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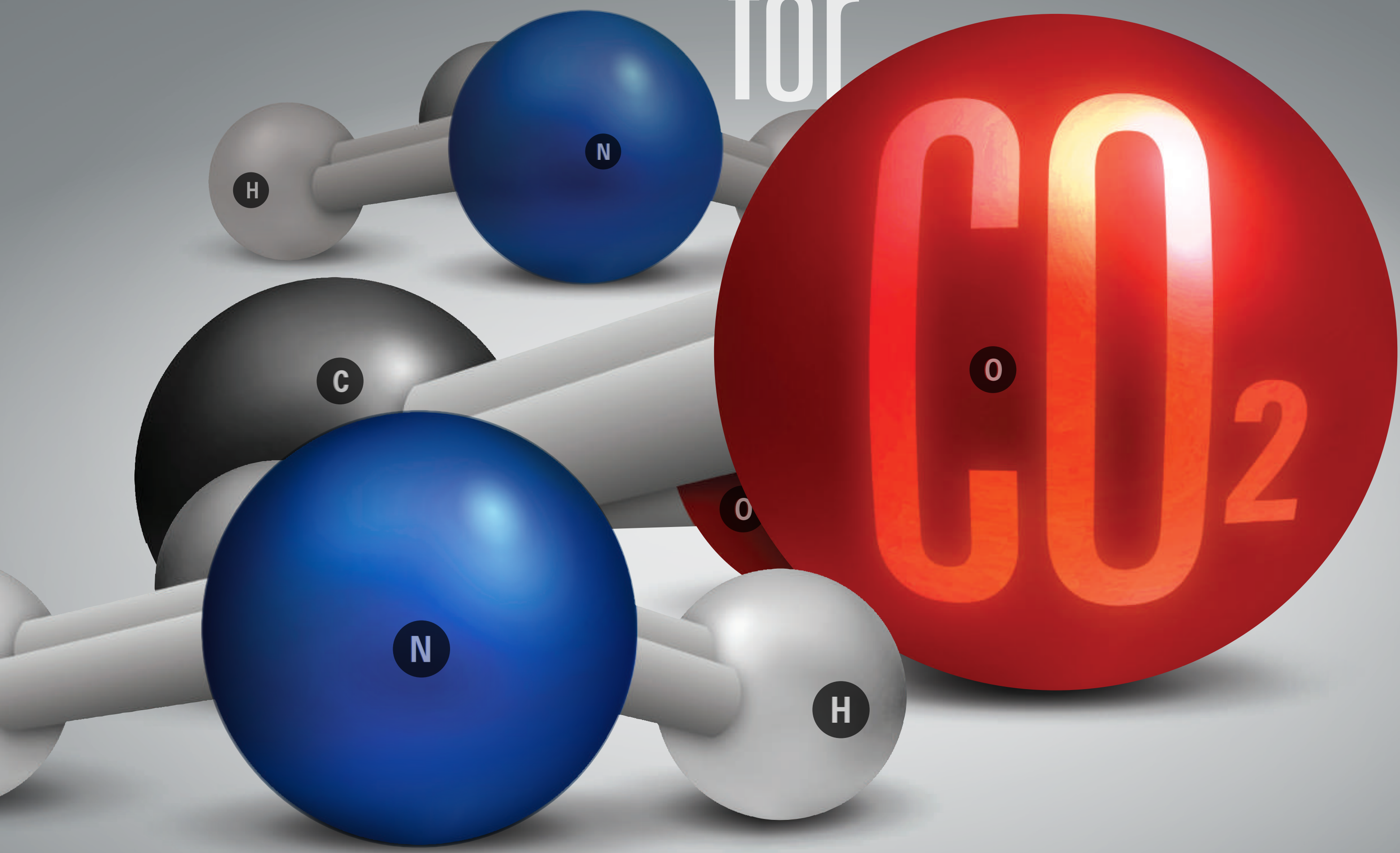
THE OFFICIAL MAGAZINE OF THE AMMONIA REFRIGERATION INDUSTRY ■ **MARCH 2015**

CONDENSER

The Case for CO_2

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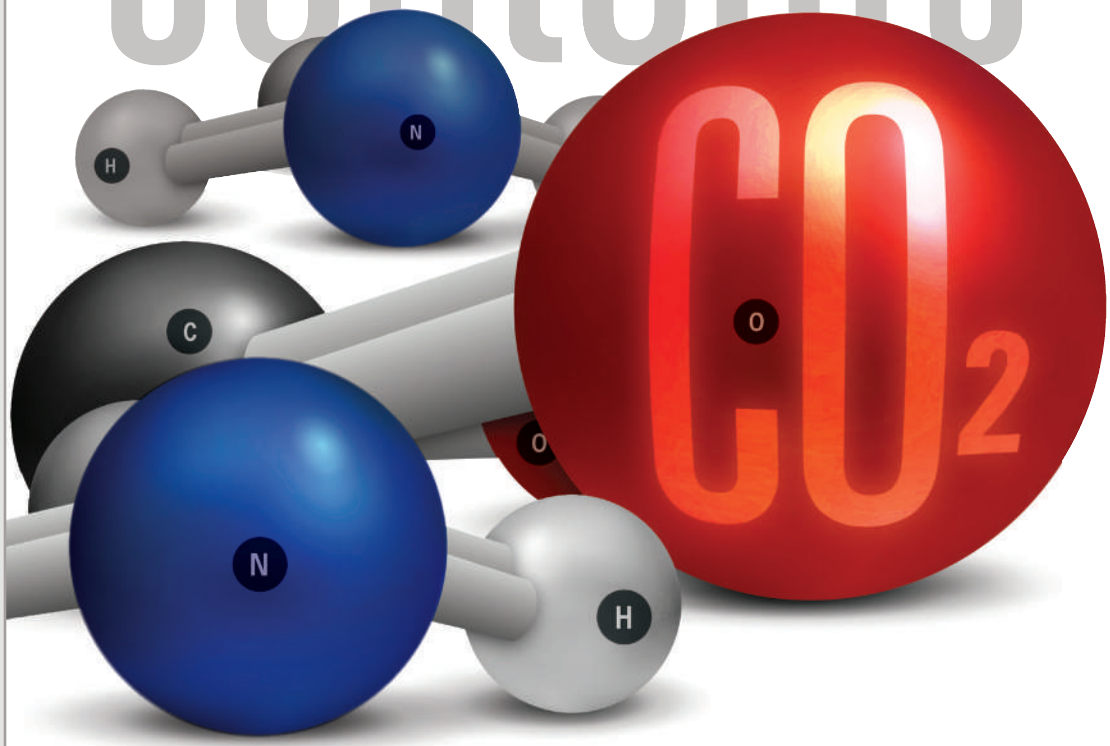

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COVER STORY

The Case for CO_2

The use of CO_2 as a refrigerant has grown in recent years, thanks to market demand spurred by a combination of environmental regulatory actions and technology advances in microprocessor controls and valve design.

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chairman's MESSAGE

MARCOS BRAZ

Our IIAR Annual Conference and Exhibition in San Diego is finally here! The conference team has prepared a tremendous program for those of you attending this year, and while this is the last annual meeting during my term as Chairman, this year's conference represents just the beginning of many exciting developments for IIAR and its members.

This year's conference represents just the beginning of many exciting developments for IIAR and its members.

We met many important goals in 2014, and we will now build on those achievements in the year ahead and beyond.

The pending completion and release of the IIAR-2/ ANSI Standard and ongoing standards work such as the recent approval of the IIAR-4 and IIAR-8 standards, as well as relationship building efforts with government representatives, set a solid foundation for a number of new objectives as we look to the future.

The IIAR continues to build a strong international association profile and credibility that enables us to extend our global reach.

I am extremely happy to announce that our very first International Chapter was recently founded in Costa Rica with support of new local members and government. The Chapter will represent IIAR in the Central America and Caribbean. We are also in advanced negotiations with representatives in Peru and Ecuador to start chapters in those countries as well.

Our International committee with tremendous support from IIAR's Staff is doing incredible work, including within several regions in India, with the aim of continued international advocacy, government relations and membership growth.

In addition to International chapter development we are also working with local organizations in Colombia in May 2015 and Mexico in October 2015 to host regional seminars in those nations. These seminars are part of our continued support to international alliances with other important organizations that support natural refrigerants.

These joint ventures will enable us to share information and best practices as we also learn from our colleagues in these countries.

These programs are made possible by the hard work of our Committees that are supporting these efforts. We truly are encouraged by these developments that will help us take our membership-building efforts to the next level as we move forward.

IIAR continues to focus on providing our members with the safety standards, regulatory support, industry technology trends and other member services that are necessary to operate an ammonia system in today's environment.

Each opportunity for sharing knowledge and information, such as our upcoming conference, and international seminars, is a chance for us to build and strengthen the resources we have available for our members.

Through our vast library of IIAR Technical Bulletins, IIAR Ammonia Data Book, the recent introduction of Technical Paper compendiums and of course our IIAR Standards, we are developing the world's largest and best information resource for our membership and the industry in general.

One of the best parts of being IIAR's Chairman over the past year has been the opportunity to be part of the great work of our Committees.

The IIAR-2 standard is now working its way through the public review process and will become an ANSI certified document.

This process, along with the recent approval of the IIAR-4 and IIAR-8 standards is a testament to the hard work, knowledge and professionalism of our industry volunteers.

If you have volunteered on any one of our member committees, please accept my warmest and sincere thank you!

I would like to take this opportunity to personally thank each one of our Board of Directors and Executive Committee for your valuable insight of the organization, collaboration and dynamic participation throughout the year, while giving us your time and expertise so generously.

Without our volunteers we wouldn't be where we are today, ready for the future as the most progressive, globally recognized and leading advocate for the safe, reliable and efficient use of ammonia and other natural refrigerants.

I would also like to encourage you to join in this excellent work as both a member and committee volunteer.

To all of our members, friends and colleagues, it has truly been an honor to serve as your Chairman.

I am looking forward to seeing many of you at the conference. And beyond that, I'm looking forward to seeing where the achievements of the past few years take us as we move towards the future of our industry. ■

president's MESSAGE

BY DAVE RULE

This issue of the Condenser marks the end of the last member year, and the beginning of a new one. It also marks our annual conference, where we come together from all corners of our industry to talk about the trends and technology shaping our business – at IIAR's Annual Industrial Refrigeration Conference and Exhibition.

Whether you're a longtime IIAR member, a first time attendee or a committee member dedicating your time and attention to one of our many projects, your contribution to this industry, and at this conference is vital.

It's an exciting time for our industry, a time of change. As regulations and technologies evolve at a breakneck pace, we're seeing new opportunities and applications for refrigeration grow like never before.

We are truly an industry in transition. And while all corners of our business world are expanding, we're seeing the impact of three central trends on our business environment.

First, CO_2 technologies, long considered something of an outlier from a technology perspective, are moving into the mainstream, and opening the door in new commercial arenas, such as supermarkets.

Second, new, low-charge systems are also expanding our marketplace, but in an entirely different way, by introducing new industrial and commercial applications for ammonia that allow us to operate more efficiently and below some federal regulatory thresholds such as those set out under the process safety management and risk management programs.

Third, the phase out of R-22 here in the United States, and the broader F-gas phase out currently underway in the European Union, is starting to heavily influence decision processes in the commercial and industrial market.

Propelled by regulatory change and environmentalism, and fueled by our industry's relentless development of new, ever safer and more efficient technologies, an unmistakable trend has emerged.

The world is moving towards natural refrigerants. I'll use this month's column to lay out the goals your organization is working hard to meet and the initiatives we're taking in this new membership year.

The face of our industry will look very different in even five years, and that means that now is a critical time for IIAR to take a leadership position, especially when it comes to our primary mission, which is guiding the industry in standards development and code adoption.

I'm happy to report to you that your staff, volunteer leadership and committee members have risen to that challenge. In the last year, we've made incredible progress on the development of IIAR-2, the most comprehensive safety standard for ammonia in the world.

IIAR-2 is already having an impact on changes in building codes and construction standards, and we've submitted changes to the IMC and UMC to reflect this new body of safety information.

IIAR-2 is truly our industry's flagship standard, and it's just the tip of the iceberg. We're rounding out this effort with an entirely new suite of IIAR standards. This year, your staff is hard at work creating several new member tools and services.

First, is a dedicated website portal to deliver support to our end-user community. This portal will feature access to customized IIAR information and resources for this important membership sector. Similarly, this year, we launched a website portal for our regulatory community – to provide easy access to essential industry standards, guidelines and training materials for OSHA and the EPA.

And, to facilitate easy access for all of our members to the publications and services that make IIAR the technical authority of this industry, we're excited to announce that we'll launch a new IIAR member app in just a few months.

Meanwhile, we're continuing our strong commitment to advocacy and education. On the advocacy side, IIAR has re-committed to a 5-year formal alliance with OSHA, which the agency considers one of its most successful industry programs.

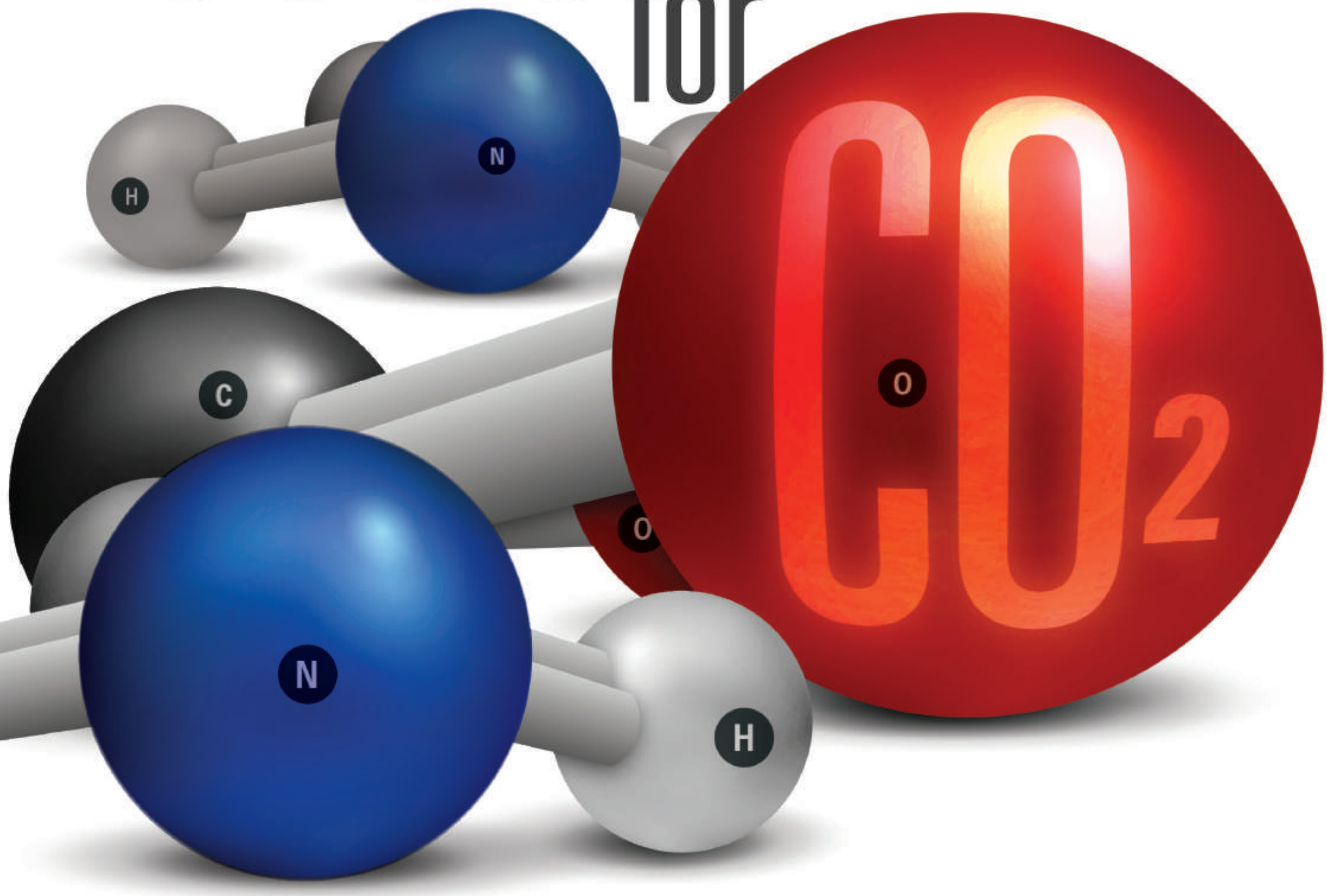
And finally, on the education front, we began work in partnership with RETA to identify ways to grow our industry's pool of new talent. By developing a community college-level curriculum that can be delivered by schools across the nation, we hope to prepare the next generation for a career in our industry with a core refrigeration program.

I've mentioned some big goals that IIAR is moving forward to meet. We've set the bar high, and all of these exciting projects take a significant effort from your staff to realize.

These projects also depend on the hard work of our volunteer committee members and board leaders, who often put their dedication to this organization before their own professional and personal obligations.

That dedication has put us in a stronger position than ever to pursue the new opportunities, more global mindset and important transitions that are setting the stage to make this new member year more exciting than ever. ■

The Case for CO_2



The use of CO_2 as a refrigerant has grown in recent years, thanks to market demand spurred by a combination of environmental regulatory actions and technology advances in microprocessor controls and valve design.

While CO_2 systems are still more expensive than conventional refrigerants in the commercial world, proponents of CO_2 say the technology is ready to be embraced by retailers and end users alike as a way to alleviate regulatory and corporate pressure to find an environmentally friendly alternative to refrigerants with high global warming potential.

"Because of pressure to meet environmental goals, the market, and our industry is looking at how we can use natural refrigerants like CO_2 again in the mainstream," said Scott Martin, Director of Sustainable Technologies for Hillphoenix.

"There is a real movement in our industry to seriously consider CO_2," said Dan O'Brien, Vice President of Sales and Marketing for Zero Zone. "As big global companies have said they're going to be green – and utilize refrigerants with low global warming potential – credibility for CO_2 is building."

Both Hillphoenix and Zero Zone manufacture CO_2 systems for the commercial and industrial markets, where each company said they're seeing an increased interest in CO_2 projects in sectors as varied as grocery, pharmaceutical and cold storage.

U.S. companies, Target, Coca Cola, Nestlé and Red Bull, as well as Canadian food retailers Sobeys and Loblaws, are among several retailers who have made formal corporate commitments to natural refrigerants.

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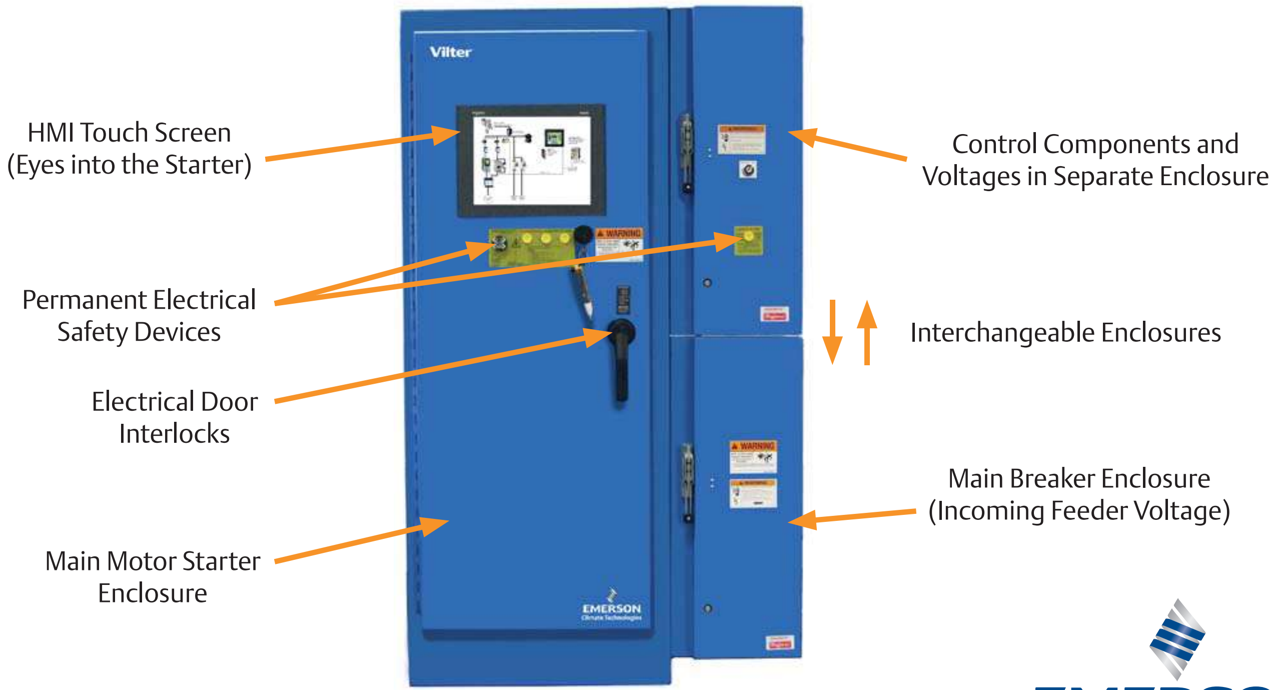

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Vilter

EMERSON Climate Technologies

As costs mount for retailers caught in a seemingly never-ending cycle of system upgrades or replacements – to accommodate new phase-outs of refrigerants deemed environmentally unfriendly by the EPA – CO_2 is emerging as an attractive solution with the potential of solving operational challenges.

"In my career, R12 and 502 has been replaced by 22, which has been replaced by 404A, which was replaced by 407 and now 407 is about to be replaced by a new series of refrigerants released later this year. That's five sets of refrigerants, and each one of those changes comes with development work you have to do to make them work in a system," said Martin. "Supermarkets are building stores every day, so all of a sudden, you have this large install base, and you're starting to look at . . . when do I convert this store to a next generation refrigerant that takes me out of this cycle?"

"That's where CO_2 comes in. It's a refrigerant that is never going to be taxed or regulated because it's environmentally benign," he said.

Expense is still a major decision factor for this type of customer, but other factors, such as the potential to deal with regulatory pressure and boost corporate environmental image, are also starting to play a big role in the decision making process, said O'Brien.

"Our customers are now at the point where they're making decisions according to factors that justify natural refrigerants, and even though CO_2 may mean investing a little bit more money, the other payoffs are attractive," he said. "In some cases, company policy and philosophy is outweighing and becoming more important than the initial cost of building these systems."

"In the commercial market, we're seeing customers trying CO_2. Among large grocery retailers in the U.S., they want to do one or two stores. They're not making a large commitment yet, but they want to understand it and be ready."

That's a sentiment echoed by Bent Wiencke, Manager, Refrigeration Engineering for Nestlé USA. "There's a lot of end user interest in CO_2 and the end user market is absolutely assessing CO_2 as a viable alternative to conventional ammonia systems. But this needs to be evaluated on a case-by-case basis and weighed against other technical solutions providing a high degree of safety and possibly less complexity. An example is, low charge ammonia systems and the use of brines as a secondary refrigerant."

"CO_2 technology still has its challenges finding its marketplace in smaller applications where it's competing with commercial HVAC and chiller equipment," he said. "This is predominantly here in the U.S. and Canada where we see a significantly lower price level of commercial equipment when compared to Europe, and currently no legislative pressure exists to phase out HFC refrigerants" at the same level as in Europe.

Wiencke added that, "Purely from a cost standpoint, CO_2 systems still have a long journey ahead before they can compete. Without legislative pressure or corporate mandates to switch to natural refrigerants, [that journey] may even get a tad longer."

As for what it will take to spur widespread adoption, only time will tell, as the sector works towards a critical mass of projects that it hopes will increase the pool of suppliers, and buyers, enough to bring manufacturing costs down. To see what could happen in the U.S. CO_2 market may mean looking no further than Europe.

Momentum behind the use of CO_2 as a refrigerant started building there as early as 2000, when European countries began imposing taxes on HFCs and HCFCs to deter their use, said Andre Patenaude, the director of CO_2 business development for Emerson Climate Technologies, a refrigeration engineering and design consultant.

The taxes drove the commercial supermarket sector to look for and start developing technology that would make CO_2 a good option for modern systems and requirements, and it has been growing for several years, he added.

"Three years ago there were about 1,000 transcritical CO_2 systems in Europe; about a year ago there were 3,000, and now there are probably 5,000 to 6,000 systems," he said. "It's growing there, and I believe it's safe to say the U.S. will have a similar pattern, depending, of course, on how much legislation drives it. But it's already in supermarkets without creating major issues, so I think it's a trend that's taking off," he said.

To realize that kind of growth here in the United States, the market will need more component suppliers and an update to the codes and standards that describe CO_2 systems and their use.

While the pool of CO_2 component suppliers is increasing in the U.S., it still hasn't gotten big enough, or specialized enough, to start bringing down the cost of manufacturing the systems, a hurdle many see as the last big barrier to growth in this country.

"There are more suppliers than there used to be that are making components that we use for CO_2 systems, but a lot of the components we use are unique and special for CO_2," said Hillphoenix's Martin. "In the beginning there were only one or two suppliers, but now that number has tripled or more, and that's driving down the cost of components, which is driving down the cost of systems."

"There's just starting to be enough volume now to make CO_2 systems efficient enough to produce," he said. "This sector is hitting its stride, but it took this long for volume to build to the point that this even looks economically feasible."

While the pool of CO_2 component suppliers is increasing in the U.S., it still hasn't gotten big enough, or specialized enough, to start bringing down the cost of manufacturing the systems, a hurdle many see as the last big barrier to growth in this country.

From that perspective, growth may be a volume game, but it's also a complexity game, said Zero Zone's O'Brien.

“One of the things we've seen in systems we've built is that we end up dealing with the reality that a lot of equipment manufacturers haven't optimized the equipment they're selling specifically for CO_2 systems,” he said. “We don't have a lot of equipment available yet that is designed to address the unique properties of CO_2. That means we're not able to take full advantage of the capabilities of CO_2 systems [as an industry] as we may in the future. It will take an investment from the equipment manufacturers and others that are building these systems to truly realize the potential of CO_2.”

Such an investment could be seen as one that would benefit the industry in general, as industrial refrigeration looks to the codes and standards that have the potential to spur growth for all natural refrigerants.

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“Our regulations here still impose some pretty significant requirements around pressure” in CO_2 systems, said Mark Dutton, Segment Manager for Cold Storage, Heatcraft Kysor/ Warren. “We look forward to the opportunity to harmonize U.S. standards with the broader international standards driven from Europe. That will help reduce system cost and improve component availability.”

Heatcraft Kysor/ Warren manufactures CO_2 systems and components for the commercial and industrial markets.

IIAR President Dave Rule agreed with Dutton, saying, “The lack of updated CO_2 standards has the potential to hinder the growth of CO_2 in the U.S. market.” Rule added that IIAR will focus attention on the development of standards for CO_2 systems in the coming year.

And that effort will be a big step forward for CO_2 system manufacturers, especially in the commercial applications world, said Zero Zone's O'Brien, adding that new standards will also facilitate the development of better training resources to help solve another growth problem faced by the sector – the shortage of operators who know and are comfortable with CO_2 systems.

“What's exciting at this stage is that for so long CO_2 has been discussed as an attractive technology option, and for so long, the standard response for not putting CO_2 out there in the systems we use today has been: ‘we don't have the people who know how to handle CO_2, or we don't have the components to build the systems.’ That's not necessarily the case anymore,” he said.

“Those problems are becoming less and less of a reality as more of these systems are being installed. We're seeing CO_2 systems gaining a foothold in new applications and we're installing them in places we haven't commonly used them before. The growth of CO_2 is just a matter of time and project volume.” ■

EPA Issues Enforcement Alert on Anhydrous Ammonia

iiar government RELATIONS

BY LOWELL RANDEL, IIAR GOVERNMENT RELATIONS DIRECTOR

In February 2015, the Environmental Protection Agency issued an enforcement alert entitled: "Anhydrous Ammonia at Refrigeration Facilities Under Scrutiny by U.S. EPA." The EPA's Office of Civil Enforcement issues alerts such as this periodically to highlight areas where the agency is placing enforcement priority.

According to EPA, "evidence gathered by the U.S. Environmental Protection Agency (EPA) indicates that some refrigeration facilities may be failing to properly manage hazardous chemicals, including anhydrous ammonia, as required by the Clean Air Act (CAA) Section 112(r)." The alert is intended to inform the industry that companies must take responsibility to prevent accidental releases of dangerous chemicals like anhydrous ammonia through compliance with CAA's Chemical Accident Prevention Program. EPA cites a number of recent releases and enforcement cases as a reason for issuing the alert.

For facilities with over 10,000 pounds of ammonia, the primary regulation EPA uses is the Risk Management Program. The alert reminds facilities subject to RMP that they must:

- Analyze the worst-case release scenario to determine the potential effects of a release of an extremely hazardous substance.
- Complete a five-year accident history.
- Coordinate response actions with the local emergency response agencies.
- Submit to EPA a written Risk Management Plan, which is a summary of the Program, updating the plan every five years or as changes occur.

Facilities that have processes from which worst-case releases could reach the public, or where accidental releases within the past five years have resulted in certain offsite impacts have additional requirements. For example, owners and operators of Program 3 processes must:

- Conduct an analysis to identify and resolve hazards associated with the process, which must be updated every five years.
- Have a release prevention program, with requirements to:
  - compile process safety information about the chemicals, equipment, and applicable industry standards, and ensure compliance with such industry standards,
  - use safe operating procedures,
  - train employees,
  - maintain equipment,
  - conduct compliance audits every three years,
  - investigate accidents,
  - manage changes that could affect a process,
  - perform pre-startup review,
  - have an employee participation plan,
  - prevent accidents from hot work, and
  - have a program to manage contractors who are working on or around a process.

The alert also discusses the role that the EPA's General Duty Clause plays in regulating refrigeration facilities with less than 10,000 pounds of ammonia. The Clean Air Act Amendments of 1990 includes Section 112(r)(1), which defines EPA's General Duty Clause:

"…The owners and operators of stationary sources producing, processing, handling or storing such substances [i.e., a chemical in 40 CFR part 68 or any other extremely hazardous substance] have a general duty [in the same manner and to the same extent as the general duty clause in the Occupational Safety and Health Act (OSHA)] to identify hazards which may result from (such) releases using appropriate hazard assessment techniques, to design and maintain a safe facility taking such steps as are necessary to prevent releases, and to minimize the consequences of accidental releases which do occur."

While facilities with less than 10,000 pounds of ammonia do not need to file a formal Risk Management Plan, EPA, through its General Duty Clause, expects facilities to:

- Determine if, and under what circumstances, a release could occur.
- Put in place procedures and controls to prevent a release.
- Implement a plan of action should a release occur.

EPA's General Duty Clause is very broad in its application and there are few details provided on how to comply. EPA has published some guidance on how inspectors are to apply the General Duty Clause in the document entitled "Guidance for Implementation of the General Duty Clause Clean Air Act Section 112(r)(1). This document outlines three steps that can help demonstrate compliance:

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EPA inspectors tend to lean on their experience with RMP when using the General Duty Clause, so facilities under 10,000 pounds will benefit from proactively determining how they are addressing recognized hazards.

EPA Issues Enforcement Alert on Anhydrous Ammonia

- Adopt or follow any relevant industry codes, practices, or consensus standards.
- Be aware of unique circumstances of your facility which may require a tailored accident prevention program.
- Be aware of accidents and other incidents in your industry that indicate potential hazards.

Industry members have reported that EPA is increasing the use of its General Duty Clause authority to bring citations in ammonia refrigeration facilities. EPA inspectors tend to lean on their experience with RMP when using the General Duty Clause, so facilities under 10,000 pounds will benefit from proactively determining how they are addressing recognized hazards. There have been reports of EPA inspectors citing facilities under the General Duty Clause and pulling from RMP standards to make their case for meeting the General Duty Clause. This is particularly true for companies with multiple facilities, some of which are regulated under RMP. Inspectors will assert that the company should be readily aware of hazards because some of their facilities are subject to RMP.

There have been reports of EPA inspectors citing facilities under the General Duty Clause and pulling from RMP standards to make their case for meeting the General Duty Clause.

In cases of both RMP and the General Duty Clause, the EPA alert recognizes the role of industry standards such as those developed by IIAR to help facilities comply with regulations. In addition to IIAR standards, IIAR also publishes Process Safety Management and Risk Management Program Guidelines and the Ammonia Refrigeration Management (ARM) manual to assist members with compliance. The ARM manual is specifically designed for facilities with less than 10,000 pounds of ammonia, while the PSM & RMP Guidelines provides compliance resources for facilities with more than 10,000 pounds.

Finally, the EPA enforcement alert discusses lessons learned from recent inspections of ammonia refrigeration systems. The list below highlights areas where EPA is placing enforcement emphasis in the ammonia refrigeration industry:

- Identifying the hazards that a facility's refrigeration systems present is crucial.

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Part of this analysis should include understanding the gap between the safety requirements of new industry codes and standards and the standards to which the facility was built and developing a plan to address safety deficiencies. In some cases, that plan must include making facility upgrades.

- Preventive maintenance is the standard for the industry. The maintenance program, including inspections, should be documented.
- Gathering sufficient information

Inspectors will assert that the company should be readily aware of hazards because some of their facilities are subject to RMP.

about the piping and equipment is crucial so that facilities understand the hazards associated with their refrigeration system and can develop a proper maintenance program.

- Refrigeration systems that are missing key controls, such as emergency shutoff valves, because they were not built to industry codes and standards in effect at the time of construction need to be upgraded.
- Halting corrosion of pipes and equipment should be a priority.
- Hammering and shaking of equipment and pipes risks breakage and ammonia releases.
- Defrosting is important. Ice buildup can impede access to important equipment and dangerously weigh down piping.
- Adequate ventilation in a safe location is required for machinery rooms.
- Ability to shut down the system without entering the machinery room is necessary.
- Ammonia pressure relief devices should not be located where they could spray ammonia onto people.
- A trained operator is critical to running an ammonia refrigeration system.
- A well-maintained closed loop system should limit accidents occurring during startup.

This list provides important insight into the types of issues EPA inspectors will be examining when inspecting ammonia refrigeration facilities. IIAR members are encouraged to review the list and ensure their RMP programs and ARM programs (in facilities with less than 10,000 pounds) are being actively implemented to address these hazards. IIAR has been in contact with EPA regarding the enforcement alert and will be meeting with key officials to further discuss the alert and its implications on the industry. ■


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Welcome to San Diego and the 2015 IIAR Industrial Refrigeration Conference & Exhibition!

It's time again for the industrial refrigeration industry's largest conference and we think this will be one of the best and most informative programs we've ever produced. I'd like to take this opportunity to welcome all attendees to the 2015 IIAR Industrial Refrigeration Conference & Exhibition.

If this is your first conference we are so glad to have you with us. If you are a long-time IIAR member who has attended before, welcome back! Beautiful, sunny San Diego is an ideal place to learn about the latest equipment, products, services and technologies that our industry has to offer.

As always, the IIAR Technical Program is the core of the conference. The series of presentations will include rigorously peer reviewed technical paper presentations, experiential workshops, and interactive panels on topics ranging from global refrigerant trends to low charge ammonia systems.

The IIAR conference draws refrigeration professionals from all across the United States and increasingly from around the world.

This international gathering of the key decision-makers in our industry is the perfect opportunity to network and learn from colleagues from all corners of the globe.

This year the conference will feature an international program with paper presentations in Portuguese, Spanish, and Mandarin.

In addition, all technical papers presented in English will be offered with simultaneous interpretation in Spanish and all international language presentations will be offered with simultaneous interpretation in English. With our ever expanding global reach, we're expecting to deliver the broadest and most comprehensive update on technologies that are important to you.

We are also introducing the IIAR CO2: Design and Application in Industrial Refrigeration educational program.

This one-of-a-kind condensed learning experience is designed to instruct attendees on the basic engineering principles needed to design a variety of energy efficient CO2 systems. We've been fortunate to have acknowledged leaders in this field share their understanding and their design methodology with our attendees.

I would like to thank each and every company who provided the important financial support for IIAR through their participation at this conference and to send a special thank you to all the companies that encourage and support the essential volunteer work of our members.

And of course, thanks also go out to our members whose participation and collaboration in exchanging information, experience and expertise make this conference such an incredible learning event – paper authors, workshop presenters and panel participants who develop the presentations are all an integral part of making this such a great conference.

Welcome to San Diego, and enjoy the conference!

Best Regards,

Mark Stencel
2015 Conference Chair

2015 IIAR CONFERENCE SPONSORS

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Morning Coffee Break
Wednesday, March 25

Baltimore Aircoil Company
Luggage Tags

Bitzer
CO_2 Education Program
Sunday, March 22

Colmac Coil Manufacturing Inc.
Afternoon Coffee Break – Tuesday, March 24

DEEM – A Mechanical and Electrical Company
Exhibit Hall Wi-Fi

Delta Tee
Petco Park Cheeseburger Station
Monday, March 23

Evapco
Lunch Exhibit Hall – Monday, March 23
Craft Beer Lounge Petco Park

Farley's Refrigeration
Continental Breakfast
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Parker
Morning Coffee Break – Monday, March 23

Mirbraz and Associates
Morning Coffee Break – Tuesday, March 24

Regal
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Republic Refrigeration, Inc.
Chairman's Reception – Sunday, March 22

Refrigerated & Frozen Foods
Charging Station

S&S Refrigeration Group
Afternoon Coffee Break – Monday, March 23

RVS
First Timer's Reception – Sunday, March 22

Stellar – Taking Solutions Further
Hotel Room Keys

Vilter
Keynote Speaker
Hot Dog Station Petco Park – Monday, March 23

EXHIBITOR LISTING

Hilton San Diego Bayfront • San Diego, CA • March 22-25, 2015

A. Blasquez E. Refrigeracion Industrial S.A. de C.V. . . . . Booth #308
A. Blasquez E. Refrigeracion (ABE) is the largest ammonia refrigeration contractor company in Latin America, specializing in refrigeration systems for breweries, beverages food and cold storage industries. ABE - your refrigeration partner in Mexico.

AAIM Controls . . . . . . Booth #309
From starters and drives to PLC systems and microprocessor designs, AAIM Controls has the expertise for all your automation requirements with over 90 years of combined refrigeration controls experience.

Acuren . . . . Booth #408
Acuren's industry-leading mechanical integrity services for ammonia refrigeration systems include; Corrosion Under Insulation Scanning (CUI), Computerized Radiography (CR), API Tank and Vessel Inspections, and our exclusive inspection data management system, DMAPS.

Advanced Energy Control . . . . Booth #10
Advanced Energy Control (AEC) is an automation controls company that specializes in the latest technology for industrial refrigeration control with an emphasis on energy management.

Airfoil Impellers. . . . . Booth #218
Cast aluminum fan blades, machine room exhaust fans, product cooler fans, blast freezer fans, and general ventilation fans.

Airgas . . . . Booth #300/302
Airgas Specialty Products offers anhydrous ammonia, pump-outs, field service, safety video, safety training, and Cold Flow Sampler (for determining water in ammonia).

Air Conditioning, Heating, and Refrigeration Institute. . Booth #1
The Air Conditioning, Heating, and Refrigeration Institute (AHRI) is the trade association representing manufacturers of HVACR and water heating equipment within the global industry, with a performance certification program covering 40+ products, including unit Coolers.

Alfa Laval . . . . Booth #415
Alfa Laval is a leading manufacturer of compact and efficient semi-welded, gasketed, brazed and AlfaNova 100% stainless steel plate heat exchangers, as well as shell-and-tube heat exchangers.

American Industrial Refrigeration . . . . Booth #600
We build Confidence by delivering quality solutions to help our partners succeed. American Industrial Refrigeration, a Corval Group company, specializes in the design, installation and service of turnkey industrial refrigeration systems.

Ammonia Refrigeration Foundation (ARF). . . . . Booth #14
ARF is a non-profit research and education foundation organized by members of IIAR. The goal of the Foundation is to support research and educational efforts in industrial refrigeration, particularly in the area of ammonia and natural refrigerants.

Analytical Technology, Inc. . . . . Booth #420
ATI designs and manufactures a complete line of ammonia gas detectors both fixed and portable and additionally gas detectors for 32 other toxic and combustible gases.

APCCO . . . . Booth #323
APCCO is a Design Build Industrial Refrigeration Contractor providing Engineering, Construction, Maintenance, Compliance Services, Insulation, Parts Sales and Compressors Rebuilding for a wide range of Industrial, Food and Beverage facilities.

APR Plastic Fabricating, Inc. . . . . Booth #17
APR Plastic Fabricating is a leading manufacturer and distributor of custom designed and fabricated plastic tanks, liners, secondary containment systems, and process tanks for the metal finishing and waste treatment industries.

APSM . . . . Booth #621
APSM provides PSM software and services for effective compliance management.

Armstrong International . . . Booth #208/210
Armstrong provides intelligent system solutions that improve utility performance, lower energy consumption, and reduce environmental emissions while providing an "enjoyable experience."

ASTI . . . . Booth #9
ASTI was established in 1991 in recognition of the long standing need for training in the safe handling of ammonia. ASTI offers training in accordance with OSHA Standard 1910.120(q) – emergency response to hazardous substance release.

Azane Inc. . . . . Booth #622
Azane is a world-leading manufacturer of low charge ammonia cooling solutions. Their range of low charge ammonia packages are suitable for temperature controlled storage, process cooling and HVAC applications.

Bacharach, Inc. . . . . . Booth #707
Fixed continuous monitors for the detection of gases including ammonia, CO, Co2, CFCs, HFCs, CH4 and more featuring multiple alarm, sensor and relay configurations. From one to 64 points, the units are ideal for chillers, walk-in freezers, public spaces, physical plants in commercial and industrial applications.

Baltimore Aircoil Company (BAC) . . . . Booth #201/203
BAC is a worldwide manufacturer of heat transfer and ice thermal storage products. BAC's products include evaporative condensers, cooling towers, closed circuit cooling towers, ice thermal storage systems and equipment controls.

Bassett Mechanical, Inc. . . . . Booth #124
Bassett Mechanical a leader in custom mechanical contracting service and engineering throughout the United States. Our expert engineering, technical and field management make us your single source provider for project planning, design, installation and service.

Bitzer US, Inc. . . . . . . Booth # 519
BITZER is a leading manufacturer of Ammonia Screw Compressors and semi-hermetic reciprocating CO2 Compressors for both subcritical and trans critical applications. BITZER also manufactures high efficiency, low charge Ammonia Compressor Packages at its Oakwood, Georgia factory.

Cal Therm Insulation . . . . Booth #404
Cal-Therm Insulation is a full service mechanical insulation contractor based in Southern California. For the past 40 years our company has serviced clients in the Refrigeration, Food & Beverage producers, and Chemical segments. We continually strive to exceed the clients expectations while delivering Insulation Systems that deliver optimum energy efficiency, and quality at a competitive price.

Calibration Technologies . . . . Booth #224
Calibration Technologies is a manufacturer of gas detection equipment, specializing in Ammonia. CTI's engineers and technicians have over 30 years of experience in system design, sales and field service. Calibration Technologies provides detection for NH3, CO2, CO, H2S, H2, O2, CH4, R22 and more in a variety of industries including cold storage, food processing, sea vessels, chemical plants and many others.

CAMCO Lubricants . . Booth #605
Nationally known for both the CAMCO 717 series ammonia refrigeration oil and for high quality food-grade lubes for all air compressors, gear, hydraulic, vacuum, and grease applications.

Century Refrigeration, a Division of RAE Corporation . . . . Booth #419
Century Refrigeration is the leader in Comdustrial™ Refrigeration Systems: The ideal balance of commercial and industrial refrigeration markets. We offer flexibility in design surrounded by durability in construction.

Chester-Jensen . . . . . Booth #105
Chester-Jensen manufactures air agitated ice builders, instant chillers, plate heat exchangers and other heat transfer equipment.

CIMCO Refrigeration, Inc. . . . . Booth #204 / 206
CIMCO Refrigeration specializes in the engineering, design, manufacture, installation, and service of industrial, process cooling, and recreational refrigeration systems. With key locations across North America and around the world, we provide unique cooling solutions to meet our client's needs.

Colmac Coil Manufacturing, Inc. . . . . Booth #516/518/520
From its newly opened second factory in Illinois, Colmac is supplying its Aircoil™ and custom aluminum, stainless, and galvanized steel evaporators to Midwest and Eastern markets.

Concepts and Designs, Inc. . . . . Booth #117
Concepts and Designs is a premier supplier of dehumidification systems for humidity and condensation control. Dehumidification provides a permanent solution to avoid contamination hazards in compliance with the USDA zero tolerance.

Cool Air Incorporated . . . . Booth #602
For over 30 years, Cool Air Incorporated has provided quality ammonia leak detection systems and equipment. Please review our new website @ www.coolairinc.com for all our product line and calibration videos.

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Cornell Pump Company . . . . Booth #700
Cornell Pump presents the latest innovations in refrigerant pumps including their new high-pressure, low-speed 2.5 CBH. Cornell also manufactures high quality glycol and chiller pumps.

Cyrus Shank . . . . Booth #708
The Cyrus Shank Company manufactures and sells industry-leading relief valves and other products for the refrigeration industry such as relief valves, shut-off valves, bolted bonnet shut-off valves, flanged valves, expansion valves, needlepoint valves, check valves, three-way valves, line valves, purge valves, manifolds, brass valves, etc.

Danfoss . . . . . .Booth # 523 & 525
Danfoss' complete line of refrigeration valves and electronic controllers includes assembled valve stations in one shared housing and weld-in motorized, solenoid and control valves designed to 754 psg.

DEEM, LLC. . . . . Booth #11
Based in Indianapolis, Indiana – DEEM has over 1,200 employees in nine (9) states serving clients with industrial/commercial refrigeration requirements for the pharmaceutical, food & beverage and cold storage marketplace. Mechanical and electrical services are also part of our skill set along with design engineering and process piping.

Delta Tee International, Inc. . . . Booth #219
Delta Tee manufactures heat exchangers, pressure vessels and systems, complete capabilities in designing and manufacturing shell and tube heat exchangers for refrigeration, air conditioning, chem-process, food and other applications.

Design Ready Controls . . . . Booth #522
DRC is a control panel builder and wire harness provider with extensive experience supporting OEM customers. Through operational excellence and automation, we reduce costs, improve quality, and shorten delivery times for our OEM customers.

Draeger Safety, Inc. . Booth #325
Draeger offers a full line of fire and gas detection equipment for the ammonia industry. The Draeger Sensor is the foundation for success in the ammonia industry market. With our new advanced product line, Draeger is ready for your gas detection needs.

DualTemp Companies, Inc. . . . . Booth #425
Providers in the finest of design, construction, installation, service, and supplies for the industrial refrigeration market. Dual-Temp also provides equipment, training, and supplies to meet all your safety requirement.

Dyplast Products, LLC . . . . Booth #607
Dyplast Products, LLC is a premier manufacturer or ISO-CI polyiso rigid insulation foams used as mechanical pipe insulation in the refrigeration market.

EcoClear . . . . Booth #710
EcoClear is a professional coil cleaning and energy savings company that specializes in cleaning chillers, cooling towers, and evaporators/condensers. EcoClear has serviced a wide variety of clients, helping them save up to 20% on their energy cost. As a final step in the cleaning process, EcoClear applies a coating that ensures equipment runs at a higher rate of efficiency between cleanings.

eurammon. . . . . Booth #12
eurammon is a joint initiative by leading global companies, institutions, and individuals committed to increasing the use of natural refrigerants. eurammon has an excellent global network of co-operation agreements with international associations.

EVAPCO, Inc. . . . Booth #311/313
EVAPCO is a leading supplier of refrigeration products and systems; including AHRI certified evaporators, condensers, hygienic air handlers, packaged refrigeration systems, water treatment, ASME vessels and recirculators, manufactured in 20 facilities located in 10 countries. Our mission is to offer innovative solutions which make life simpler, more reliable and more sustainable for you.

Extol of Ohio, Inc. . . .Booth # 113
Extol fabricates and disributes STYROFOAM , isocyanurate, cellular glass, perlite, and phenolic insulation for piping equipment. Coplete valve system, contoured heads, fittings, PVC, aluminum, vapor, and weather barrier caulks and coatings. Extol also provides specification assistance. Extol offers materials for refrigeration chilled water, steam and process systems.

Farley's Frigeration. . . . . Booth #200/202
Farley's S.R.P. Inc. — AKA / DBA Farley's Frigeration: Family owned and operated, industrial refrigeration contractor/parts supplier. Our Mission: To support and provide the highest quality of parts, equipment and service while offering very competitive prices. All delivered efficiently by friendly, qualified personnel with"Farley's personal touch service guarantee" Providing "Getability" Since 1978.

Freije-RSC Engineered Solutions . . . . Booth #216
Freije-RSC Engineered Solutions is an organization with 50 plus years of experience in the industry. Specializing in Food Process, Food Distribution and Pharmaceutical Industries. Capabilities include Refrigeration, Insulated Panels, Mechanical, Plumbing, Electrical, Engineering and Service.

Frick by Johnson Controls . . . Booth #301/303/305
Full line of refrigerant equipment for most applications. Rotary Screw Compressor Packages and Packaged Chillers with VSD, Condensers, Evaporators, AcuAir Hygienic Air Handlers, Vessels, Heat Exchangers, Controls, and Replacement Parts.

Gamma Graphic Services . . . . Booth #411
Gamma Graphics provides non-destructive testing (NDT) services on ammonia refrigeration piping. We are able to identify corrosion on wet or saturated insulation without having to cut holes or breach the vapor barrier on piping in any way. We also provide conventional ultrasonic inspection services on ammonia vessels.

Garden City Community College . . . . Booth #418
Ammonia Refrigeration, Boiler, PSM/ RMP, Adv RETA Prep, "Hand-On" Ammonia Refrigeration training since 1996, 4 ½ Day Format-Earn College Credit- Degree Opportunities Conforms to OSHA & EPA regulations.

GCAP, LLC (Garden City Ammonia Program) . Booth #712
Garden City Ammonia Program is the world's largest industrial technical school involved in training over 2,000 operators, technicians, engineers, and managers yearly. We have the largest hands-on labs in the industry. GCAP specializes in industrial ammonia refrigeration, industrial CO2 refrigeration, steam boilers, and PSM/RMP compliance training and services.

GEA Heat Exchangers,Inc., PHE Division. . . . . Booth #322
GEA PHE Systems -manufacturer of FlatPlate heat exchangers perfect for ammonia refrigeration applications with flow rate up to 1,645 tons. Products meet ASME/CRN requirements manufactured in York, PA.

GEA Refrigeration North America . . . . Booth #318/320
Screw and piston compressors, refrigeration system controls, package & process systems, chiller, freezing systems, ice systems. Parts service, preventive & predictive maintenance compressor rebuilds, and training.

Gf Piping System . . . Booth #625
COOl-FIT ABS Plus is complete pre-industrial plastic piping system for glycol and secondary cooling piping systems. It is UV resistant, vapor-tight, and 100% water-tight and requires minimum installation time.

Grundfos . . . . . . Booth #109, 111
Pumping Solutions for today- Innovative thinking for tomorrow. Grundfos offers the industry's broadest line of Refrigerant/CO2 Pump, Energy Efficient Pumps, Pumping Systems and Controls.

H.A. Phillips & Co.. . . Booth #220
Phillips manufactures liquid level controls, valves, Level Eye sight glasses, injectors, ASME pressure vessels, gas-powered and pumped recirculation systems, PHE chillers, the Anhydrator system cleaner and PUR air purger. Phillips is the distributor for Danfoss IR products for the US and Canada.

Hansen Technologies Corporation . . . . Booth #401/ 403
Hansen Technologies offers innovative industrial refrigeration solutions to meet your application needs, including: multi valve stations, controls, shut-off, pressure-relief and solenoid valves, regulators, pumps, auto-purgers, level controls and safety detection systems.

Hantemp Corporation . . . . Booth #521
Stainless Steel long-neck, two and three way ball valves with optional control motors and lock-out tag-out features. Also stainless steel level controls for ammonia and other liquids.

Hench Control, Inc. . . Booth #406
Hench Control is a manufacturer and service provider of modular energy management systems for industrial refrigeration which quantifiably cut energy cost, improve profitability and significantly reduce the CO2 footprint for the environment.

Henry Technologies . Booth #101
Heat Exchangers, Condensers, Chillers, Pressure Vessels & HVAC/Refrigeration Components. Henry Technologies Ltd. takes pride in providing high quality HEX/ PV to our global partners in industrial and commercial applications. Customer Satisfaction, Quality Designs, Product Quality and On Time Deliveries are our primary goals. Let Henry Technologies Ltd. be a partner to your future success.

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Hermetic Pumps . . . . Booth #405
Hermetic has been dedicated to the development and production of hermetically sealed pumps. Based on our experience in chemical, petrochemical and process industry we designed canned motor pumps specifically for refrigerant services.

Hill Brothers Chemical Company . . . . Booth #623
Hill Brothers has supplied anhydrous ammonia to the refrigeration industry, as well as other industrial ammonia users. From tank truck, mini bulk and cylinder delivery to storage tanks, equipment, and evaluation services, Hill Brothers is your complete ammonia supplier.

Hillphoenix . . . . Booth #624
Hill PHOENIX specializes in the design and manufacturing of halocarbon, carbon dioxide transcritical and secondary refrigeration systems for commercial warehousing and industrial refrigeration applications.

Honeywell Analytics, Inc. . . . . Booth #104/106
Honeywell Analytics manufactures the industry's most complete range of monitoring instrumentation for ammonia and other refrigerant gases. We offer fixed-installed units (Manning), portable services, controllers, service/support second to none.

Houghton Chemical . . . Booth #3
Houghton Chemical is a fourth generation heat transfer fluid company. We manufacture inhibited glycols including: propylene (SAFE-T-THERM®), ethylene (WINTREX®), biobased, and aluminum-safe glycols. Our personnel are directly available.

Howden Compressors, Inc. . . . . Booth #500/502
Howden Compressors offers the most complete range of screw compressors available in the world for virtually any compressor application-refrigeration to gas relinquifation, gas compression or cryogenics, and more.

Industrial Consultants, LLC . . . . Booth #306
Industrial Consultants - your compliance connection for OSHA and EPA related training and services including HAZMAT, refrigeration, PSM/RMP, lockout/tagout, confined space and incident command.

Industrial Refrigeration Technical College. . . . Booth #319
Industrial Refrigeration Technical College (IRTC) has become the premier Ammonia and CO2 Industrial Refrigeration training facility. IRTC has a live state of the art hands on training lab that features VFD compressors, Quantum, G-Force micro's, VFD condensers, VFD evaporators, hygienic air unit, liquid recirculation, thermo siphon oil cooling, plate chiller, falling film water chiller, auto purger, and PLC controls.

Industrial Service & Fabricators, Inc.. . . . . Booth #620
Industrial Service and Fabricators custom designs and fabricates pressure vessels, tanks, and liquid recirculator assemblies. Products include recirculators, receiver intercoolers, accumulators, surge drums an oil post.

Innovative Refrigeration Systems, Inc. . . . . Booth #317
Innovative Refrigeration Systems specialize in customized turnkey industrial refrigeration systems. We design and build computer-controlled ammonia refrigeration, large tonnage Freon systems and large CO2 systems for the cold storage and food process markets.

Insul-Therm Intl., Inc. . . Booth #603
Insul-Therm International is a leader in the fabrication and distribution of insulation products for refrigeration and process systems. Our product offerings include TRYMER™ , STYROFOAM™ , SARAN™ , foamglas, Mylar and many other lines.

Integrated Circuit Systems, Inc. . . . . Booth # 421
We build hand-crafter, custom-made UL control panels and systems primarily for the industrial refrigeration arena. What set us apart from the competition; our control systems work. No Exceptions.

Interstate Chemical Company, Inc. . . . . . . Booth #103
INERSTATE Chemical Company is manufacturer of INERTCOOL industrial heat transfer fluids. These fluids include ethylene glycol, ethanol and INTERCOOL BIOGREEN made from totally renewed resources.

ISEL, Inc.. . . . . Booth #121
Isel is a manufacturer of industrial lubricants with an expertise in ammonia refrigerant-lubricant interaction. It's how we can deliver on your expectations and provide the best products and services possible.

ISN Software Corporation . . . . Booth #711
ISN's online contractor management database, ISNetworld, connects corporations with safe, reliable, contractors and suppliers from capital-intensive industries. ISN collects and verifies health and safety, procurement, insurance, quality and regulatory information from 58,000+ contractors and suppliers.

Isotherm, Inc. . . . . Booth #407
Custom manufacturer of heat exchangers and pressure vessels with innovative design. We serve various industries, such as industrial ammonia refrigeration, food & beverage and chemical process. We hold ASME "U" and "R" stamps.

ITW Insulation Systems . . . . Booth #119
ITW Insulation Systems supplies TRYMER polyisocyanurate pipe insulation and XPS pipe insulation billets, former products of Dow Chemical Company. Additionally, ITW specializes in aluminum and stainless steel jacketing, sheets, and elbows.

Jamison Door Company . . . . . . Booth #123/ 125
HCR/ Jamison Door will feature HCR Air Door Technology and BMP Rollup Door.

JAX Refrigeration, Inc. . . . . Booth #108
"We aim to freeze!!" - JAX Refrigeration, Inc. specializes in the engineering design, installation, service, and parts of industrial refrigeration, HVAC / mechanical, process systems. At JAX, "every system is a custom system."

Kathabar – an Alfa Laval brand . . . . Booth #417
Kathabar, an Alfa Laval brand, designs and manufactures liquid and dry desiccant dehumidification systems for a wide range of applications, including industrial, commercial, institutional, and LEED facilities.

K-FLEX USA . . . . Booth #709
K-FLEX USA is a leading manufacturer of elastomeric, closed cell insulation products that are easy-to-use and deliver reliable and lasting performances.

Lanham Insulation, Inc. . . . . Booth #506
For more than 30 years, Lanham Insulation has provided unparalleled quality and reliability in mechanical insulation services. From inception, our expertise and pursuit of excellence have earned us the trust and confidence of our customers. The Lanham team of industry-leading insulation professionals focuses exclusively on the complete success of each project, to ensure the highest levels of safety, quality, and efficiency. Our fundamental mission is to deliver complete satisfaction with superior quality and value.

Lanier Technical College . . . . Booth #702
The Ammonia Refrigeration Program at Lanier Technical College in Oakwood Georgia is dedicated to providing the ammonia refrigeration industry with the best, state-of-the-art, hands-on, live system training in ammonia refrigeration system operation, maintenance, and support.

LEWA-Nikkiso America, Inc. . . . . Booth #114
Canned motor seal-less pumps for ammonia refrigeration.

Logic Technologies, Inc. . . . . Booth #601
Logic Technologies, the industry's foremost leader in factory automation and computer controls, provides turnkey, state-of-art automation systems for ammonia formulization and production, and is setting the standard for today's automation.

Logix . . . . Booth #324
Logix Refrigeration Energy Management Systems provide energy-efficient operation of refrigeration equipment with documented savings up to 40%. No other refrigeration energy management system is easier to use or more capable.

LUDECA, Inc. . . . . Booth #410
LUDECA, Inc. leading provider for Maintenance Solutions including Laser Coupling Shaft Alignment and Belt Alignment tools; vibration analysis and balancing equipment; software services, and training.

M&M Refrigeration . . Booth #402
M&M Refrigeration manufactures both reciprocating and rotary screw compressor packages, packaged refrigeration systems, pressure vessels, and microprocessor control systems.

Marking Services Incorporated . . . . Booth #703
Marking Services is your partner for ammonia refrigeration pipe labels, valve tags and signage materials and services. In addition to the manufacture of identification products, we provide turnkey services for material installation and P&ID updates/creations.

MIRO Industries, Inc . Booth #115
MIRO Industries, Inc. provides solutions for supporting rooftop pipe, conduit, duct and walkway systems that prevent damage to the roof membrane.

MRBraz & Associates, PLLC . . . . Booth #618
Industrial refrigeration engineering for cold storage and food processing facilities. Our design approach is environmentally friendly and promotes energy efficiencies with highest center of safety to operate.

Multi-Wing America . . Booth #617
Multi-Wing is North America's leading supplier of high-performance axial flow fan blades, producing 500, 000 units annually, specializing in custom solutions for HVAC and Refrigeration applications.

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Mayekawa-MYCOM . . . . Booth #212/214
The MYCOM TRUE Touch compressor control panel complements the industry leading efficiency of Mycom compressors and superior package design by offering features such as a user friendly touch screen interface, remote panel monitoring, and a USB interface.

North Star Ice Equipment Corporation . . . . Booth # 222
North Star Ice Equipment is a World Leader in Ice Technology. We provide cooling solutions based on large volumes of high quality flake ice by designing and manufacturing a full range of reliable and durable ice equipment.

Olympic Engraving . . Booth #116
Specializing in industrial identification solutions, Olympic Engraving provides innovative products to the ammonia refrigeration industry including pipe markers, signage and valve tags. Exceptional customer service, superior quality, and excellent value is what our customers experience with every order. Give us a try and you'll be a customer for life.

Omega Thermo Products, LLC . . . . Booth #120
Heat exchangers/ evaporators, including falling film chillers, ice machines, cooling tables/ conveyor, cooling jackets, and specialized cooling/cryogenic equipment.

Owens Corning . . . . . Booth #304
You now have a choice for your XPS pipe insulation requirements - Owens Corning FOAMULAR type IV XPS Pipe Insulation. Benefits include exceptional long-term thermal performance and moisture resistance, reduced material costs versus Type XIII XPS and long service life. All of this brought to you by the same trusted company you can count on for FOAMULAR cold floor applications.

Parker Hannifin Booth #507/509
Parker's Refrigerating Specialty Division manufactures one of the most complete lines in industrial refrigeration; including state of the art flow control valves, safety relief, service and expansion valves and system solutions.

Paul Mueller Company . . . . Booth #508
Paul Mueller will feature their falling film chiller, semi-welded plate and frame heat exchanger, brazed plate heat exchanger and heat recovery equipment.

PermaTherm, Inc. . . . Booth #321
PermaTherm is a premier manufacturer of pipe insulation, serving the ammonia refrigeration and cold chain industry for over 20 years. As a leading design manufacturer and supplier of rigid pipe insulation, PermaTherm has developed a complete pipe insulation system for the ammonia refrigeration industry with millions of linear feet of trouble-free pipe installed throughout the country. The PermaTherm pipe insulation system provides superior thermal performance and environmental attributes, while yielding tremendous savings at every phase of your project!

Petrochem Insulation, Inc. . . . . Booth #412
Petrochem is a single source specialty contractor, providing mechanical insulation, metal structures, scaffolding, fireproofing, painting & coatings, heat tracing and lead and asbestos abatement services nationwide from eleven regional offices. We're a certified MBE company.

Phoenix Air Systems. . . Booth #4
Manufacturers of hygienic critical food grade industrial and commercial HVACR and process air handling and ammonia refrigeration systems. Specialist in hygienic air units, we have a quick ship system (typically 10-13 week lead time).

Polyguard Products, Inc. . . . . Booth #704/705
RG2400™ Corrosion Gel ZeroPerm™, Vapor Barrier, AlumaGuard ™ Weather Barrier, ZeroPerm™ Ultra Vapor and Weather Barrier Membrane, RG2400™ CSA Structural Steel Corrosion Protection.

PROTEXUS, Inc. . . . . . Booth # 223
PROTEXUS specializes in Compliance Solutions for the Ammonia Refrigeration Industry. Five-year and Annual Mechanical Integrity Inspections, Compliance Audits, PHA, RMP, Training, NDT, and Total Compliance Solutions.

The PROS Company . Booth #130
PROfurbish (rebuild) screw compressors and gear boxes. All brands, makes, and models.

Quote Express . . . . . . Booth #221
QuoteExpress CAD-BIM- Estimating software is designed for refrigeration contractors to automate the preconstruction process. Our Cloud enabled solution is the fastest, most accurate way to produce precise accurate data. Call 800-813-7020 for more information.

Refrigeration Valves & Systems Corp. (RVS) . . . . Booth #315
RVS is a preferred supplier of innovative industrial refrigeration products including factory assembled, packaged recirculation systems and ASME pressure vessels of all types and sizes. RVS, a subsidiary of Evapco, is committed to providing superior technical support and the highest quality products with fast, on-time shipments to meet your construction schedule.

Regal . . . . Booth #501, 503
Regal is a leading manufacturer of electric motors, mechanical and electrical motion controls and power generation products. For 30+ years, its leesport, PA facility (formerly RAM Motors) has served the refrigeration industry with purpose built designs.

Republic Refrigeration, Inc. . . . . Booth #611, 613, 615
Industrial refrigeration system design, modular packaged refrigeration systems, equipment skids, Process Safety Management and Risk Management Services, pipe installation, refrigeration controls, control and power wiring, parts, service quality, integrity, and performance. We do it right the first time!

RETA . . . . Booth #2
RETA exists to enhance the professional development of industrial refrigeration system operators and technicians through training and education events focused on safe and efficient operation.

Schneider Electric . . . Booth #400
Schneider Electric manufactures industrial refrigeration solutions including AC motors, variable speed drivers, and system controls specifically designed for the industrial refrigeration market focused on control and energy efficiencies.

SCS Tracer Environmental . . . . . . Booth #701
Environmental engineering and consulting services focusing on PSM & RMP compliance for ammonia refrigerated facilities. Consulting services include PSM & RMP development, Compliance Audits, Mechanical Integrity Inspections, Operator Training, OSHA/EPA Inspection Assistance, Facility Energy Audits, and overall consulting.

SGS Refrigeration, Inc. . . . . Booth #604, 606
SGS Refrigeration Inc. manufactures a full line of Industrial Evaporators and Unit Coolers, Product Coolers, Special Cooling Coils under the SGS/Krack Industrial brand in Dixon, Illinois… Proudly Made in the USA!

Shambaugh and Son, L.P. . . . . Booth #307
Shambaughs Design-Build Refrigeration Division provides Low Temperature Ammonia Refrigeration systems, Fluid Process, Storage Systems, Preventative Maintenance and Emergency Ammonia Refrigeration Service and Spare Parts sales to clients throughout the U.S.

Sinteco Americana Incorporated . . . . Booth #112
Sinteco manufactures special air handling installation for food industry processes. Sinteco Hygiene® AHUs - stainless steel or polyester, Textile air distribution ducts Aertex® and s.s. AERMET®, and clean rooms special product & design.

SmartWatt Energy, Inc. . . . . Booth #122
SmartWatt Energy works with clients throughout the United States to design and install multi-measure energy™ efficiency projects. Clients look to SmartWatt to provide large-scale savings through turnkey energy auditing, engineering, project management and installed services.

Stellar . . . . Booth #207, 209
Stellar is a fully integrated design, engineering, construction and mechanical services firm that provides a comprehensive range of self-performed services. Stellar creates food processing plants, refrigerated warehouses, and distribution centers.

Summit Industrial Products . . . . Booth #422
Summit Industrial Products is a manufacturer of synthetic lubricants which include several ammonia refrigeration and food grade lubricants. Our ammonia refrigeration and food grade lubricants are NSF H1 certified. Summit also manufacturers descalers/degreasers and oil/water separators.

Tanner Industries, Inc. . . . . Booth #423
Full service anydrous ammonia distributor for ammonia refrigeration. Acknowledged for product quality and service dating back to 1890. Storage tanks pump-out services and safety training. Member NACD.

TechCold International . . . . Booth #609
TechCold International is on the cutting edge of energy saving industrial refrigeration control technology, with a proven track record of delivering control solutions for over 10 years on a global scale. By adopting an open infrastructure, non-proprietary approach to industrial refrigeration controls, TechCold International offers cost-effective solutions helping organizations reduce energy consumption and increase profitability.

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Teikoku USA, Inc. . . . Booth #424
Teikoku is the world's largest manufacturer of seal-less, canned motor pumps, and the leading supplier of pumps to the refrigeration industry. Our highly reliable and easy to maintain pumps are perfect for pumping ammonia.

TGB Insulation, LLC . . Booth #706
We are a Mechanical Insulation contractor that specializes in Commercial and Industrial insulation with a strong background in industrial refrigeration.

Th Witt . . . . Booth #619
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Manufactures components for the industrial and commercial refrigeration industry. Supplying products such as: Oil Separators, Accumulators, receivers, oil pots, Shell and tube heat exchangers, and level detection devices.

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Zero Zone . . . . Booth #504
Zero Zone designs and manufactures quality custom industrial refrigeration solutions: chillers, Freon and CO2 based systems, liquid overfeed and related equipment for cold storage, food processing, pharma, and other applications.

Never Stop Learning

BY KEM RUSSELL

Over several decades I have met and worked with many outstanding refrigeration operators and engineers. These refrigeration operators have been able to truly operate their systems in an efficient, effective, and safe manner while keeping any ammonia releases down to incidental levels. Likewise, many of the refrigeration engineers I've met have been people whose knowledge and experience made them people I could rely on for helpful and reliable input on ammonia system design and operation.

We should be willing to continue to learn, to advance our knowledge, our understanding, our abilities, as well as keep us, the public and the environment safe.

I have also met some people whose outlook and attitude has been puzzling. Here are a few examples:

In the mid-1980's I was doing field checking during construction of a "state of the art" large ammonia system for a new food distribution center.

The company that would own and operate this new facility had been operating smaller and much older ammonia facilities.

In meeting with the refrigeration person who would be responsible for the operation of this new ammonia system, I briefly reviewed what would be involved in this "new" system. I told this person about the two-stage system that would be used, which was different than what they had previously operated.

I explained that the rooms and areas of the facility would be a combination of flooded and liquid recirculation temperature controlled zones, and the entire refrigeration system would be controlled by a computerized system.

After my review I asked, "Do you have any questions I can help with?" The person looked at me and said, "Nope. I know ammonia."

I was taken aback by that comment, and I thought to myself, "maybe I didn't explain very well what this new system would be like, especially compared to what they had before." The reality was that this person thought they already knew all there was to know about the operation of an ammonia refrigeration system, and they didn't need additional help or information to "do their job."

Ever met someone like this? As it turned out, once the system was up and running, it was only a few months before this particular person left the company.

That employee could have easily been an asset to the company, due to all of their past experience, but they were not willing to learn, and move forward as things changed.

In another ammonia refrigeration facility, several different people were brought in to analyze what could be done to reduce the ever growing energy cost of the system operation.

Several different ideas were suggested. These included: use of frequency drives for condensers and ammonia pumps; addition of auto purgers; lowering of condensing pressure; increasing suction pressure; modifying line sizes where appropriate to reduce pressure losses, and others. Several of these suggestions were taken, however, the one that would make the largest impact on energy use . . . increasing the suction pressure, was not.

Over many years the refrigeration operators found it much easier to just set the suction pressure low and let the system run.

Sound familiar? This method didn't cause much concern in the past, only because energy cost was low. Now this type of operating procedure was having a significant impact on the facility profit due to much higher energy costs.

At yet another facility, the management had learned a small amount about the OSHA "Process Safety Management," and EPA "Risk Management Program," but chose to ignore these plans. The first time EPA visited the facility they found nothing in place, which resulted in a large fine and some legal discussions.

It was agreed with EPA that steps would be taken to put the programs in place. The head of refrigeration – along with a few other people – implied "We know how to do this. No problem," and proceeded to put together what little they understood about all of the elements of these programs.

The next time EPA came to visit, I had the opportunity to sit in on the review of the program that had been developed.

I was surprised by what had and had not been put together, and I wondered, "how can this program be acceptable?"

I wasn't the only one with these thoughts. The head of the EPA inspection team was also amazed at what had not been accomplished, especially since the company had agreed in a legal settlement with EPA to get the program(s) properly developed and in place.

One of the important things these people do to stay on top of their game is to take the opportunity to be involved in organizations where they can both learn, and help others to learn.

The "We know how to do this. No problem," attitude didn't work, and another large fine was given.

Soon after this meeting, the head of refrigeration found it wise to seek employment opportunities elsewhere.

What happened? Those who said they knew what to do, didn't.

Nor did they take any proactive steps to learn about the requirements of these programs, nor did they look to obtain qualified help to assist in development of all of the program elements.

Several years ago at one of the IIAR Conferences, there was a very interesting speaker, named Sam Geist.

In one of his recent updates in his "Quick bites" website, a message stated: "Change is continuous. Improvement is continuous. Execution is continuous. No beginning, no end."

No one is ever too old or too young to gain new knowledge. As much as we humans don't like change, change will happen.

It is important that we stay in touch with what is happening in our industry. Some past methods may still be appropriate for ammonia refrigeration systems.

But there are continual advances in material science, in equipment design, in control methodologies, and in regulations.

We should be willing to continue to learn, to advance our knowledge, our understanding, our abilities, as well as keep us, the public and the environment safe.

Again, there are many very knowledgeable people in the ammonia refrigeration industry. You may be one of them.

One of the important things these people do to stay on top of their game is to take the opportunity to be involved in organizations where they can both learn, and help others to learn. For myself, being involved in IIAR for many years I have learned not only by attending technical presentations, Workshops, Panels, and exhibitions at the annual IIAR meeting, but also from participating in various committees and task groups. In addition I have met and learned from some of our industry's best leaders. You can too. ■

The Codes and Standards Conundrum

BY BENT WIENCKE, ENGINEERING MANAGER REFRIGERATION, NESTLE USA

In discussions on which codes and standards should be adhered to, I am all too often reminded of Daniel Patrick Moynihan who is the former U.S. Senator attributed with saying "Everyone is entitled to his own opinion, but not to his own facts."

Borrowing from this logic, the codes and standards we must adhere to should not be opinion, but they should instead be fact-based to ensure any scrutiny is passed and potential code violations avoided.

All too often, the common opinion in our industry is that we should simply follow the latest version of IIAR-2 and ASHRAE 15, and by doing so we are covered.

Not so fast, there is a little more to it than this. To get a handle on codes and standards, we must first gain a better understanding of the terms, commonly, loosely, and interchangeably used in these discussions.

First, let's define what, exactly, a standard is.

"A standard is a document that applies collectively to codes, specifications, recommended practices, classifications, test methods, and guides, which have been prepared by a standards developing organization or group, and published in accordance with established procedures." (Source: SES-1, "Recommended Practice for Standards Designation and Organization")

Now, let's consider . . . what is a consensus standard?

"Consensus standards are standards developed through the cooperation of all parties who have an interest in participating in the development and/or use of the standards. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution. Consensus implies more than the concept of a simple majority but not necessarily unanimity." (Source: ANSI's "Standards Management: A Handbook for Profit") 1)

From an understanding of standards, we can move to codes, and ask . . .what is a code?

"A code is a collection of mandatory standards, which has been codified by a governmental authority and thus become part of the law for the jurisdiction represented by that authority such as the Uniform Building Code and National Electrical Code." (Source: ANSI's "Standards Management: A Handbook for Profit") 1)

And finally, what is a model code?

A model code is, "(US) A proposed building code that is written and published by building-official associations (e.g., BOCA, ICBO, and SBCC); available for adoption by states, counties, and municipalities." (Source: McGraw-Hill Dictionary of Architecture and Construction.)

Once we understand the basic definitions of codes and standards, it's time to move on to the idea of compliance.

"Compliance is the adherence to rules, regulations, standards tests, or other requirements." (Source: ANSI's "Standards Management: A Handbook for Profit")

And to understand compliance, we also have to understand conformance. "Conformance is the state of having satisfied the requirements of some specific standard(s) and/or specification(s). Conformance is used with respect to voluntary standards and specifications, whereas compliance is used with respect to mandatory standards and regulations." (Source: ANSI's "Standards Management: A Handbook for Profit")

Meanwhile, the phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities.

Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority.

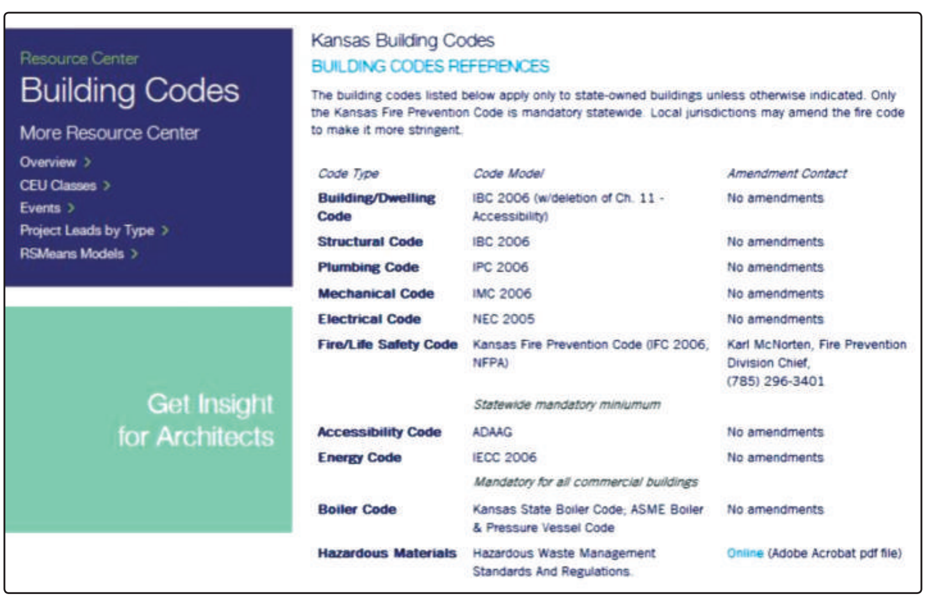
"For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction." (Source: NFPA 72: National Fire Alarm and Signaling Code Handbook, 2013)

Given these definitions, noncompliance with specific code requirements should not automatically be considered a code violation. If noncompliance constitutes a code violation, it is for the authorities having jurisdiction and the attorneys to decide.

Where deviations or a potential for deviation exist, it may be possible to get a variance from the authorities having jurisdiction.

A variance is an official document allowing the owner and operator to take exception to certain code requirements and, if necessary, use alternate measures.

Consequently, adherence to a standard such as ANSI/IIAR-2 2014 only becomes



Kansas Building Codes

BUILDING CODES REFERENCES

The building codes listed below apply only to state-owned buildings unless otherwise indicated. Only the Kansas Fire Prevention Code is mandatory statewide. Local jurisdictions may amend the fire code to make it more stringent.

Code Type	*Code Model*	*Amendment Contact*
Building/Dwelling Code	IBC 2006 (w/deletion of Ch. 11 - Accessibility)	No amendments
Structural Code	IBC 2006	No amendments
Plumbing Code	IPC 2006	No amendments
Mechanical Code	IMC 2006	No amendments
Electrical Code	NEC 2005	No amendments
Fire/Life Safety Code	Kansas Fire Prevention Code (IFC 2006, NFPA)	Karl McNorten, Fire Prevention Division Chief, (785) 296-3401
	Statewide mandatory miniumum	
Accessibility Code	ADAAG	No amendments
Energy Code	IECC 2006	No amendments
	Mandatory for all commercial buildings	
Boiler Code	Kansas State Boiler Code; ASME Boiler & Pressure Vessel Code	No amendments
Hazardous Materials	Hazardous Waste Management Standards And Regulations	Online (Adobe Acrobat pdf file)

continued on page 34

a regulatory requirement if the standard was adopted by the code that is in effect at the time the project was executed. Due to the code cycle, it is not uncommon for codes in effect to refer to standards that are six- to nine years old.

It is important to realize here that the owner and operator of a facility has the ultimate responsibility, and that all regulatory requirements are met.

Unless the installing contractor or A&E firm was willfully negligent, it is most often the owner and operator of a facility who carries the burden when noncompliance issues arise.

Authorities having jurisdiction in their participation in design review meetings and permit issuing activities do not carry any liability, and assume no responsibility.

Using an example, a hypothetical ABC Food Company is planning to build a new facility with an ammonia refrigeration system with a charge above 10,000 lbs of ammonia in Lebanon, KS located in Smith County, Kansas. When planning to build a new facility, or simply expand an existing system, a good starting point is to consult the CMD website with the following link:

http://www.cmdgroup.com/Resource-Center/Building-Codes/

The reader is encouraged to follow along using this link. This website provides useful information such as who the Authorities Having Jurisdiction are, contact information, the model codes adopted, and links to the AHJ websites. By visiting the AHJ website it can be determined if the AHJ adopted the model codes in its entirety or if modifications have been made and addendums have been issued.

The screenshot of the website appears on the upper right side of this page.

Scrolling further down this website, no other codes or code amendments apply to Smith County. The CMD website reveals that the 2006 IBC, IPC, IMC and IFC have been adopted without any amendments.

Obtaining a copy of the 2006 IMC reveals that chapter 11 is an entire paragraph dedicated to refrigeration with specific requirements including reference to the following standards:

“1101.6 General. Refrigeration systems shall comply with the requirements of this code and, except as modified by this code, ASHRAE 15. Ammonia-refrigerating systems shall comply with this code and, except as modified by this code, ASHRAE 15 and lIAR-2.”

ASHRAE
American Society of Heating, Refrigerating
and Air-Conditioning Engineers, Inc.
1791 Tullie Circle, NE
Atlanta, GA 30329-2305

Standard Reference Number	Title	Referenced in code section number
ASHRAE—2001	ASHRAE Fundamentals Handbook—2001	312.1, 603.2
15—2001	Safety Standard for Refrigeration Systems	1101.6, 1105.8, 1108.1
34—2004	Designation and Safety Classification of Refrigerants	202, 1102.2.1, 1103.1
ASHRAE—2000	HVAC Systems and Equipment Handbook—2000	312.1

IIAR
International Institute of Ammonia Refrigeration
Suite 700
1101 Connecticut Ave., NW
Washington, DC 20036

Standard Reference Number	Title	Referenced in code section number
2—99	Equipment, Design, and Installation of Ammonia Mechanical Refrigerating Systems	1101.6

It is noteworthy to point out that IIAR 2-99 is referenced, a 16-year-old standard, and ASHRAE 15-2001, a 14 year old standard. Both the IFC 2006 and IBC 2006 make reference to the IMC, but also list additional requirements, such as emergency control systems, egress requirements and others.

In addition to visiting the above CMD website, it is always recommended to also consult with the Authorities Having Jurisdiction, ensuring that the CMD website is up to date and referencing the latest codes and amendments in effect.

If logic prevails, an end-user and contractor may be tempted to conform to the latest ASHRAE-15 and IIAR-2 revisions.

However, this may generate conflicts with current codes and local requirements. One example is the relief header termination.

IIAR-2 recommends discharging to the atmosphere, which is in conflict with numerous local requirements still requiring diffusion tanks. Another example is the removal of so-called fireman's boxes, which was removed from IIAR-2 several years ago.

The before-mentioned examples are typical examples that require detailed code research, and possibly discussions with the Authorities Having Jurisdiction to ensure conformance.

And finally, this article wouldn't do justice to the reader if OSHA isn't included in this discussion.

If somebody – in the context of this article – asks the following question: "Is OSHA buying into this?" the answer would be "definitely maybe."

In the United States all facilities are subject to EPA's General Duty Clause requirements (Section 112(r)(l) of the Clean Air Act) and to the General Duty Clause in section 5(a)(1) of the Occupational Safety and Health Act (29 U.S.C. § 654(a)(1)). If the facility operates an ammonia refrigeration system with an ammonia charge above 10,000 pounds they are subject to OSHA's Process Safety Management (PSM) Standard (29 CFR 1910.119), the USEPA's Risk Management Program (RM Program) Regulation (40 CFR Part 68).

With PSM being a performance standard, and not a prescriptive standard, the intent of this standard can best be described in the spirit of the following, by saying: "Say what you mean and mean what you say."

Consequently, documenting which codes and standards a refrigeration system was designed and built to, is of utmost importance, regardless of whether the ammonia refrigeration system is covered under PSM/RM Program, or falls under the General Duty Clause.

Failure to properly document may lead OSHA to choose the specific RAGAGEP (Recognized and Generally Accepted Good Engineering Practice) requirements which apply to that facility, which could mean that they would enforce the latest IIAR standards and bulletins. Citations for nonconformance with the latest standards would most certainly follow. OSHA may also challenge an owner and operator by asking why safer technologies were not employed in the design of the refrigeration system.

As an example, IIAR2-99 still refers to an older method for sizing relief valve headers. It would be difficult to argue that the older method is safer, or as safe, as the newer method referenced in the latest IIAR-2 revisions, as the rationale behind the new method is widely published. Concerning emergency ventilation requirements, it may be prudent to follow the latest IIAR-2 standard using 30 air changes per hour. In this case more is better and it may avoid any future conflicts, such as upgrading the ventilation system should the system be expanded or modified in the future. Consequently, using the above examples, an end user or owner would be ill-advised to not follow the latest standards. The employer should document that equipment complies with recognized and generally accepted good engineering practices.

The complexity of ensuring that applicable codes and standards are being adhered to stresses the importance of conducting detailed research, and clearly specifying the standards to be followed prior to the detailed design of the system, and most importantly, prior to installation. Failure to do so may result in OSHA citations and costly upgrades in the future.

In conclusion, prior to any new installation, expansion, or major modification, a detailed code research should be conducted. ■

TECH PAPER roundup

IIAR Technical Program Highlights Growth of Natural Refrigerants

The growth of natural refrigerants such as ammonia and CO_2 in industrial and commercial facilities, and the regulatory restrictions that accompany their use will be a central topic of discussion in technical papers to be presented at this year's IIAR Annual Conference in San Diego.

Rajan Rajendran of Emerson Climate Technologies will provide a summary of the variety of refrigerant options, both natural and synthetic, and what the future holds for ammonia and CO_2.

Since the Montreal Protocol went into effect in 1989, resulting in the phase-out of ozone-depleting chemicals, ammonia has remained the standard refrigerant of choice for industrial applications. Technological advancements in electronics and software have made natural refrigerant systems even more efficient.

But, Rajendran points out, synthetic refrigerants will not disappear from the landscape.

"There was a time when people thought synthetic refrigerants in non-industrial applications would be completely wiped out, but the chemical companies have figured out how to develop very low GWP (global warming potential) fluids," he said. "While natural refrigerants will become more important, they are not going to replace all synthetics. Synthetic refrigerants are not going to give up their territory without a fight."

As recently as five years ago, the air-conditioning and refrigeration applications were dominated by a handful of refrigerants, including ammonia in large industrial systems. Today, CO_2 as a refrigerant in stationary refrigeration has grown in usage and acceptance in Europe and Australia and is making inroads in North America.

Rajendran said that CO_2 will play a major role in supermarket refrigeration, especially in cold climates where the periods of trans-critical operation are limited to a few days in the year. The cascade refrigeration system will also become common, he said.

Ammonia will continue to play a dominant role in industrial refrigeration, he added. Although the future will offer more refrigerant options than ever before, Rajendran cautions against making choices that could lead to "unintended negative consequences."

"These are not black-and-white choices," he said. "Many people are looking at natural refrigerants as a safe bet against government regulations."

A proposal to amend the Montreal Protocol to regulate the GWP content of all synthetic refrigerants will lead to growth in the use of ammonia and CO_2, he added.

Kurt Liebendorfer, vice president of Evapco, Inc., will address the issue of government regulations in a paper that explores the regulatory and code implications for low charge ammonia systems.

"Kurt's paper ties in nicely with Rajan's," said Eric Smith, IIAR vice president and technical director. "Rajan makes the case that ammonia is a great option, and Kurt's paper lays out the sticking points for what you have to overcome to implement an ammonia system. It gathers all the requirements from the codes, standards and regulatory agencies in one place for people to reference."

OSHA, IIAR, ASHRAE and others have various regulations and standards related to the quantity of refrigerant in a system, along with specific actions or designs that must be followed, said Liebendorfer.

His paper identifies these regulated threshold quantities so that designers, contractors and end users can better understand the various threshold requirements. Liebendorfer calls his paper a "building block."

"The demand for reduced ammonia charges is being driven by regulatory pressures," he said. "So we need to know what the codes say and what the criteria are. Is some of that driven by the amount of ammonia in the system? I found that there isn't much said that relates to charge quantity. But maybe there should be. That's why I'm presenting this paper."

Liebendorfer points out that the current criteria are driven solely by ammonia safety. For instance, for every pound of ammonia release through a system's highest capacity relief valve, a water diffusion tank must hold two gallons of water, with no current threshold quantity for the diffusion tank. "If you have a low-charge system with 500 pounds of ammonia, is that a permissible threshold?" he asked. "There probably should be more threshold quantities that allow for the relaxation of certain requirements if you have low quantity ammonia, because there is less risk."

In researching his paper, Liebendorfer was surprised to learn that there are not regulatory exemptions or allowances when designing a low-charge system. "This paper is a blueprint for what designers must know to meet codes and regulations. The underlying theme is they pretty much have to do the same as larger charge systems," he said. "But maybe there should be allowances. This paper is a tool to continue the dialogue."

In related technical papers, Stefan Jensen of Scantec Refrigeration Technologies will present a case study on the operation of a cold storage facility with a direct expansion ammonia system, while John Ball, the former chief design engineer at Luke Air Conditioning, and Klaus Visser, the founding principal of KAV Consulting Pty Ltd., explore using evaporative condensing for CO_2.

"The theme in all these papers is analyzing and implementing the use of natural refrigerants in the changing landscape of our industry," Smith said. ■

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U.S. Chemical Safety Board Issues Bulletin on Hydraulic Shock

The U.S. Safety Chemical Board, or CSB, issued a safety bulletin on Jan. 15 that provided recommendations for industries utilizing anhydrous ammonia in bulk refrigeration operations.

The bulletin focused on how to avoid a hazard called "hydraulic shock," which is defined as a sudden, localized pressure surge in piping or equipment that often occurs when vapor and liquid ammonia are present in a single line and are disturbed by a sudden change in volume.

This abnormal transient condition results in a sharp pressure rise with the potential to cause catastrophic failure of piping, valves and other components.

In pointing out lessons to prevent hydraulic shock, the CSB report noted that it is vital to avoid a manual interruption of evaporators in defrost and to ensure that control systems are password protected so that only trained, authorized personnel have the authority to manually override the system.

The report also suggested that each evaporator coil in an ammonia refrigeration system should be controlled by a separate set of valves.

It went on to say that an emergency shutdown should be activated in the event of an ammonia release if the leak cannot immediately be isolated and controlled.

The report also stressed the danger of bypassing safety controls put in place to prevent an ammonia release.

"This issue really comes back to IIAR safety standards," IIAR president Dave Rule said. "It's always important to identify any procedures and standards that aren't being followed correctly, which could result in ammonia accidents."

However, IIAR said it does not agree with all of the conclusions reached in the CSB report, which was issued following a recent ammonia release resulting from hydraulic shock.

The report suggested that a freezer with four coils running on one bank of valves can cause hydraulic shock, and recommended that every evaporator have its own bank of valves.

"That might be good practice in very large, low-temperature scenarios, but it's not necessarily a panacea," said Eric Smith, IIAR vice president and technical director. "There are some instances where grouping evaporators is entirely appropriate."

IIAR said it will continue gathering information on the CSB report and hopes to submit a response in the near future.

"It was good to have a report that gives an overview to help prevent this type of accident in the future," Rule said. "The goal is to have everyone working together for a safer industry by following IIAR standards. IIAR and the CSB are working toward the same goals in following appropriate safety standards and design guidelines, and by making sure operators are properly trained and adhering to the safety protocol." ■

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R-22 Phase Out Begins in U.S.

The recently issued U.S. government schedule for the phase out of R-22 is set to create opportunities for both the providers of natural refrigerants and for the developers of small charge technologies.

Those opportunities will become available as end users see "natural refrigerants as a more stable refrigerant choice for the future," said Lowell Randel, IIAR's Director of Government Relations.

Fostering the growth of those opportunities is the Environmental Protection Agency's regulation that is steering the nation away from R-22.

That rule is designed to end R-22 use within the United States as quickly as possible, while providing industry some time to make the transition, he said.

R-22 is a hydrochlorofluorocarbon (HCFC)-22 that has been used as a refrigerant because it has a relatively low ozone depletion potential, but now, even HCFs with low ozone depletion potentials are being banned under the Montreal Protocol, which seeks to protect the ozone layer by phasing out the production of substances responsible for ozone depletion, as well as those that have high global warming potential.

R-22 is a greenhouse gas that has a global warming potential 1,810 times as powerful as carbon dioxide.

As directed by the Montreal Protocol, in October 2014, the EPA issued its final rule —Protection of Stratospheric Ozone: Adjustments to the Allowance System for Controlling HCFC Production, Import and Export, 2015-2019 — that schedules the phase out of HCFC-22, which is mostly R-22.

The EPA developed the schedule for the phase out of R-22 in accordance with the Montreal treaty and the Clean Air Act, said Randel.

Once the EPA determined a baseline production level, the agency developed the schedule for the reduction of allowable amounts of R-22 that can be produced or imported from 2014 to 2020, so that by 2020, HCFC use is projected to decline by 99.5 percent below the baseline level.

Under the schedule, for 2015, the rule caps the production and import of R-22 at about 22 million pounds, which is a 29 million pound reduction from the 51 million pounds allowed in 2014.

For 2016, the cap is set at 18 million pounds of R-22; for 2017, 13 million pounds; for 2018, 9 million pounds; for 2019, 4 million pounds; and by 2020, the production and importation of R-22 is ended, according to the schedule.

The EPA's phase out of R-22 is an aggressive schedule, and industry might find it to be more aggressive than expected, "but at this point, everyone knows that this is moving forward, so they are going to have to make their transition plans to match the schedule," Randel said.

The rule does allow for the use of reclaimed R-22, but even that can become problematic as far as supply goes, according to Randel. R-22 that meets the reclamation standard can be recycled and reused, so it will remain an option, but limited supplies will increase its cost, he said.

Eventually, organizations are going to have to make decisions on which refrigerant they use for the longer term, and that is where the opportunity exists for the producers of natural refrigerants.

"If you're in the ammonia or CO^2 business, you can expect that some of the organizations that are transitioning away from R-22 are going to make the leap to natural refrigerants," he said.

Such decisions by organizations become more likely as the trend grows in Europe to move away from HFCs. And the EPA has indicated that the U.S. is probably going to phase out the use of such HFCs as well.

While organizations will be aware that HFCs are likely to be banned in U.S., they will also be aware that the EPA is not going to ban ammonia or CO^2.

"From a policy perspective, organizations are going to end up saying natural is the more stable refrigerant," Randel said.

The levels of how much ammonia or CO^2 will be used in an organization's refrigeration system will be determined by how large those refrigeration operations are, said Randel. In addition, because regulations for the safe use of ammonia such as the EPA's Risk Management Program and the Occupational Safety and Health Administration's (OSHA) Process Safety Management are imposed on larger systems with over 10,000 pounds of ammonia, smaller charge systems that avoid those regulations are likely to become attractive to users, and that creates opportunities for those technologies.

The technologies that have been developed over the last few years make it possible for organizations to use smaller charges of ammonia and still maintain the level of refrigeration that is needed by a facility, he said. ■

ARF*news*
AMMONIA REFRIGERATION FOUNDATION

IIAR Opens Search for New ARF Executive Director

The International Institute of Ammonia Refrigeration is looking for a new executive director for the Ammonia Refrigeration Foundation to lead the non-profit research and education organization toward continued growth and expansion.

"Having the right person in that role is critical," said Bob Port, ARF chairman. "We will be reaching our goal for the endowment fund in the next year or two and we need to be utilizing the money that is available to fund research and scholarships under the leadership of a new Executive Director."

ARF's mission is to support research and educational efforts in industrial refrigeration, particularly in the area of ammonia and natural refrigerants. ARF also funds industry scholarship programs and recognizes outstanding contributors to the industrial refrigeration profession.

"We're at a point now where we can commit to research projects year in and year out and we're driving toward developing an on-going, sustainable scholarship program," Port said.

Tim Facius led ARF as executive director for the past two years, providing exceptional leadership during a time when the foundation's endowment increased from $1.3 million to $2 million. In addition to expanding ARF's activities and fundraising, Facius served as an invaluable resource for IIAR and was a motivating factor in the foundation's growth, said Port.

"Tim gave the foundation direction," Port said. "We need another person like him to step up and be that kind of leader, someone who will continue to drive our important goals forward."

The executive director position is a volunteer position, and requires a two-year commitment of approximately ten hours per week. Key responsibilities include working with the ARF Board of Trustees to identify high-level donor prospects and to execute fundraising campaigns; working with IIAR staff to communicate the foundation's mission to IIAR membership and the ARF board; overseeing financial management of the foundation; and coordinating monthly meetings of the ARF board.

"The foundation is in an extremely healthy condition," Facius said. "Our $2 million endowment gives us a solid base and the flexibility to pursue the kind of research projects we feel are important. There are also a lot of exciting things happening on the education side. We want the scholarship piece to be a bigger part of our overall work. We're moving towards a new scholarship program, which would mean more of a balance between scientific research and bringing in young talent to the industry."

Facius said he is proud to have installed structure, discipline, procedures and documentation in the operations of the foundation during his term. "It positions us for a smooth hand-off to new leadership," he said.

"The leadership is really multifaceted, from the chairman to the board to the trustees to my part as executive director, to the support IIAR has provided," he said. "It's all that coming together as a team that has made the foundation what it is today.

"For me, it's been a very rewarding experience and an exciting way to give back to the industry for such an important cause. The concept of funding research and drawing in new talent is a real and tangible way that IIAR and ARF can better the industry that we're working in."

ARF said in a recent report that it hopes to have a new executive director in place by June. ■

IIAR members interested in volunteering for the ARF Executive Director role should contact Bob Port, ARF Chairman at 402-240-5906, via email at bob_port@conagrafoods.com or IIAR President Dave Rule at 703-312-4200, via email at dave_rule@iiar.org.

IIAR Chapters Installation Project: Good News from the International Committee

BY ADOLFO BLASQUEZ PE, IIAR INTERNATIONAL COMMITTEE CHAIR

Because we are always looking to make the information that we produce available to a greater number of end users for the benefit of our industry, the International Committee, following the direct request of our IIAR Chairman, Marcos Braz, has initiated the IIAR Chapters Implementation Project worldwide.

I've entrusted Federico Alarcón, the Latin America Project Administrator, with the task of designing a methodology to accomplish this goal.

We welcome new members in regions that have previously had a lower level of participation in IIAR to join the International Committee in its efforts to spread the knowledge offered by IIAR around the world.

He submitted a document covering two necessities: serving as a guide for setting up chapters and serving as an agreement to be signed by those members who are willing to join the chapter´s executive committee.

Under this plan, those members would commit to the implementation and operation of the chapter. In this way the "Agreement-Guide for Setting Up IIAR Chapters" emerged.

It is useful to note how we will define our chapters:

"A chapter is a formal representation of IIAR outside the United States and in countries where there are members of any category willing to come together to organize activities promoting our principal task: education."

Due to our successful experience with this country in 2013, it was recommended that we begin with Costa Rica.

In a productive trip where we had the opportunity to interview a number of our IIAR members, government authorities and academics; we decided that the Chapter based in Costa Rica should be responsible for all of Central America and the Caribbean. We now have an agreement from a committee that is already meeting to develop their annual plan.

Efforts are well on their way to reproduce this experience in Ecuador, Peru and Mexico in the short term; and in Argentina, Chile, Uruguay and Colombia in the medium term.

While Federico is managing the chapter development efforts in the Spanish speaking countries of the Western Hemisphere, Chris Combs, the International Programs Director, is taking the lead in what has been termed the continental region.

These regions include Brazil, the only Portuguese speaking country in South America, and the rest of the countries outside the United States and Latin America.

He is currently working with Samir Shah, the International Committee's Regional Vice Chair (RVC) for India and South Asia, on forming chapters in India.

Samir has already identified individuals in five major Indian cities interested in forming chapters. They will conduct meetings with interested parties at the upcoming ACREX show in Bangalore.

Beyond India, Chris has made arrangements for a meeting in Dubai with interested parties from the industrial ammonia refrigeration sector based in the United Arab Emirates, and, in the coming months, plans to reach out further to members in the Africa and Middle East regions as well as Brazil to arrange for the establishment of additional IIAR International Chapters.

We also aim to carry the project further east, especially to China, in collaboration with our RVC for China and the Mekong Basin countries, Guy Evon Cloutier, and other members in the region.

Given the vast size as well as the linguistic and cultural diversity of the continental region, we aspire to grow our current network of RVCs and other volunteers to collaborate in establishing Chapters throughout the world.

We welcome new members in regions that have previously had a lower level of participation in IIAR to join the International Committee in its efforts to share safety standards, technical information and training materials offered to IIAR members around the world.

Chris is leading the development of a more detailed manual to establish and outline the operations of IIAR chapters in English and Spanish languages.

There will be a presentation and discussion of this content at the International Committee meeting in San Diego, where we aim to further advance the development of IIAR Chapters.

Through this important program, we intend to increase the IIAR membership and to make more IIAR materials available in order to generate safe operating practices for ammonia and other natural refrigerants used in our industry worldwide.

Without a doubt, an expansion of this type constitutes an enormous challenge for IIAR. In the absence of precedents for this type of growth, we must proceed making the necessary adjustments to perfect our methods. With the goal to expand our international presence; this is clearly good news. ■

Satisfying EAP and ERP Requirements

Every owner of an industrial ammonia refrigeration plant with more than 500 pounds of ammonia in the United States is required by government regulations to have an action and, or, response plan in place should an emergency event occur.

But determining if those plans satisfy OSHA requirements regarding medical treatment and rescue during an ammonia release is not as black-and-white as one might think.

Every plant is different, with unique needs related to size, staffing, location and the availability of first responders.

Although each industrial plant must address the medical and rescue concerns associated with an emergency, the nature of their response can vary depending on their specific circumstances.

OSHA requires that an Emergency Action Plan, or EAP, contain a detailed set of procedures to be followed by employees performing rescue or medical duties, while the Emergency Response Plan, or ERP, must address medical treatment and first aid.

But how do plant owners make sure they are satisfying these requirements? That's where the waters become muddied.

The reason for that is that these regulations are more performance-based than prescriptive, which means that the regulation places more emphasis on specifying a performance standard for the desired outcome than on how the outcome will be achieved. Thus, plant owners are left to determine, in many cases, the best approach for their particular circumstances.

So where do they go for help? The IIAR Ammonia Data Book and the Safety Data Sheet both offer information about fire control, first aid and chemical characteristics, but neither is sufficient on its own to satisfy OSHA's requirements.

"Both are excellent resources that would support what you need to know when putting together an EAP or ERP, but they in no way fully cover the need," said Gary Smith, president of the Ammonia Safety & Training Institute.

"These books provide specific information about ammonia, the response-related concerns, the hazards, the risks and the details about first aid. But they don't lay out a reporting system or an evacuation procedure or even how to set up medical and rescue responsibilities."

The IIAR recently produced a module and training video package to help solve this problem. Titled "The IIAR Ammonia Refrigeration, Education and Training Program: Making the First 30 Minutes Count," the package spells out how to set up an Emergency Action Plan, EAP, and an Emergency Response Plan, ERP, to satisfy the requirements of both OSHA and the EPA.

For example, it recommends that procedures be put in place in regard to the performance of rescue and medical duties.

"It could be public safety responders, but that must be arranged," Smith said. "It can't just be, oh, they will handle that. You must touch base beforehand and let them know what you're expecting from them."

In order to satisfy OSHA requirements regarding medical treatment and first aid, the employer should list the locations of first aid kits and other medical support equipment on site, such as automated external defibrillators.

Such first aid equipment must be checked routinely – recommend weekly – to ensure they are sufficiently stocked.

And there must be at least one employee qualified to administer first aid to injured personnel until medical help arrives.

An accounting of employees certified in first aid and CPR should be listed. A list of key personnel with contact information as well as contact information for local emergency responders, agencies and contractors should be included.

Make sure any external department or agency identified in your plan is prepared to respond as outlined in your plan. A documented teaming agreement is helpful in clarifying who is doing what. Medical, decontamination, and rapid entry rescue policies should be reviewed and practiced during joint-training sessions with fire and medical service providers.

Your emergency plan must include the location of hospitals, medical clinics, or facilities close by to handle emergency medical cases. It's good to bring the Ammonia Safety Data Sheet and/or the IIAR Ammonia Data Book with a victim of an ammonia injury to the treating medical team, said Smith. Ammonia injuries are rare, skin and eye injuries require an immediate focus on the correct ways of treatment.

The Plant emergency planner should make sure that the local medical providers are prepared to handle ammonia injuries with advanced life support services. The Agency for Toxic Substances & Disease Registry, (ATSDR) provides an excellent reference guide. See "Medical Management Guidelines for Ammonia," on the Agency's website.

If an infirmary, clinic, or hospital is not close to your workplace, ensure that onsite employees have adequate training in first aid. The American Red Cross, some insurance providers, local safety councils, fire departments, or other resources may be able to provide this training.

The EAP should detail who will direct rescue operations. It should include a company employee designated as an emergency planner who will work in tandem with first responders.

Further, employees are not required to enter danger zones to attempt a rescue. However, the EAP does require the plant to make arrangements to safely evacuate employees from the danger area; to notify first responders; and to provide first aid and basic decontamination until public safety services are on the scene.

"OSHA is concerned with worker safety in regards to implementing an action or response plan," Smith added. "Specifically, that means the safety elements that are associated with responders and workers and how they both will be protected in an emergency." ■

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Non-Condensable Gases in an Ammonia Refrigeration System

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

Although it could take many years for non-condensable gases to accumulate in an ammonia closed-circuit mechanical refrigeration system – enough to cause abnormal operations to be evident – that buildup will almost certainly occur if it isn't managed.

All of the installed purge connections (multi points) on the condenser coil outlets can be cross connected to a single purge line which is connected to an automatic purger. It is crucial that only one solenoid purge valve be opened at a time. Opening two or more valves tied together equalizes the coil outlet pressures and the effect of the vertical drop legs is lost.

Non-condensable gases are foul gases and should not be thought of like water contamination, because they are vapors that will not liquefy in the refrigeration system at its operating pressures and temperatures.

Non-condensable gases may be introduced to a system during continuous operation or as a result of opening the system for service.

Systems that operate in vacuums on the low side provide sources for contaminants to infiltrate into the system. These leak sources may occur at valve stem packings, compressor shaft seals, bonnet gaskets, non-welded (threaded) connections, incorrect welds, and control transducers.

If piping, and, or, tubes are not properly secured, movement may occur causing rub points, pipe deterioration or weld cracks, resulting in a non-condensable leak source.

New systems must be completely evacuated prior to charging in order to ensure that all non-condensable gasses are removed. Similarly, when a system is opened for service, a complete evacuation must be performed prior to charge and startup to remove all contaminants.

Although relatively small in quantity, ammonia refrigerant that breaks down over time leads to accumulation of hydrogen and nitrogen in the system. The breakdown of the lubricating oils becomes hydrocarbon gases.

As these non-condensable gasses build up in the system, they must be removed through purging to ensure efficient operation of the system.

Accumulated non-condensable gases cause reduced condenser capacity and higher operating head pressures. The result is increased power input at the compressors and the operation of additional condenser fans in order to maintain system performance.

Energy costs continue to increase in an attempt to hold the system operating temperatures.

The overall refrigeration system decreases in efficiency and may reach a situation where the likelihood of an unplanned shutdown can occur.

As the compressor discharge superheat increases, the compressor wear accelerates, the refrigerant and oil breakdown, and these factors contribute to an increased scaling risk at the evaporative condenser tubes.

Scale building on the condenser coil may cause additional maintenance costs and decreases the condenser life.

For each four pounds of excess head pressure caused by non-condensable gases in the system, the energy cost to operate the refrigeration system compressor capacity increases 2 percent while the compressor capacity decreases 1percent. Installing a (proper type and sized) purger is essential to remove non-condensable gasses, and reduce the system's short term and long term costs.

Removal of the non-condensable gases can be done manually or with a properly connected and operated automatic purger.

Manual purging can avoid the initial cost of the purger and its installation, but requires labor to perform each service.

Manual purging typically releases more refrigerant per purge, is an exposure risk, may be a local compliance concern, and the purge amount tracking (purge point counts and total open times) is not as consistent or accurate.

It is highly recommended to install a multi-point automatic purger that functions continuously to scavenge and remove the non-condensable gases. Although a purger can be used to remove non-condensable gases that are present due to inadequate system evacuations, it is highly recommended to perform the evacuations adequately prior to charging and startup.

Some systems that do not operate below atmospheric pressure (do not operate in a vacuum).

Non-condensable gases will eventually accumulate in these systems from the refrigerant and oil breakdown. Contaminants may also be present in the system due to inadequate evacuation.

Installing a (proper type and sized) purger on these systems is highly recommended.

The location to install purge connection points in the system piping is critical. Purging during system operation can be effectively accomplished if the purge points have been installed at the condenser coil outlets and the appropriate drain traps are installed.

The appropriate sized drain traps help capture the non-condensable gases at the condenser coil outlet purge points so the purger receives non-condensable gases instead of condensed liquid.

The non-condensable gases are carried through the condensing coil with the refrigerant liquid and vapor and tend to accumulate in the condensing coil outlet header.

All of the installed purge connections (multi points) on the condenser coil outlets can be cross connected to a single purge line which is connected to an automatic purger.

It is crucial that only one solenoid purge valve be opened at a time. Opening two or more valves tied together equalizes the coil outlet pressures and the effect of the vertical drop legs is lost.

Checking the system for non-condensable gases can be done by identifying the condenser pressure and temperature of the refrigerant leaving the condenser.

Use a Pressure-Temperature Chart to convert the temperature identified to what the theoretical condensing pressure should be.

If the actual gauge pressure reading taken of the condenser pressure is higher than what the theoretical condensing pressure comparison indicates, then the difference is indicating that non-condensable gases exit.

As an example, if a 10 pound difference is indicated, a 5 percent increase in power costs and a 2 ½ percent decrease in compressor capacity are occurring. Or, if a 20 pound difference is indicated, a 10 percent increase in power costs and a 5 percent decrease in compressor capacity are occurring. Non-Condensable Gases must be managed and removed to avoid higher overall increased operating costs. ■

VAPOR VALVE SIZING: An updated approach

By Robert Sterling, President, Sterling Andrews Engineering, PLLC

Editor's Note

The current methodology for valve sizing has been accepted in the industrial refrigeration industry for years. This paper will review past efforts undertaken in the literature and standards to determine suitable methods for quantifying the compressible flow pressure drop in valves and attempts to compare them while providing a base rationale for which, if any, are appropriate methods for determining pressure drop.

This study on industrial vapor valve sizing recommends that a new approach, through the use of widely-standardized methods for calculating vapor flow valve pressure drops, be adopted in the industrial refrigeration industry on the part of engineers, contractors and valve manufacturers.

While the current practice is to select valves based on the load capacity they are connected to, the author suggests that this may not be the most appropriate method as it can be based on assumptions that may not always hold true.

The paper displays a methodology to look at valves individually and use parameters that are specific to the application rather than an assumption.

This can lead to a more accurate sizing of valves which could in turn reduce costs and/or improve operating characteristics.

The industry is likely to consider this proposal carefully as it holds promise for improving efficiency and the IIAR piping committee may include these methodologies in the piping handbook which provides guidelines on pipe and valve selection.

In addition, purveyors of valves may wish to consider the implications for how their catalogue data is presented and how a designer could select valves.

Calculation of pressure drop in vapor flows through valves has made substantial advancements in the past half-century. Currently-used methods for determining pressure drop through valves with vapor flows (assumed to be either saturated or superheated refrigerant vapor states) were identified and evaluated. Attempts at providing a standard means for industrial ammonia system engineers to calculate vapor valve pressure drops have been undertaken in the past, notably by the IIAR. At present, the IIAR makes available an explicit set of equations, based on C_v, and provided in the Ammonia Refrigeration Piping Handbook (2004).

It is often the case that in HVAC&R, valves are sized based on capacity in Tons of Refrigeration. This does not allow for accurate sizing for types of valves not rated in those terms and will often not predict the correct valve for a specific application. This study recommends the use of widely-standardized methods for calculating vapor flow valve pressure drops be adopted in the industrial refrigeration industry on the part of engineers and contractors.

INTRODUCTION

A commonly applied metric or performance characteristic available for almost every type and size of valve is its "flow coefficient" or C_v. C_v (unless specifically called out as being otherwise) is universally understood to represent the volume flow rate flow coefficient of water at standard conditions (60°F)through a valve for a 1 psig pressure drop (gpm/psi). While arguments can be made for and against a liquid C_v as the characteristic on which to rate a valve intended for compressible flow, it is nevertheless the most easily obtained characteristic for any valve intended for use. Specific characteristic valve data other than the C_v are not widely published for industrial refrigeration valves.

This paper will review past efforts undertaken in the literature and standards to determine suitable methods for quantifying the compressible flow pressure drop in valves and attempt to compare them while providing a base rationale for which, if any, are appropriate methods for determining pressure drop.

In all cases, areas of interest will be limited to vapor flows where pressure drop, $\Delta P \leq 0.5$ P (inlet pressure), or non-choked, pure vapor flow [2,3,6]. Flows where pressure drop is sufficient to cause condensing (at pressures above approximately 400 psig for ammonia) are not considered as this would not constitute pure vapor flow. In addition, the methods considered are for turbulent flow through a valve, and assumed valid above Re = 10,000 [3]. The assumption of turbulent flow at low pressure drops in common refrigerant service valves can be readily accepted and is not a blanket statement or poor assumption. It can be easily demonstrated with any valve for which the connection size is known, as is shown below.

It should be noted before proceeding that the standard, ANSI/ISA 75.01.01 uses the smallest throat diameter in the valve as the characteristic dimension for the Reynolds number referred to above. This information is not typically available in regular catalog literature for refrigerant valves. However, if the connection size of the valve is known, it can be substituted as the characteristic dimension and will be conservative (in other words, if the port is smaller than the connection size, Reynolds number will be underestimated by using the connection size). Reynolds numbers calculated for low pressure drops in refrigerant valves using the connection size rather than the smallest internal diameter are typically orders of magnitude higher than the minimum threshold of 10,000 given above.

A 4-inch gas-powered suction valve with a C_v value of 276 with saturated ammonia vapor at 40°F is considered. A pressure drop of 0.25 psig is assumed to demonstrate a reasonably low pressure drop at high inlet pressure. Note that the mass flow to generate a 0.25 psig pressure drop has been determined using the ANSI/ISA 75.01.01 equation for vapor flow pressure drops through valves, which is discussed in detail in subsequent sections. The mass flow, 4,351 lb/hr, corresponds to a heat removal of 175.5 TR at 40°F with the liquid supply at 86°F.

The diameter is assumed as the nominal size, 4 inches. The definition of the Reynolds number is:

where:

$$Re = \frac{\rho \cdot V \cdot d}{\mu}$$

ρ is the fluid density

V is the fluid velocity

d is the characteristic dimension, in this case the nominal diameter of the valve

μ is the dynamic viscosity

To determine the Reynolds number using the available information from above, the equation is rearranged, substituting velocity in terms of the mass flow.

$$V = \frac{massflow}{\rho \cdot Area} = \frac{massflow}{\rho \cdot \frac{d^2 \cdot \pi}{4}}$$

$$Re = \frac{\rho \cdot \frac{massflow}{\rho \cdot \frac{d^2 \cdot \pi}{4}} \cdot d}{\mu} = \frac{4 \cdot massflow}{\mu \cdot d \cdot \pi}$$

Substituting values and correcting units (the dynamic viscosity of saturated ammonia at 40°F is $6.177*10^{-6}$ lb/ft-s, from NIST's REFRPROP 9.1)

$$Re = \frac{4 \cdot 4349.6 \cdot \frac{lb}{hr}}{6.177 \cdot 10^{-6} \cdot \frac{lb}{ft \cdot s} \cdot 4 \cdot in \cdot \pi} \cdot \frac{12 \cdot in}{ft} \cdot \frac{1 \cdot hr}{3600 \cdot s} = 747{,}100$$

The result is Re = 747,100. This is well above the threshold for Re = 10,000 mentioned above, and is based on the largest cross sectional internal area of the valve, which is larger than the actual minimum diameter. Therefore, the assumption of turbulent flow in typical design cases for refrigerant vapor flow will be considered accurate within the scope of this analysis.

In addition, although various resources provide means of accounting for fittings attached directly to a valve, for simplicity, the focus of this paper will be valves installed at line size without attached fittings. Most catalog ratings for refrigeration valves assume no attached reducers.

To clarify the content of the work that follows, two points are made here:

Although R-22 as a refrigerant for new system design is not very relevant, it is included, along with ammonia, in the comparisons made between the ISA method and the IIAR method because manufacturers' ratings for valves on R-22 are readily available, whereas other refrigerant ratings are not.

ISA has published a 2012 version of the 75.01.01 standard, which was not directly observed for the writing of this paper. However, a summary of changes was obtained and it was found that the equations used here did not change in the update of the standard. The 2007 update, from which the equations were taken, has been cited.

INCOMPRESSIBLE FLOW EQUATION

The basis of compressible flow equations is the incompressible flow equation, which relates the valve characteristic to the pressure drop as follows [1,2]:

$$C_v = Q \cdot \sqrt{\frac{SG}{\Delta P}} \qquad (1)$$

Where:

C_v is the valve characteristic flow coefficient

Q is the flow in US gallons per minute

SG is the specific gravity as compared to water at 60°F

ΔP is the pressure drop through the valve, $P_1 - P_2$ in psi

Equation (1) provides universally-accepted results for calculated pressure drop when liquid is sufficiently subcooled to prevent flashing and flow is not choked, as it is the definition of C_v. For compressible flows, this formula is not considered suitable because it does not account for changing density with changing pressure.

MODEL FOR COMPRESSIBLE FLOW PRESSURE DROP

The concept of using C_v, the incompressible flow coefficient, to model flow for vapor through valves, has been fairly standard for many decades Turnquist [2]. Equations for this have taken various forms, including but not limited to the following:

$$C_v = \frac{Q}{1360} \cdot \sqrt{\frac{SG_{air} \cdot T_1}{P_1 * \Delta P}} \qquad (2)$$

$$C_v = \frac{Q}{1364} \cdot \sqrt{\frac{SG_{air} \cdot T_1}{P_2 * \Delta P}} \qquad (3)$$

$$C_v = \frac{Q}{963} \cdot \sqrt{\frac{SG_{air} \cdot T_1}{(P_1 + P_2) * \Delta P}} \qquad (4)$$

where:

Cv is the valve characteristic flow coefficient

Q is the flow rate in SCFH

P1 is the inlet pressure in psia

P2 is the outlet pressure in psia

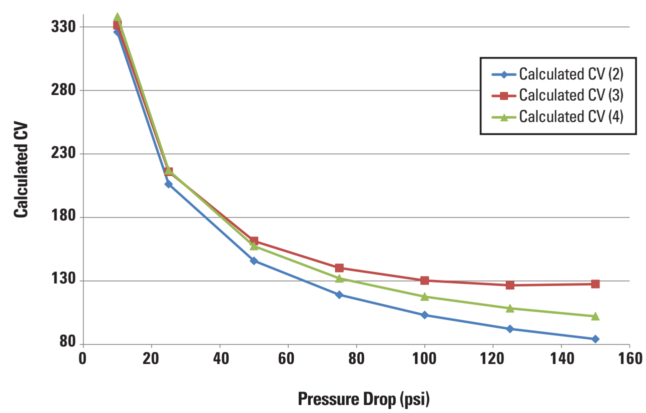
T1 is the absolute inlet temperature in R (°F + 460R)

ΔP is the pressure drop through the valve, P1 – P2, in psi

SG_{air} is the inlet specific gravity with respect to air at standard conditions (14.7 psia and 60°F)

Equations (2), (3), and (4) may produce widely-varying results [2]. As an interesting note, a flow of 1,000,000 SCFM at various pressure drops was used to compare the results of these equations for C_V. The results have been calculated and plotted in Figure 1:

Figure 1 Calculated C_V Using Equations 2-4



The form of equations (2), (3), and (4) (either C_v or Q, the volumetric flow, is almost universally alone on one side or the other) is indicative of the fact that interest in performing accurate calculations has been toward determining the required valve C_v from an incompressible flow under conditions where pressure drop is known (in the case of Figure 1 at 50, 100, and 150 psi Turnquist [2]). This is certainly due in part to the fact that a valve manufacturer can control the aforementioned conditions during testing and is interested in determining the C_v of a particular valve (these equations come from valve manufacturers). In many non-refrigeration cases, where flow is commonly expressed in terms of mass flow rather than heat flow (lb/hr instead of TR or BTU/hr), this can easily be compared to a previously-calculated required Cv in order to determine the suitability of a particular valve for service. However, such a design approach is inconvenient for engineers designing and diagnosing refrigeration systems because in most cases where refrigeration valves are being sized, pressure drop (and consequently valve outlet pressure) is unknown.

For industrial refrigeration engineers, while considering an initial acceptable pressure drop through a valve (say, 2 psi) is often convenient as a starting point, as is more often the case, the engineer must consider the actual pressure drop in individual valves and overall pressure drop in an entire valve train. In doing so, trade-offs can be made depending on the performance of the chosen valves. This necessitates an ability to accurately predict the pressure drop in each valve and total pressure drop in the overall valve assembly.

The obstacle presented to the design engineer is that all formulas considered accurate for the vapor flow pressure drop are implicit for ΔP, and so iteration of one form or another is required [2,4,6]. This is clearly accepted by the IIAR as an organization, since the equations in the Ammonia Piping Handbook are also implicit for ΔP, but is an off-putting concept to many industrial refrigeration engineers who would prefer to use an explicit equation. The down side to this preference is that, at times, making these equations explicit requires simplifying assumptions that compromise the accuracy of the resulting equation and so are difficult to defend given the availability of current standards and knowledge.

To illustrate this point in the case of sizing valves for vapor flow, a simple comparison can be made of the results of some of the available formulas for calculating pressure drop. The following flow condition will be used for an Ammonia vapor stream at 20°F:

$$Q = 90{,}528\frac{ft^3}{hr}$$

$$C_v = 166$$

$$P_1 = 48.21\ psia$$

$$SG = 0.595$$

$$T_{abs} = 480R$$

One of the available explicit equations is listed in [1]. With the inlet information above, the pressure drop is calculated as:

$$\Delta P_A = \left(\frac{Q}{1360 \cdot C_v}\right) \cdot \frac{SG \cdot T_{abs}}{P_1} = \frac{90{,}528}{1360 \cdot 166} \cdot \left(\frac{0.595 \cdot 480}{48.21}\right) = 0.953\ psi$$

The vapor flow above represents a 246 TR ammonia load at 86°F liquid inlet temperature and saturated 20°F vapor coming into the valve. The valve flow coefficient represents one manufacturer's valve, for which the manufacturer publishes a 2 psi pressure drop at these conditions, more than twice the calculated pressure drop from the above explicit expression. The manufacturer's rating is known to be based on an implicit equation in Turnquist [2]. The simplifying assumption in this equation appears to be that the flow through a valve is not significantly affected by the expansion factor (discussed later), but it would appear that this is not a trivial simplification and in fact destroys the validity of the equation.

It is therefore asserted that, in the case of vapor flow pressure drops, an implicit equation for ΔP will provide superior results to those simplified explicit equations available. Turnquist [2], the basis for the IIAR equations, gives the following:

$$Q = 636 \cdot C_v \cdot (2.20 - \frac{\Delta P}{P_1}) \cdot \sqrt{\frac{\Delta P \cdot P_1}{G_g \cdot T_1}} \qquad (5)$$

where:
C_v the valve characteristic flow coefficient
Q is the flow rate in SCFH
P_1 is the inlet pressure in psia
P_2 is the outlet pressure in psia
T_1 is the absolute inlet temperature in R (°F + 460R)
ΔP is the pressure drop through the valve, P1 – P2, in psi
G_g is the inlet specific gravity with respect to air at standard conditions (14.7 psia and 60°F)

The middle term is an early version of what has come to be known as the expansion factor Y. It has been determined partially by derivation and partially by empirical analysis. Although Equation (5) is similar in form to later equations in ISA 75.01 and other publications, there are some key differences, most-notably that P1 appears in the numerator under the radical. In addition, the Y term does not consider some of the properties that have since been determined to affect the expansion factor.

It is clear that, since the time of the work done by Turnquist, those associated with the ISA, Fisher (now Emerson), and Crane have taken a leading role in furthering work in this area. ANSI/ISA 75.01.01-2007 is widely accepted as the current standard for performing control valve flow calculations. While vapor flow formulas listed in the standard are similar to Turnquist [2] for predicting pressure drop in valves for compressible flow, the formulas in the ISA standard are more complex, inasmuch as they also consider the compressibility factor Z as well as the specific heat ratio of the fluid and an additional valve characteristic, x_T. In addition, while Turnquist [2] develops an expression based on averaging a family of lines generated by calculating Y (the adiabatic expansion factor) at various ratios of pressure drop to inlet pressure, Buresh, et al [5] takes a more-direct approach by plotting flow over critical flow against an abscissa that is the square root of the pressure drop ratio divided by the critical pressure drop ratio:

$$\frac{Q}{Q_c} = Ordinate$$

$$\sqrt{\frac{\frac{\Delta P}{P_1}}{\frac{\Delta P_{critical}}{P_1}}} = Abscissa$$

This plot of essentially raw data is then directly curve-fitted as a sine function, with no averaging of empirically-derived results. Turnquist [2] appears to be a dead-end branch in the tree of development of gas sizing equations, and is referenced by Buresh, et al [5] only for comparison to other contemporary equations. As mentioned previously, substantial work has been contributed to the field since Turnquist [2], and much is referenced in the ISA standard. The form of the equations in that standard are now discussed.

In similar units to Turnquist [2] (ft^3/hr) ANSI/ISA 75.01.01-2007 [3] provides the following:

$$Q = 1360 \cdot C_v \cdot P_1 \cdot Y \cdot \sqrt{\frac{x}{G_g \cdot T_1 \cdot Z}}$$

$$Q = 1360 \cdot C_v \cdot P_1 \cdot (1 - \frac{x}{3 \cdot F_\gamma \cdot x_T}) \cdot \sqrt{\frac{x}{G_g \cdot T_1 \cdot Z}} \quad (6)$$

where:

F_γ is specific heat ratio factor of the vapor, $Cp/C_v/1.4$. Although not explicitly stated, it is assumed that this is the specific heat ratio at standards conditions (14.7 psia, 60°F). An inspection of values in Annex C of the ANSI/ISA standard shows that this is the case. Note that, in reality, specific heat ratios may vary significantly over various temperature ranges for real gasses.

G_g is the ratio of the density of the gas at standard conditions to that of dry air at standard conditions

P_1 is the inlet pressure in psia

Q is the flow in SCFH

T_1 is the absolute inlet temperature in R (°F + 460R)

x is the ratio $\Delta P/P_1$

x_T is the pressure differential ratio, defined as the limit of x where choked flow begins, where

$$x_T = \frac{x_{choked}}{F_\gamma}$$

Typical values based on various control valve types are listed in ANSI/ISA 75.01.01-2007 [3]. For globe-style valves, 0.65 to 0.75 is a common range of values for x_T according to Table 1 of that standard.

Y is the expansion factor, which is given by

$$Y = 1 - \frac{x}{3 \cdot F_\gamma \cdot x_T} \quad (7)$$

Z is the compressibility factor for the gas at flow conditions

It is interesting to note that the coefficient of 1360 is the same as a formula in Turnquist [2] put forth in that paper to be less-than accurate in predicting pressure drops based on real valve data gathered on 32 different valves. However, this is probably coincidental, since the Y factor appears to be significantly changed as well. The form of equation (6) in ANSI/ISA 75.01.01 2007 [3] is noted in Driskell [6], published in 1970, 9 years after Turnquist. However, the key difference between the 1970 work and the 2007 standard is that specific heat ratio effects are acknowledged but assumed negligible in Driskell [6].

The flow equation (6) can be rewritten, replacing x with $\Delta P/P1$, as:

$$Q = 1360 \cdot C_v \cdot P_1 \cdot (1 - \frac{\Delta P}{3 \cdot F_\gamma \cdot x_T \cdot P_1}) \cdot \sqrt{\frac{\Delta P}{G_g \cdot T_1 \cdot Z \cdot P_1}} \quad (8)$$

Note that, as opposed to Turnquist, the inlet pressure under the radical is now in the denominator. This change can be seen as early as in Buresh, et al [5], likely because the later work is a departure from a strictly empirical analysis.

As x_T can only be determined by experiment for a valve, this introduces a level of complexity requiring a value that most valve manufacturers either cannot or will not provide in their engineering literature. Fortunately, the value of x_T can be approximated from the Table in the standard, as mentioned above. Some action by valve manufacturers on this lack of available information will be needed, as stated in the conclusions.

Although it is not explicitly stated in any work cited here thus far, all formulas appear to be based on the following assumptions:

1. The specific gravity at standard conditions can be used and simply adjusted for temperature. Variations of the formulae interchange the ratio of molecular weights of the gas to air with the specific gravity (ANSI/ISA 75.01.01 2007 [3] explicitly states that these are considered interchangeable).
2. The specific heat ratio remains constant
3. The ideal gas equation of state is applicable ($P_v = nRT$)

COMPARISON OF THE IIAR METHOD

The IIAR Piping Handbook presents the following as the means for calculating pressure drops through vapor valves:

$$Q_m = 1.6124 \cdot C_v \cdot (2.2 - \frac{\Delta P}{P}) \cdot \sqrt{\frac{T_1 \cdot \Delta P}{P \cdot M}} \quad (9)$$

C_v is the valve characteristic flow coefficient

M is the molecular weight of the fluid (called out in the Handbook as 17.031 for ammonia

ΔP is the pressure drop through the valve, P1 – P2, in psi

P is the (entering) pressure in psia

Q_m is the actual rate in actual CFM at the flow temperature and pressure

T_1 is the absolute entering temperature in R (°F + 460R)

The IIAR Piping Handbook cites Turnquist [2] as the derivation for the above. It is curious to note that, while the Y term is identical to Turnquist, the inlet pressure under the radical is now in the denominator and the inlet temperature is in the numerator. The coefficient has also changed significantly. In addition, the specific gravity at standard conditions has been replaced by the molecular weight ratio to air, and (presumably, upon initial inspection) the molecular weight of air has been pulled from beneath the radical and incorporated into the coefficient.

These differences represent changes to the equation required to convert from the final result of the Turnquist equation [2] from SCFM to CFM. The IIAR formula can be derived as follows. Referring back to Equation (5), the way in which the equation has been written suggests the assumption of ideal gas behavior.

$$P \cdot v = \frac{R_{air} \cdot T_1}{144}$$

$$v = \frac{R_{air} \cdot T_1}{144 \cdot P}$$

where:

R_{air} is the specific gas constant of air in ft-lbf/lb-R. The reason for using the specific gas constant and not the universal gas constant is expressed in terms of moles. The universal gas constant must be divided by the molar mass of the fluid, yielding the specific constant.

T_1 is the absolute inlet temperature (°F + 460R)

P is the absolute inlet pressure in psia

v is the specific volume in cubic feet per pound

This can be recognized as the ideal gas law. In this case, the factor of 144 corrects square inches to square feet to yield specific volume in cubic feet per pound mass. The above must be substituted into Equation (5) (note that the left side is multiplied by v while the right side is multiplied by its equivalent, R_{air} x T_1/P). In addition, SCFH must be converted to actual CFM. This requires that SCFH be multiplied by the density of air at standard conditions of 14.7 psia and 60°F (0.07636 lb/ft3), ρ_s, and divided by 60 (hours to minutes).

1. The form of the equation differs slightly from Turnquist [2] (which is in fact what the IIAR method is).
2. The ISA method considers specific heat ratio and x_T, the pressure differential ratio, as they affect the expansion factor, Y.
3. The ISA method considers the compressibility factor, Z (though not in the Y term).

An evaluation of the accuracy of the ISA method has been undertaken by Riveland [4] and an alternate form of the expansion factor Y recommended by Riveland under certain circumstances. This alternative form of the equation is beyond the scope of this paper, but information in [4] is useful for validating the use of the ISA method for ammonia. While the assumptions underlying the ISA method, those of ideal gas behavior with Y uncorrected for real gas behavior (even though Z is represented in the equation under the radical) are not always correct, Riveland [4] asserts that the ISA equations (assuming ideal gas behavior and correcting with Z) give results within 3% of predicted real fluid behavior (comparison is made using equations for real gases listed in Appendix B of [3]) within the limits of their validity, chiefly where the specific heat ratio, γ, remains as $1.08 < \gamma < 1.65$ (which is certainly valid for ammonia up to well above 300 psig saturated vapor

$$Q = 636 \cdot C_v \cdot (2.20 - \frac{\Delta P}{P_1}) \cdot \sqrt{\frac{\Delta P \cdot P1}{G_g \cdot T_1}} \quad \text{(5) (Restated)}$$

$$\frac{Q \cdot \rho_s \cdot v}{60} = Q_m = \frac{636}{60} \cdot \rho_s \cdot \frac{R_{air} \cdot T_1}{144 \cdot P} \cdot C_v \cdot (2.2 - \frac{\Delta P}{P}) \cdot \sqrt{\frac{M_{air} \cdot \Delta P \cdot P}{M \cdot T_1}} \qquad G_g = \frac{M}{M_{air}}$$

The terms T_1 and P can be combined under the radical, and so

$$Q_m = (\frac{636}{60} \cdot \rho_s \cdot \frac{R \cdot T_1}{144 \cdot M_{air}} \cdot \sqrt{M_{air}}) \cdot C_v \cdot (2.2 - \frac{\Delta P}{P}) \cdot \sqrt{\frac{\Delta P \cdot T_1}{P \cdot M}} \quad (10)$$

Looking now only at the terms within the first set of parentheses in equation (10).

$$\frac{636}{60} \cdot \rho_s \cdot \frac{R \cdot T_1}{144 \cdot M_{air}} \cdot \sqrt{M_{air}}$$

$$\frac{636}{60} \cdot 0.07636 \cdot \frac{lb}{ft^3} \cdot \frac{1545.398}{144} \cdot \frac{ft \cdot lbf}{mol \cdot R} \cdot \frac{mol}{28.97 \cdot lb} \cdot \sqrt{28.97 \cdot \frac{lb}{mol}} = 1.614$$

The calculated coefficient of 1.614 is very close to the familiar 1.6124 from Equation (9), and the difference is most-likely due to rounding error. Restating the IIAR equation,

$$Q_m = 1.6124 \cdot C_v \cdot (2.2 - \frac{\Delta P}{P}) \cdot \sqrt{\frac{T_1 \cdot \Delta P}{P \cdot M}}$$

PERFORMANCE OF THE IIAR METHOD

The above section reviewed early and contemporary approaches to determine gas pressure drop in valves, and set in context the method supplied by the IIAR for such sizing. The question remains as to the results provided by the IIAR method versus the almost half-century-newer approach recommended in ISA 75.01.01-2007. The following main differences apply to the ISA method:

and many other refrigerants in various pressure ranges), and additionally, where the "isentropic exponent" remains near 1.4, which for ammonia is the case over the saturated temperature range of -50°F through 120°F, where this exponent ranges from 1.47 to 1.58.

In contrast to ISA, the method from the IIAR piping handbook does not consider any real gas effects, nor the effects of the specific heat ratio on Y, the expansion factor, as this was not well understood at the time Turnquist [2] was published.

A comparison of the results of each method can be made by the use of simple spreadsheets. In this analysis, NIST's REFPROP version 9.1 has been used to determine refrigerant properties under various conditions. The results are provided in the Tables listed. Valves from two different manufacturers were analyzed.

Note that for all valves analyzed below, the value of x_T has been assumed at 0.75. This assumption may not be completely valid, but is consistently applied. The value is not published by either manufacturer considered.

Table 1 lists the results of the analysis for Manufacturer 1. Two sizes of valve are listed, 1" and 4", with the corresponding C_v. For Table 1, which lists suction capacities and pressure drops, the conditions for the flow are 86°F liquid feed with saturated vapor at the valve inlet at the given pressure (inlet temperature is a saturated temperature). Where the suction temperature is listed at -20°F, the liquid feed is assumed to be at +10°F (the literature specifies two-stage operation for this suction temperature, but does not list the intermediate pressure or saturation temperature).

On the right side of Table 1, calculated pressure drop results of the IIAR formula and ISA formula are compared. The table lists the manufacturer's published capacity and its corresponding results, and immediately following, the calculated capacity that corresponds to the IIAR formula producing a pressure drop corresponding to the published nominal value (2 psi or 5 psi).

In general, compared to the capacity listed in the manufacturer's literature, the IIAR equation tended to under predict pressure drop by between 2% and 13%. This would mean that the valves are actually conservatively rated according to the IIAR equation (meaning that the valves will flow more than the listed TR at the given pressure drop), possibly due to the addition of some safety factor by the manufacturer. However, when these values are compared to the results from the ISA equation, the capacities listed predict higher-than-catalog pressure drops in many cases (though not all). When compared to the calculated pressure drop from the IIAR equation, the ISA equation calculates results for pressure drop between 8% and 12% higher. These results represent a significant difference in calculated pressure drop. This of course assumes that the formula in ISA 75.01.01 is not over predicting the pressure drop, but the specific heat ratio factor for the refrigerants used is well-within the limits for accurate calculation and represents almost half a century of work in this area since the time that the basis for the IIAR equation was developed.

Table 2 lists the results in a similar manner as Table 1, with the exact same conditions, but with R22 as the refrigerant, again for Manufacturer 1. The results show that the manufacturer's listed capacities are conservative based on the IIAR equation, similar to the ammonia capacities for the same valves. Results showed differences in the results versus the catalog baseline similar to the ammonia results. However, with respect to how the methods compared to each other, the ISA method predicted pressure drops that were between 11% and 16% higher than the IIAR method, over 30% higher than for ammonia.

The results in Tables 2 and 3 indicate a significant difference in calculated results between the IIAR equation and a nationally-recognized standard for valve sizing, which increases as a refrigerant's specific heat ratio differs further from air and its compressibility factor differs further from Table 1. These properties are known to be of significance with respect to pressure drop through a vapor flow valve. Although 10-15% may not make a difference in valve size in many applications, it should be recognized that this is based on saturated vapor only, which is seldom the case in dry suction lines. The differences begin to become even more significant when superheat is introduced (see Table 3).

Table 3 lists a smaller sampling of calculated pressure drops than Tables 1 and 2, and considers valves from Manufacturer 2. The refrigerant conditions are a liquid temperature of 90°F, an evaporator saturated pressure as indicated, and 12°F of superheat. The saturated temperature is shown in the Table 3, with the superheated temperature listed in parentheses.

Again, it is clear that the IIAR equation tends to under predict the pressure drop through each valve as compared to the catalog rating (indicating some conservatism in the rating). The ISA equation tends to predict higher pressure drops at the catalog rating than what is indicated in the catalog, and in the case of the conditions analyzed, provides pressure drops that are between 17% and 30% higher than the IIAR-predicted value. This is significant and can make a substantial difference in design versus actual pressure drops where superheated vapor is returned to the compressors.

In an effort to compare the equation results at higher pressures and temperatures, valves from both manufacturers were analyzed in Table 4. Table 4 is based on catalog ratings for discharge gas capacities. The first four rows of Table 4 are ratings for a 1" valve from Manufacturer 1. It is clear again that the capacities listed are either consistent or slightly conservative with regard to the catalog capacities. However, the pressure drops predicted by the ISA equation are between 7% and 30% higher than the IIAR values. Interestingly, the valves from Manufacturer 2 list catalog capacities for which the ISA equation predicts within 4% the catalog pressure drop. This is shown in the last two rows of Table 4. The reason for this difference could not be determined for the writing of this paper.

The question may arise within the engineering or contracting communities as to the significance of these findings, considering that valves may or may not be selected with a granularity approaching that which would make a 20% difference significant. The answer to this question is that such results are significant in at least (2) inter-related ways:

1. It is typical in many refrigeration engineering circles to select a valve based on a catalog rating, but these ratings are specific to a single condition, as is mentioned in all refrigeration valve manufacturers' catalogs. This demands a reasonable method of determining a more accurate predicted pressure drop. This alone may not be enough to sway some into believing that this will affect the outcome of valve selection. However, in addition to this, the consideration must be made that valves are almost never placed into service by themselves, but are typically installed as part of valve trains. These valves must also be properly sized, and a miscalcula-

tion of pressure drop in the design phase can at times lead to large energy penalties incurred by the end user in lowering "house" suction to the point where a single room, designed to operate close to the nominal suction temperature, will meet the required design temperatures. There are many cases in which a marginal valve as part of a valve train is the correct choice, but judicious selection of the other components is necessary, requiring accuracy greater than within 20%.

2. At high suction pressures, an additional 0.5 psi drop through a valve train will only incur an approximately 0.3°F temperature penalty at 40°F for example. However, at -20°F, this penalty more than triples to over 1°F.

CONCLUSIONS

The above analysis compares equations from two main sources, the IIAR Piping Handbook and ANSI/ISA 75.01.01, for determining flow or pressure drop through a given valve. Assumptions were made about the characteristic x_T of the valves from two manufacturers and their catalog ratings compared in tables.

It should be noted that both manufacturers were contacted and both indicated that the only experimentally-determined valves for their valves are C_v on water. All other performance characteristics are calculated, not measured. Manufacturer 1 indicated that the IIAR equation was used to calculate their ratings, though it appears that some, possibly arbitrary, safety factor may have been added to dry suction vapor capacities. Note that all valves analyzed were inlet pressure regulators. Manufacturer 2 did not indicate a method of calculation for their capacity ratings.

The ISA equation tended to consistently calculate higher pressure drops than the IIAR equation for the same valve. ISA considers compressibility and specific heat ratio effects that the IIAR equation does not. The results were at least 14% higher for pressure drops in suction vapor valves with the ISA equation versus the IIAR, with values ranging much higher and diverging more for R22 than for ammonia.

These conclusions indicate that some consideration should be made for changes to the IIAR Piping Handbook and the IIAR's chosen method of calculating pressure drop in a valve for a given flow. There is a stark lack of experimental data for comparison, and a standardization of valve rating method should be considered for industrial refrigeration valve manufacturers. The IIAR should consider adopting the ANSI/ISA method of calculating valve pressure drop performance.

In addition, manufacturers of valves for industrial refrigeration applications should consider publishing data on the value of x_T for each valve they produce to enhance the accuracy of pressure drop calculations. This will lead to increased understanding of how valve performance compares between manufacturers, and an increased ability of the design engineer to provide refrigeration controls that operate more efficiently and predictably. Performance testing on various refrigerants for a select group of valves may also provide an indication of the accuracy of the ISA equations for pressure drops of vapor flows.

Refrigeration engineers designing industrial systems should continue to aid the IIAR in determining, as is possible, the applicability and usefulness of the published equations.

Although simple sizing of valves based on catalog ratings for specific conditions has often been adequate in the past to provide working systems, both the design of refrigeration systems by table and the rating of valves by older methods should be updated to include modern understanding of valve/fluid interaction. Innovation in the industrial refrigeration industry depends on the commitment of manufacturers, industry organizations, engineers, and contractors to avoid stagnation in design techniques.

Table 1 Comparison of ISA 75.01.01 and IIAR for Non-Choked, Turbulent Vapor Flow, Ammonia Suction Vapor Capacities, Manufacturer 1

Valve Size	Cv	xT (est.)	Refrigerant	F_{sh}	Z	Inlet Temp (°F)	Inlet Pressure (psia)	Liquid Feed Temp (°F)	M (lb/lbmol)	Load (TR)	Massflow (lb/hr)	dP, ISA (psi)	dP, IIAR (psi)
1"	11.7	0.75	Ammonia	0.942885	0.941789	20	48.194	86	17.03026	17	426.06	1.99	1.8
1"	11.7	0.75	Ammonia	0.942885	0.941789	20	48.194	86	17.03026	17.8	446.11	2.19	1.99
1"	11.7	0.75	Ammonia	0.942885	0.941789	20	48.194	86	17.03026	27	676.68	5.38	4.84
1"	11.7	0.75	Ammonia	0.942885	0.941789	20	48.194	86	17.03026	27.4	686.7	5.57	5
1"	11.7	0.75	Ammonia	0.942885	0.96873	-20	18.279	10	17.03026	12	261.27	1.99	1.84
1"	11.7	0.75	Ammonia	0.942885	0.96873	-20	18.279	10	17.03026	12.4	269.98	2.15	1.98
1"	11.7	0.75	Ammonia	0.942885	0.96873	-20	18.279	10	17.03026	18	391.91	5.47	4.9
1"	11.7	0.75	Ammonia	0.942885	0.96873	-20	18.279	10	17.03026	18.12	394.52	5.57	4.99
4"	166	0.75	Ammonia	0.942885	0.941789	20	48.194	86	17.03026	246	6165.29	2.08	1.88
4"	166	0.75	Ammonia	0.942885	0.941789	20	48.194	86	17.03026	254	6365.79	2.22	2.01
4"	166	0.75	Ammonia	0.942885	0.941789	20	48.194	86	17.03026	382	9573.75	5.35	4.81
4"	166	0.75	Ammonia	0.942885	0.941789	20	48.194	10	17.03026	389	9749.18	5.57	5
4"	166	0.75	Ammonia	0.942885	0.96873	-20	18.279	10	17.03026	166	3614.29	1.88	1.74
4"	166	0.75	Ammonia	0.942885	0.96873	-20	18.279	10	17.03026	176.5	3842.91	2.16	2
4"	166	0.75	Ammonia	0.942885	0.96873	-20	18.279	10	17.03026	251	5464.99	5.19	4.67
4"	166	0.75	Ammonia	0.942885	0.96873	-20	18.279	10	17.03026	257.2	5599.98	5.58	5

Table 2 Comparison of ISA 75.01.01 and IIAR for Non-Choked, Turbulent Vapor Flow, R22 Suction Vapor Capacities, Manufacturer 1

Valve Size	Cv	xT (est.)	Refrigerant	F_{sh}	Z	Inlet Temp (°F)	Inlet Pressure (psia)	Liquid Feed Temp (°F)	M (lb/lbmol)	Load (TR)	Massflow (lb/hr)	dP, ISA (psi)	dP, IIAR (psi)
1"	11.7	0.75	R22	0.849902	0.908116	20	57.795	86	86.468	6.5	1092.92	2.05	1.81
1"	11.7	0.75	R22	0.849902	0.908116	20	57.795	86	86.468	6.84	1150.09	2.28	2.01
1"	11.7	0.75	R22	0.849902	0.908116	20	57.795	86	86.468	10	1681.42	5.15	4.46
1"	11.7	0.75	R22	0.849902	0.908116	20	57.795	86	86.468	10.54	1772.22	5.79	5
1"	11.7	0.75	R22	0.849902	0.948357	-20	24.91	10	86.468	5.2	699.6	1.96	1.78
1"	11.7	0.75	R22	0.849902	0.948357	-20	24.91	10	86.468	5.49	738.61	2.21	2
1"	11.7	0.75	R22	0.849902	0.948357	-20	24.91	10	86.468	7.9	1062.85	5.25	4.58
1"	11.7	0.75	R22	0.849902	0.948357	-20	24.91	10	86.468	8.18	1100.52	5.77	5
4"	166	0.75	R22	0.849902	0.908116	20	57.795	86	86.468	92	15469.08	2.04	1.8
4"	166	0.75	R22	0.849902	0.908116	20	57.795	86	86.468	97	16309.79	2.28	2
4"	166	0.75	R22	0.849902	0.908116	20	57.795	86	86.468	144	24212.47	5.33	4.6
4"	166	0.75	R22	0.849902	0.908116	20	57.795	10	86.468	149.5	25137.25	5.79	5
4"	166	0.75	R22	0.849902	0.948357	-20	24.91	10	86.468	73	9821.26	1.92	1.74
4"	166	0.75	R22	0.849902	0.948357	-20	24.91	10	86.468	78	10493.95	2.22	2.01
4"	166	0.75	R22	0.849902	0.948357	-20	24.91	10	86.468	112	15068.24	5.24	4.58
4"	166	0.75	R22	0.849902	0.948357	-20	24.91	10	86.468	116	15606.39	5.76	4.99

Table 3 Comparison of ISA 75.01.01 and IIAR for Non-Choked, Turbulent Vapor Flow, Suction Vapor Capacities, Manufacturer 2

Valve Size	Cv	xT (est.)	Refrigerant	F_{sh}	Z	Inlet Temp (Sat, Sup) (°F)	Inlet Pressure (psia)	Liquid Feed Temp (°F)	M (lb/lbmol)	Load (TR)	Massflow (lb/hr)	dP, ISA (psi)	dP, IIAR (psi)
1"	13.3	0.75	Ammonia	0.942885	0.98138	20 (32)	48.194	90	17.03026	23.6	588.19	3.22	2.64
1"	13.3	0.75	Ammonia	0.942885	0.972886	-20 (-8)	18.279	90	17.03026	14.5	371.79	3.5	2.99
1"	13.3	0.75	R22	0.849902	0.975533	20 (32)	57.79	90	86.468	8.9	1479.74	3.28	2.53
1"	13.3	0.75	R22	0.849902	0.966766	-20 (-8)	24.91	90	86.468	5.8	1024.12	3.67	3.02

Table 4 Comparison of ISA 75.01.01 and IIAR for Non-Choked, Turbulent Vapor Flow, Discharge Vapor Capacities, Manufacturers 1 and 2

Valve Size	Cv	xT (est.)	Refrigerant	F_{sh}	Z	Inlet Temp (°F)	Inlet Pressure (psia)	Liquid Feed Temp (°F)	M (lb/lbmol)	Load (TR)	Massflow (lb/hr)	dP, ISA (psi)	dP, IIAR (psi)
1"	11.7	0.75	Ammonia	0.942885	0.915663	140	169.3	86	17.03026	31	779.26	2.13	1.99
1"	11.7	0.75	R22	0.849902	0.806385	140	172.87	86	86.47	11	1861.86	2.16	1.97
1"	11.7	0.75	Ammonia	0.942885	0.915663	140	169.3	86	17.03026	49	1231.74	5.43	5.05
1"	11.7	0.75	R22	0.849902	0.806385	140	172.87	86	86.47	17	2877.42	5.26	4.79
1"	13.3	0.75	Ammonia	0.942885	0.909429	180	180.76	90	17.03026	40.3	1008.79	2.9	2.26
1"	13.3	0.75	R22	0.849902	0.861277	180	183	90	86.47	14.2	2369.23	2.92	2.27

Note: Evaporator Temperature is +15°F for Manufacturer 1, +40°F for Manufacturer 2

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