iiar®
THE OFFICIAL MAGAZINE OF THE AMMONIA REFRIGERATION INDUSTRY ■ NOVEMBER 2019

# CONDENSER

## IIAR Moves Forward on $CO_2$ Standard

# ELIMINATES HAZARDS & FACILITATES COMPLIANCE

POP-EYE™

- Detects and indicates when a relief valve lifts
- LED Indication:
  - LED indicator with 360° visibility
  - Battery operated, 7+ years life
  - Blinks for 2+ weeks after a lift
- Not for retrofit on existing valves
- National Board Certified capacities
  - No change in ratings
  - No piping changes
  - No setup, calibration, or wiring


Lift Detection with LED Indication

**POP-EYE**™ and **ACT**® (Anti Corrosion Technology) now standard on H56xx Series relief valves

HANSEN TECHNOLOGIES

# contents

## 8 COVER STORY

## IIAR Moves Forward on $CO_2$




**CONDENSER STAFF**

Publisher
**David Rule**

Editor-In-Chief
**Andrea Collins**

Creative Director
**Bill Ellis**

V.P. Marketing and Sales
**Eileen McKeown**

V.P. and Technical Director
**Eric Smith**

Staff Writers
**Mindy Long**
**Rob Duca**

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


**Correction: August 2019 Condenser Issue**

*The article "Future Focus" in the August 2019 issue of Condenser incorrectly reported the composition ofTemper Technology's secondary refrigerant. The article should have said that Temper Technology's secondary refrigerant, also called a heat transfer fluid, is based on organic salts, potassium acetate and potassium formate together with an advanced corrosion protection package.*

# president's MESSAGE

BY DAVE RULE

## Register Now, the IIAR Heavy Equipment Show is Just Around the Corner!

The end of the year is coming to a close quickly, and that means your IIAR staff at headquarters is busy preparing for the next annual conference, in March at the Rosen Shingle Creek Hotel and Resort in Orlando, Florida. I'm excited to announce many additions to this Heavy Equipment Show that are new in 2020 and highlight the many advantages of IIAR membership, so consider this your official invitation to another can't-miss IIAR conference!

First, The IIAR conference and expo will have a new location in Orlando this year, the Rosen Shingle Creek Hotel and Resort. More about that in a moment.

The 2020 conference is set to continue the dual industrial-commercial technical track introduced last year, and with the larger Heavy Equipment Show, will come a larger and much expanded education program to address both the industrial and food retail sectors of the refrigeration inductry.

Every conference highlights the value of IIAR membership, but the ability to attend and participate in the annual conference is just one advantage of being an IIAR member. There are year-round benefits that will pay off for you and your colleagues in many ways.

The IIAR 2020 meeting is considered our "Heavy Equipment Expo," featuring the largest equipment displays in the industry. Manufacturers and suppliers from the United States, Canada, Mexico, Europe, Asia and other parts of the world will be represented, along with the largest technical program ever assembled by IIAR, featuring 18 technical papers, nine workshops and several expert panel discussions.

Additionally, this upcoming show will focus on new technology – including innovative products, industry best practices and safety, along with regulatory updates – for food processing, distribution and the food retail sectors of our industry.

The conference will open with a special education program on Sunday that will take a deep dive into the latest technology in the rapidly developing field of secondary coolants in ammonia and $CO_2$ refrigeration applications.

This program will have sessions on building the business case for a secondary refrigerant loop in a primary refrigerant system, secondary refrigerant properties and ranges of application, a case study on carbon dioxide as a secondary coolant, pipe systems and selection, including "smart" pumps as applied to secondary refrigerant loops, and more.

Anyone interested in exploring the latest technology in this expanding demand for secondary loop application with natural refrigerants will want to register for this class.

And before the conference program gets underway, the Ammonia Refrigeration Foundation will take center stage with its Fifth Annual William E. Kahlert Memorial Golf Tournament.

This year, the Foundation's golf tournament will be played at the headquarters hotel site on the Rosen Shingle Creek Club course. This course, which was designed by the renowned Arnold Palmer Design Company, is a hand-crafted course with features reminiscent of the finest classics in the world.

Some of the course's features harken back to the golden age of golf course design, with elevated greens and strategically placed bunkers surrounded by enchanting flora and wildlife. The 18-hole, par 72 course is designed to give golfers of all levels more forgiveness and entertaining strategic options that challenge your entire game, while rewarding the diligent player.

The entire day will be devoted to the tournament with a team event competing for a "new" coveted trophy, special individual prizes, along with food and refreshments. All tournament proceeds will go to support the important work and mission of your Foundation.

So, if you have not already done so, I invite you to register now for the IIAR Natural Refrigeration Conference and Expo, March 14-18 in Orlando, Florida.

IIAR membership helps keep you plugged into changes in industry standards development and is the best way to be sure that personnel can keep informed of technical changes in refrigeration, both regulatory changes and safety practices. And the annual conference is where that education and networking is most on display.

This event will be your best opportunity to expand your technical knowledge, support your Foundation and network with your colleagues and friends. I look forward to seeing you in Orlando!

chairman's **MESSAGE**

BRUCE NELSON

# Energy and Sustainability

I often think about the mystery of human thought. How something unseen and metaphysical can affect and alter things that are seen and physical. The old saying is certainly true, that "Ideas have consequences". As an engineer I was taught that entropy (disorder) unavoidably increases in the universe according to the second law of thermodynamics. That over time things run down – which as someone who is now somewhat advanced in years I can certainly attest to! However, I also observe that by taking thought we can actually add order to things and to processes that were disordered. In fact, it is the unseen things that tell us how things can and ought to be.

By putting our heads together and using our collective creativity we can make our refrigeration systems more efficient, more reliable, safer, and more sustainable. This is part of the great and noble mission we share as members of IIAR.

Based on the results of the survey and its other findings, the Task Force recommended to the Board of Directors that IIAR proceed with the formation of a new Energy and Sustainability Committee. The Board then voted unanimously to do so. The next step in the process will involve a meeting for anyone interested in participating in the new committee at our next Annual Conference in Orlando, March 15-18 2020 (see: https://www.iiar.org/iiar/events/2020_conference/2020_annual_conference.aspx?websitekey=74f03f30-6d9c-441c-bac6-1800e2b0f023). If you are interested in participating in the new IIAR Energy and Sustainability Committee as a voting or corresponding member, please plan to attend this meeting. Time and place for the meeting will be announced shortly, so stay tuned.

## By taking thought we can actually add order to things and to processes that were disordered

**Given the important role that energy efficiency plays in reducing the carbon footprint of our refrigeration systems, I and others in our organization have felt strongly for some time that IIAR needs to encourage and facilitate more focus on energy and sustainability. To that end, earlier this year I as your Chairman commissioned a Task Force to investigate the level of interest among our membership in the formation of a new standing Energy and Sustainability Committee. Our Past Chair, Mike Lynch, very kindly agreed to chair the Task Force and reported the results of a survey conducted recently to the Board of Directors at our October meeting. The results were interesting and gratifying. A few highlights from the survey and Mike's report include:**

**90%** responded that energy costs impact on profitability were Moderate to Very High

**88%** responded that their company had Average to Excellent insight into energy costs

**81%** responded that their company had Moderate to Very High control over energy costs

**83%** responded that their company had Moderate to Very High control over energy utilization

**91%** responded that IIAR should form a Committee focused solely on energy efficiency within our industry

# IIAR Moves Forward on $CO_2$ Standard

The use of carbon dioxide as a refrigerant has continued to increase, and the IIAR is moving closer to finalizing a new $CO_2$ standard, which will address several critical aspects of $CO_2$ refrigeration, such as installation, startup, inspection, testing and maintenance.

"It will be a document that end users, contractors and business operators can reference and know it is covering what they need for $CO_2$," said John Collins, industrial sales manager for Zero Zone and chairman of the IIAR committee developing the standard. "It is more comprehensive than many of the other documents the industry has available. Some of the current codes that are covering $CO_2$ have some limitations."

Tony Lundell, director of standards and safety for IIAR, said the new $CO_2$ standard is intended to be a comprehensive safety standard document that provides minimum safety requirements for the food processing distribution, cold storage, food retail and other sectors of the refrigeration industry.

The rise in the popularity of $CO_2$ has led to the need for a standard. "As $CO_2$ has taken off and become a common refrigerant, it became apparent that a standard was needed to define the parameters for safe design, operation and maintenance of systems utilizing $CO_2$ refrigerant," said Chuck Taylor, president of CRT Design and Engineering.

Bob Czarnecki, a member of IIAR's board, led the task force that first explored the need for a standard. "It will provide a document that doesn't have just design, but has operation, startup and maintenance," he said. "That is something not currently available, and that will be of value to the end user."

Collins said the expectation is that the standard will make it easier for those who have been considering $CO_2$ for new applications to choose the refrigerant. "One of the items that is a limiting factor right now for end users and contractors is the uncertainty around how to apply $CO_2$, how to install the piping, and what is necessary to have a safe system," Collins said. "This document addresses more completely many of those aspects."

The structure and the format of the $CO_2$ standard is based on the existing suite of IIAR standards. "We took the content and the structure of IIAR 1 through 6 and incorporated it into one $CO_2$ document," Collins said.

The standard outlines consistency in design as well as a basic minimum level of quality, Lundell said. It will also improve safety operations in end user facilities for technicians and operators.

The $CO_2$ standard provides directions for designers and engineers, said Ekle Small, vice president of engineering at JAX-MEAS, a contractor. "It gives us a document we can reference when advising regulatory officials of what we use for a minimum code for safety and design," he said. "You can always exceed the requirements of the document, but it gives the engineer a sound basis to start with, and it defines the minimum safety standard for the community as a whole."

Small said there is a lot of hesitation related to what to do and what is required in terms of a contractor installation. "I think the standard will help," he said, adding that the standard will give contractors a consistent and familiar template to follow.

Mike Trumbower, design engineer for Parker Hannifin, said that having a standard is also helpful for component manufacturers such as Parker Hannifin. "It will help steer and give direction to where we go with our design to ensure safety," he said.

Taylor said the standard will make the application of $CO_2$ systems more uniform, which will make them more reliable systems and easier for the end user to operate and maintain.

## A WIDE RANGE OF BENEFICIARIES

This standard is intended for the refrigeration industry as a whole. "It had been created with the intention to


Comprehensive Cold Chain Solutions
Vilter offers the most innovative products and solutions for industrial refrigeration compression. As experts in streamlining cold chain efficiencies, our solutions can effortlessly be integrated into your business processes. Backed by Emerson reach and support, we are certain to have a solution for your needs in every corner of the globe.
VILTER™
EMERSON™
Emerson Electric Co. © 2019. Vilter is a business unit of Emerson Electric Co. All Rights Reserved.
EMERSON. CONSIDER IT SOLVED™

cover not just the heavy industrial side of our industry, but also the commercial side. That is a much broader group than what is typically looking at the IIAR ammonia standards," Collins said.

Collins said IIAR realized it should broaden its vision in terms of the audience for its standards. "Recognizing the fact there is so much more $CO_2$ in the retail or commercial side of the refrigeration world than ammonia, we have been very intentional about trying to engage that side of the refrigeration industry," he explained.

As a result, IIAR engaged other organizations, including the North American Sustainable Refrigeration Council (NASRC), to gain a broader perspective for the standard. "Right now, we're encouraging engagement from as many people that have an interest. Our philosophy has been to engage with as wide of a group as we can and make sure the document is solid and is comprehensive," Collins said.

$CO_2$ has some unique properties and characteristics that make defining a standard necessary so that the industry has criteria and standards developed by experts to facilitate a safe, reliable and fully operational systems, Taylor said. "The last thing our industry needs is a person that really doesn't understand the unique properties of a $CO_2$ design system resulting in a faulty project that could damage the reputation of the technology for everyone."

$CO_2$'s properties require different materials as well as specific practices for managing pressure, operating the systems and designing the equipment, Collins said. "Having one document specific to $CO_2$ will make it easier for the industry to move to using the refrigerant going forward," he said.

One of the biggest areas that is unique to $CO_2$ is pipe materials. "The industry is evolving and developing rapidly to make $CO_2$ more widespread. Some of the things being developed on the product level are piping material, valves and other system components," Collins said. "Because $CO_2$ is unique and operates at higher pressures, the technology is specific to $CO_2$."

Trumbower said the high operating pressure of $CO_2$ is the biggest challenge. "With keeping $CO_2$ in mind, we've been developing products to address that." "The standard is going to help us address other parts of the $CO_2$ systems and the higher-pressure characteristics of $CO_2$."

Dolbec said that as a rack manufacturer, the challenge is to get components approved for installation in North America. "The $CO_2$ market is growing, so we get demand for systems that are larger and larger, so we need components that are designed and manufactured to install in these larger systems," he said. "The UL components aren't following at the pace [development] needs to be."

Requirements for $CO_2$ systems change significantly depending on how the system is arranged and the type of operating conditions, Collins said. "The fact that air-cooled systems operate in a transcritical mode is unique to $CO_2$. Addressing that reality in this standard has been one significant thing that is unique to $CO_2$ and has required time to determine how to evaluate those elements of design and safety aspects of operating in a transcritical mode," he explained.

Collins said one of the biggest issues the $CO_2$ industry is dealing with is technology and system design processes that aren't fully established for $CO_2$ at this point. "To a degree, it's like shooting at a moving target because the industry is evolving so quickly," he said. "We're trying to create a framework and definition that doesn't tie the hands of the industry to develop and evolve as these new technologies come to light."

Lundell said standards development is a difficult project that is never done. As new technology and experience evolves, revision for continuous improvement is a normal part of the process. Under the IIAR/ANSI procedures, we are required to update each standard every five years to ensure they address new technology and changes that have occurred in the industry.

## ANTICIPATED RELEASE DATE

The document has been out for public review and garnered more than 130 comments, which the IIAR standards committee is reviewing. "As we address these 130-plus comments, the committee will respond to the originating commenters and see if we can reach a consensus on each topic," Lundell said.

The goal is to make the standard available for a second public review prior to the IIAR annual conference in March 2020, Collins said. "Coming out of that we'll have a very good picture as to how things stand and how much work we have remaining. I think everybody would like to see the published document sooner rather than later."

Lundell said the release depends on input from public review, how many comments are received and how quickly the committee and association resolve them. He added that the timeline is a consensus process that follows specific ANSI guidelines.

Taylor said responding to comments forces the committee to really evaluate what they've written to produce a better document. "There were several points raised that sparked significant discussions."

The committee has tried not to over-specify safety issues which those in the ammonia industry are used to addressing. "We've come at this from a much more safety-focused industry but continuously have had to think through and consider whether it really needs to have a certain safety feature or if it can be specified more like other commercial refrigeration systems," Taylor said.

## THE STANDARD'S HISTORY

Collins said because $CO_2$ is a natural refrigerant, it made sense for IIAR to develop the standard. "We already have a $CO_2$ handbook that has been published for a number of years. The standard is a logical progression for our organization to address current design and safety issues with this document."

IIAR's board of directors instructed the standards committee in 2015 to evaluate what a $CO_2$ standard should cover and what it would look like. Over the course of the intervening five years, the committee has been working with the refrigeration industry to develop this document," Collins said.

"Our intent is that all parties working with $CO_2$ refrigeration will benefit. It is a document we can all look at and give us a commonplace to understand how we're going to build, install, inspect, test and maintain these systems. It is comprehensive in that regard in terms of scope and audience," Collins said.

Taylor said ultimately the benefit is to the end user because the result is the contractors and engineers have a level playing field of how to safely design and install a system.

Lundell said "IIAR's vision is to create a better world through the safe and sustainable use of natural refrigerants" and "IIAR's mission is to provide advocacy, education and standards for the benefit of the global community in the safe and sustainable design, installation and operation of ammonia and other natural refrigerant systems. The new $CO_2$ safety standard is a significant step forward to improve our industry and achieve this mission."

# Advancements in Refrigeration Equipment Require Advanced Lubricants

Any machinery with moving parts requires a lubricant, and the lubricant landscape within the refrigeration industry has gotten more complicated over the past 25 years as new types of equipment have entered the marketplace.

Based on the application and compressor type, lubricant selection varies depending on factors such as working conditions, compressor efficiency and life expectancy, compressor cost and metallurgy, and the refrigerant being compressed. All of those factors directly affect the decision of which lubricant

**Based on the application and compressor type, lubricant selection varies depending on factors such as working conditions, compressor efficiency and life expectancy, compressor cost and metallurgy, and the refrigerant being compressed.**

**Jalesh Kalra, general manager, commercial, for CPI Fluid Engineering.**

A major factor driving the change has been regulatory requirements, which have led to increasing numbers of end-users seeking low-global warming potential refrigerants, such as ammonia and $CO_2$, which in turn has produced more options and greater competition in the refrigeration space.

There is no one-size-fits-all lubricant that can be used in every application, said Jalesh Kalra, general manager/commercial, for CPI Fluid Engineering, a division of Lubrizol Corporation.

"You want to get the best product and check all the boxes: cost, efficiency, performance," Kalra said, adding that low-charge ammonia systems and ammonia/$CO_2$ transcritical systems are gaining more and more ground. "There could be many drivers for a particular compressor type."

formulation works best to deliver the expected results related to compressor performance, Kalra explained.

"There is a lot more customization, more operating conditions and proliferation of more refrigerants. The market also demands greater agility," said Flavio Kliger, Lubrizol's general manager/industrial formulated fluids and greases. "Proliferation adds complexity. In the past, it was much easier to recommend a lubricant based on fewer parameters."

Carbon dioxide and ammonia are making their way into a wider variety of commercial and industrial applications, with a wider variety of operating conditions, said Mike Costello, strategic research and innovation director for CPI Fluid Engineering.

"Since the operating envelope for $CO_2$ and ammonia has expanded, we have a broader range of requirements to investigate. Currently, we're researching ways to make lubricant formulations that would eliminate the need for the manufacturer to make a mechanical change," Costello said. He added that manufacturers today have to know more about the operating conditions to produce the most effective lubricant.

"A lubricant we developed five years ago doesn't necessarily work in newer systems, so we may need to adjust the base stock and additive chemistries to meet the new requirements," Costello said.

Glenn Short, president of BVAdvanced Products, a division of BVA, Inc., said that historically, mineral oils were used over 100 years, but that has changed. "The changes were initially in the refining of the mineral oil over the years," he said. It is essential for those in the industry to understand how changes in equipment and refrigerants affect the lubricants, which can also be called working fluids.

"To a lot of these guys, refrigeration oil is refrigeration oil," Short said. "They practically think the mineral oil and polyol ester are the same thing. It never occurred to them that they couldn't use them the same way."

Synthetic hydrocarbons such as polyalphaolefin (PAO) oe alkylbenzene (AB) offer improved performance due to having superior lower temperature properties and less volatility. Polyalkylene glycols (PAG) and their end-capped polyether can be used where miscibility is required. $CO_2$ applications require lubricants such as the capped polyalkylene glycol or polyol ester (POE) to be miscible. HFC and HFO refrigerants primarily use polyol esters, polyvinyl ether (PVE), or in some cases polyalkylene glycols or their capped derivatives. Hydrocarbon refrigerants may use any of these lubricants.

Refrigeration lubricants have several jobs to do. They must lubricate bearings and compressor parts and act as an oil seal for the compressed gas, Short said. They also sometimes must act as a heat


A+P PENTHOUSE
COLMAC COIL
Manufacturing Inc.
A roof-mounted, insulated penthouse air cooler for industrial applications
3 Standard Configurations:
▶ Complete unit
▶ Coil, base, fans, structural frame
▶ Coil with drainpan and legs only
Options:
● Fan discharge ducts
● Ammonia detection
● Custom curbs
● Fan speed control
● Interior service lighting and outlets
● Pitched roof
Visit us at IIAR 2020 in Orlando Booth #717
Available for ammonia, freon, CO2 and glycol systems
Contact us today to learn more: 1.800.845.6778 | www.colmaccoil.com

transfer fluid and therefore can't create any heat-transfer problems. They also need to be stable with the refrigerant, which can sometimes require additives, and be compatible with various materials, such as elastomers and metal. Using a polyol ester in an ammonia system produces viscous sludge or rubber-like solids.

The right lubricants play a critical role in ensuring new technology can work as it should. "It is always an ecosystem. The refrigerant manufacturers, the refrigerant supplier and the compressor manufacturers all have to move together and not independent of each other," said Jalesh Kalra, general manager, commercial, for CPI Fluid Engineering. "They all have to fall in place for a new design to work."

A lubricant is made up of a base oil and an additive package, and there are a variety of base oils that can be used depending on the application, Kalra said. Base oils could include polyalkylene glycols, mineral oils, polyol ester or a blend of alkyl benzene and mineral oil. Selection of these oils will very much depend on what specific application the lubricant is intended for. "Having a complete base oil 'toolkit' is necessary for a supplier to tailor the lubricant products to the specific needs of global customers," he said.

When a new technology comes out, it affects all parties in the lubricant supply chain, including oil producers and the lubricant manufacturers. Suppliers must closely monitor evolving technology and works closely with equipment manufacturers to meet their needs.

"There are many good solutions but there is no one best solution that works for all applications. Everyone is trying to find the right solution for their application," Costello said, adding that lubricant suppliers also have to keep an eye on costs and ensure a lubricant doesn't become too expensive.

Equipment manufacturers will often approach lubricant manufacturers with information about new compressors they're developing and the operating conditions. "We may have to adjust the base stock and additive chemistries to operate in the window they're proposing" Costello said. "There are a lot of new conditions coming out. If you have too much refrigerant solubilized in the lubricant, it may be too thin and create wear. Conversely, if you don't have enough, it may be too thick and create efficiency losses."

> **When a new technology comes out, it affects all parties in the lubricant supply chain, including oil producers and the lubricant manufacturers. CPI closely monitors evolving technology and works closely with equipment manufacturers to meet their needs.**
>
> **Jalesh Kalra, general manager, commercial, for CPI Fluid Engineering.**

Short said his company likes to work with the compressor designer/manufacturer whenever possible. "If they are developing a new machine, they'll talk to lubricant suppliers that they feel have the expertise in their area," he said. "They'll say, 'We are going to use this refrigerant, and we'd like it to have these technologies.'"

Short said he sees the need for a broader understanding of the range of viscosities available. Refrigerants affect the operating viscosity of lubricants. "Once it is in the compressor, it is a lubricant within a dissolved fluid," he explained. "It mixes with the $CO_2$ or the ammonia. The result of that is different for each refrigerant and each lubricant type and is also dependent on operating conditions."

While the refrigerant is in a gaseous state in the compressor, it is a liquid in the condenser and evaporator. Short said lubricant manufacturers consider the seal for the compressed gas. "The objective is to get the gas from lower pressure to higher pressure. The resulting viscosity for how much the oil dilutes can affect efficiency," he said. "As the gas is compressed, you have the heat from the compression, and the oil is heating up. Most designs they want to cool the oil back down."

That means the lubricant can become a heat transfer fluid, so lubricant manufacturers have to know the heat-transfer properties of the oil. "The oil has to be stable with that refrigerant. You don't want it to react or break down because of the refrigerant," Short said.

Miscibility, the property of two substances to mix and form a homogeneous solution, can affect how much oil accumulates in the evaporator. "It is a whole system we have to think of, not just a compressor," Short said. He added that lubricants can create heat-transfer problems. "You also have to make sure the additives in formulated lubricants don't create problems, such as plugging a capillary."

Short said the most critical element with $CO_2$ is stability. "$CO_2$ does react with water and make carbonic acid. Acids, in general, break down lubricants the fastest," he said. It is possible to remove the acid with additives, but those additives are expensive.

Higher pressure tends to be hotter, which results in less thermal stability. "That's usually addressed between the base stock and additive chemistry," Costello said.

Short said $CO_2$ is an unusual animal. "Oils at one temperature might be heavier than liquid $CO_2$, but at another temperature, they're lighter," he said. "It makes the whole task a lot more difficult."

Typical $CO_2$ systems operate at high pressure. "It doesn't affect the lubricant as much as it affects the system," Costello said. "The traditional lubricants we used for $CO_2$ are very soluble and significantly lower the working viscosity."

That means manufacturers have to be aware of the working viscosity of the lubricant. "You have to use a lubricant that is not going to be too soluble," Costello said.

On the other hand, ammonia is the opposite of $CO_2$ because it is not very soluble in traditional lubricants, Costello said. "The idea is to increase the polarity of the lubricant to try to make it more soluble in the ammonia, so you don't have a lubricant that carries out of the compressor sump into the system, which can cause efficiency loss or worse" he said. "We're trying to formulate a lubricant that gives you the right solubility."

Kliger said lubricant manufacturers have to find the right balance of miscibility to optimize wear and efficiency. "If it is too soluble, it carries too much, and you lose efficiency. If it carries too little, you get wear," he said.

Ammonia equipment manufacturers have found some equipment isn't as compatible with traditional lubricants as they had expected. "Ammonia is not miscible with mineral oil or other hydrocarbon oils," Short said. "Designs with DX evaporators require a lubricant with higher miscibility to prevent the accumulation of the lubricant in the evaporator. We have developed miscible lubricants to solve the evaporator issues that also have the correct balance of viscosity and solubility for the compressor."

Short said price is the No. 1 driver in the ammonia industry, and equipment manufacturers always want to know how much improvements to mineral oils will cost.

Kalra said end users need to be sure their lubricant supplier has strong supply chain capabilities. "It isn't just about getting the right product. It has to be available where it is needed, reliably and globally," he said, adding that suppliers need to be able to produce the lubricants, ramp up production and deliver on quality consistently, in the packaging needed with resilient supply chain backbone.

AMMONIA REFRIGERATION FOUNDATION

# news

## Foundation Sees Fundraising Success

The Ammonia Refrigeration Foundation is in the midst of its annual fundraising drive, and this year is already looking promising, said Joe Mandato, chairman of the ARF board of trustees.

Your foundation has set a fundraising goal of $500,000. "I think that's a reasonable goal," Mandato said. "I anticipate we will reach the goal, but I hope to make more than that in total contributions."

ARF is concentrating its fundraising efforts in the period between October 2019 and the conclusion of the IIAR annual conference, scheduled for March 2020 in Orlando.

Fundraising is so important to the foundation because at this point in time, the organization can generate a limited return with the amount of money held in its reserves and conservative investment strategy, Mandato said. In order to grow its programs, the foundation relies on the support of the industry.

"Our programs – particularly the research program and the scholarship program – are both very active right now and require significant money to fund," Mandato said. "It's imperative for the foundation to continue to increase its base asset position in light of what we think the reality of our investment return is going to be, compared to what our expenses will be moving forward."

Mandato stressed that the foundation is doing important work to advance the industry, and to make it more sustainable.

An example of the foundation efforts is ARF's research arm, which recently completed a computational fluid dynamics (CFD) study on the recommended positioning and quantity of ammonia detectors in refrigerated spaces – particularly cold storage facilities.

"The question was: 'are we putting too many or too few ammonia detectors in a room, and are we putting them in the correct location'," Mandato said. "The idea being to hone-in based on scientific information and multiple CFD models to come up with best practices."

He added this is just one example of the many research contributions your foundation has made to the industry. "The purpose of the research projects that we're working on is to make sure that the systems being installed are done so cost-effectively… and are inherently safer."

Additionally, this year's cohort from the scholarship program was the largest yet. This program is critically important, Mandato said, to the sustainability and longevity of the industry. As refrigeration veterans retire, they need to be replaced by people from younger generations with the knowledge and expertise to get the job done.

"What we're focusing on now is communicating to these scholarship recipients the many opportunities that are available within the industry," Mandato said. "We're creating direct connections for them to companies in the industry so that when they graduate, we can bring them in [seamlessly]."

Ultimately, by contributing, Mandato said donors to the foundation are helping promote and sustain the industry that has given so much to them. "Many of us – myself included – made our livelihoods working in the industrial refrigeration market," he said. "This is an opportunity to give back to the industry that made us what we are."

*For more information on your foundation's programs or to learn how to donate, visit the website at iiar.org/foundation.*

### Announcing New Team Trophy!

**IIAR is making a big change to the annual William E. Kahlert golf tournament event! The important foundation fundraising event is held every year, most recently in 2019 in Phoenix.**

**Traditionally, the winning team gets their team name on IIAR's official "headquarters trophy," and now, there's even more reason to get involved and get competitive! Starting this year, each winning team member will also get their own team trophy to proudly display in their office of choice.**

**Mike Lynch presents the team trophy award to Adolfo Blasquez in recognition of his team's win at the 4th annual William E. Kahlert golf tournament in 2019.**

5TH ANNUAL

# WILLIAM E. KAHLERT MEMORIAL GOLF TOURNAMENT

## March 14, 2020

Rosen Shingle Creek
Orlando, FL

ARF
AMMONIA REFRIGERATION FOUNDATION

**For more information, e-mail us at golf@nh3foundation.org**

The Ammonia Refrigeration Foundation is a 501(c)(3) education and research organization celebrating 13 years of support to the natural refrigeration industry.

All proceeds from this annual tournament are used to support The Foundation's scholarship, research and outreach programs.

**In conjunction with the 2020 Natural Refrigeration Conference and EXPO March 15–18, 2020 • Orlando, FL**

iiar®

# Clean Evaporator Coils Reduce Energy Expenditure, Lower Costs

Numerous factors can contribute to decreases in a refrigeration system's energy efficiency, not the least of which is its cleanliness. Much of the time, when facility operators see a facility's efficiency drop, they believe that indicates they must replace the systems with larger units, when in fact, they often simply need to clean the systems they're currently using - particularly the evaporators.

The evaporator is the component of a closed-circuit refrigeration system that absorbs heat by vaporizing liquid refrigerant. The evaporator coil is the part of the system not enclosed in a pressure vessel.

There are two types of evaporators: forced draft, in which air is pushed through the coils, and induced draft, with air pulled through the coils by fans.

Without proper maintenance, either type of systems can be negatively affected in significant ways by various types of contamination, including dust, process or product particles, pollen, mold and bacteria, according to IIAR materials.

Evaporator coils and fan surfaces attract debris, and dirty fans and coils decrease their efficiencies and the system's refrigeration effect while increasing compressor discharge head pressures and delivered supply air temperatures. The adverse effects of these contaminants all lead to increased energy usage.

"A unit may typically be oversized by 10 to 30 percent. Engineers must then select compressors in to meet that overage in their design," said Brian Hindt, president of Ecoclear Coil Cleaning. "A clean coil should shut down and quit asking for ammonia periodically during the day – ideally every hour." However, if the coils are dirty, the system can begin running so inefficiently that to maintain the temperature of a particular space, it never stops running.

In fact, according to manufacturer's maintenance materials, a coil with a layer of contamination just the thickness of a dime will lose up to 21 percent of its efficiency. Therefore, it's imperative that any facility looking to lower its energy usage and associated costs should schedule regular cleaning and maintenance.

"Clean evaporator coils deliver improved airflow to provide lower chilled air temperatures and absorb heat at greater efficiencies," said Tony Lundell, director of standards and safety at IIAR. "[Cleaning] reduces an operation's energy usage, optimizes compressor capacities and enhances the system's refrigeration effect."

The frequency of this required maintenance depends on the type and size of the facility, but Hindt said roughly speaking, a system should be cleaned about once a year or year-and-a-half. It depends on the load that you're putting through the coil and what type of materials are in the environment you're trying to cool, he added.

However, it's not enough to wheel in a pressure washer and hose everything off. In fact, Hindt said that can often cause more harm than good. By pushing the contaminants to the middle of the coil apparatus, debris can become compacted, degrading airflow through the system and potentially damaging components.

There are three levels of cleaning, according to coil manufacturers, and IIAR materials: cleaning, sanitizing and protecting.

The objective of cleaning is to remove visible contaminants from fans, coil tubes, fin surfaces, drain pans and lines. There are four basic types of cleaners to accomplish this: acids, alkalines, solvents and detergents. It's imperative that the right chemicals be selected for the right application, coil manufacturers warn. If not, components could be damaged.

A step beyond cleaning is sanitization. This removes visible and non-visible growing contaminates from all components, including bacteria, mold and other pathogens. This type of cleaning is particularly important in facilities that handle food products, because avoiding contamination is always a major consideration. To sanitize a system, proper water temperatures, pressures and techniques must be applied to prevent pushing contaminates deeper into the system, and chemical cleaners must be thoroughly rinsed from every surface of the system.

"Removing contamination from evaporator coil surfaces not only reduces energy usage and improves the refrigeration effect, but also reduces or eliminates product safety risks, such as in food and other open-product manufacturing facilities," Lundell said.

Hindt agreed. "These units are huge harborage points for bacteria – the Listeria, the Salmonella, the E. coli that may be found in these food processing plants, most of it is harbored in a dark, wet, cold place," he said.

The final level is protection, in which a protective coating is applied to the coils to prevent the accumulation of contaminants, increase overall energy efficiency and extend equipment life. According to coil manufacturer's recommendations, there are two basic types of coatings – water attractive and water repellant. Each coating type has its benefits, and which to employ depends on the type of system in consideration.

One of the best ways to measure the increased efficiencies of a particular cleaning regimen is to examine the cost savings over time. Hindt says these savings can be tremendous. "We typically see the cost for cleaning the coils in a facility returned to the customer very quickly through the improved operating efficiencies," he said. By comparison, he noted that replacing standard lighting with LEDs usually takes three to five years to see a return on investment, while proper cleaning can return the cost in five to six months.

Unfortunately, proper cleaning is rarely thought about in terms of increasing energy efficiencies and decreasing costs. Most operators fail to consider the operating efficiencies, Hindt said. they just want to keep their facility at the right temperature, and they'll pay whatever it costs to do so. Many don't realize that by simply cleaning their systems, they could realize tremendous cost savings as well as decreased energy consumption.

# ATI has Replacement Ammonia Gas sensors for many Honeywell, Manning & Calibration Technologies models.

## SENSOR OPTIONS

$195.00

MANNING/HONEYWELL REPLACEMENT


PORTABLE SENSOR

**For over 15 years, ATI has manufactured the ammonia sensors used in your Manning Systems leak detectors. Now, you can buy direct from the source and save time & money.**

- Economical, Dependable, and Direct from the Manufacturer.
- 18 Month "no hassle" warranty. New sensors supplied at half off if required less than 18 months from shipment.
- And, we offer our own gas transmitters and alarm systems for your expansion needs.

## LOCATE $NH_3$ LEAKS

### C16 PortaSens II Portable Ammonia Detector

ATI's C16 PortaSens II portable leak detector is used to check for gas leaks in storage areas, around process equipment and piping, and in confined spaces prior to entry.

### FEATURES

- Interchangeable "Smart Sensors" for Over 30 Gases
- $NH_3$ Sensors from 0-50 to 0-2000PPM

# ASME Low Temperature Requirements for Impact Testing

RICHARD MERRILL

For those of us that didn't major in metallurgy, steel was always a pretty simple material. It was pretty springy and flexible stuff. Just about any shape was possible. Steel could be loaded up to a point and it would bend, but when unloaded it would spring back to its original shape. If we loaded it a little further, it would flex further, but when unloaded, it would spring back a little but not all the way. It had taken a permanent set. We call it a permanent set, but it can usually be loaded in the other direction to restore it to nearly the original shape and condition. Just don't flex it too many times or it might break due to fatigue failure.

One of the nice things about most steels is that they will yield a significant amount before they fail under tension. Yielding provides a bit of safety before failure. This nice quality is known as "ductility". That is the ability of the material to yield before it breaks. Metallurgists measure the point of yield and quantity of yield in various materials to categorize them. However, carbon steel is not always a simple material. In refrigeration pressure piping and vessels, ductility becomes a very important characteristic that we need to pay attention to, especially at low temperatures.

At refrigeration and freezing temperatures, the ductility of carbon steel can diminish, and the metal can become brittle. Under stress, the metal can fracture with very little warning.

In WWII the might of American industry was a major factor in winning the war. One of our most notable products were the cargo ships known as Liberty Ships. During the war, over 2700 were built in 18 US shipyards. In 1943, the US launched three ships per day. Design was simple, materials were inexpensive, and construction was speedy. The carbon steel loss of ductility was soon experienced during the winter when ships were crossing the North Atlantic Ocean. About 1500 ships experienced serious cracks in their hulls and decks. Twelve ships broke in half and sunk. Designs were modified but the Liberty Ships were never quite safe in the cold.

We find ourselves, 70 years later using much the same carbon steel for our pressure vessels and pressure piping at lower and lower system design temperatures. The two controlling codes, ASME Section VIII for vessels and ASME B31.5 for piping, have recognized the problem and have methods for dealing with the loss of ductility at low temperatures. Both codes are under the control of the ASME and use common allowable stress tables for carbon steel plate and pipe and, mostly, common stress calculation methods. See Table 502.3.1.

Different specification materials experience a loss in ductility at different temperatures. In the allowable stress tables, minimum allowable temperatures are specified. For some materials it is specified as simply a temperature (i.e. -20°F) and for other materials the user is sent to a table of values (i.e. Curves A, B and C in Table 523.2.2) where the minimum temperature is a function of metal thickness. Thinner materials are less likely to experience brittle fracture due to lower internal stresses. The thinner materials have lower minimum temperatures specified in the charts. If your system lowside design temperature is warmer than the material minimum temperature, brittle fracture is not going to be a prob-

**One of the nice things about most steels is that they will yield a significant amount before they fail under tension.**

**There is another property known as "malleability". It is a measure of metal's ability to endure compression instead of tension. Malleable metals can be hammered or rolled into very thin sheets. Both ductility and malleability are measures of plasticity of the metal. However, some materials may be good at one property and not another.**

## A Historical Note

**As a historical note, before WWII the ASME "room temperature" safety factor was 5.0. During the war it was "temporarily" changed to 4.0. That temporary provision lasted until 2005 when B31.5 changed to 3.50 following the lead of the 2001 pressure vessel code. The justifications were: better steel, better fabrication methods, better stress calculations, safer system operations and of course, costs. So far it seems to be working ok.**

## High Pressure Testing

**Typically, ASME B31.5 and ASME Section VIII require a post fabrication strength test at 1.1 to 1.3 times the design pressure. This type of testing, especially in the field gives some people heartburn. However, some experts claim that high pressure testing is a very good idea. Especially for low temperature vessels and piping. When performed at room temperature a pressure test approaches the material yield stress and gives the assembly a nice little stretch. It relieves and equalizes pent up stress concentrations from the manufacturing/fabrication process. Then, at a later date, when the piping or vessel is at design temperature, there would be fewer and smaller stress concentrations and a much safer installation.**

lem. If your lowside design temperature is below the material minimum temperature, there is more work to be done.

Allowable stresses for most of the listed materials we are using are based on the tensile strength of the specific material. ASME takes that tensile strength and divides it by 3.50. It is often referred to as a “safety factor” but ASME prefers not to call it that.

For other materials that have no ductility at any temperature, such as cast iron, they divide the tensile strength by a factor of 10. A lot more safety than the 3.5 factor.

ASME B31.5 has rules governing refrigerant piping of all types (not just ammonia). B31.5 follows the rules and conventions of ASME Section VIII but in several areas, it simplifies those rules and lists fewer material choices than listed in the Boiler and Pressure Vessel Code. In cases where B31.5 simplified the rules, they were always more conservative. A good example of this conservatism is the low temperature rules. Prior to around 2001 if the design temperature went below the minimum allowed metal temperature, the safety factor immediately went to 10. If you can maintain stresses below the “safety factor of 10” you should be able to avoid impact tested materials. One trick to keep the stresses low is to specify thicker materials or higher pipe schedules or different materials.

In practice, B31.5 works like this: Paragraph 523.2.2, simply stated, tells us when the metal temperatures go below the material allowed minimum, allowed stress from Table 502.3.1, it gets multiplied by 0.35. Multiplying that “room temperature” allowable stress by 0.35 results in an allowable stress that is one tenth of the material tensile strength. (1/3.5 x 0.35 = 1/10). If your design stresses are below that number, you are exempt from impact testing requirements.

However, this is a pretty severe and abrupt penalty. If you slip from a -20°F to a -21°F design temperature, you have an instant derate by 65%. But the ASME Boiler and Pressure Vessel Code, Section VIII, UCS-66 has its own rules for calculating allowable stress in carbon steel used in a cold vessel. It has a sliding scale stress derate. The lower the temperature, the greater the derate on the allowable stress. Dropping from -20°F to -21°F is no problem.

Table 523.2.2
Impact Exemption Temperatures

| Thickness, in. | Curve A, °F [Note (1)] | Curve B, °F [Note (2)] | Curve C, °F |
|---|---|---|---|
| 0.375 | 18 | −20 | −55 |
| 0.4375 | 25 | −13 | −40 |
| 0.5 | 32 | −7 | −34 |
| 0.5625 | 37 | −1 | −26 |
| 0.625 | 43 | 5 | −22 |
| 0.6875 | 48 | 10 | −18 |
| 0.75 | 53 | 15 | −15 |
| 0.8125 | 57 | 19 | −12 |
| 0.875 | 61 | 23 | −9 |
| 0.9375 | 65 | 27 | −6 |
| 1 | 68 | 31 | −3 |

GENERAL NOTE: For other nominal thickness, see Curves A, B, and C in Fig. UCS-66 in Section VIII, Division 1, ASME BPV Code.

NOTES:

(1) *Curve A.* All carbon and low alloy pipe, tube, plates, valves, fittings, and flanges listed for minimum temperature as "A" in Table 502.3.1. Use the minimum temperature in Curve A corresponding to the nominal material thickness in Table 523.2.2.

(2) *Curve B.* Specifications are ASTM unless otherwise noted. Use the minimum temperature in Curve B corresponding to the nominal material thickness in Table 523.2.2 for
- (a) A285 Grades A and B
- (b) A414 Grade A
- (c) A515 Grade 60
- (d) A516 Grades 65 and 70 (if not normalized)
- (e) API 5L Grades A25, A, and B
- (f) A135 Grades A and B
- (g) A53 Grades A and B
- (h) A106 Grades A, B, and C
- (i) A134 Grade B
- (j) all materials of Curve A, if produced to fine grain practice and normalized

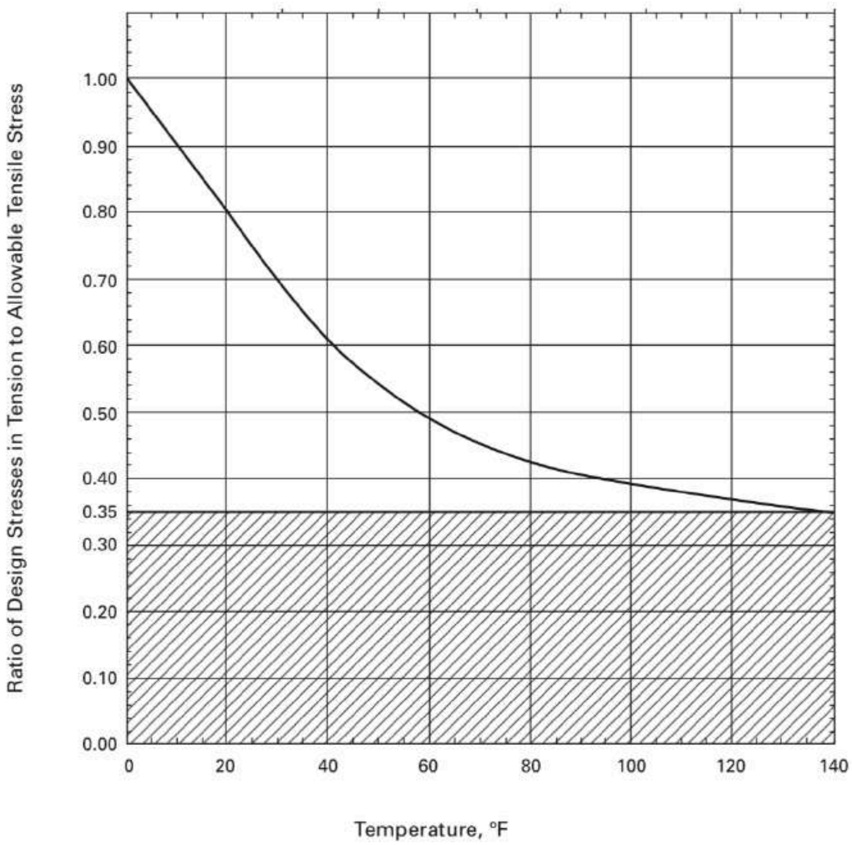
Back in the early 90’s there were a number of complaints and requests to unify the two codes. Vessel manufacturers were building vessels with piping

Table 502.3.1
Maximum Allowable Stress Valves, ksi (Multiply by 1,000 to Obtain psi)

**Table 502.3.1 Maximum Allowable Stress Values, ksi**
**(Multiply by 1,000 to Obtain psi)**

| Material | Spec. No. | Grade, Type, or Class | Min. Temperature, °F [Notes (1) and (2)] | Min. Tensile Strength, ksi [Note (3)] | Min. Yield Strength, ksi [Note (3)] | Allowable Stress Min. Temp. to 100 |
|---|---|---|---|---|---|---|
| **Seamless Carbon Steel Pipe and Tube** | | | | | | |
| Steel pipe | ASTM A53 | | B | 48.0 | 30.0 | 13.7 |
| Steel pipe | ASTM A53 | B | B | 60.0 | 35.0 | 17.1 |
| Steel pipe | ASTM A106 | A | B | 48.0 | 30.0 | 13.7 |
| Steel pipe | ASTM A106 | B | B | 60.0 | 35.0 | 17.1 |
| Steel pipe | ASTM A106 | C | B | 70.0 | 40.0 | 20.0 |
| Steel tube | ASTM A179 | . . . | −20 | 47.0 | 26.0 | 13.4 |
| Steel tube | ASTM A192 | . . . | −20 | 47.0 | 26.0 | 13.4 |
| Steel tube | ASTM A210 | A-1 | −20 | 60.0 | 37.0 | 17.1 |
| Steel pipe | ASTM A333 | 1 | −50 | 55.0 | 30.0 | 15.7 |
| Steel pipe | ASTM A333 | 6 | −50 | 60.0 | 35.0 | 17.1 |
| Steel tube | ASTM A334 | 1 | −50 | 55.0 | 30.0 | 15.7 |
| Steel tube | ASTM A334 | 6 | −50 | 60.0 | 35.0 | 17.1 |
| Steel pipe | API 5L | A | B | 48.0 | 30.0 | 13.7 |
| Steel pipe | API 5L | B | B | 60.0 | 35.0 | 17.1 |

Table 523.2.2
Reduction in Minimum Design Metal Temperature Without Impact Testing




connections with a lesser wall thickness than the thickness required by the piping code. The resultant mismatch caused extra work for internal beveling of the thicker pipe and extra steps of inspection during fit-up. And it also caused extra material costs.

B31.5 did the work and got it through the ASME bureaucracy for the 2001 Edition. And in 2006 the language of paragraph 523.2.2 was clarified to make it clear that either method: the "safety factor = 10" method or the "temperature reduction curve" method from Section VIII were available to the designer.

The temperature reduction method isn't as bad as it looks.

Figure 523.2.2 shows both methods. The left side asks you to divide your calculated design stress by the room temperature allowable stress for your material (from Table 502.3.1). If you enter the chart at 0.35 or below (in the shaded area) you are good for just about any low temperature. The scale across the bottom of the chart tells you how many degrees you can go below your material specified minimum temperature from 502.3.1. If you enter the chart above the 0.35 number, you traverse over to the curve. Then if you go down from there it tells you the temperature reduction from the minimum that you are allowed for your selected material.

If you've gotten this far and all is well, you won't need to use impact tested material. Congratulations. If not, B31.5 paragraph 523.2.2 is titled "Impact Tests" but it has a rather incomplete description of the impact testing procedure as described in Section VIII, UG-84. This is better left to the metallurgical test labs used by your material supplier.

However, all is not lost. There are other solutions to the brittle fracture problem, all spelled out in paragraph 523.2.2. For example, carbon steel that is thinner than 0.10 inches is exempted down to -55°F. There are pipe specifications that include impact testing, such as A333, Grades 1 and 6 certified down to -50°F and some other grades are certified down to -150°F. Some aluminum and stainless-steel specs are totally resistant to low temperature embrittlement… good to -425°F.

One last point: While the hoop stress in a piece of pipe is very easy to calculate, there is much more to be considered. B31.5 requires that we consider stresses in the pipes due to weight loads, wind, seismic, vibration and thermal expansion or contraction. Paragraphs 519, 520 and 521 discuss the calculation of these extra loads. With anything more than a simple run of pipe, the B31.5 methods get very complex. Numerous software developers have software packages that do a much better job evaluating piping networks. It seems that ASME has deferred to these software packages for these problems. Regardless, all the other stresses must all be considered in the design, especially at low temperatures. It is most important to adequately support your piping such that it is protected from external loads and to be sure the piping is unconstrained with respect to thermal expansion and contraction.

## History of B31.5

**B31, the original Pressure Piping Code was established in 1926. It was a single document to fit all piping applications. Over the years it became too cumbersome and it was split into multiple sections in the '40's. Just to name a few: Power Piping (steam) B31.1, Process Piping 31.3, Pipeline Systems B31.4, Building Services Piping B31.9 and Hydrogen Piping B31.12.**

**These Codes are all run by Sub-Committees of the B31 Main Committee that oversees the work. They try to maintain a uniform philosophy and language wherever possible. The other thing that they do is maintain all the documents in parallel. That is to say the same topics are covered in similarly numbered paragraphs. For example: Where B31.5, paragraph 504.2.1 talks about Pipe Bends, paragraph 304.2.1 in B31.3 and paragraph 904.2.1 in B31.9 should also talk about Pipe Bends. A very nice feature.**

**Only recently, in 2001, the Scope of B31.5 was expanded to include Heat Transfer Components, such as condenser coils and evaporator coils under the Refrigeration Piping rules.**

# From the Montreal Protocol to the Paris Agreement: How Refrigerants Have Felt the Chill of Global Environmental Regulations

EILEEN M. MCKEOWN, IIAR, VICE PRESIDENT, MARKETING AND SALES

International refrigerant related environmental regulation began in a laboratory at the University of California, Irvine, in 1973 when a postdoctoral fellow, Mario J. Molina, under the supervision of F. Sherwood Rowland, made a groundbreaking and controversial hypothesis that chlorofluorocarbons (CFCs) could destroy ozone (O3) in the Earth's stratosphere.

CFCs, synthetic chemicals classified as halocarbons, are composed of carbon, fluorine, and chlorine. CFCs can also be manufactured to contain hydrogen in place of one or more chlorines; these are called hydrochlorofluorocarbons (HCFCs). These stable molecules degrade very slowly once released to the atmosphere and can hang around for hundreds of years in the lower atmosphere before making their way to the outer layer of the atmosphere called the stratosphere.

At the time of Molina's discovery, CFCs were used plentifully in applications that enhanced quality of life for many people: refrigeration, air-conditioning, and aerosol spray cans all employed the compound in some fashion. CFCs were well suited to these applications as they are considered non-toxic and nonflammable, and they are readily converted from a liquid to a gas and vice versa. These stable compounds can also be used quite safely in close proximity to humans with little to no threat to life or health upon contact.

Molina's hypothesis that CFCs could destroy ozone was based on a theory that photons from ultraviolet light could break CFCs apart to release chlorine atoms and other products. Because the chlorine atom has an unpaired electron it is considered a radical, meaning that it can easily react with ozone molecules breaking them apart. CFCs slowly make their way to the stratosphere where they are bombarded by high-intensity ultraviolet light which in turn splits the molecule into its building block components. Chlorine is then free to attack ozone molecules at will. Later studies found that 1 chlorine atom has the potential to break down 100,000 ozone molecules alone.

Molina's discovery was so significant because ozone comprises the stratospheric ozone layer, which surrounds the earth like a delicate protective atmospheric eggshell. Discovered in 1913 by a team of French scientists, the ozone layer protects us from the harmful effects of the sun by absorbing and filtering ultraviolet rays. UV rays in high concentrations or intensity cause several adverse health effects, including skin cancer, cataracts, and impaired immune systems.  They have also been found to damage delicate food crops like soybeans along with animal and marine life.  Put simply, a little sun is good, a lot of sun is bad, and the ozone layer protects us from a lot of sun.

In 1985, a team of English scientists validated Molina's hypothesis through the discovery of a rapidly growing stratospheric ozone hole at the South Pole. Once considered natural thinning and reforming, they found that the ozone was no longer reforming to its prior state after each spring thaw. Instead, it began to thin and continued to thin. In scientific fact, a giant hole was forming in the ozone layer that could no longer naturally repair itself, and CFCs were directly to blame.

## BRIEF HISTORY OF REFRIGERATION

What did all this mean for refrigeration?  As noted previously, at the time of Molina's discovery, CFCs were in wide use as coolants in refrigeration and air-conditioning systems worldwide. That CFCs were inert and non-toxic made them well suited as refrigerants, particularly for use in units that most people use in their homes every day.

The concept of refrigeration is not new to humankind; it has been around for thousands of years. From the use of naturally formed ice blocks harvested from rivers and lakes to the invention of mechanical refrigeration in the mid-1800s, refrigeration is a staple convenience for most people. Refrigeration stops the progress of bacteria on foodstuff, helping food stay fresh longer. According to the U.S. Department of Agriculture, the refrigerator is one of the most important pieces of kitchen equipment for keeping food safe. From the field to the table, refrigeration – whether in industrial (cold storage and distribution warehouses), commercial (local grocery stores), or residential (home appliances) – touches everyone's life by keeping food fresh, safe, and readily available for consumption.  It has implications in other industries including longevity of pharmaceuticals and lifesaving drugs as well.

When mechanical refrigeration was invented, the first refrigerants used, like anhydrous ammonia (NH3), methyl chloride (CH3Cl), and sulfur dioxide (SO2) were easily synthesized and quite readily manipulated from gas to liquid, a necessary attribute for the mechanical refrigeration process. They were also naturally occurring compounds, meaning they occur naturally in the environment. Unlike CFCs, Mother Nature makes them, and Mother Nature disposes of them with little to no adverse effect on the environment. However, these refrigerants have properties that make them both potentially toxic and flammable and consequently can be dangerous to human health.

In 1928, Thomas Midgely, an American inventor, developed CFCs as an alternative to those refrigerants first used when mechanical refrigeration was invented, addressing the issues of toxicity and flammability of these early, albeit environmentally friendly refrigerants. CFCs along with HCFCs, were manufactured with good intentions in order to solve a problem regarding industrialization and to mitigate risk to human health.

As soon as DuPont mass produced the first CFC compound in the 1930s, refrigeration units in every home became a possibility, and as technology and raw materials were prioritized for use in home appliances, refrigeration units in every home soon became a reality. Because CFCs were deemed physically safe, they weren't heavily regulated at the time. Dumping CFCs into the atmosphere, through leaky or poorly maintained refrigeration systems was considered inconsequential. You were really just out the cost of replacing the refrigerant, which at the time, was relatively inexpensive. No one yet knew what was happening to CFCs high up in the atmosphere. Save for their one fatal flaw, they were ideal refrigerants – stable, energy efficient, safe to use around people, and ultimately beneficial to improving quality of life.

## CFCS A GLOBAL POLLUTANT – THE MONTREAL PROTOCOL

After discovery of the widening ozone hole in the Antarctic in 1985, which the research of Molina had predicted in 1973, CFCs were now considered public enemy number one on a global scale. The man-made substance that was meant to help humans thrive was now found to be detrimental to their health along with the health of all life on Earth.

The global community took notice and then acted. CFCs were not only a point source pollutant, meaning their release and subsequent breakdown only affected local or immediately adjacent areas, they also affected the entire world by travelling to the highest reaches of our atmosphere and damaging the protective stratospheric ozone layer. CFCs were a global pollutant. Everyone everywhere would be made particularly vulnerable to the effects of increased solar radiation, and something had to be done about it.

In 1987, as a result of the 1985 United Nations (UN) Vienna Convention for the Protection of the Ozone Layer, the Montreal Protocol on Substances that Deplete the Ozone Layer was signed into force and ratified by every nation in the world. No other treaty before or since has had the same signing power of the Montreal Protocol. Every nation on Earth came together to help mitigate and prevent the effects of CFCs and subsequently HCFCs on the stratospheric ozone layer. According to the UN this treaty is the most successful global environmental action to date.

Initially, parties to the Montreal Protocol agreed to cut CFCs by 50 percent over 12 years, but, due to initial success, they swiftly accelerated the reduction rate to 100 per-cent by 1992. In its 30-year history, the treaty has resulted in the reduction of nearly 100 ozone-depleting (ODP) chemicals by nearly 100 percent. Manufacturing or producing CFCs is now illegal and has been banned since 1996. Manufacturing and producing HCFCs will be illegal in the next 10 years as well.

The good news is that the due to the Montreal Protocol and subsequent commitment to phase-out ODP substances, the ozone layer is beginning to heal and, according to the UN, is likely to recover completely in the next several decades.

The universal success of the Montreal Protocol is due to several factors. First, stratospheric ozone depletion was the first truly global environmental challenge that the world had been exposed to collectively. The concern it caused unified independent nation states and made it easy for them to come together to address the issue in a real way. Second, national governments, like the Unites States, had already made strides to phase-out CFCs prior to the formation of the treaty. The U.S. Environmental Protection Agency (EPA), for instance, went to great lengths to regulate these compounds as part of the Toxic Substances Control Act in the late 1970's based on Molina's research alone. Third, the general public learned of the controversy and started pushing back on industry by boycotting the use of CFCs in consumer products, essentially refusing to participate in purchasing products that contained the substances. Finally, and maybe most importantly, private industry, having received clear signals from scientists, government, and the general public, were already moving in the direction of replacing CFCs and HCFCs with new alternatives.

## HFCS A NEW SOLUTION

Indeed, seeing profits diminish, facing unwieldy regulation, and learning of potential environmental damage, industry had already begun working on creating and developing CFC alternatives long before the Montreal Protocol was signed into force. When the Montreal Protocol was brought to the table, hydrofluorocarbons (HFCs), compounds comprised of hydrogen, fluorine, and carbon, were already in production and nearly ready for market. Many of these HFCs were also acceptable drop-ins for CFC and HCFC refrigerants already in use, which made the transition even easier. In fact, DuPont, a market leader in CFC production, was an enthusiastic champion of the Montreal Protocol mainly because the company was already poised to bring new alternatives to the marketplace. The public, government, industry, and the world were prepared for the change. Together they made it happen, and it happened rapidly.

HFCs quickly became the immediate answer to the nasty ODP substances of the past. They were engineered to eliminate chlorine and in so doing become a zero ODP substance. Fitting nicely into the mandates of the Montreal Protocol, HFCs could be, with a small amount of retrofitting, used in much the same way and in the same applications as CFCs and HCFCs with many of the same beneficial effects.

In the meantime, while HFCs were being phased-in as substitutes for CFCs and HCFCs, the international scientific community was hard at work outlining a new global environmental problem better known as global warming. Scientific study of the subject of global warming and climate change ramped up precipitously in the mid 1990's buoyed by the success of the Montreal Protocol and the discoveries made regarding the atmosphere therein.

## HFCS AND GLOBAL WARMING

Global warming is the idea that the overall temperature of the Earth is gradually increasing. This gradual increase in temperature is attributed to the greenhouse gas effect, which is caused by increased levels of carbon dioxide, methane, nitrous oxide, HFCs, and other pollutants known as greenhouse gases (GHGs). GHGs are substances that trap the sun's radiation in the Earth's atmosphere, making the Earth warmer. Fluorine, a primary building block of HFCs, was found to be one of the most highly potent GHGs of them all, thousands of times more potent than carbon dioxide. HFCs are considered to have a very high global warming potential (GWP).

An elegant solution to one global environmental problem had quickly become a primary offender of another.

## THE KYOTO PROTOCOL, PARIS AGREEMENT AND KIGALI AMENDMENT

The first international attempt at regulating HFCs as part of a larger, comprehensive GHG emission phase-down directive began in 1992 with the formation of the United Nations Framework Convention on Climate Change (UNFCCC) convened in Rio de Janeiro, Brazil as part of the UN Earth Summit program. During this first meeting it was agreed by member states that climate change in the form of global warming was in fact occurring and that human activity had a forcing effect on this change. The goals outlined in this convention were meant to prevent irreparable harm to the climate due to man-made activities. Over 190 countries, including the United States, agreed to participate and continue to meet annually to discuss the effects of climate change worldwide. These meetings have resulted in two key legally binding international treaties affecting GHGs, the 1997 Kyoto Protocol and the 2016 Paris Agreement.

### THE KYOTO PROTOCOL

The Kyoto Protocol was adopted on December 11, 1997 with the intent to set internationally binding GHG emission reduction targets in order to combat the man-made effect on climate change. This treaty focused on obtaining support of industrialized nations to agree to voluntarily phase-down their total amount of GHG emissions. Developing countries were exempted but asked to participate voluntarily. The treaty has faced a lack of consensus primarily due to the fact that only industrialized nations were to be made legally responsible for emission phase-down targets. There has also been some controversy with regard to clean development and emissions trading programs as part of the treaty. Both the United States and Canada have pulled out of this agreement, however, many countries like Australia and the European Union (EU), which is currently comprised of 28 European member countries, have only just recently committed to new binding phase-down targets. Many HFC regulations, particularly in the EU, have been born from participation in this treaty.

### THE PARIS AGREEMENT

On December 12, 2015, parties to the UNCCC reached a landmark agreement to combat climate change and intensify the actions and investments needed to curb GHG emissions. Considering lessons learned from the Kyoto Protocol, this treaty focused not only on phase-down of emissions, but also with mitigation, adaptation and financing programs to help create a sustainable future.

The Paris Agreement brought both industrialized and developing nations together to undertake ambitious efforts to combat climate change. The Paris Agreement is a more overarching treaty on global warming and climate change and is based on voluntary nationally determined contributions (NDCs). It also includes a method to provide monetary support to assist developing countries to participate. While not receiving universal adoption, the Paris Agreement has been signed into force by over 80 percent of the parties to the UNCCC at this time. While, many of it's primary trading partners have signed the treaty, including Canada, Mexico and the United Kingdom (U.K.), the United States has currently withdrawn from this agreement.

## THE KIGALI AMENDMENT

Based on all the new data regarding climate change and global warming, the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer was negotiated in 2016. It has since been ratified by 79 nations at the time of this writing. Directly targeting HFCs as GWP substances, all nations participating have agreed to gradually phase-down HFCs by more than 80 percent over the next 30 years and replace them with more environmentally friendly alternatives.

Immediately surprising to the international community was that nations that had originally participated in the Montreal Protocol did not readily sign on to the Kigali Amendment. The United States was one of those nations. Less than half of the UN member nations have currently ratified this treaty. It was clear that the Kigali Amendment lacked the enthusiasm and the popular support of the Montreal Protocol and we are left to ask ourselves why.

Climate change and global warming are subjects that are confusing to many people. Endless media bombardment of polarized global warming and climate change opinions has made the public skeptical of what they see and hear on the news and from the scientific community. When the issue of the stratospheric ozone layer was introduced, little time was wasted between identification of the problem and implementation of the solution, leaving no time at all for confusing alternate theories to be suggested or supported.

The concept of climate change or global warming is also less tangible and more complicated than the concept of the stratospheric ozone layer. Climate change affects many Earth Systems in a multitude of ways, with both human interference and natural Earth cycles contributing to the problem. It does not hang on one major substance either; many high GWP pollutants and industries contribute to the problem of global warming. It's not as easy as declaring that phasing out HFCs will immediately fix or, in fact, have any significant effect on the problem at all.

Finally, and again likely the most important reason, industry is not already sitting on powerful new acceptable alternatives ready to be brought to market. Markets are simply not poised to make an easy transition. HFCs fit nicely as substitutes for CFCs and HCFCs, but similar obvious or easy substitutes are not available for HFCs.

United States and HFC Regulation

Even though the United States has decidedly pulled back from participation in international treaties involving HFC and total GHG emissions phase-down programs, there is still HFC regulation being pushed through at the state and federal level.

When the United States unexpectedly pulled out of the Paris Agreement, many U.S. states were emboldened to create their own alliance in 2018. The U.S. Climate Alliance, at the time of this writing, includes 25 U.S. states wherein each member state has agreed to implement policies that advance the goals of the Paris Agreement, aiming to reduce greenhouse gas emissions by at least 26-28 percent below 2005 levels by 2025. HFCs are considered low-hanging fruit regarding GHG emissions and will likely be phased down at the state level within the scope of the alliance's objectives.

The EPA has also attempted to regulate HFCs at the federal level. Having overseen the transition away from ODP substances per regulation created through participation in the Montreal Protocol, the EPA attempted to regulate HFCs and substances with high GWP in much the same manner as ODP substances.

The EPA's Significant New Alternatives Policy (SNAP) program was established under the Clean Air Act to identify and evaluate acceptable substitutes for ODP substances. Its primary purpose was to help industry transition to new acceptable non-ODP substances. At the time the program was created, HFCs were considered acceptable substitutes, however, all that changed in 2015 when the EPA expanded the scope of the SNAP program to include acceptable new alternatives to GWP substances, meaning that HFCs were now on the chopping block if an acceptable new alternative was readily available for use to replace them.

The EPA was summarily sued by an HFC manufacturer and the legal finding, held up by the D.C Circuit Court of Appeals, was mostly in favor of the manufacturer. It essentially found that the EPA had exceeded its authority by using a program meant to eliminate ODP substances in order to regulate HFCs as high GWP substances. Environmental groups, however, are currently poised to sue the EPA in an effort to resurrect the program mandate on GWP substances once again. In short, increased U.S. regulation through federal mandate with respect to HFCs is not completely out of the question just yet.

It is also important to note that the Kigali Amendment remains in play here in the United States as well. It is still sitting on the President's desk waiting for a signature and is considered not off the table just yet. Many industry stakeholders remain keen for the President to support the Kigali Amendment, citing an increase in economic opportunity and job development if the amendment were to be ratified. Again, it remains to be seen how this will play out.

The United States is also facing a lot of International pressure to sign on to the Paris Agreement, with arguments that China and India are more likely to comply with GHG phase-down objectives if we do.

On the international stage, many of the United States' primary trading partners have signed all three treaties; the Kyoto Protocol, Paris Agreement and the Kigali Amendment. The EU, for instance, is a primary driver in phasing down HFC refrigerants on the world stage with strict F-gas regulations already in force. Canada is also not far behind.

## WHAT ARE THE ALTERNATIVES?

It is easy to conclude that based on the international movement toward the phase-down of GWP substances, that HFCs have a very uncertain future. Evolving regulation and competing industry investments do not guarantee that they are a safe bet to employ as the refrigerant of choice moving forward. But what are the potential alternatives?

Lower GWP HFCs, hydrofluoro-olefin (HFO), and HFO-HFC blends have all been proposed as possible alternatives to current high GWP HFC refrigerants. Lower GWP often comes with one drawback though, increase in potential flammability. None of these options has yet become the leader of the pack.

HFO refrigerants have lower GWP because they are highly unstable compounds, this same instability is a leading factor in an HFO's propensity to break down under high temperatures. Certain HFOs can be quite flammable as well. When these HFOs are burned they create hydrogen fluoride, add a little water to the equation and you get hydrofluoric acid which can contaminate water supplies. Hydrofluoric acid has been known to dissolve glass. Hydrogen fluoride can also cause deep chemical burns, absorbing through the skin where it can have long-lasting effects on human health far beyond initial contact.

HFOs are often blended with HFCs, however, this blend is essentially just upping the GWP of the HFO and increasing the flammability and potential toxicity of the HFC. HFC and natural refrigerant blends have also been suggested. The drawback with any blend is that most have a habit of separating, and thus, producing what is termed "glide' - when a refrigerant blend begins to separate over time, the performance characteristic begins to change or glide - which makes them a less than ideal substitute in practical application.

One thing is for sure though, the market is heavily investing in the research and development of new alternatives to HFCs, hoping to manufacture the perfect compound that is both good for the environment without forcing global warming and good for people without causing immediate harm to health.

## BACK TO NATURALS

NH3 has been widely and consistently used in industrial refrigeration applications since the 1800s. It can be argued that it is the longest-lived refrigerant still on the market. NH3 has excellent thermodynamic properties and high energy efficiencies when used in refrigeration systems which made it hard to move away from on an industrial scale. And, the long and successful use of NH3 in industrial systems proves that its hazards are easily managed. New technology in refrigeration equipment has also made it possible to lower NH3 loads, meaning less of the refrigerant is needed to create a similar effect. This essentially makes the use of NH3 around people and in new applications much safer. Safety standards and codes have also been developed specifically for the NH3 community making the industry safer throughout the years. Toxicity and flammability issues with better technology, lower charges, and increased safety measures make NH3 a good refrigerant to count on. NH3 is a time-tested refrigerant that has proven that it can be made safe to use, is energy efficient, and good for the environment.

$CO_2$ is another natural refrigerant that has made great strides in practical application in recent years. The benefit of $CO_2$ is that it is neither toxic nor flammable and can be used in close proximity to people with a low immediate threat to health. It has found a niche in food retail as many grocery stores have voluntarily decided to move away from the use of HFCs via corporate mandated environmental sustainability programs. The only issue with $CO_2$ is that it can be difficult to manage as it requires higher system pressures and there are limitations to its geographical application due to ambient temperature and humidity issues. However, those issues are being addressed with new advances in technology as well.

Other natural refrigerants including hydrocarbons (propane), water, and air are all still being considered as possible alternate replacements to HFCs through the adaptation of new technology and safer system designs.

Refrigeration increases food safety, prevents food loss and helps feed the masses of the world. For those reasons alone it is here to stay. With population projected to explode in the next 30 years, with some estimates reaching the 11 billion mark, the need for refrigeration becomes more imperative. However, ever increasing regulation and concern for the environment has put the refrigeration market on the defense and looking for a sustainable future.

Without a clear path forward where do we go? We go back to the beginning with natural refrigerants and better technology. NH3, $CO_2$, propane and other naturals have the potential to become the last refrigerants that ever need be applied to modern refrigeration applications. With regard to regulation of refrigerants, the way back becomes our way forward.

## REFERENCES

Air Now. (2014). "Good Up High Bad Nearby—What Is Ozone?" Retrieved 10/24/2019 from https://cfpub.epa.gov/airnow/index.cfm?action=gooduphigh.index.

American Chemical Society. (2019). "Chlorofluorocarbons and Ozone Depletion." Retrieved 10/24/2019 from https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/cfcs-ozone.html.

EU Climate Action. (2019a). "Climate-Friendly Alternatives to HFCs." Retrieved 10/24/2019 from https://ec.europa.eu/clima/policies/f-gas/alternatives_en.

EU Climate Action. (2019b). "Fluorinated Greenhouse Gases." Retrieved 10/24/2019 from https://ec.europa.eu/clima/policies/f-gas_en.

JMS Consulting. (2018). "Economic Impacts of U.S. Ratification of the Kigali Amendment." Retrieved 10/24/2019 from http://www.ahrinet.org/App_Content/ahri/files/RESOURCES/Kigali_JMS_04-19-18.pdf.

Mawell, J., et al. (1997). "There's Money in the Air: The CFC Ban and DuPont's Regulatory Strategy." Business Strategy and the Environment, 6, 276–286. Retrieved 10/24/2019 from https://eng.ucmerced.edu/people/awesterling/SPR2014.ESS141/Assignments/DuPont.

McKenna, P. (2019). "What's Keeping Trump from Ratifying a Climate Treaty Even Republicans Support?" Retrieved 10/24/2019 from https://insideclimatenews.org/news/12022019/kigali-amendment-trump-ratify-hfcs-short-lived-climate-pollutant-republican-business-support-montreal-protocol.

Mexichem Fluor, Inc. v. EPA. (2015). Retrieved 10/24/2019 from http://climatecasechart.com/case/mexichem-fluor-inc-v-epa/.

National Oceanographic and Atmospheric Association. (2019). "Chlorofluorocarbons (CFCs)." Earth System Research Laboratory, retrieved 10/24/2019 from https://www.esrl.noaa.gov/gmd/hats/publictn/elkins/cfcs.html.

Science History Institute. (2019). "Mario Molina." Retrieved 10/24/2019 from https://www.sciencehistory.org/historical-profile/mario-molina.

The Ozone Hole. (2019). Retrieved 10/24/2019 from http://www.theozonehole.com/cfc.htm.

United Nations Climate Change. (2019). "What Is the Paris Agreement?" Retrieved 10/24/2019 from https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement.

United Nations Climate Change. (2019). "What is the Kyoto Protocol" Retrieved 10/24/2019 from https://unfccc.int/kyoto_protocol

United Nations Development Programme. (2019). "Montreal Protocol." Retrieved 10/24/2019 from https://www.undp.org/content/undp/en/home/2030-agenda-for-sustainable-development/planet/environment-and-natural-capital/montreal-protocol.html.

United Nations Environment Program. (2019). "The Kigali Amendment to the Montreal Protocol: HFC Phase-Down." Retrieved 10/24/2019 from http://multimedia.3m.com/mws/media/1365924O/unep-fact-sheet-kigali-amendment-to-mp.pdf.

United Nations Sustainable Development Goals. (2018). "Montreal Protocol Assessment Reveals Healing Ozone, Untapped Potential for Climate Action." Retrieved 10/24/2019 from https://www.un.org/sustainabledevelopment/blog/2018/11/montreal-protocol-assessment-reveals-healing-ozone-untapped-potential-for-climate-action/.

United Nations Treaty Collection. (1987). "Montreal Protocol on Substances that Deplete the Ozone Layer." Retrieved 10/24/2019 from https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-2-a&chapter=27&clang=_en.

United States Climate Alliance. (2019). "About Us." Retrieved 10/24/2019 from https://www.usclimatealliance.org/.

United State Department of Agriculture. (2015). "Refrigeration and Food Safety." Retrieved 10/24/2019 from https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/safe-food-handling/refrigeration-and-food-safety/ct_index.

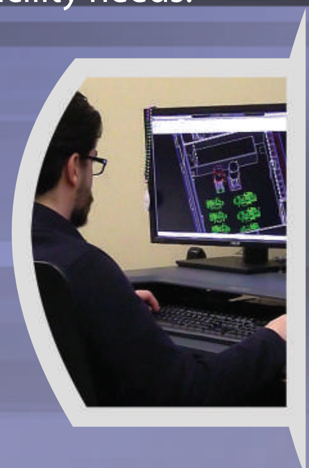
United States Environmental Protection Agency. (2019). "Phasing Out HCFC Refrigerants to Protect the Ozone Layer." Retrieved 10/24/2019 from https://www.epa.gov/sites/production/files/2015-07/documents/phasing_out_hcfc_refrigerants_to_protect_the_ozone_layer.pdf.

United States Environmental Protection Agency. (2019). "Significant New Alternatives Policy: Reducing Hydrofluorocarbon (HFC) Use and Emissions in the Federal Sector through SNAP." Retrieved 10/24/2019 from https://www.epa.gov/snap/reducing-hydrofluorocarbon-hfc-use-and-emissions-federal-sector-through-snap.

# "Just the Cold, Hard Facts."


## Custom Penthouses & Modular Engine Rooms

Republic Refrigeration's penthouse and modular engine rooms are custom-designed to fit your facility needs.



## EXPERT DESIGN

Every successful project begins with a quality design, and Republic Refrigeration maintains the most experienced and highly qualified engineering team to ensure that happens every time.

# International Update: A Focus on Education in Latin America

In Chile, the International Committee of the IIAR has been working with the University of Santiago's department of mechanical engineering along with the Chilean Chamber of Refrigeration and Air Conditioning (CChRyC) to develop a diploma track specifically to prepare refrigeration engineers to work with ammonia systems. The first class – 14 engineers in total – recently graduated.

Chile's government is using IIAR Standards to create national guidelines for the use of ammonia refrigeration systems, but the process has been slow, International Director Yesenia Rector said. Instead of waiting for the IIAR standards to be signed into law, Rector said the university and by extension the professional students involved in the program were proactive about the process – learning about best practices in this specific corner of the industry – to be prepared for when the laws are finalized.

"The first 14 students have graduated, and they are enjoying their IIAR membership and studying and applying the norms as they go," Rector said. "But there will be some changes coming for the second version of the diploma."

Rector said as the program grows, they will likely partner more closely with CChRyC, their local memorandum of understanding partner, to help deliver the curriculum to a wider audience more efficiently. "I'm very hopeful that this will develop into a bigger program," she said.

Speaking of this partnership, Rector said IIAR will also be participating in a conference sponsored by CChRyC in May. It's important that IIAR maintain a presence in the country while fostering strong relationships with its industry partners, Rector said, so that natural refrigeration can become more prevalent.

Outside of Chile, IIAR, along with Argentina's Institute of Mechanical Technology, is getting close to finalizing its national norms governing the use of ammonia refrigeration systems based on IIAR standards. Once it is signed into law, IIAR will be providing support and technical materials.

Also, in Argentina, the National Technical University is reviewing a proposal from IIAR to create a diploma track similar to what is offered in Chile. However, instead of focusing on professionals already in the field, this program will seek to educate engineering students to help sustain the industry and help it grow. The program is still in its early stages, but Rector said she hopes it will be ready for classrooms by the first half of 2020.

**The first 14 graduates of the IIAR, Chilean Chamber of Refrigeration and Air Conditioning-sponsored ammonia refrigeration training program at the University of Santiago, pose for a group photo after receiving their diploma.**

**Outside of Chile, IIAR, along with Argentina's Institute of Mechanical Technology, is getting close to finalizing its national norms governing the use of ammonia refrigeration systems based on IIAR standards.**

Meanwhile, the IIAR chapter in Mexico has just finalized its plans for 2020 and 2021, with a heavy focus on education, Rector said. The objective is to develop programs either through local universities or other instructional bodies to train professionals using IIAR standards, ANR courses and other technical publications.

Finally, in Costa Rica – the flagship country in the region where national norms have already been established using IIAR standards – the Academy of Natural Refrigerants will offer a certificate course taught in Spanish on IIAR 2. Rector said around 40 students are expected to become certified through the course, which will be offered next April.


iiar®
2020 NATURAL REFRIGERATION
CONFERENCE & HEAVY EQUIPMENT
EXPO
MARCH 15–18 • ORLANDO, FLORIDA
Register Now at www.IIAR.ORG/EVENTS
Special Guest Speaker NASCAR Hall of Fame Inductee Russell "Rusty" Wallace, Jr.!
Programs Include:
• Methods for Saving Energy in Cold Storage Warehouses
• Permanent Refrigeration Plant Performance Optimization Using Continuous Real Time Analysis
• Reducing Capital and Energy Costs Through Refrigeration Energy Modeling

# Understanding Bond Yields and the Yield Curve

FINANCIAL TECH TIP

When it comes to investing in bonds, one of the first factors to consider is yield. But what exactly is "yield?" The answer depends on how the term is being used. In the broadest sense, an investment's yield is the return you get on the money you've invested. However, there are many different ways to calculate yield. Comparing yields can be a good way to evaluate bond investments, as long as you know what yields you're comparing and why.

## CURRENT YIELD

People sometimes confuse a bond's yield with its coupon rate (the interest rate that is specified in the bond agreement). A bond's coupon rate represents the amount of interest you earn annually, expressed as a percentage of its face (par) value. If a $1,000 bond pays $50 a year in interest, its coupon rate would be 5%.

Current yield is a bit different. It represents those annual interest payments as a percentage of the bond's market value, which may be higher or lower than par. As a bond's price goes up and down in response to what's happening in the marketplace, its current yield will vary also. For example, if you were to buy that same $1,000 bond on the open market for $900, its current yield would be 5.55% ($50 divided by $900).

If you buy a bond at par and hold it to maturity, the current yield and the coupon rate are the same. However, for a bond purchased at a premium or a discount to its face value, the yield and the coupon rate are different.

If you're concerned only with the amount of current income a bond can provide each year, then calculating the current yield may give you enough information to decide whether you should purchase that bond. However, if you're interested in a bond's performance as an investment over a period of years, or want to compare it to another bond or some other income-producing investment, the current yield will not give you enough information. In that case, yield to maturity will be more useful.

## YIELD TO MATURITY

Yield to maturity is a more accurate reflection of the return on a bond if you hold it until its maturity date. It takes into account not only the bond's interest rate, principal, time to maturity, and purchase price, but also the value of the interest payments as you receive them over the life of the bond.

If you buy a bond at a discount to its face value, its yield to maturity will be higher than its current yield. Why? Because in addition to receiving interest, you would be able to redeem the bond for more than you paid for it. The reverse is true if you buy a bond at a premium (more than its face value). Its value at maturity would be less than you paid for it, which would affect your yield.

If you paid $960 for a $1,000 bond and held it to maturity, you would receive the full $1,000 principal. That $40 profit is included in the calculation of a bond's yield to maturity. Conversely, if you bought the bond at a $40 premium, meaning you paid $1,040 for it, that premium would reduce the bond's yield because the bond would be redeemed for $40 less than its purchase price.

Yield to maturity lets you accurately compare bonds with different maturities and coupon rates. It's particularly helpful when you're comparing older bonds being sold in the secondary market that are priced at a discount or at a premium rather than at face value. It's also especially important when looking at a zero-coupon bond, which typically sells at a deep discount to its face value but makes no periodic interest payments. Because all of a zero's return comes at maturity, when its principal is repaid, any yield quoted for a zero-coupon bond is always a yield to maturity.

Because zero-coupon bonds do not pay interest until maturity, their prices tend to be more volatile than bonds that pay interest regularly. Interest income is subject to ordinary income tax each year, even though the investor does not receive any income payments. Bonds sold prior to maturity may be worth more or less than their original cost.

## YIELD TO CALL

When it comes to helping you estimate your return on a callable bond (one whose issuer can choose to repay the principal before maturity), yield to maturity has a flaw. If the bond is called, the par value will be repaid and interest payments will come to an end, thus reducing its overall yield to the investor. Therefore, for a callable bond, you also need to know what the yield would be if the bond were called at the earliest date possible. That figure is known as its yield to call. The calculation is the same as with yield to maturity, except that the first call date is substituted for the maturity date.

A bond issuer will generally call a bond only if it's profitable for the issuer to do so. For example, if interest rates fall below a bond's coupon rate, the issuer is likely to recall the bond and borrow money at the new, lower rate. The larger the spread between current interest rates and the original coupon rate, and the earlier the first date the bond can be called, the more important yield to call becomes.

## AFTER-TAX YIELD

It's also important to consider a bond's after-tax yield: the rate of return after taking into account taxes (if any) on the income received. A tax-exempt bond typically pays a lower interest rate than its taxable equivalent, but may have a higher after-tax yield, depending on your tax bracket and state tax laws.

Bond A is a tax-exempt bond paying 4%; Bond B is a taxable bond paying 6%.

For purposes of this illustration, let's say you're in the 35% federal tax bracket and pay no state taxes. Bond A's after-tax yield is 4%, but Bond B's yield is only 3.9% once taxes have been deducted. Bond A has a higher after-tax yield. Note that in some states you will have to pay income tax if you buy bonds that have been issued by other states. In addition, while municipal bonds are not subject to federal income taxes, they may be subject to federal, state, or local alternative minimum taxes. If you sell a tax-exempt bond at a profit, there are capital gains taxes to consider.

## WATCHING THE YIELD CURVE

Bond maturities and their yields are related. Typically, bonds with longer maturities pay higher yields. Why? Because the longer a bondholder must wait for the bond's principal to be repaid, the greater the risk compared to an identical bond with a shorter maturity, and the more reward investors demand.

On a chart that compares the yields of, say, Treasury securities with various maturities, you would typically see a line that slopes upward as maturities lengthen and yields increase. The greater the difference between short and long maturities, the steeper that slope. A steep yield curve often occurs when investors expect a faster-growth economy and rising interest rates; they want greater compensation for tying up their money for longer periods. A flat yield curve means that economic projections are relatively stable, so there is little difference between short and long maturities.

## EXAMPLES OF YIELD CURVES

Sometimes the yield curve can become inverted when short-term interest rates are higher than long-term rates. For example, in 2004 the Federal Reserve Board began increasing short-term rates, but long-term rates didn't rise as quickly. A yield curve that stays inverted for a period of time is believed to indicate that a recession is likely to occur soon.

## IMPORTANT FACTS TO REMEMBER ABOUT YIELD TO MATURITY

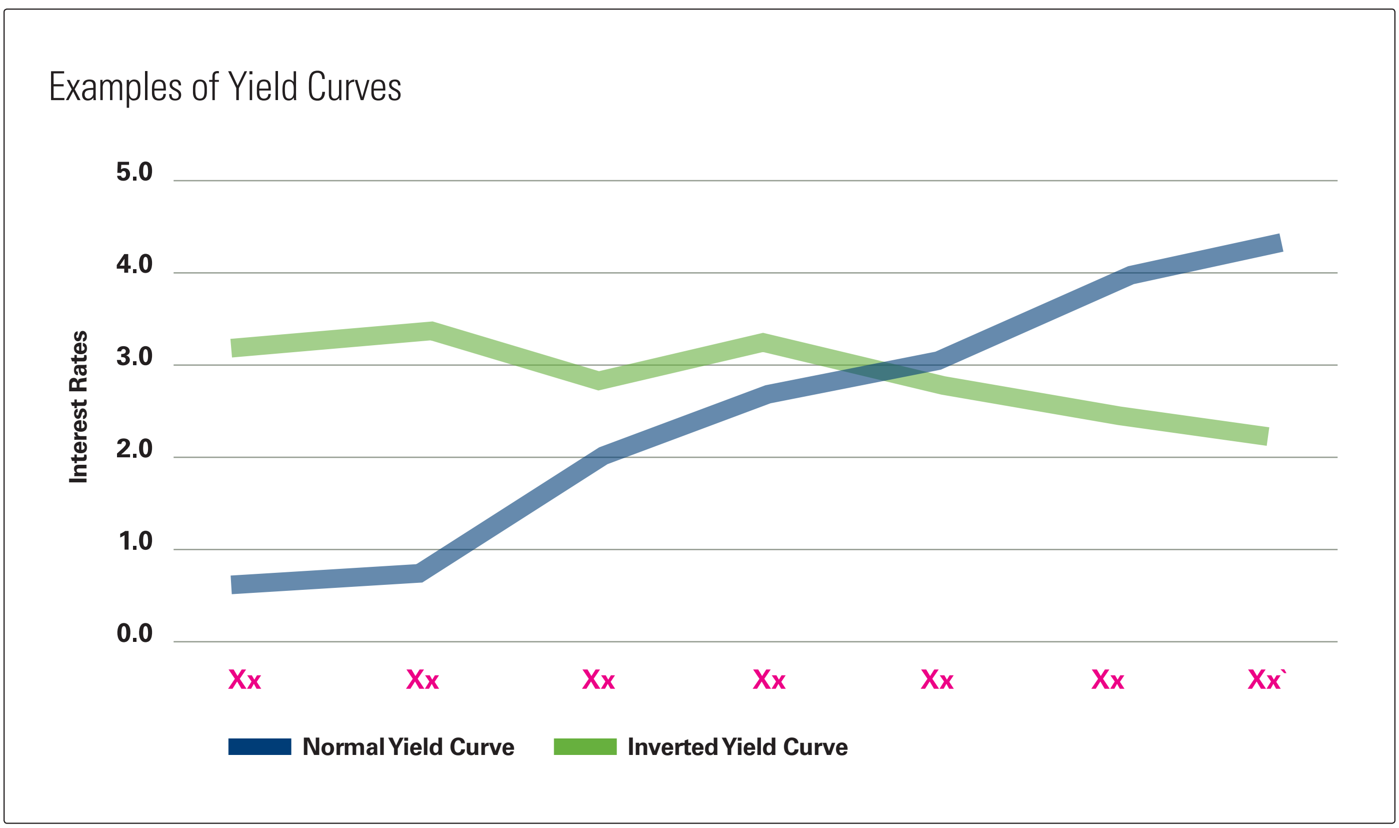
If you sell a bond before it matures, your effective yield could be different from its yield to maturity.

The yield to maturity calculation assumes you reinvest the coupon payments at that same yield rate. If you spend those interest payments, or if interest rates fall, you wouldn't be able to get the same yield when you reinvest your interest payments. That would mean your actual yield could be less than the yield to maturity percentage.

All investing involves risk, including the potential loss of principal, and there is no guarantee that a bond will be worth what you paid for it when you sell. Specific risks associated with bonds include interest rate risk (potential loss of value from a rise in interest rates), inflation risk (decline in the purchasing power of a bond's interest payments), liquidity risk (difficulty selling a bond), and default risk (if the issuer defaults on payments or repayment of principal).

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

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



# Pre-emergency preparedness

BY KEM RUSSELL


Are you prepared? I think most of us think we are prepared, at least to deal with whatever we expect to happen. The trouble is that often what we come up against is not something we expected – therefore we are not prepared to deal with it. For ammonia refrigeration whether a system has 400 lbs. or 40,000 lbs. (or more) we should do pre-emergency planning and training. Having people, training, equipment, etc. in place and properly functioning before the emergency can greatly reduce the impact of an incident.

In the RMP Amendment, published in 2017, Section §68.93 "Emergency preparedness coordination activities" paragraph (b) says in part, "… coordination shall also include consulting with local emergency response officials to establish appropriate schedules and plans for field and tabletop exercises required under § 68.96(b)." Doing field and tabletop exercises in this RMP Amendment is focused on "responding" facilities. However, doing field and tabletop exercises can be a valuable method in order to be prepared for an emergency for any size of system.

The majority of people do not consider their preparation for an emergency, and only seriously think about what they should do after the emergency occurs. I say that with great confidence having been a volunteer for Search & Rescue for over 20 years. For example: how many people that are lost have a map? Answer: Almost none. Here's another, how many people with a GPS device know how to work that device and/or know what the coordinates mean? Answer: not very many.

Doing tabletop or field exercises is practicing and learning appropriate actions before a real emergency occurs. This is pre-emergency preparedness. These exercises can help a facility find what works or doesn't work in their emergency plan (action or response), and can also find small, yet crucial details that need additional clarification or options in your emergency plan. The purpose of these exercises is to both improve your emergency plan and the function of your emergency team, so the outcome is better.

Let me assume that you have never done these types of exercises. It helps if it is pre-determined who is going to function in what position(s) in the exercise, and it can be valuable to have persons involved who have specific experience and knowledge relevant to the type of emergency being prepared for. Also, decide who is going to be in charge (Incident Commander). You need a team to deal with emergencies. Trying to be the "Lone Ranger" in an emergency will very likely lead to undesirable outcomes.

## TABLETOP DRILLS

Tabletop drills are a discussion-based session where team members meet in an informal, classroom type setting, to discuss their roles during an emergency and their responses to a particular emergency situation. It can be helpful to have outside persons involved in a tabletop, such as someone from the local Fire Department or Hazmat Team, a representative from a refrigeration contracting company, the president of the Local Emergency Planning Committee, etc. Having people from outside the organization involved in an exercise should improve overall coordination for when an actual emergency occurs.

For the tabletop drill someone pre-determines a realistic emergency scenario at the facility. For example, a refrigerant line gets hit, or a relief valve releases, or maintenance is being done and a release occurs. The scenario should not give realistic specific/detailed information about exactly what or how something happened. Asking and understanding the situation and figuring out what to do is part of the learning process that the team needs to go through as they work to understand the emergency and to determine the best actions. There should be a facilitator to guide the team through their discussion of the scenario.

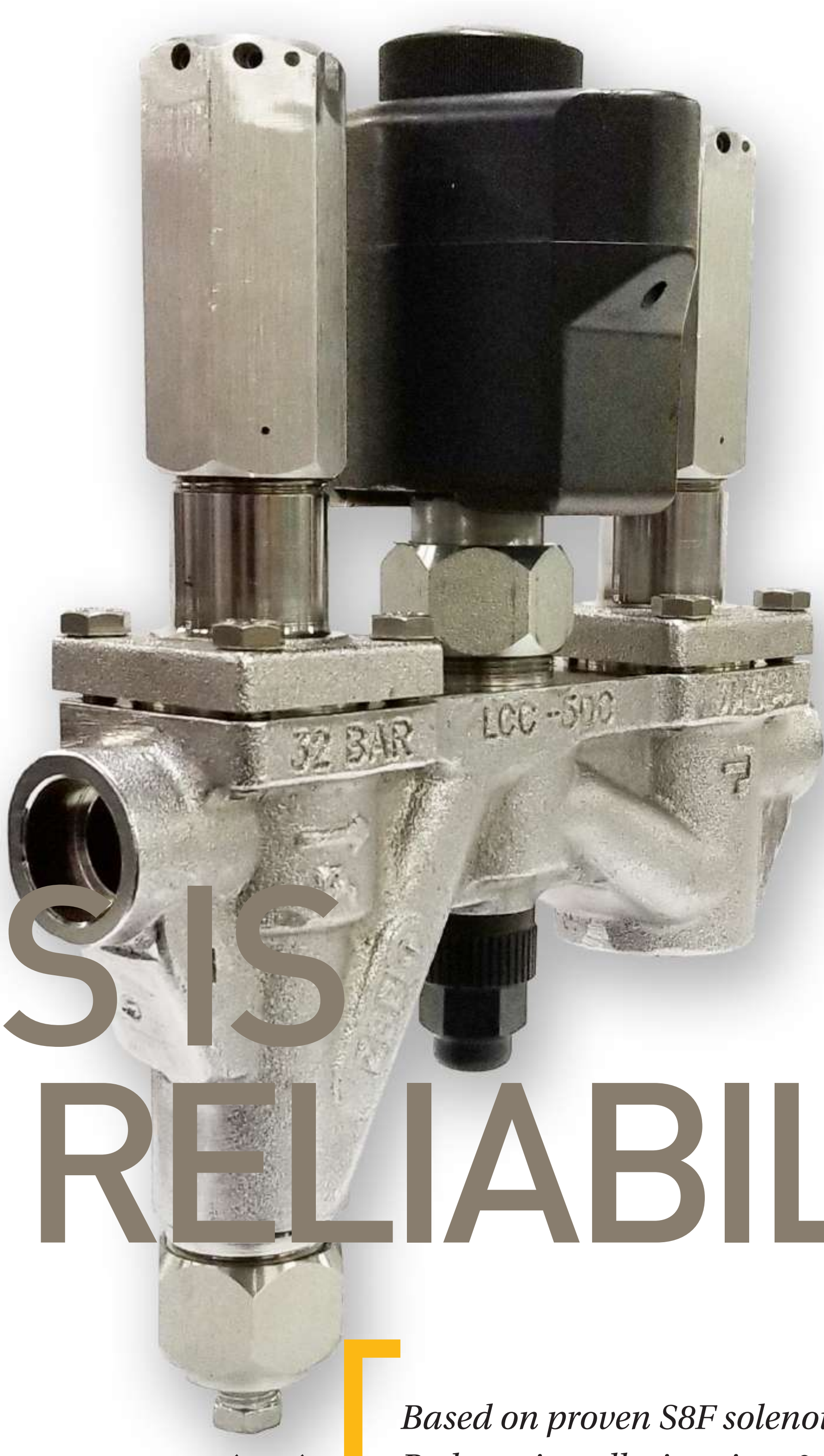
In addition to allowing the team to practice their response in real-time, the value in tabletop exercises is that they can help identify weaknesses and gaps in an organization's response before a real emergency happens. Confusion about responsibilities, poor decisions, lack of understanding of what could occur, inadequate training or equipment, identifying new vulnerabilities, and finding weak points in the processes don't indicate failure; rather, these are precisely what tabletop exercises are designed to weed out.

Once the scenario is presented the team starts determining what should be done to deal with the emergency using their present emergency plan. The team should have clear objectives in mind. They may be as simple as, Life Safety (onsite and offsite); Facility/Product protection; Environmental. The facilitator should help the team with suggested considerations, not solutions. If the team discussion is going well, the facilitator may just listen and take notes for discussion after the exercise.

After the exercise, it's essential for the team to explain what their actions were and discuss any shortcomings in the response. It should be documented what worked as well as what didn't so vulnerabilities are identified and recommendations for improvement are determined. These recommendations can improve the emergency plan; help the next exercise run more smoothly; and ensure more effective actions of the team when an actual emergency happens.

## FIELD EXERCISES

Field exercises can be simple or complex, but these exercises are the real "boots on the ground" type of practices.




# THIS IS RELIABILITY

*S8 Valve Station (S8VS)*

*Based on proven S8F solenoid and RSF strainer*
*Reduces installation time & cost by 50%*
*Plated for enhanced service life*

Parker's S8VS provides our partners with reliable operation and reduced installation costs for purge point solenoids, liquid feed applications, and pilot valves. This reflects Parker's commitment to helping solve the world's greatest engineering challenges.

parkerrealsolutions.com/S8VS

Parker

ENGINEERING YOUR SUCCESS.

These exercises mimic reality as close as possible in both the use of personnel and equipment.

A simple exercise might be an evacuation or shelter-in-place. This exercise might only involve facility personnel.

A more complex exercise could involve facility personnel, and Fire Department responders and equipment. If your Fire Department has a Hazmat Team that will respond to ammonia releases, involve them and see how facility personnel and the outside responders work together to address a pre-determined scenario. For example; I have been involved in several exercises where the machine room was "smoked" (using a smoke generating machine), the Fire Dept. and Hazmat Teams were pre-alerted to the exercise (only responding to the site when notified by their dispatch), an ambulance service was pre-alerted to the exercise and responded as the exercise unfolded, and the facility personnel practiced their evacuation and shelter-in-place plan. Such exercises also involved calls to the National Response Center (NRC), the State, and the local LEPC. All being first informed that "This is a drill not a real emergency".

The somewhat complex exercises don't take much time to coordinate, but you do have to find a time and date that works best for all involved (Facility and Fire Department).

A very complex exercise would involve multiple groups outside of the facility. Such emergency exercises are typically "mass casualty incidents" or "MCI's". In these exercises there are multiple victims so that the multiple groups of responders can be actively involved, testing and practicing their own responses. These events take time to organize and develop, usually many months.  Such exercises might involve the Fire Department, Law Enforcement (State Patrol, Sheriff, Police), Ambulance Service (land and air), Hospital(s), State Hazardous Response Team, State Emergency Management, Media, Local Emergency Planning Committee, Public Works, Department of Transportation, etc. All of these groups are very professional, knowledgeable, and experienced in what they do.

If you have ever heard of the saying, "herding cats", you will have an idea of the effort needed to put a very complex emergency exercise together. The challenge with such large events is how beneficial this field exercise will be for facilities personnel. To determine that you must be involved and participate in the entire development process for the event. If you are not, you could be side-lined to a lesser involvement than you planned, still this will be a learning experience.

The lesson learned is, you should do exercises, table-top and field, and you should coordinate with your local groups. Doing the exercises on a regular basis, at least annually, will have your team much more prepared for when an emergency happens, and it will happen.

Coordinating with your local groups who would be involved in emergencies will prepare you to better understand what your various local groups can do, who they are, and how you might be able to work with them.  If you practice and coordinate, do pre-emergency planning and training, the result will be knowing you were much better prepared to do the best you can.

# Cyrus Shank

# QUICK RELEASE MANIFOLD

## Taking the Next Major Step in Technology

**More Dependable**

**Quicker Installation**

**Less Maintenance**

**All of Your Manifold & Relief Valve Components in**

# ONE COMPLETE INTEGRATION

*Cyrus Shank* *331.212.5488* *Info@CyrusShank.com* *www.CyrusShank.com*

# Regulatory Reforms Advance in Canada and U.S.

## iiar government RELATIONS

BY LOWELL RANDEL, IIAR GOVERNMENT RELATIONS DIRECTOR

Regulations are a major consideration for the industrial refrigeration industry in the United States, Canada and many other countries. IIAR has long worked to improve the regulatory climate in the U.S. and is now working to broaden its influence across the globe. In some cases, this takes the form of promoting IIAR standards in countries that do not have well established regulatory schemes. In other cases, IIAR is working to advance regulatory reforms to reduce regulatory burdens while maintaining safety.

Recent developments in Ontario, Canada and the U.S. highlight examples of how IIAR is working to address regulations impacting the industry.

**TSSA is now in the process of implementing the operating engineers components of the legislation. Since passage, industry has held multiple meetings with TSSA to discuss implementation**

### TSSA IMPLEMENTING REGULATORY REFORMS IN ONTARIO, CANADA

IIAR has been working closely with the Global Cold Chain Alliance over the last few years to reform an outdated regulation impacting facilities in Ontario, Canada. In 2015, industry representatives initiated meetings with the Technical Standards and Safety Authority (TSSA) to discuss Ontario regulations related to attendance requirements for operating engineers. Under long-standing Ontario policy, facilities have been required to provide operating engineers on a continuous (24/7) basis based solely on the horsepower present at the facility. Industry explained to TSSA that the prescriptive nature of this policy has not kept up with advancements in technology and increasingly safer systems and procedures. TSSA acknowledged that the policy was very prescriptive and that a review of the regulation was warranted.

As a result of the industry bringing these issues forward, TSSA commissioned a study to examine the Ontario policy, along with the approaches from other jurisdictions in Canada and North America. At the completion of the study, it was determined that further action should be taken. A task force was formed with representatives from the various industries and sectors impacted by the policy. This group met on numerous occasions and ultimately arrived at a consensus that an alternative approach was needed for the operating engineers regulation. The task force named this alternative "Path 2", which would provide a framework by which facilities could develop their own performance-based risk and safety management plans based on the specific needs of their individual facilities. A technical committee was then formed to take a deeper look at how a Path 2 process could work. IIAR Board member Dave Malinauskas participated was a member of the technical committee and played an important role in the committee's work. At the end of the process, the TSSA and the Ontario Ministry of Government and Consumer Services concurred that the old operating engineers policy was too prescriptive, not risk-based and exacerbates the shortage of qualified operating engineers.

These concepts were then taken up by the Ontario Parliament through Bill 66, Restoring Ontario's Competitiveness Act, 2019. This legislation is broader than just the operating engineers policy and was designed to improve the climate for businesses in the province. Bill 66 was approved by the Ontario Parliament and received Royal Assent during the summer of 2019.

TSSA is now in the process of implementing the operating engineers components of the legislation. Since passage, industry has held multiple meetings with TSSA to discuss implementation. TSSA has stated that the goals of the new regulation are to:

- Enhance safety
- Reduce regulatory burden
- Drive innovation
- Improve compliance
- Address labor shortage

The new policy is broken down into two paths. Path 1 is a modified version of the current policy that prescribes attendance requirements based on horsepower and some additional factors. Facilities will receive a score that determines what class of facility they will be assigned and the corresponding attendance requirement.

Path 2 provides a more flexible approach that is based on site-specific risks and how a facility plans to mitigate such risks through the development of a Risk and Safety Management Plan. Plans would be developed by facilities and submitted to TSSA for approval. If the plan is approved, the facility will be registered and receive periodic audits to ensure that the facility is following the plan that was submitted.

TSSA is intending to base the Risk and Safety Management Plans on the Chemical Industry Association of Canada's Process Safety Management Standard (CSA Z767-17). This approach is similar to Process Safety Management in the United States. Companies with facilities in Ontario considering the Path 2 approach are encouraged to review CSA Z767-17. The IIAR PSM/RMP Manual can be a useful resource to assist facilities in developing Risk and Safety Management Plans and complying with the new program. TSSA will also be developing guidelines to assist facilities in their evaluation of the Path 2 approach.

TSSA has indicated that they intend to have draft guidelines for Path 2 completed by the end of 2019 and offer a consultation period for industry in early 2020. The feedback received from stakeholder consultation will be incorporated into the draft guidelines and a final draft is expected to be available by spring 2020. IIAR and GCCA will continue to actively engage with TSSA as the implementation process moves forward.

### RMP RECONSIDERATION RULE NEARS COMPLETION

While Ontario moves forward with changing regulations related to operating engineers, the U.S. EPA is inching closer to completion of changes to the Risk Management Program regulation. One of the last regulations finalized at the end of the Obama Administration was a rule that amended the RMP program and added requirements to regulated facilities. Shortly after taking office, the Trump Administration issued a series of delays to the effective date of the RMP amendments and began the process of rulemaking to reconsider the changes made by the Obama Administration. The so-called "Reconsideration Rule" would rescind problematic provisions included in the amendments rule, included the removal of provisions related to third party audits, root cause analysis, information sharing and safer technology analysis.

The Proposed Rule was published in May 2018. IIAR gave oral comments supporting the reconsideration rule at an EPA public meeting and, along with a coalition of industry partners, submitted written comments supporting the rulemaking. EPA has since been working to evaluate public comments and finalize the rule. In September 2019, EPA submitted the Final Rule for review by the White House Office of Management and Budget (OMB). This is one of the last steps before a rule can be finalized. OMB review can generally last up to 90 days. It is expected that the final reconsideration rule will be issued in late 2019 or early 2020.

IIAR joined like-minded partners in meeting with OMB to stress the importance of finalizing the regulation and rescinding problematic provisions. IIAR emphasized its concerns with the Obama era policy regarding independent third-party audits and the need for clarity as the compliance dates are fast approaching. IIAR will continue to work with EPA, OMB and partners to advance the interests of the industrial refrigeration industry as the RMP regulations evolve.

# Developing and Implementing Effective Ammonia Refrigeration System Operating Procedures

**Michael Keller, CIRO**
**PSM Compliance Specialist, Bassett Mechanical**

**ABSTRACT**

This paper provides guidance on developing and implementing operating procedures for ammonia refrigeration systems. The regulatory information is based on the U.S. Occupational Safety and Health Administration (OSHA) Process Safety Management (29CFR1910.119) standard (1992), the Environmental Protection Agency (EPA) Chemical Accident Prevention Provisions' (40 CFR part 68) Risk Management PlanRule(1996), and the IIAR standards for Developing Operating Procedures for Closed-Circuit Ammonia Refrigeration Systems (ANSI/IIAR7-2013). Other focus areas include a step-by-step guide and recommendations for effective technical writing, training, and various related topics.

## INTRODUCTION TO OPERATING PROCEDURES

Written operating procedures are necessary to ensure the ammonia refrigeration system operates within its design parameters and to minimize the possibility of an unplanned, unintended ammonia release. OSHA recognizes this necessity by making operating procedures a requirement of the process safety management (PSM) program.

The first part of 29 CFR 1910.119(f)(1) (OSHA 1992) states [author's emphasis] "The employer shall develop and implement written operating procedures that provideclear instructions for safely conducting activities involved in each covered process."

The purpose is "safely conducting activities" on the covered process, that is, the ammonia refrigeration system. The goal has been and always will be safety. While compliance with OSHA and EPA requirements is important, the true objective is the safety of employees and the welfare of the public. All other positive outcomes are the result of achieving the primary goal of safety. Costly OSHA and EPA citations are prevented. Equipment is undamaged. Significant periods of downtime are averted.

The environment is protected from toxic contamination. Significant financial loss due to contaminated food products is avoided. Customers are happy. Consumers are happy. Trust in the company is preserved, and the public image of the company's good name is protected.

There are several other good reasons for developing and implementing written procedures for operating the ammonia refrigeration system. Operating procedures help ensure consistency among operators and shifts. Everyone operates the equipment in the same way using the same parameters. Unsafe conditions created by operators taking shortcuts are prevented, and the operator who attempts a better, faster, and easier way can be held accountable.

Written operating procedures help to preserve continuity through the revolving door of operators and technicians. As operators come and go, the way the equipment is operated often gradually shifts. Subtle changes in procedures pass from operator to operator. The procedures and operating conditions of today look nothing like they did when the equipment was first commissioned. The changes become normalized over time and often result in the equipment being operated outside its intended design operating conditions.

Written operating procedures save time and money. Operators do not have torely on the supervisor or other operators when they are unsure about a particular

procedure. Step-by-step procedures provide operators a defined path for completing their task and gives them confidence knowing they are performing the procedure correctly and safely.

Written operating procedures are also useful for training new operators. The

IIAR's "Process Safety Management & Risk Management Program Guidelines" (2012) states that written procedures should be the "primary training tool" for operator training. When training new operators, the procedures should be used to help ensure important details are not missed and to verify that the operator understood the training.

## FEATURES OF AN EFFECTIVE OPERATING PROCEDURE

An effective operating procedure should provide enough information to allow a trained operator to control the operation of the refrigeration system and its equipment successfully and safely. It should detail the action steps required to start and stop the system and its equipment. The procedure should provide normal operating parameters and designed maximum allowable limits to minimize the possibility of a catastrophic incident caused by operator error.

Written operating procedures aim to provide well-defined and detailed instructions for operating the refrigeration system. They should be written such that operators can easily understand them at their reading level. The operators are the target audience, and the writer needs to consider their backgrounds and levels of education. English may not be the operator's primary language. Procedures should be written to meet everyone's needs, even if that means translating the procedures into another language.

Written procedures should use terms and titles used at the facility and known by the operators. If the high-temperature vessel is called an accumulator, it should not be referred to as a receiver. If the main electrical room is called the MCC Room, it should not be referred to as the Main Electrical Panel Control Room. To avoid confusion, refer to equipment by its known designations.

Written operating procedures should be equipment specific. They should be more than general operating guidelines for various equipment types. Procedures should provide action steps that are specific to the equipment being operated yet written to be both comprehensive and concise. To be effective, written procedures should be detailed enough to ensure all the necessary information for completing the tasks is included but written briefly and succinctly.

Finally, written operating procedures should be accurate, reliable, and in agreement with the manufacturer's recommendations. When changes are made to equipment, processes, and operations, the procedures should be updated accordingly and reflect current operating conditions at the facility.

## OSHA REQUIREMENTS FOR DEVELOPING WRITTEN OPERATING PROCEDURES

This section covers both the OSHA PSM standard (1992) and the EPA risk management plan (RMP) rules (1996). In November of 1990, amendments to the Clean Air Act (originally 1963 and 1970) were enacted into law by Congress. These amendments required OSHA and EPA to develop standards for chemical process safety to protect workers, the public, and the environment from accidental releases of highly hazardous chemicals. In reality, OSHA had already published the initial draft of Process Safety Management of Highly Hazardous Chemicals in the federal register and started the public review process six months prior. The final version of the standard was adopted in February of 1992. The EPA published its final version of the rule, the Accidental Release Prevention Requirements: Risk Management Programs (RMP) in June of 1996. The language of the prevention program section is nearly identical to OSHA's PSM program.

## UNDERSTANDING PERFORMANCE-BASED STANDARDS

Some OSHA standards provide very specific instructions on what is required. For example, standard railings for floor and wall openings must be constructed so that the vertical railing is 42 in. high and includes an intermediate rail halfway up. The PSM standard, however, is a "performance-based" standard. When OSHA creates a performance-based standard, it states "what" must be performed, but does not dictate "how" to perform it. For instance, in the training element of the PSM standard, OSHA requires that the means used to verify that an employee understood the training are documented. But it does not dictate the method of verification, whether it is a written test, through demonstration, a verbal exchange, and so forth.

As a performance-based standard, PSM requirements are written to achieve a specific objective. Emphasis is placed on the desired outcome. The desired outcome in this case is to ensure the refrigeration system is operated safely and prevent catastrophic incidents. Making the standard performance based means that companies have

the flexibility to tailor their programs to the facility's and employees' needs. The challenge for companies is deciding at what point their program complies with the regulation and whether OSHA will agree.

In June of 2017, OSHA gave an update on its National Emphasis Programs (NEP) from 2014 to 2016, noting that 66% of all general industry violations from NEP inspections during that period were related to the PSM program. Of the 14 PSM program elements, violations related to operating procedures were the fourth leading cause of citations at 13.5% (OSHA 2017). It is important that written operating procedures are in place, that they contain accurate and complete information, and that operators are trained to perform the procedures as written.

## DIAGNOSING THE STANDARD

The operating procedures requirement of the PSM program is the fourth of 14 elements included within the program—-after the employee participation, process safety information, and process hazard analysis sections, which may or may not be by design. Regardless, the three previous sections should play an intricate role in the proper development of the written operating procedures.

The employee participation element requires that employees are consulted on the "conduct and development of process hazards analyses and on the development of the other elements of process safety management in this standard" (OSHA 1992; 1910.119(c)(2)). This includes the operating procedures element of the standard.

Consulting the workers makes sense. The operators interact with the equipment every day and can be the best resource for understanding how it operates. Even during new system startups, employees can provide feedback on the standard operating procedure (SOP) format and how to make them easier to understand and follow.

The process safety information (PSI) element is the single most important element when developing operating procedures. This information is the foundation for developing operating procedures, and they cannot be completed without it. For instance, an accurate set of piping and instrumentation diagrams (P&IDs) is necessary for identifying valve positions during normal operations and shutdowns.

Health hazards identified in the PSI section should be referenced and included within the operating procedures. Safety systems and their function, safe lower and upper operating limits, the consequences of deviation, and the steps needed to correct or avoid them are all associated with both elements of the PSM program. Therefore, ensuring all necessary information has been compiled and is ready for quick reference is required.

The process hazard analysis (PHA) also has an important role in developingwritten operating procedures. The PHA is used to identify hazards and potential failures within the ammonia refrigeration process. Some hazards are mitigated by engineering controls designed into the system. The high-level float switch on a low- pressure receiver is a good example. Other hazards are controlled administratively through the use of specific operating procedures. For instance, hazards associated with opening the system are addressed through the use of a line break procedure.

The PHA generates a list of operating procedures that should be written to address specific hazards.

The operating procedures section 1910.119(f) (OSHA 1992) is divided into four subparagraphs:

1) Development and Implementation (f)(1);

2) Accessibility (f)(2);

3) Review, changes, and certification (f)(3); and

4) Safe work practices (f)(4).

## DEVELOPING AND IMPLEMENTING

OSHA (1992) begins the operating procedures paragraph section by stating the following:

"The employer shall develop and implement written operating procedures that provide clear instructions for safely conducting activities involved in each covered process consistent with the process safety information and shall address at least the following elements." 29 CFR 1910.119(f)(1)

The employer is responsible for developing and implementing written operating procedures. Providing verbal instructions is insufficient. The procedures must be written and implemented as part of the process operation. Two things should be addressed when developing written operating procedures: clarity and consistency.

First, written operating procedures should provide "clear instructions" to ensure the ammonia refrigeration system is operated safely. As discussed previously, the procedures should be easily understood by the operators. They should provide specific instructions for operating the system and its individual components.

Second, the written procedures must be consistent with or in agreement with the PSI. This is one reason why the PSI needs to be complete and accurate. This cannot be overstated. Developing written procedures and then realizing the P&IDs are inaccurate is a costly mistake.

The standard requires the following elements to be addressed within the operating procedures:

1) Steps for each operating phase,

2) Operating limits,

3) Safety and health considerations, and

4) Safety systems and their functions.

## STEPS FOR EACH OPERATING PHASE

The standard provides a list of operating phases, which is generally considered the minimum number of procedures required. These operating phases include

- Initial startup;
- Normal operations;
- Temporary operations;
- Emergency shutdown, including the conditions under which emergency shutdown is required and the assignment of shutdown responsibility to qualified operators to ensure that emergency shutdown is executed in a safe and timely manner;
- Emergency operations;
- Normal shutdown; and,
- Startup following a turnaround, or after an emergency shutdown.

OSHA does not define the individual operating phases because the standard is performance based, allowing companies to have the flexibility to define operating phases to meet their needs. The EPA booklet "General Guidance on Risk Management Programs for Chemical Accident Prevention (40 CFR PART 68)" (2009) provides

some guidance and insight into the various phase elements. But this is a guidance document only and should not be considered legally binding. The following are brief descriptions of each operating phase:

Initial startup refers to the steps required to verify the equipment is ready for startup and the actions to start the equipment are performed. This step may include visual inspections, pressure tests and evacuation, electrical system checks, and programming setpoints. Once the equipment is prepared, the procedure should include the necessary steps to start the equipment, such as leak checks, valve positioning, startup, verification, and so on.

Normal operations refers to actions taken while operating the equipment under normal conditions. This step may include procedures to ensure the equipment is operating within its normal design parameters, such as making visual inspections and completing the operating logs.

Temporary operations refers to actions taken to operate the refrigeration system when it is operating outside normal operation. For example, during off production hours cross-over valves are opened to equalize pressure among systems. In this case, the procedure should include steps taken to ensure changes to the system are performed safely and adequately.

Emergency shutdown refers to actions taken to shut down the system and equipment when an emergency upset occurs. This procedure must define when an emergency shutdown is required and who is both qualified and responsible for performing the emergency shutdown.

Emergency operations refers to actions taken to continue operating the system during an emergency. If the plant is not operated during an emergency, this procedure would not apply.

Normal shutdown refers to actions taken to stop equipment under normal circumstances, which could be as simple as pushing a button and verifying system conditions.

Startup following a turnaround, or after an emergency shutdown refers to actions taken to restart the system after a significant shutdown has occurred, such as after an emergency or an extended period of maintenance. Referring to the initial startup procedure is not uncommon, as many of the steps follow the same sequence.

The EPA guidance document (2009) stresses an important point. Companies should not "spend any time on" procedures for operating phases not applicable to their system or equipment.

## OPERATING LIMITS

Operating procedures must include the operating limits of the equipment. This could include normal operating limits and maximum allowable limits. Normal operating limits usually refer to the operating limits based on the operational needs of the facility and product. Maximum allowable limits, however, refer to the safe operation of the equipment, and operating outside of these limits will cause an unsafe condition.

The "consequences of deviation" and "steps required to correct or avoid deviation" must be included. The operator must be provided information on what specific dangers are posed when operating the system outside its acceptable operating limits. The steps needed to avoid the deviation and to bring the system back within acceptable limits must be included.

## SAFETY AND HEALTH CONSIDERATIONS

Under the procedure's safety and health section, operators must be provided information regarding ammonia's properties and health hazards. Some of this information can be easily obtained from the safety data sheet and process safety information. However, it must be provided within the operating procedures for quick and easy reference for the operator. The operator must be informed of precautions to prevent exposure and control measures if exposure does occur. Ammonia quality and inventory control measures should be specified, as well as any other hazards that may be unique to ammonia.

## SAFETY SYSTEMS AND THEIR FUNCTIONS

The operating procedures must include a list of all safety systems and their functions. This list could include ammonia detection systems, alarm and cutout functions, pressure relief systems, emergency shutdown systems, liquid control systems, ventilation controls, and so on. Information related to function may include the type of safety control, how it is activated, and its activation point if activated automatically.

## ACCESSIBILITY

The operating procedures must be made "readily accessible" to the employees. How this is accomplished is up to the employer. The procedures can be printed or made available electronically on a computer. Whichever way the procedures are made available, they should be available and easily obtained. Having a contingency plan is a good idea if the computer crashes or the paper copies are lost.

## REVIEW AND CERTIFICATION

Once the procedures are created, they must be maintained and kept current. There are two separate requirements. OSHA requires that the procedures are

- Reviewed as often as necessary to ensure that they reflect current operating practices, and
- Certified annually as being current and accurate.

The standard requires the procedures to be reviewed "as often as necessary" to ensure accuracy. This does not mean written procedures need to be reviewed annually. As often as necessary may only require the procedures to be updated during a management of change procedure. In a letter of interpretation dated March 9, 1994, OSHA states, "There is no requirement for an annual review" if an effective management of change system is in place ensuring that the procedures are updated when modifications to the system occur. However, this is a very big "if" for many companies, so a periodic review may be prudent and worth the effort.

Employers must certify annually that the procedures are current and accurate. The certifier should be someone who represents the employer, such as an engineering manager, a utilities supervisor, or similar. A formal certification document or some other method should be developed to show the procedures have been certified as being accurate.

## SAFE WORK PRACTICES

Finally, the OSHA PSM standard for operating procedures requires employers to "develop and implement safe work practices" to control hazards associated with operating and maintaining the ammonia refrigeration system. The list of safe work practices include

- Lockout/tagout,
- Confined space entry,
- Opening process equipment , and
- Control over entrance into the facility.

The safe work practices "shall apply to employees and contractor employees" who operate and maintain the system. The employer is responsible for ensuring that the procedures are being adhered to.

## IIAR REQUIREMENTS AS PROVIDED IN ANSI/IIAR 7-2013

Advocating for "the safe, reliable and efficient use of ammonia and other natural refrigerants," IIAR is tasked with developing consensus standards for the ammonia refrigeration industry. Consensus standards adopted by the industry may not reduce or detract from the minimum requirements set by OSHA and EPA. However, they may add additional requirements specific to the industry they represent. These additional requirements become industry standards adopted by regulatory agencies, and industries are held accountable for following them.

As of March 2019, IIAR is in the final stages of updating ANSI/IIAR 7-2013, "Developing Operating Procedures for Closed-Circuit Ammonia Refrigeration Systems." This standard follows many of the requirements of the OSHA PSM standard (1992). However, it includes some additional elements. This paper will focus on and attempt to highlight the additional requirements in the IIAR standard.

The IIAR standard is divided into four sections:

**Part 1—General** is the introductory section that presents the purpose and scope, definitions for terms, and reference standards.

**Part 2—Developing and Maintaining Operating Procedures** outlines general requirements that must be followed for developing and maintaining operating procedures.

**Part 3—Equipment** lists by equipment type items to consider when documenting operating procedures.

**Part 4—Appendices** is informative only and consists of explanatory material, operating procedure documentation, operating procedures for specialized equipment, and reference sources. It should not be considered part of the standard for compliance.

## IDENTIFYING PURPOSE AND SCOPE

The IIAR standard aims to provide minimum requirements for developing written operating procedures. It applies to facilities that utilize ammonia as the refrigerant in a "stationary closed-circuit refrigeration system." Its scope is "for those who develop, define, or review operating procedures," and all facilities with closed-circuit ammonia refrigeration systems "shall comply with" the requirements of the standard. Note that the standard applies to all systems matching these criteria, not just systems with 10,000 or more pounds of ammonia. Regardless of size and activity, the industry requirement is based on the type of system (stationary closed-circuit refrigeration) and refrigerant being used (ammonia).

Part 2, Chapter 4.1 reaffirms this requirement: "Written operating procedures shall be developed and implemented to provide clear instructions for safely conducting activities involving the closed-circuit ammonia refrigeration system."

## DIAGNOSING THE STANDARD

Part 2 of the IIAR 7-2013 provides requirements for general content that the operating procedure must include. The written procedures must address a minimum number of operating phases, referred to as "activities." These activities include initial startup, normal operations, temporary operation, normal shutdown, emergency shutdown, and emergency operations. One procedure is changed from "startup procedures following a turnaround" to "startup procedures following abnormal shutdown conditions or turnarounds" and specifies power failures and emergency shutdowns as examples.

Along with the operating phases already mentioned, the IIAR requires the procedures to be "customized to reflect the type and the style" of the equipment. Procedures for nonroutine tasks are also required and should be developed while planning the project or task. The miscellaneous topics section of this paper provides further discussion on procedures for nonroutine tasks.

The IIAR has identified the following six safety and regulatory concerns that must be considered and addressed within the SOP:

1) Personal protective equipment;
2) Buddy system (an additional item that is not in the PSM standard);
3) Lockout/tagout procedures;
4) Confined space entry procedures;
5) Equipment and piping opening procedures; and
6) Regulatory requirements, which indicate that the procedures must comply with regulatory requirements.

Chapter 5 of IIAR 7-2013 outlines requirements for maintaining the operating procedures. This chapter follows many of the same OSHA PSM requirements for accuracy and availability. The procedures must be reviewed and updated as needed when changes are made to the system. Operators and technicians must be able to "obtain current operating procedures quickly and easily" to do their job. The caveat is to ensure the operator has the most up-to-date and accurate procedure. The IIAR standard specifies, "The version of each operating procedure shall be documented so that changes made to the operating procedures can be clearly tracked" (IIAR 2013, 5.1).

A system must be in place to document the version of the procedure. This can be a revision date, a revision number, or any other method deemed appropriate. It is used to track changes made to the procedures and to help the operator ensure he or she has the most current procedure in hand when performing a task.

Part 3 of IIAR 7-2013 specifies items that "shall be considered" while writing the procedures. The requirements are separated by equipment type and operating phases. Many of the requirements are the same for the various equipment types. The following is a brief overview by operating phase.

Things to consider for Initial Startup Procedures include

- Appropriate conditions to ensure a safe startup;
- Corrective actions for conditions outside acceptable limits;
- Lockout/tagout procedures;
- State of the electrical disconnect;
- Position of isolation and service valves;
- Lubrication systems, if required;
- Alarm systems; and
- Steps to start or activate the equipment.

Things to consider for Normal Operating Procedures include verification that parameters are within expected operating ranges and troubleshooting as necessary.

Things to consider for Temporary Operating Procedures include

- Steps to consult supervisory personnel to establish temporary operating parameters,
- Steps to modify the equipment to operate under temporary parameters,
- Procedures to monitor the equipment while operating under temporary operating parameters, and
- Lockout/tagout procedures.

Things to consider for Normal Shutdown Procedures include

- Steps to stop the equipment, and
- Steps to prepare the equipment for stand-by operation.

Things to consider for Emergency Shutdown Procedures include

- Identification of the person responsible for emergency shutdown,
- Steps to stop the equipment,
- Steps to isolate the equipment from

the system and remove all sources of power,

- Notification procedures, and
- Steps to document the cause for an emergency shutdown.

Things to consider for Emergency Operating Procedures include steps to operate the equipment under emergency operations, for example, when the equipment is operating under conditions outside of expected operating limits.

Things to consider for Startup Procedures Following Abnormal Shutdown Conditions or a Turnaround include

- Appropriate practices if the equipment will be started;
- Appropriate conditions to ensure a safe startup;
- Corrective actions required if conditions are outside of expected operating limits;
- Lockout/tagout procedures;
- State of the electrical disconnect;
- Position of isolation and service valves;
- Lubrication systems, if required;
- Alarm systems; and
- Steps to start or activate the equipment.

Because there are multiple equipment-specific items to consider, those responsible for developing and updating operating procedures are highly recommended to obtain a copy and fully review the IIAR standard.

## DEVELOPING AND IMPLEMENTING

The process of developing and implementing written operating procedures is easier when broken down into steps. Planning is key to a successful and positive project outcome. Having the right information and determining who will be involved and how the work will be completed will help ensure that the project goes smoothly and is completed in a timely manner.

The following are steps for developing and implementing operating procedures:

1) Gather PSI,

2) Select a format,

3) Determine who should be involved,

4) Write the procedure(s),

5) Verify for accuracy,

6) Certify the procedure(s),

7) Implement and provide training, and

8) Hold people accountable.

## GATHER PSI

As stated previously, having accurate process safety information is critical. Take time to verify the PSI for accuracy. Specific PSI useful for developing the procedures include

- Safety data sheets;
- P&ID;
- Block flow diagrams;
- System design capacities and control parameters;
- U-1A forms for vessels;
- Equipment manufacturer data reports;
- Equipment installation, operating, and maintenance manuals; and
- Instrumentation and control system documentation.

## SELECT A FORMAT

When selecting a format first determine how the procedures will be kept and made available to the employees. If the procedures will be kept electronically and one of the multiple online PSM safety software programs used, formatting may be constrained by the software. If utilizing standard office software, more flexibility in formatting to meet the needs of the facility may be available.

Also important is considering what information will be included within the procedure. Operating procedures have morphed over time to include two major sections: the SOP and the technical operating specifications (TOS). The SOP section includes the steps for each operating phase, and the number of operating phases that will be needed for each piece of equipment should be considered.

The TOS section will include OSHA-required information, such as (1) operating limits, including the consequences of deviation and steps to correct or avoid deviation; (2) safety and health considerations; and (3) safety systems. Additional parts of the TOS section may include (4) objectives and purpose; (5) responsibilities; (6) equipment identification and design specifications; (7) function and operation; (8) department and location; (9) applicable safe work practices; and (10) a list of related reference documents, such as operator and maintenance manuals, P&IDs, lockout/tagout procedures, and so forth.

There are other things to consider as well. Determine how the revisions will be tracked. Will each procedure include its own revision table, or will a separate log be maintained? Will a copy of the equipment-specific P&ID be included? What other identifying information should be included, such as pictures, diagrams, tables, and so on?

Lastly, enlist the help of the operators. Ask them what would make the procedures easier to use and follow. Determine what would be useful and what they would consider unnecessary. Listen to their ideas and recommendations. Apply what makes sense. Not all recommendations need to be implemented, but getting the operators to participate in the process and feel fully vested in the final result is important.

## DETERMINE WHO TO INVOLVE

The situation may largely determine who to involve in writing the procedures. If the facility has been in operation for several years, enlist the help of the experienced operators. They know the system and understand its operation. If the facility is new, the writing may be left to the engineering management team. If the business is a corporation with multiple facilities, assistance may be obtained from experienced operators at other facilities. The design contractor, installing contractor, or an experienced PSM consulting firm may also be hired. In this situation, ensure that the procedures will be provided in both hard copy and in an electronic format that can be edited. Otherwise, modifying the procedures when changes to the system and/or operation occur will be harder.

## WRITE THE PROCEDURE(S)

In some situations procedures from another facility can be useful for creating new operating procedures. But in most instances they cannot be adopted outright. The procedures must be tailored to the operational requirements of the specific equipment and facility.

### VERIFY FOR ACCURACY

Test the procedure. Have someone watch an operator perform the procedure to ensure it is effective. Steps may be missing, and/or steps may not be needed. If so, change the procedure and retest it. Use multiple people throughout the process to provide varying perspectives. Ensure all information necessary to perform the procedure safely and effectively is included.

### CERTIFY THE PROCEDURE(S)

Whoever is identified as the employer's certifying official should be involved in the verification process. The certifier should formally certify the procedures once they are finalized.

### IMPLEMENT AND PROVIDE TRAINING

Writing the procedures is not enough. The procedures must be implemented, meaning used and followed as part of the facility's normal operation. Operators need to be trained to follow them as written. Specific information on training requirements can be found in the training requirements section later in this paper.

### HOLD PEOPLE ACCOUNTABLE

Finally, operators need to be held accountable to ensure they are performing the written procedures correctly. Operators who deviate from completing the procedures as written need to be counseled and disciplined if necessary.

### A BRIEF DISCUSSION OF TECHNICAL WRITING

The following are 10 simple principles for clear and concise technical writing.

#### Use Short Words

Avoid using capacious, incommodious, and ostentatious terminologies. When possible, use words no more than two to three syllables in length.

#### Use Short Sentences

Write one sentence per action step. Avoid telling the operator to open the valve and start the compressor after checking the pressure and verifying sump water levels and making sure the condenser fans and pumps are operating properly.

#### Use the Active Voice

**Passive:** "The hand expansion valve needs to be set at the minimum position for liquid flow."

**Active:** "Set the liquid flow hand expansion valve to its minimum position."

#### Start Action Steps with Action Verbs

Starting action steps with action verbs helps to keep sentences shorter and easier to follow. Examples include "open the…," "check for…," "turn the…," "inspect for…," and so on.

Adding an action descriptor (adverb) is acceptable, for example, "slowly open the…," "carefully inspect for…," and so on.

#### Avoid Redundancy

Planning in advance before performing the procedure is important but overstated.

#### Avoid Things that Are Implied

You should avoid using the word "you" as you should know you are being told the specific steps to the procedure you are performing.

#### Substitute Wordy Phrases with Single Words

Using the word "always" as a substitute for "at all times" and "if" as a substitute for "in the event of" are good examples.

#### Be Specific

Statements such as "after a few minutes" and "when the pressure is lower" are vague and subjective. State the number of minutes and at what pressure.

#### Use Smart Formatting

- Simple fonts are easier to read than more complex fonts.
- If everything is in bold, then nothing stands out as bold.
- If everything is CAPITALIZED, people will think they are being yelled at.
- Horizontal bulleted items are more effective than long lists in paragraph form.
- Several short paragraphs with no space between them become one long paragraph that is overwhelming and unread.

#### Spell Check

Enough saed.

### TRAINING REQUIREMENTS

Training follows the operating procedures element. The training element has three requirements:

- Initial training,
- Refresher training, and
- Training documentation.

Employees must be trained in an "overview of the process" and the operating procedures they will be required to perform. The training must occur before the operator is required to perform the procedure. Emphasis must be placed on safety and health, emergency procedures, and applicable safe work practices. An exception exists for employees who are already involved with operating the process. The employer can document in writing that the operator has the necessary "knowledge, skills, and abilities" to operate the system safely. This is for initial training only.

The employer is required to consult with employees to determine the appropriate frequency of refresher training. Refresher training is required at a minimum every three years. However, training may be required more often to ensure that the "employee understands and adheres" to the requirements of the procedure.

As with all things OSHA related, training must be documented. Employers are required to determine whether the employee understood the training and document the method of verification, such as a written test, a verbal question and answer period, demonstration, and so forth. The documentation must include the employee's name and date of training. Contract employees should also receive documented training when they operate systems.

### MISCELLANEOUS TOPICS

#### State Requirements

Before developing and implementing operating procedures, verify whether your state has requirements in addition to those provided by OSHA and EPA. This may be especially relevant for states that operate under their own state plans for occupational safety and health. State plans must meet the minimum requirements of federal OSHA, but they may establish stricter regulations that the employer must follow.

#### Procedures for Nonroutine Tasks

Nonroutine tasks are an inevitable part of operating and maintaining an ammonia refrigeration system and include those activities that are not covered within the normal operating phases.

These could include changes in system components and equipment, modifications to piping configurations, additions of new equipment and systems, repairs to piping, procedures for maintenance and repairs, and so on.

Whenever these types of procedures are performed, potential for accidents and injuries increases. Performing nonroutine tasks is inherently dangerous for several reasons. For example, these tasks usually involve opening the system, and they are dangerous because they are nonroutine and as such are not performed often and may contain several unknowns. There are human factors to account for. Intentionally or unintentionally, people are prone to error. There are various levels of competency, training, and experience. Overconfidence, distractions, inattentiveness, fatigue, and forgetfulness can lead to oversights and miscalculations. Throw in the fact that several people may be involved, and the possibilities for an unplanned incident multiply.

For these reasons developing written procedures for performing nonroutine tasks is important. Nonroutine procedures should be developed in the same way and follow the same path as standard procedures. Gather the necessary process safety information. Select the format. Determine who will help. For example, difficult pumpouts involving multiple systems may require help from an outside contractor.

Write the procedure. Verify it for accuracy. Do a dry run. Walk the system to ensure nothing was missed. Look for potential hazards, and address all concerns. Certify the procedure as accurate. Written operating procedures for nonroutine tasks are necessary for the safety of employees and a successful project outcome.

### One Procedure for Multiple Equipment

A question frequently asked is, "Can like equipment be grouped into one procedure?" While the PSM standard (OSHA 1992) does not specifically address this question, OSHA does address a similar question in a letter of interpretation dated July 12, 2006. The context of the question is lockout/tagout procedures. The question asks if "generic procedures" that state "close the suction valve and discharge valve" are acceptable in lieu of actual valve numbers. OSHA provides the following response:

The lack of procedural clarity and specificity can result in employees failing to isolate the key valves, permitting exposure to the hazardous energy during the servicing or maintenance work. Simply listing valves by their functionality (such as suction valve, discharge valve, etc.) may lead to confusion and error with respect to those valves that must be closed to effectively isolate hazardous energy, due to inadequate employee direction.

While this does not answer the question directly, perspective on OSHA's view and the importance of providing procedures that are equipment specific can be inferred. Eliminate or at least minimize any possibility for operator confusion.

### Maintenance Procedure vs. Operating Procedure

Similar to operating procedures, the PSM program requires written maintenance procedures. Understanding their commonalities and differences is important. Like operating procedures, maintenance procedures must be written and implemented. Before operators are allowed to perform a maintenance procedure, they must be trained on an overview of the process and the specific procedure they will be required to perform. However, some differences include that maintenance procedures do not have to be certified annually. Furthermore, training is required only once, unlike operating procedures, which require training at a minimum every three years and more often if necessary. At the employer's discretion, operating procedure requirements may be adopted and used for maintenance procedures.

## SUMMARY

Operating procedures provide detailed instructions on how to operate the system and its equipment safely and efficiently. They ensure that systems are operated within the manufacturers' designed parameters and provide a systematic set of instructions for the operators to follow.

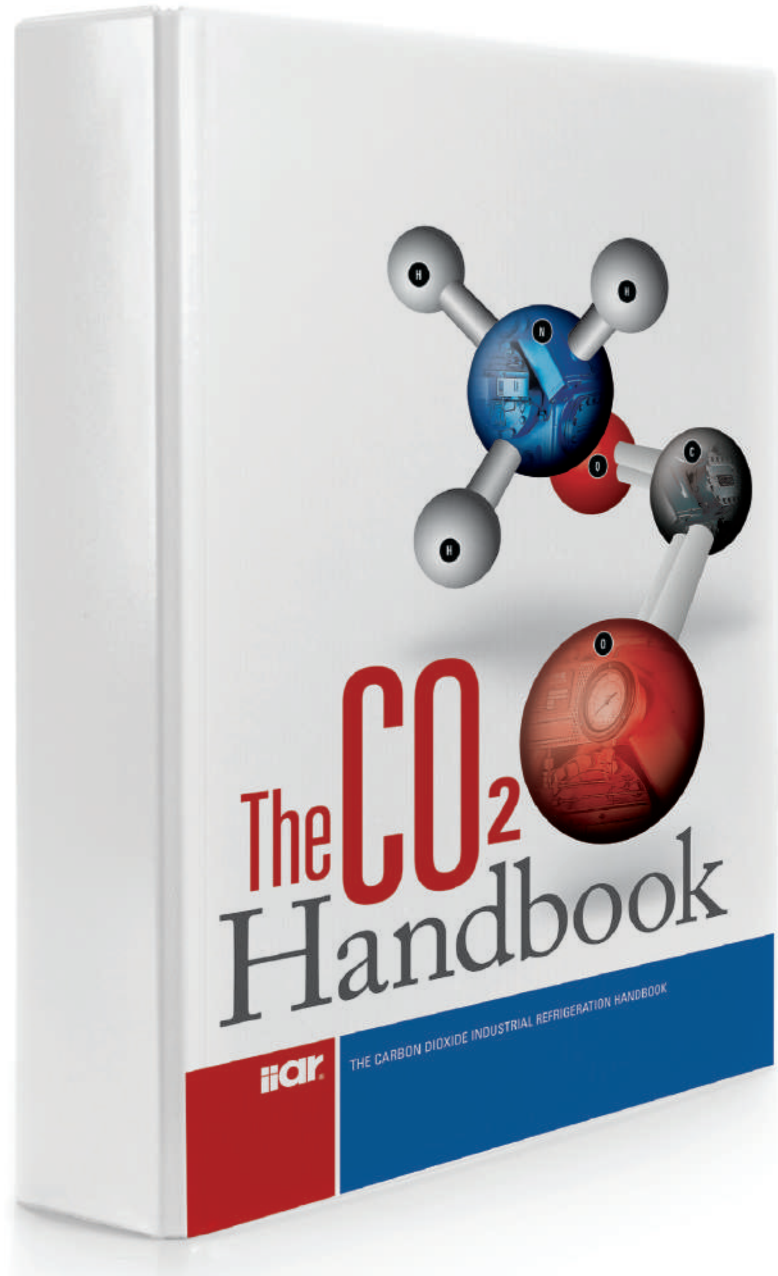
When developing and implementing operating procedures, consider the following questions:

- Do the procedures provide clear instructions?
- Are the procedures consistent with the available process safety information?
- Do the procedures cover all operating phases, including the minimum required?
- Are the procedures accurate and effective for the safe and efficient operation of the system and its components?
- Do the procedures meet applicable regulatory requirements?
- How will the procedures be used and followed?
- How will the procedures be kept current?

To be effective, operating procedures must be properly written, implemented, followed, and kept current. Written procedures not only satisfy regulatory compliance but provide a multitude of other benefits for the company and the operators

## REFERENCES


1. EPA (Environmental Protection Agency). (1996). "Chemical Accident Prevention Provisions (40 CFR Part 68)." Washington, D.C.: EPA.
2. EPA (Environmental Protection Agency). (2009). "General guidance on risk management programs for chemical accident prevention (40 CFR PART 68)." Washington, D.C.: EPA.
3. IIAR. (2013). "Developing operating procedures for closed-circuit ammonia refrigeration systems." ANSI/IIAR 7-2013. Alexandria, VA: IIAR.
4. IIAR. (2012). Process Safety Management & Risk Management Program Guidelines.Alexandria, VA: IIAR.
5. OSHA (Occupational Safety and Health Administration). (1994). "Highly Hazardous Chemicals as it applies to operating procedures and certify on an annual basis.– [1910.119]." Letter of interpretation, March 9. Washington, D.C.: OSHA.
6. OSHA (Occupational Safety and Health Administration). (2006). "PSM compliance for ammonia refrigeration systems.–[1910.38; 1910.119; 1910.119(d)(3)(i); 1910.119(d) (3)(ii); 1910.119(e)(3); 1910.119(j)(6)(i); 1910.119(j)(6)(ii); 1910.119(k)(2); 1910.119(l)(2)(i); 1910.119(l)(4); 1910.119(l)(5); 1910.119(m)(3); 1910.119(o)(1); 1910.120; 1910.134; 1910.147; 1910.147(c)(4)(ii)]." Letter of interpretation, July 12. Washington, D.C.: OSHA.
7. OSHA (Occupational Safety and Health Administration). (1992). "Process safety management of highly hazardous chemicals (29 CFR 1910.119)." Washington, D.C.: OSHA.
8. OSHA (Occupational Safety and Health Administration). (2017). U.S. Department of Labor-OSHA "CHEM NEP Update – Industry Outreach (presentation)." Washington, DC, June 7, 2017.


The $CO_2$ Handbook
iiar
THE CARBON DIOXIDE INDUSTRIAL REFRIGERATION HANDBOOK


RG-2400®
Corrosion is the enemy.
RG-2400 is the solution.
Industry leader offering proven products.
RG-2400 LT
ReactiveGel®
1 GALLON PAIL
(128 Fluid Ounces; 3.8 Liters)
Polyguard RG-2400 Corrosion Control Gel responds with elements of new and existing steel pipe to form an ultra-thin glasslike protective surface. This layer of protection will fight off everything nature throws at it.
Polyguard®
Innovation based. Employee owned. Expect more.
www.Polyguard.com
214-515-5000

# Industrial Refrigeration Solutions for a World of Applications

## Compressor packages, controls, chillers, and more

GEA's robust lineup of solutions features screw and reciprocating compressor packages spanning 60 to 6083 CFM, each paired with the industry-leading GEA Omni™ control panel. Our expertise also extends to chillers, custom-engineered systems, service support and training. Talk with us to learn why quality-driven contractors and end users worldwide choose GEA and how we can meet your process-critical cooling requirements.

**GEA North America: 717 767 6411 | sales.unitedstates@gea.com**

GEA engineering for a better world

**gea.com**