.

When preparing this technical paper, the Ammonia Incident Database was modified by restricting incidents included in the database to those that occurred in the United States and Canada. Incident data from other countries was excluded for two reasons. First, U.S. and Canadian incident data came from a wide range of events and included incidents that resulted in relatively minor consequences. Incident data from other countries tended to include only reports of incidents with catastrophic consequences. Second, the database compiler had extensive knowledge and understanding of the practices followed at facilities operating ammonia refrigeration systems in the United States and Canada, but limited experiences regarding the practices followed in the rest of the world.

The goal of the Ammonia Incident Database is to compile details regarding contemporary events, analyze that data, and compare the results with historical incident data in an attempt to answer the following questions:

1. Have the number of incidents increased or decreased?
2. What were the consequences of the incidents?
3. In what daypart did the incidents occur?
4. Which industry sectors were responsible for the incidents?
5. In which geographic regions did the incidents occur?
6. Where in the facility did the incidents occur?
7. What were the most common causes of the incidents?
8. How effective are ammonia mitigation systems?
9. What can be learned from incidents resulting in catastrophic consequences?

The remainder of this paper will address these questions.

Analysis of Ammonia Incident Data

An analysis of the of the Ammonia Incident Database indicates that intensive safety efforts are underway in many segments of the refrigeration industry, but also that there's still a way to with regard to ammonia release prevention programs.

1. Have the Number of Incidents Increased or Decreased?

Figure 3 answers the question concerning the changes in incident numbers—a question that always arises when analyzing or developing safety procedures for the industrial ammonia refrigeration industry. Between 2008 and 2018, ammonia incidents per year reported in the Ammonia Incident Database was relatively constant, averaging 64 reported incidents in the United States and Canada per year. Thus, the number of incidents neither increased nor decreased—it remained essentially constant during that time period.

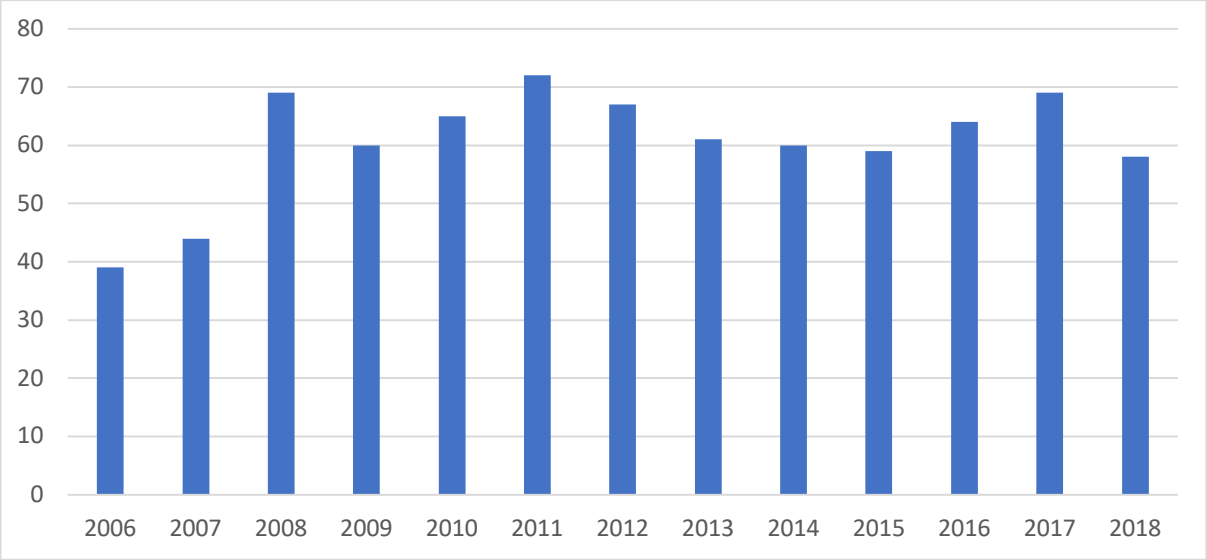

Figure 3. Ammonia Incident Database: number of incidents.

2. What Were the Consequences of the Incidents?

Two assumptions were made when determining the consequences of the ammonia incidents:

1. No off-site consequences were assumed to have occurred if people were ordered to move simply to improve emergency vehicle access to the site. This is consistent with EPA guidance for the preparation of the RMP's five-year accident history (EPA 2009).

2. EPA defines "injuries" for the five-year accident history as any effect that results either from direct exposure to a chemical or from indirect consequences caused by an ignition of a chemical vapor cloud (e.g., a window shattering after an ignition) and that requires medical treatment or hospitalization (EPA 1994). Medical treatment means treatment, other than first aid, administered by a physician or registered professional personnel under standing orders from a physician (EPA 1994). When analyzing the incident data, all persons taken to a hospital were assumed to have been provided with medical treatment and were thus injured.

When data obtained via the IIAR survey was compared with data from the Ammonia Incident Database, more on-site and off-site consequences were reported for incidents in the Ammonia Incident Database than were reported in the IIAR survey (see Figure 4). This is not surprising given that incidents reported via publicly available sources were more likely to result in consequences. Approximately 93% of the incidents in the Ammonia Incident Database resulted in on-site consequences vs. 26% in the IIAR survey. Likewise, 33% of the incidents in the database resulted in injuries vs. 3% in the IIAR survey. The incidents recorded in the Ammonia Incident Database from June of 2005 to September of 2019 resulted in more than 1,500 people requiring treatment for exposure to ammonia. Though the majority of injuries were relatively minor, it

still averaged to one person in the United States or Canada being treated for ammonia exposure every 2.5 days.

The following additional information was gleaned from the Ammonia Incident Database:

- Off-site responder personnel (e.g., the fire department) responded to virtually all (99%) of the incidents.
- The average duration of each incident was approximately four hours.
- The average amount of ammonia released during each incident was calculated to be 2,900 lb, although the accuracy of this figure is questionable because
  - No release amount was reported for the majority of incidents in the database;
  - Numerous incident reports identified "small releases" but no quantity, and the event was not included in the calculations; and
  - The relatively high estimate was skewed by several large ammonia releases in the database.

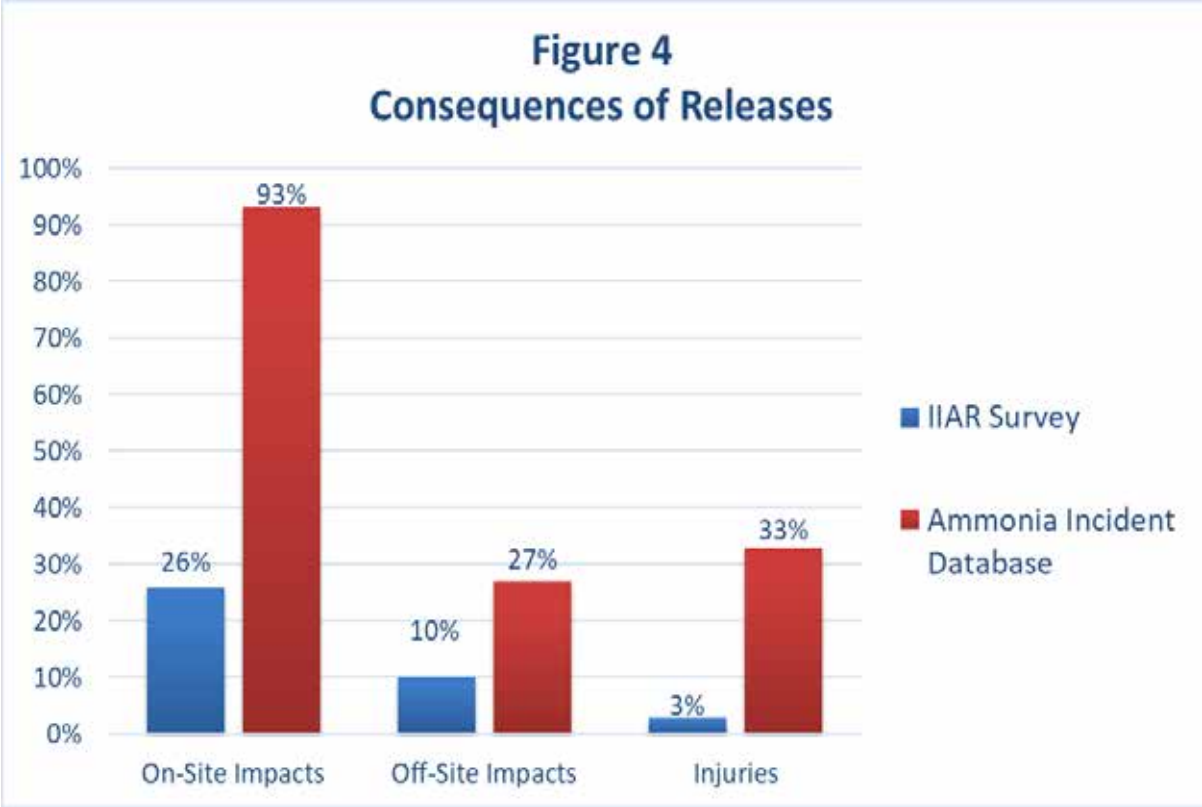

Figure 4. Consequences of releases.

3. In What Daypart Did the Incidents Occur?

The time of day may have affected the timing of ammonia incidents. For example, more ammonia incidents may have occurred during off-shifts because less experienced personnel may have worked during these shifts.

For the purposes of the analysis, each incident was placed into one of three shifts:

1. First shift: 8:01 a.m. to 4 p.m.;
2. Second shift: 4:01 p.m. to midnight; and
3. Third shift: 12:01 a.m. to 8:00 a.m.

Figure 5 shows that almost 75% of the incidents occurred during the first and second shifts, which may reflect that these were the shifts when maintenance and repairs were typically performed. But the bottom line is that incidents occurred during all three shifts.

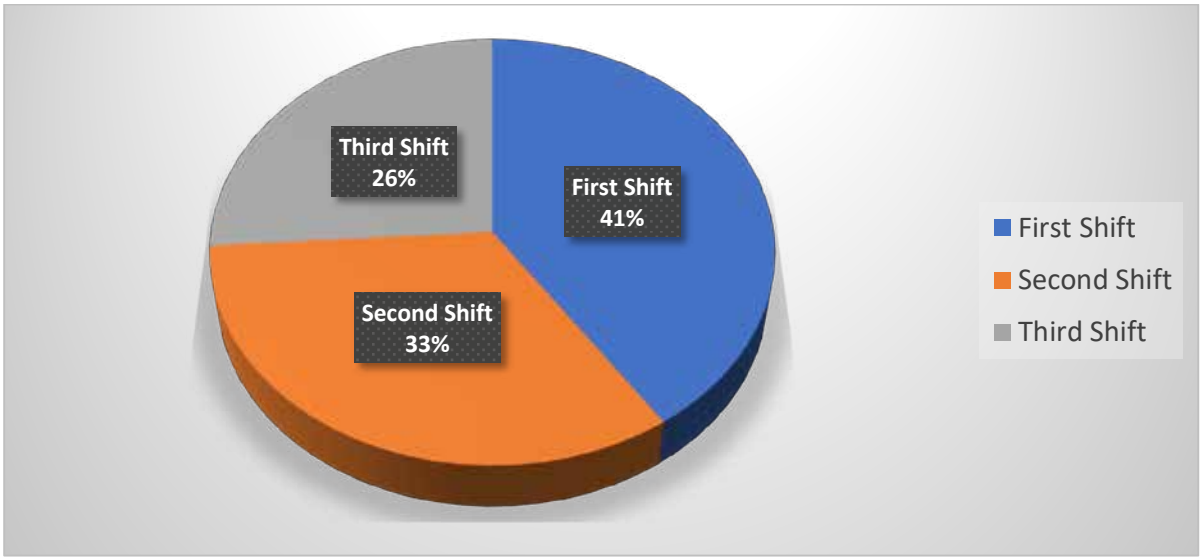

Figure 5. Ammonia Incident Database: incident time period.

The Ammonia Incident Database was examined to determine whether the ammonia incidents display seasonal variation. Figure 6 shows the breakdown by calendar quarter of incidents that occurred during the time period covered by the database. Approximately 60% of the incidents occurred during warm weather periods (second

and third quarters). This may have been due to the seasonal operation of many facilities. For example, vegetable and fruit processing facilities were more likely to be operational during warm weather periods. In addition, warm weather periods were more likely to result in higher system head pressures, which could have led to more releases from pressure relief valves.

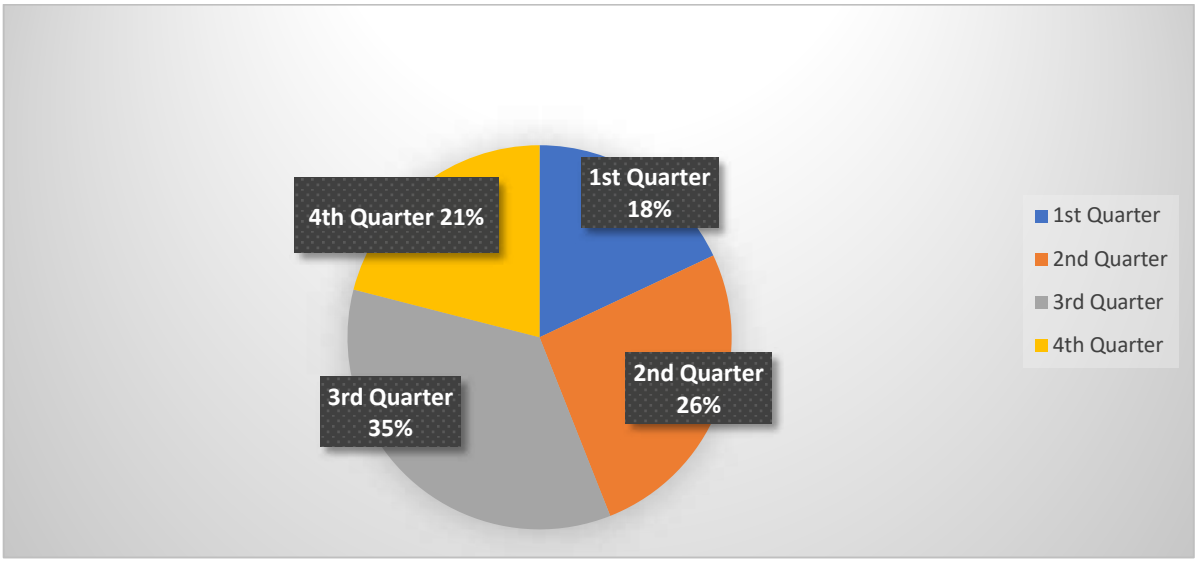

Figure 6. Ammonia Incident Database: seasonal variations.

4. Which Industry Sectors Were Responsible for the Incidents?

Table 1 summarizes incidents by industry. Four of the top five industry sectors on this list (meat and poultry processing, cold storage, dairies, and frozen food) were the top four industry sectors in EPA's RMP five-year accident history database. Three industry sectors at or near the top of the list were not present in EPA's database: ice rinks, beverage, and fruit and vegetable facilities. These three industry sectors were probably not included in EPA's database because many of these facilities contained less than 10,000 lb of anhydrous ammonia and/or were located in Canada and thus not subject to EPA's Risk Management Program.

IIAR survey data indicate that some facilities had more incidents than others. A similar trend was noted in the Ammonia Incident Database. When companies in one industry sector were compared with similarly sized companies in the same industry sector, the number of incidents sometimes varied significantly. For example, Company A in one industry sector had 29 incidents in the database, whereas Company B in the same industry sector had only four incidents.

Industry Sector	Number of Incidents
Meat and poultry processing	159
Cold storage	134
Ice rinks	103
Dairy and related facilities	80
Frozen food	75
Beverage	71
Fruit and vegetables	71
Ice plants	48
Seafood processing	30
Bakeries	18
Total in all industry sectors	789

Table 1. Ammonia Incident Database: industry sectors.

Tables 2 and 3 show the number of incidents in each region in the United States and Canada for the time period June 2005 through September 2019. Regions with higher numbers of incidents, for example, EPA Region 4 (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee) and EPA Region 5 (Illinois, Indiana, Minnesota, Ohio, and Wisconsin), appeared to reflect the total number of meat and poultry processing, cold storage, and dairy facilities located in these regions. The relatively low number of incidents in EPA Region 2 (New York, New Jersey, Puerto Rico, and U.S. Virgin Islands) most likely reflected the relatively small number of facilities operating ammonia refrigeration systems in this region. In Canada, the location of ice rinks appeared to have the greatest effect on the number of incidents occurring in each region.

EPA Region	Number of Incidents
EPA Region 1	53
EPA Region 2	27
EPA Region 3	71
EPA Region 4	132
EPA Region 5	106
EPA Region 6	93
EPA Region 7	51
EPA Region 8	32
EPA Region 9	93
EPA Region 10	68
Total in all regions	726

Table 2. Ammonia Incident Database: EPA Regions in the United States.

Region in Canada	Number of Incidents
Atlantic	13
Quebec	8
Ontario	27
Prairies	37
British Columbia	28
Territories	1
Total in all regions	114

Table 3. Ammonia Incident Database: regions in Canada.

6. Where Did the Incidents Occur?

Figure 7 shows the location within the facilities where incidents occurred. More incidents occurred in machinery rooms than in production areas (i.e., indoor areas other than the machinery room), probably because of the relatively large concentration of refrigeration equipment in machinery rooms. Approximately half of the incidents occurred outdoors. The majority of the outdoor incidents (~73%) in the Ammonia Incident Database were releases from pressure relief valves, and most of the releases from pressure relief valves resulted in injuries and/or off-site consequences.

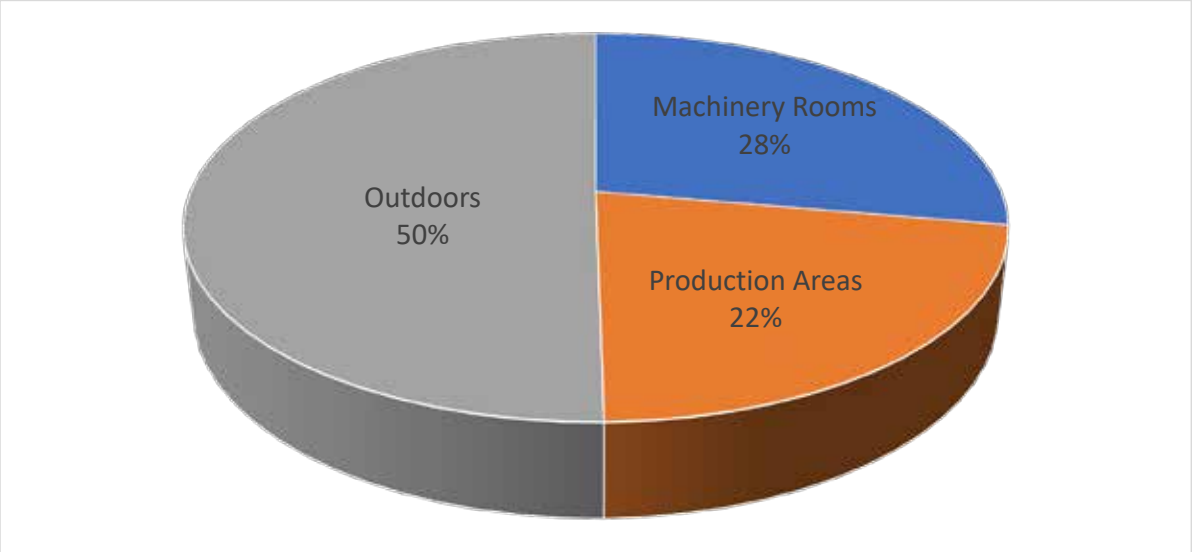

Figure 7. Ammonia Incident Database: incident location.

Figure 8 summarizes the equipment where releases occurred as reported in the IIAR survey and the Ammonia Incident Database, which indicate that 60 to 65% of the releases occurred from flanges, joints, valves, and piping. This was consistent with EPA's RMP database, which reports that approximately half of the releases originated from valves and piping.

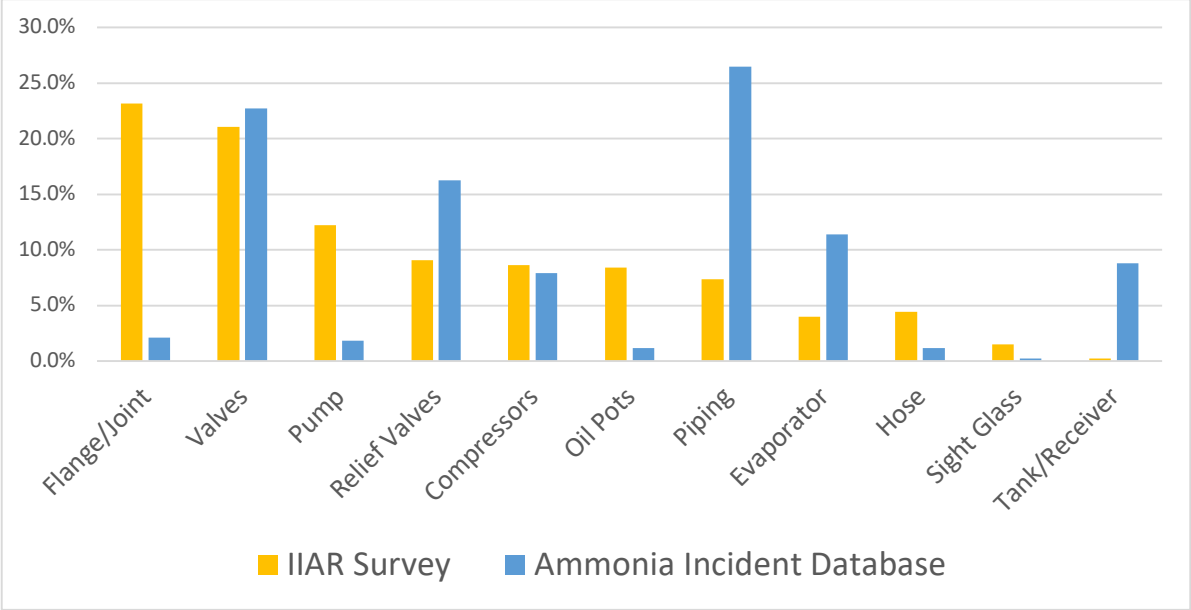

Figure 8. Equipment where incidents occurred.

7. What Were the Most Common Causes of the Incidents?

Figure 9 shows the breakdown of incidents caused by human error, equipment failure, and external events in EPA's RMP database, the IIAR survey, and the Ammonia Incident Database. Each database indicates that a similar number of incidents (between 37 and 48%) were due to human error. The biggest discrepancies were in the number of incidents caused by equipment failure (41% in the Ammonia Incident Database vs. 60% in the IIAR survey) and the number of incidents related to external events (15% in the Ammonia Incident Database vs. 1% in the RMP database and 3% in the IIAR survey). Causes of external events included fires, impacts from motorized equipment (such as forklifts), weather-related events, and damage due to structural or building failure.

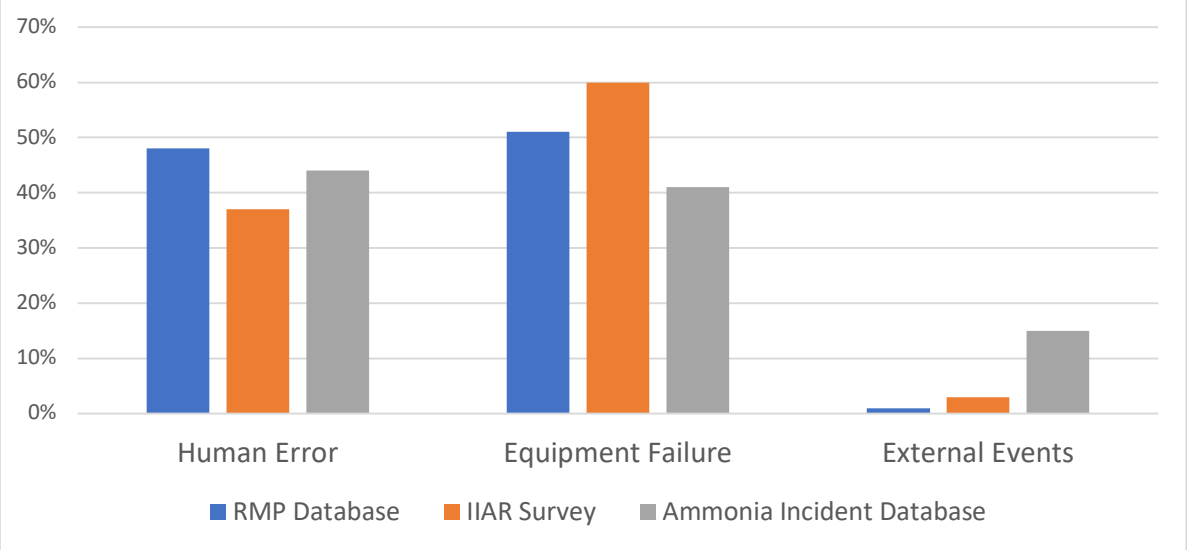

Figure 9. Causes of releases.

Table 4 summarizes the incident causes recorded in the Ammonia Incident Database. Note that no cause was identified for approximately two-thirds of the incidents. More than one-quarter (27%) of the incidents were related to line-opening operations. The database contained numerous comments referring to "residual ammonia was left in the equipment" and "the release occurred when equipment was opened while performing maintenance."

When related causes were combined into one group, the largest percentage of incidents (36%) was caused by equipment failures (faulty equipment, leaks from seals/gaskets, corrosion, and faulty pressure relief valves). The second largest group of incidents (33%) was caused by human errors (line opening, liquid transfer, oil draining, and improper valve opening).

Incident Cause	Percentage of Incidents in Database		Ammonia Safety Program Elements
Faulty equipment	17%	36%	System design (IIAR 2; IIAR 9) Hazard analysis Mechanical integrity program (IIAR 6-2019)
Leak from seal/gasket	9%		
Corrosion	6%		
Relief valve fails open	4%		
Line opening	27%	33%	Line opening procedures (IIAR 7) Operating procedures (IIAR 7) Maintenance procedures (IIAR 6) Training
Transferring liquid	3%		
Oil draining	2%		
Improper valve opened	1%		
Loss of cooling	7%	10%	System design (IIAR 2; IIAR 9) Hazard analysis
Expansion/contraction	2%		
Hydraulic or thermal shock	1%		
Impact from motorized equipment	6%	9%	System design (IIAR 2; IIAR 9) Hazard analysis Training
Structural or building failure	3%		
Decommissioning	5%	6%	Decommissioning procedures (IIAR 8) Installation procedures (IIAR 4) Start-up Procedures (IIAR 5)
Commissioning	1%		
External fire	5%		System design (IIAR 2; IIAR 9) Hazard analysis Hot work permit procedures
Ammonia theft	<1%		System design (IIAR 2; IIAR 9) Hazard analysis

Table 4. Ammonia Incident Database: incident causes.

For each group of incident causes, Table 4 lists general ammonia safety program elements that could have been used to prevent these incidents from occurring and/or minimize the consequences of the incidents. Many of these elements are directly related to current ANSI/IIAR standards.

This technical paper is not the first document to review actual incidents in the ammonia refrigeration industry. In 2001, EPA issued an updated alert on the "Hazards of Ammonia Releases at Ammonia Refrigeration Facilities." The recommendations included in this alert are strikingly similar to the items contained in the ammonia safety program elements column in Table 4. For example, the EPA alert presents the following recommendations:

- Establish training programs to ensure that knowledgeable personnel operate and maintain the ammonia refrigeration system.
- Develop and require refrigeration personnel to follow written, standard procedures for maintaining the system, including such routine practices such as oil draining.
- Provide barriers to protect refrigeration equipment, i.e., lines, valves, and refrigeration coils, from impact areas where forklifts are used.
- Develop and maintain a written preventive maintenance program and schedule based on the manufacturer's recommendations for all of the refrigeration equipment.

8. How Effective Are Ammonia Mitigation Systems?

Members of the IIAR Standards Committee spend countless hours discussing the design of mitigation systems for an ammonia refrigeration system. To aid in these discussions, the Ammonia Incident Database was reviewed for clues on ammonia mitigation systems.

Overpressure protection devices are crucial to the design of a safe ammonia refrigeration system. As mentioned earlier in this paper, the majority of outdoor releases (~73%) noted in the Ammonia Incident Database were from pressure relief

valves. And most of the releases from pressure relief valves resulted in injuries and/or off-site consequences. Where identified, one of five root causes was typically listed as the reason for improper opening of the pressure relief valve:

1. Loss of cooling in the system,
2. Overheating of equipment,
3. Extreme environmental conditions,
4. Power failures, and
5. Relief valve malfunctioned.

The first four root causes are related to the design and operation of an ammonia refrigeration system. The fifth root cause is related to the mechanical integrity of pressure relief valves. Hazard analyses should be conducted to identify the potential circumstances that are causing these pressure relief valves to open. Additional emphasis must also be placed on the design, operation, and maintenance of overpressure relief protection systems.

While reviewing the Ammonia Incident Database, a significant amount of time was spent trying to determine if any conclusions could be reached regarding safe operation of ammonia detection systems, emergency ventilation systems, and emergency shutdown systems. However, very few incidents in the database (fewer than 10) discussed ammonia detection systems, emergency ventilation systems, or emergency shutdown systems, so no conclusions were reached. The publicly available information was primarily based on initial incident reports, and any evaluations of mitigation devices most likely occurred at a later date and not publicly available. The only way to obtain data on ammonia mitigation systems seems to be obtaining incident investigation reports directly from facilities that operate ammonia refrigeration systems.

9. Incidents with Catastrophic Consequences

The Ammonia Incident Database indicated nine incidents that resulted in fatalities at facilities operating ammonia refrigeration systems and two incidents resulting in fatalities at ammonia storage terminals. Table 5 summarizes these incidents. Two issues must be emphasized based on a review of these catastrophic incidents:

1. Nine of the 11 incidents were related to line opening, liquid transfer, or oil draining operations. This supports the hypothesis that these operations are the most hazardous conducted in the ammonia refrigeration industry.

2. Three of the 11 incidents involved persons trapped in limited access areas. The location of ammonia equipment and possible escape routes must be considered during the design of the system and all subsequent hazard analyses.

When designing, operating, maintaining, and especially when conducting a hazard analysis of an ammonia refrigeration system, the following questions must be addressed for every scenario that could potentially result in an ammonia release to prevent incidents with catastrophic consequences:

1. How can the ammonia release be prevented?

2. How can the ammonia release be detected?

3. How can the persons in the area escape from the ammonia release?

4. How can the ammonia release be stopped?

5. How can the area be ventilated?

Location of Incident	Reported Causes and Contributing Factors
EPA Region 9	Release from an oil drain line (improper valve opened) Person trapped in limited access area
British Columbia	Old, obsolete equipment Corrosion Line opening during emergency repair Alarms tied to ammonia detector(s) disabled
EPA Region 1	Ruptured ammonia line Person trapped in limited access area Emergency shut-off device may not have functioned
Ontario	Release from oil drain line
EPA Region 9	Release from an ammonia valve (improper valve opened) Person trapped in limited access area
EPA Region 4	Release during line opening procedures (wrong line opened)
EPA Region 4	Release during line opening procedures (wrong line opened)
EPA Region 4	Release when transferring liquid ammonia (wrong hose used)
EPA Region 5	Release when transferring liquid ammonia (hose not properly connected)
EPA Region 7	Release when transferring liquid ammonia (leak from open line) Person trapped in limited access area
EPA Region 7	Release when transferring liquid ammonia (valve broke while it was being removed)

Table 5. Ammonia Incident Database: incidents with catastrophic consequences.

Conclusions

This paper assumes that (a) the number of ammonia incidents in the United States and Canada could be significantly reduced and (b) a study of previous incidents could help to determine the best methods for preventing and/or minimizing the consequences of future incidents. Through a review of incident data submitted to the EPA, incident data collected in response to an IIAR questionnaire, and incident data collected via publicly available sources, the following conclusions were reached for facilities operating ammonia refrigeration systems:

1. The ammonia refrigeration industry should continue to promote inherently safer technologies, including designs that minimize the total ammonia charge and designs that eliminate the use of ammonia equipment outside of machinery rooms (Jordan 2009).

2. Faulty and poorly maintained equipment were responsible for the largest number of incidents. These incidents are preventable through improvements to the system design (IIAR 2; IIAR 4) and mechanical integrity procedures (IIAR 6). In addition, facilities should identify and replace older, obsolete equipment on a timely basis.

3. Line opening operations, along with liquid transfer and oil draining operations, were responsible for the second largest number of incidents and the majority of incidents with catastrophic consequences. These incidents are preventable through the application of engineering controls (such as spring-loaded valves and pump-out systems (Engle et al. 2006)) and administrative controls (such as line opening procedures (IIAR 7), written operating (IIAR 7) and written maintenance procedures (IIAR 6), and training for system personnel). In addition, during liquid transfer operations, facilities must ensure that the transfer line/hose is suitable for

ammonia, has been properly maintained, and contains appropriate devices to limit the size of an ammonia leak if the line/hose were to rupture.

4. The design and operation of the ammonia refrigeration system should address persons who could be trapped in limited access areas when ammonia is released. Specifically, the following options should be considered, preferably in this order:

   a. Relocate the ammonia refrigeration equipment,

   b. Provide a secondary (back-up) emergency exit, and

   c. Provide personal protective equipment (PPE) that would enable personnel to escape the area in an emergency.

5. The majority of the outdoor releases (~73%) identified in the Ammonia Incident Database were releases from pressure relief valves. Hazard analyses should be conducted to identify the potential circumstances that cause these pressure relief valves to open. Additional emphasis must also be placed on the design, operation, and maintenance of the overpressure relief protection systems.

6. Additional emphasis is needed to protect refrigeration equipment from motorized equipment, especially forklifts, and from damage caused by structural or building failures.

7. Many incidents occurred during the commissioning and the decommissioning of ammonia refrigeration systems. IIAR has written standards addressing these situations (IIAR 4; IIAR 5; IIAR 8).

8. Fires affecting ammonia refrigeration systems were responsible for approximately 5% of the incidents in the database. These incidents may be prevented and/or minimized through the implementation of hot work permit procedures, the relocation of flammable materials, and improvements to fire suppression systems.

9. Adverse incidents continue to occur in the ammonia refrigeration industry (approximately one incident every three to six days), and these incidents often result in people being injured and sent to the hospital for treatment (more than 1,500 during a 14-year period).

Finally, IIAR and its members should continue the study of incidents in the ammonia refrigeration industry. Specific recommendations along these lines include

1. Contact EPA and/or the Chemical Safety Board to determine if additional, up-to-date data can be obtained from EPA's five-year accident history database.

2. Contact IIAR members to determine if they would be willing to share, on a confidential basis, reports conducted to investigate incidents that have occurred in their ammonia refrigeration systems.

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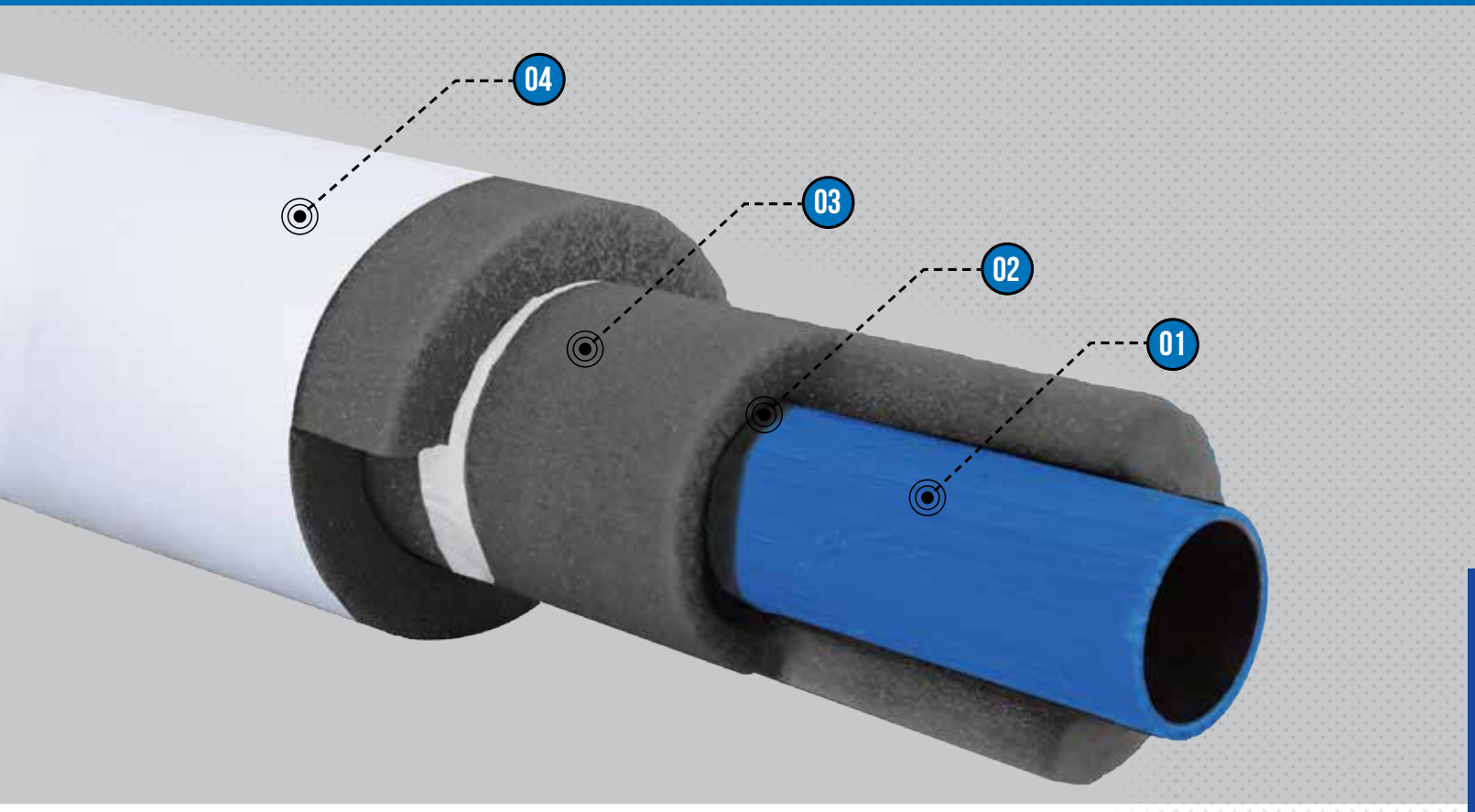

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