NORTH AMERICAN EDITION #5, APRIL 2015

ACCELERATE

ADVANCING HV MAGAZINE

US Cold Storage's CO_2 success proves skeptics wrong

Special

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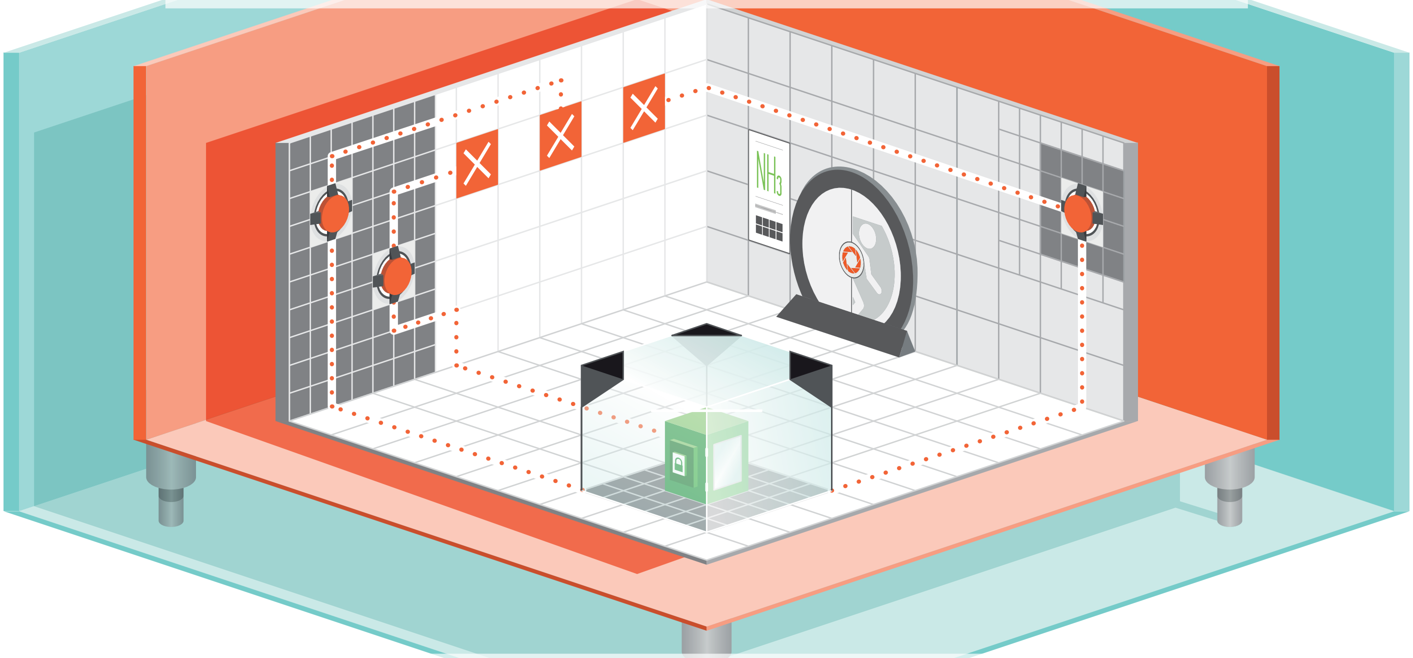
Editor's note by Michael Garry

Too much of a good thing



The world of natural refrigerants is a diverse one, spanning many business sectors that require low temperatures — and want an efficient and environmentally friendly way to achieve them.

In our first four issues, *Accelerate America* has devoted the bulk of its space to natural-refrigerant systems used by food retail and foodservice. In this issue we stick with the food theme but extend it to the industrial cold storage arena, where refrigeration is needed to process and store large volumes of foodstuff before it's sent out to stores or restaurants for consumption.

Unlike smaller refrigerated venues, the industrial sector has actually had a long history of using a natural refrigerant – ammonia, one of the most efficient and least costly refrigerants in the world, with zero impact on the ozone layer or global warming. Ammonia is so cheap that it has traditionally been used in massive quantities to achieve the very low temperatures often required by cold storage facilities.

But in this case there can be too much of a good thing. Yes, ammonia is naturally occurring and environmentally benign, but its odor is extremely pungent and it's toxic in certain quantities, which makes it highly regulated by all levels of government.

The tragic explosion at an ammonium nitrate plant in Texas two years ago has led to much greater scrutiny of ammonia refrigeration plants by the EPA and OSHA, and more penalties for end users. But this turn of events has opened up opportunities for equipment makers and end users to develop and use low-charge ammonia systems that dramatically cut the amount of ammonia, circumventing government inspections and creating a safer environment for employees and customers.

In this issue we give several examples of low-charge ammonia systems being deployed in North America. In our cover story, which begins on page 22, we describe how United States Cold Storage has been able to make an ammonia-carbon dioxide cascade system almost its go-to refrigeration technology over the past decade. Two other articles detail the inventive low-charge modular ammonia systems developed by Los Angeles Cold Storage (and marketed by NXTCOLD) and Azane, which is targeting smaller warehouses using R22 or HFCs.

Our overview of the IIAR Conference and Exhibition provides more examples of low-charge systems and components. And we have an in-depth interview with one of the world's leading experts on low-charge ammonia refrigeration, Professor Pega Hrnjak of the University of Illinois, who believes that low-charge ammonia will make its way into non-industrial applications.

Ammonia by itself, or in combination with CO_2, remains the de facto refrigerant for industrial applications. On the other hand, there are some examples of CO_2-only cold storage applications – such as the transcritical CO_2 systems used at the Plaisirs Gastronomiques warehouse near Montreal, as described on page 34.

What is striking about these changes is that they are happening in a sector – industrial refrigeration – that has been set in its ways for many decades. Yet the need for low-charge ammonia systems, in whatever form, is so profound that it is penetrating this very traditional marketplace.

But the same can be said for natural refrigerants in general -- they are changing the way the world creates cooling, slowly, but inexorably MG

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ADVANCING HVAC&R NATURALLY

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ABOUT ACCELERATE AMERICA

Brought to you by shecco america Inc., the worldwide experts in natural refrigerant news, *Accelerate America* is the first monthly news magazine written for and about the most progressive business leaders working with natural refrigerant solutions in all HVAC&R sectors.
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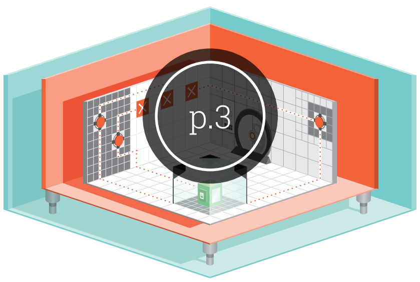
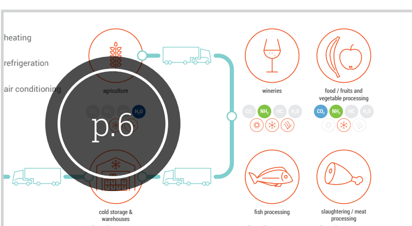
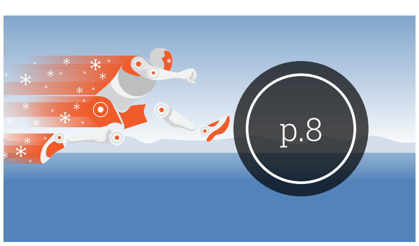
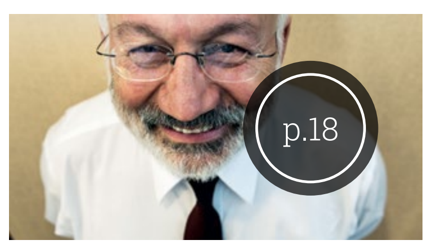


Mike Lynch from US Cold Storage







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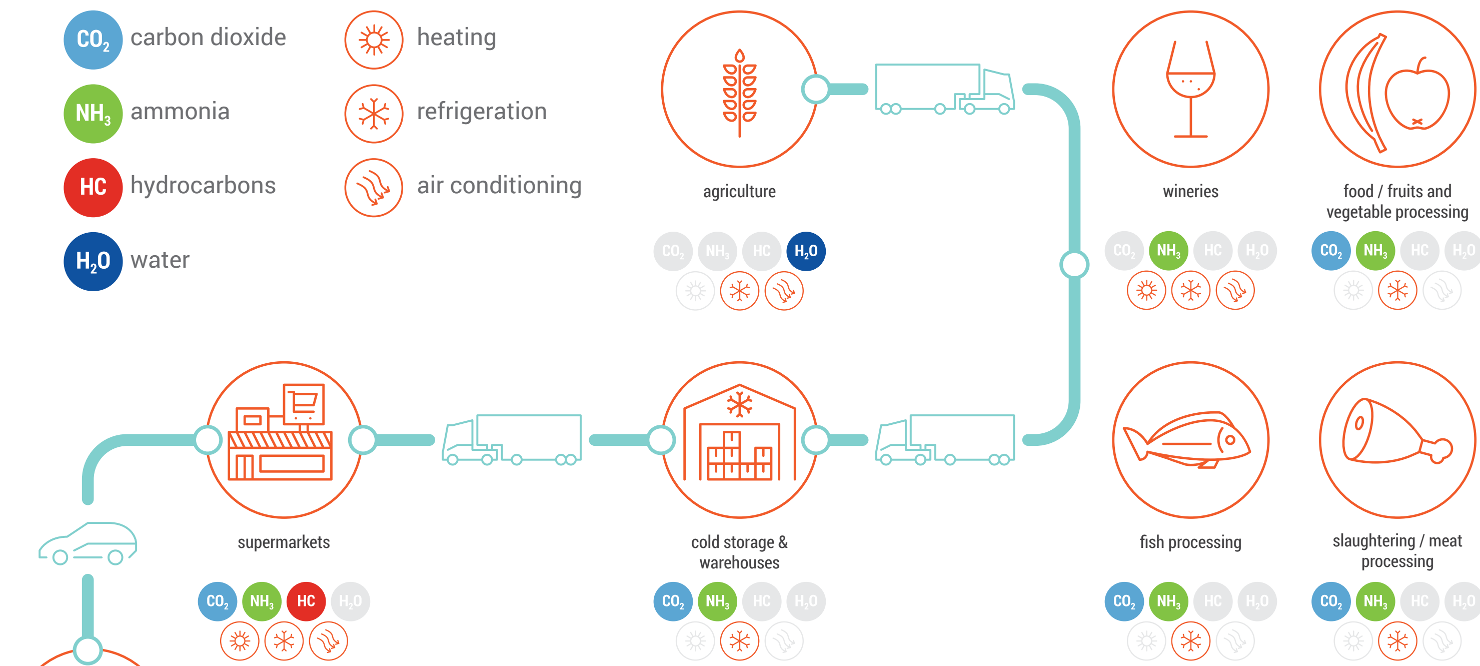
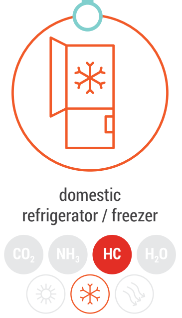




Editor's note by Jana Topley Lira

AMMONIA & BEYOND

Around the world industrial refrigeration is used in the dairy, meat, fisheries and other food industries to provide an unbroken and efficient cold chain from field to fork. The most successfully used refrigerant for these applications is ammonia, which is simply unsurpassed in terms of cost and efficiency.

In North America and Europe, ammonia represents around 90% of refrigerant market share in the food processing and cold storage sector. While the trend towards low charge ammonia systems and ammonia/CO_2 cascade systems is the focus of this issue of *Accelerate America*, the growing interest in CO_2, hydrocarbons and air within industrial refrigeration in Europe and Asia will no doubt also influence the North American industrial refrigeration market.

CO_2 systems, which can be used for industrial refrigeration applications with evaporation temperatures down to –52°C and condensing temperatures up to 5°C, are gaining interest for freezing ice cream, bread, fish, and meat. For example, a 220 kW transcritical CO_2 system with 150 kW of heat recovery and hot gas defrost can be found at an an ice cream plant in Norway.

Hydrocarbons, which can fit into any temperature range for evaporating temperatures down to –170°C, are finding their way into fruit-storage facilities. Although representing less than 5% of market share in Europe, and even less in North America, the first installation of a secondary refrigeration system using propylene (R1270) as the primary refrigerant in the U.S. has received positive reviews. Presented at last year's ATMOsphere America 2014, the installation at Auvil Fruit Co, Washington, features R290 and R1270 chillers and is reported to be simple and easy to operate, and require less maintenance than the previously installed NH_3 system. Before migrating to the U.S., these systems were originally installed in the U.K.

The Pascal Air System, developed by Mayekawa, and currently in operation at fish processing plants in Japan and South Korea, may also one day make its way to North America. Featured in a case study at ATMOsphere Asia 2015, three Pascal Air Units keep Sea Sky Global's 2,500 tons of raw tuna and processed products fresh at a state-of-the-art tuna processing plant located in Busan, South Korea.

Generally speaking, while ammonia refrigeration and ammonia/CO_2 cascade systems will continue to expand, we may soon see other natural refrigerants answering the demands of the North American supply chain with highly effective and efficient technology. Increasing regulations on fluorine and chlorine based refrigerants will certainly help to drive this change JTL

CLEARING THE COST HURDLE (PART 2)

Utility incentives can help supermarkets afford natural-refrigerant commercial systems, but first the challenge of determining their energy efficiency advantage has to be overcome

— By Keilly Witman

On January 8th of this year in Berkeley, CA, Hillphoenix, Emerson Climate Technologies, and AHT Cooling Systems USA brought together supermarket refrigeration executives and representatives from the nation's major utilities to discuss ways that utilities could help boost demand for energy-efficient natural refrigerant equipment.

After discussing energy incentives for self-contained refrigeration units that employ hydrocarbons (see Part 1 of this article, in the March issue of *Accelerate America*), the group turned its focus to incentives for supermarket refrigeration systems that use natural refrigerants.

The typical store-wide system uses about 3,000-4,000 pounds of HFC refrigerant, usually R404A, which pound-for-pound has a global warming impact that is almost 4,000 times worse than carbon dioxide's. Supermarkets leak on average about 25% of that refrigerant every year - about 750-1,000 pounds. To put the problem in perspective, that is about 4 million pounds of CO_2 -equivalent leaked every year by each supermarket, or 140 billion pounds leaked by the nation's 35,000 supermarkets. (That is ten zeroes after the number fourteen.) If you want to see how much that is in terms of number of cars on the road, go to the EPA's greenhouse gas calculator at http://www.epa.gov/cleanenergy/energy-resources/calculator.html. It's a nifty little tool that helps us regular people understand the effect of different greenhouse gas emissions relative to each other.

To be clear though, most utilities don't care one iota about the direct emissions from refrigerant leaks. In fact, many utility regulatory bodies don't allow their utilities to look at greenhouse gas emissions. All that matters to most utilities across the country is energy use.

Though many utilities advertise their incentive programs under the auspices of energy efficiency and the corresponding environmental benefits, incentives are a pure cost-benefit calculation for utilities. It is cheaper for utilities to pay people and businesses to use less energy than it is to build a new power plant. Period.

So in order to interest utilities in natural refrigerants, you have to come to them with an energy efficiency argument. As discussed in last month's article, this argument is a no-brainer when it comes to self-contained equipment. The argument for energy savings with natural-refrigerant systems is equally compelling, but it is not a no-brainer.

The amount of energy saved by a store-wide system depends greatly on the type of technology and natural refrigerant used, as well as the average ambient temperature where a store is located. Add to that the fact that every supermarket refrigeration system is individually designed and individually manufactured, and you have the opposite of a no-brainer. Perhaps we should say that it is a "whole brainer."

The crux of the complexity in determining how much energy a new natural refrigerant supermarket system is going to use lies both in the lack of actual energy data, because the energy consumption has to be estimated before the new store is built, and in the lack of some kind of a baseline against which you'd measure an energy efficiency improvement, because there is no useful national average for the energy usage of a supermarket.

Aaron Daly, Global Energy Coordinator at Whole Foods Market, cited the analogy of the electric car to describe the wholesale shift in approach necessary for natural refrigerants. "We aren't talking about a car that uses a more efficient gasoline engine; we are talking about a complete shift in the way we do things - an electric vehicle, if you will," said Daly.

In order for utilities to take advantage of the energy efficiency opportunities that will come from natural refrigerant systems, they'll need to change the way they do things to a certain extent. Instead of looking at individual components and adding up the energy savings that are achieved by each component, utilities will have to adopt a whole-system approach to energy savings.

Why should utilities get involved, if this is so complicated? Because the potential savings, ranging from 10% to 30%, are worth it (see chart on page 10.)

In other words, a utility can either try to get 33 homes to stop using electricity completely, or they can help a supermarket install a natural refrigerant system in a new store.

As stated in last month's article, the main thing that is preventing more supermarket companies from using natural refrigerants in new stores currently is the cost hurdle. Because there are only a few of these natural refrigerant systems in the U.S., equipment manufacturers cannot take advantage of economies of scale.

There just isn't enough of a market yet for manufacturers to start producing natural refrigerant components here in the U.S. According to Derek Gosselin, Product Manager, Systems Division for Hillphoenix, about 25-30% of the components for a CO_2 transcritical system are still imported from overseas.

Tristam Coffin, Energy & Maintenance Project Manager at Whole Foods Market, noted that the lack of trained service techs increases the installation and maintenance costs for natural refrigerant systems. "Many refrigeration contractors remain apprehensive about investing in the training of their techs, because the chances that they'll have the opportunity to work on a natural refrigerant system are still relatively small."

For all three of the Whole Foods Market transcritical systems installed in the last two years, Hillphoenix, the system manufacturer, had to take on the responsibility of training the installing/service contractors. In addition, said Coffin, "We received wildly different installation bids from the contractors, because the greater contractor pool simply doesn't have the experience upon which to base their estimates. Some price low to gain the experience, but the majority pad their pricing, because they are uncertain of what they are getting themselves into."

Luckily, utility incentives can be quite effective in counteracting the additional costs that often accompany new energy-efficient technologies. This inspires additional sales, which brings costs down, resulting in a virtuous cycle that culminates in the price of natural refrigerant technologies equaling or even beating that of conventional technologies.

Getting started

So how do we get this party started? Utilities and supermarkets agree on the essential factors in utility programs for natural refrigerant incentives: they have to be easy, transparent, and flexible.

Neither utilities nor supermarkets can afford to take part in a project that takes too much time and too many resources to be worth it. As Paul Anderson, Senior Group Manager of Target Corp. observed "The idea that a utility incentive project would take more time than it takes to actually build a new store is just unworkable for us."

Ideally, utilities' methodologies for natural refrigerant incentives would have enough in common across geographies to be somewhat replicable. However this is a challenging notion for individual utilities, which often don't care about any methodology but their own. But for supermarkets, which may deal with a different utility for every new store, having a methodology that crosses utility borders is essential.

"If we could get utilities to at least agree on a set of principles for how these projects would be handled, it would be enormously beneficial for us," said Harrison Horning, Director of Energy & Facilities at Delhaize America, which deals with dozens of utilities across the Northeast, the Mid-Atlantic, and the Southeast.

Transparency and flexibility, the other essential characteristics of natural-refrigerant utility incentive programs, might seem to be in opposition to each other, but both are essential for a successful program for supermarkets.

Mitch Knapke, Director of Food Retail at Emerson Climate Technologies, perhaps stated it best when he said, "Many people mistakenly believe that transparency means a lack of flexibility. I disagree. A transparent system can be highly flexible, as it would need to be in the case of utility incentives for natural refrigerant use in supermarket systems."

As stressed in the Berkeley workshop, a flexible and transparent model is needed to predict the energy consumption of a new store at the design phase, as well as a baseline against which the energy efficiency improvements would be compared.

With a multitude of models available on the market, the hard part isn't coming up with one. It is to get utilities and supermarkets to agree on which model to use. Every model has its flaws; but for utility incentive projects for new stores that will use natural refrigerants, there is no alternative but to rely on modeling when predicting the energy usage of a store that is yet to be built.

Most at the workshop agreed that the question of a baseline is the more complicated question. Once you have modeled the energy usage of a natural refrigerant system in a new store, what do you measure it against?

The choices are numerous. Do you measure the new store's energy consumption against a national average for all stores? The only thing that is certain about a national average is that it will likely be irrelevant for any one particular store. What about a regional average? That would be more relevant for a particular store in terms of the ambient air temperature in a region, but it probably won't correspond to the size or the

continued on p.10

cooling capacity of a particular store, and it might not have anything to do with the standard refrigeration technology used by a particular company. It wouldn't make sense to use a centralized DX system as a baseline for a company that hasn't built that type of system for over a decade.

A Flexible Approach

The consensus at the workshop seemed to be that an ideal baseline is whatever the company would have built in that spot instead of the natural refrigerant system. So for a company like Target, for instance, which said last year that its standard system for new stores will be a CO_2 cascade system, you'd use a CO_2 cascade system as the baseline.

Of course, the chances aren't high that Target has a store already in operation right down the block that can be used as the baseline. So even in a situation where a company has declared a standard technology, the baseline question still isn't easy to answer.

You could take actual numbers from a store that is close to the new site, and try to determine the extent to which energy usage would differ at the new store. You could take an average of the energy usage data from the company's existing stores in the region. You could also ask the company that is applying for the incentive to draw up a store plan for the technology that would have been used, if not for the natural refrigerant choice, and then model the energy consumption of that store. Many would see this as a useless exercise, but it might actually save a lot of time vs. some of the other baseline possibilities.

How to we get utilities to agree on one of these baseline methodologies? We don't. The purpose of the workshop was not to get everyone to agree on one universally acceptable methodology for every project. The purpose was to come up with a set of transparent methodologies affording the flexibility to pick the best for each individual project.

Perhaps with additional discussion, utilities and supermarkets can come up with a hierarchy of baseline methodologies. If a company has a standard methodology, with actual energy usage data from another nearby store that is relevant, use that as the baseline. If a company has a standard methodology, but does not have actual energy consumption data from an existing store close to the new store's location, use a regional average of several of the company's stores that are within a certain radius of the new store. If a company does not have a standard technology that would have been installed in the store under consideration, take the alternative store design that wasn't chosen, under the assumption that it would have been used but for the natural refrigerant technology chosen instead. And so on.

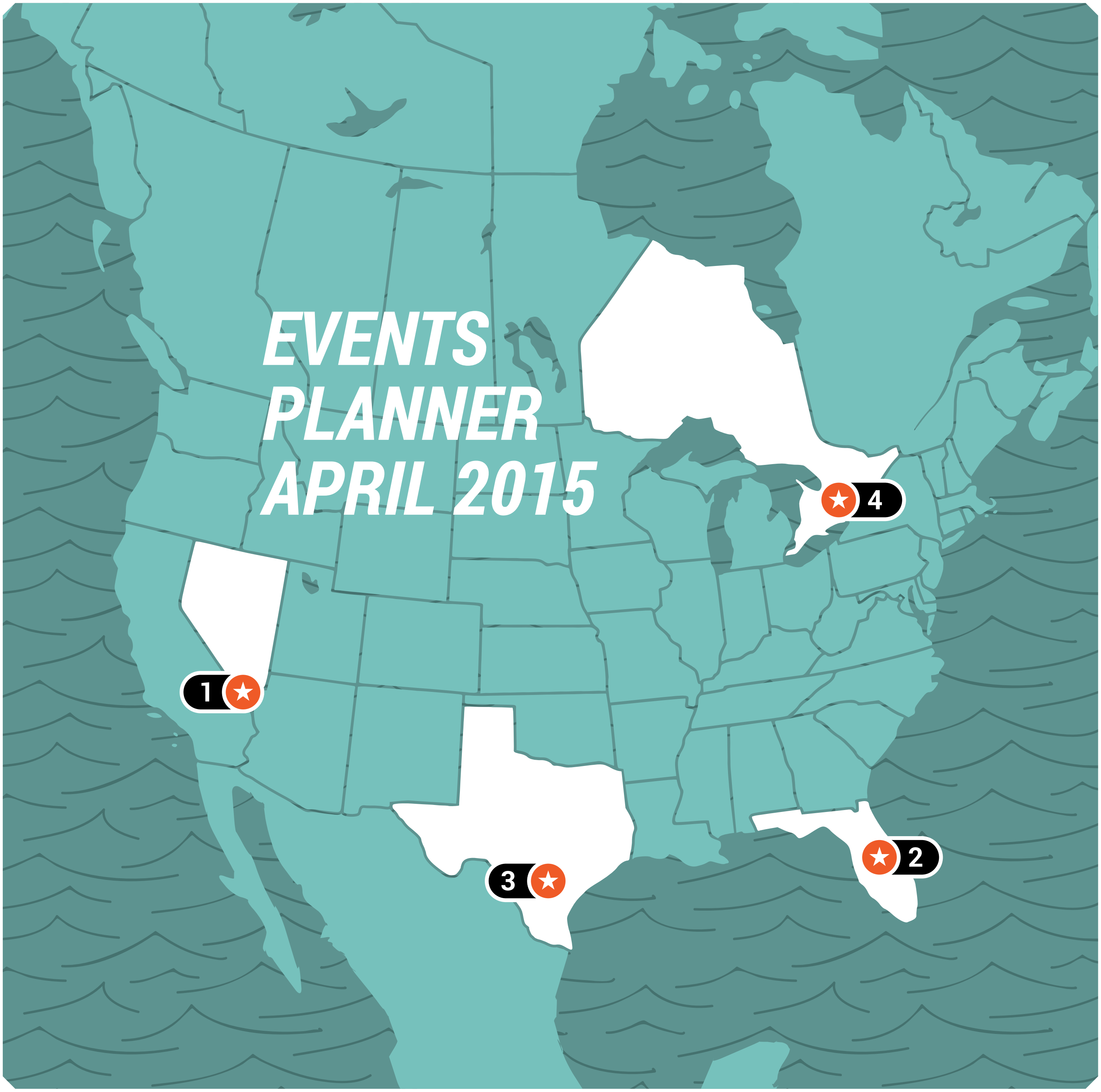
That might sound complicated and time consuming, but according to all participants in the workshop, it cannot possibly be as time consuming and complicated as starting anew, from scratch, for every new store, in every region, with each different utility. Nothing is worse than that KW

Potential electricity savings of a natural refrigerant system

Today's typical supermarket	
Average annual electricity usage per store* (kWh)	2,346,000
Percentage of total store electricity usage for refrigereation	50% (1,173,000kWh)

Potential electricity savings			
Percentage of average store energy usage	10%	20%	30%
Electricity savings in kWh	117,000	234,600	351,900
Equivalent homes electricity usage for one year**	11	22	33

* EPA's GreenChill Partnership: Average supermarket's greenhouse gas impacts -- refrigeration leaks compared to electricity consumption
**EPA's greenhouse gas equivalency calculator

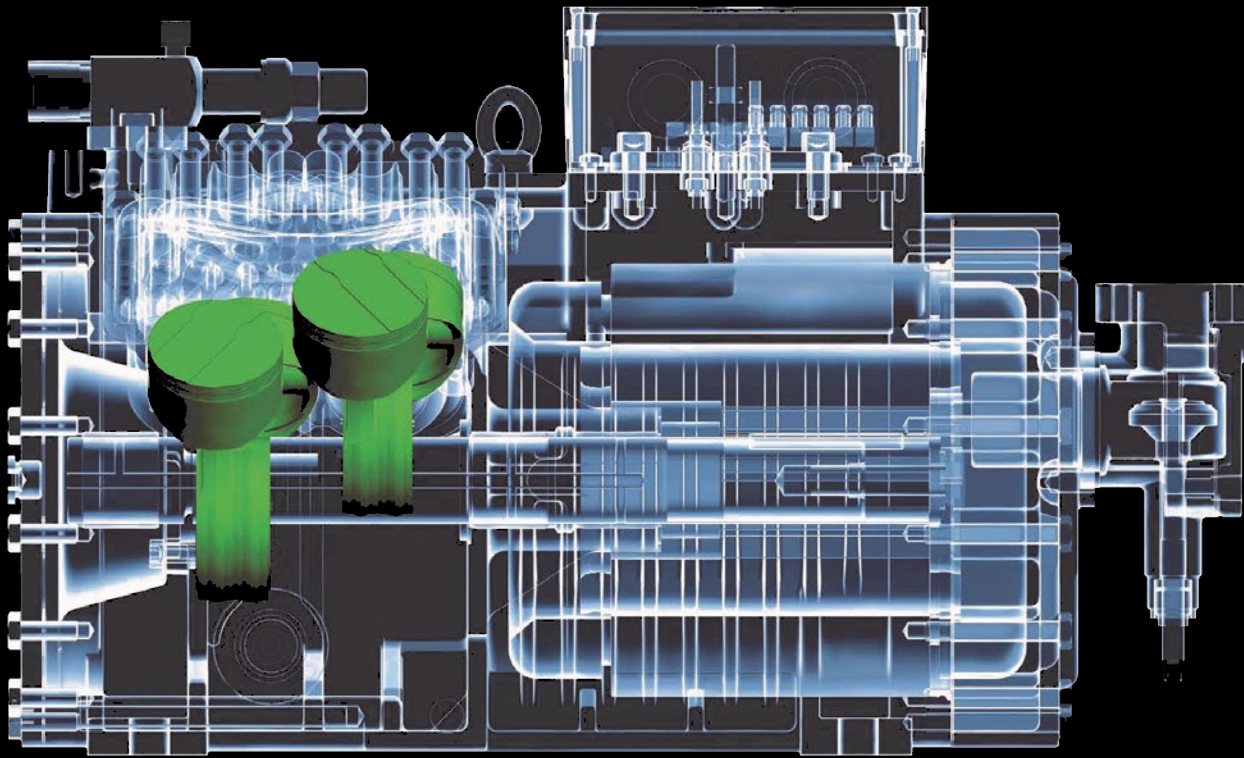


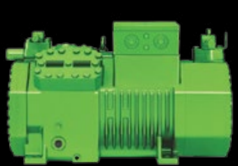
1 April 22 - 24 - Las Vegas, NV
2015 NAMA OneShow
http://www.namaoneshow.org/
twitter : @NAMAvending / #NAMAOneShow15

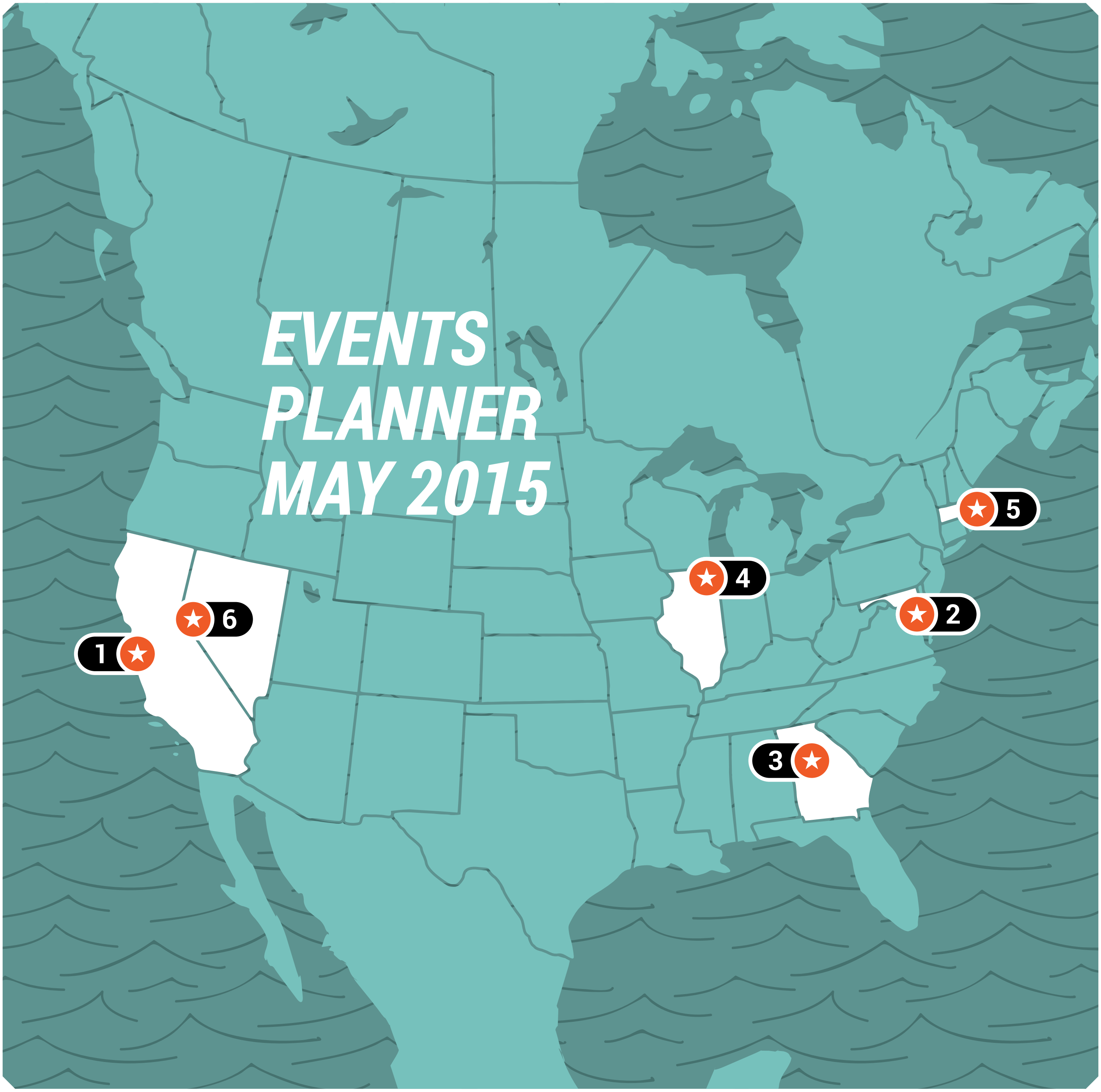
2 April 25 - 29 — Orlando, FL
124th IARW-WFLO Convention & Expo
http://www.gcca.org/124th-iarw-wflo-convention-expo/
twitter : @gccaorg / #IARW

3 April 26 - 29 — San Antonio, TX
BuildPoint 2015
http://www.buildpointevent.com/
twitter : @BuildPointEvent / #bp2014event

4 April 28 - 30 - Toronto, ON
SIAL Canada
http://www.sialcanada.com/sial/en/index.sn
twitter : @SIALCANADA / #SIAL2015







1
May 11-13 – Monterey, CA
PMA Tech Knowledge,
Produce Marketing Association
http://www.pma.com/events/tech-knowledge/program/educational-sessions
twitter : @pma / #TechKnowledge

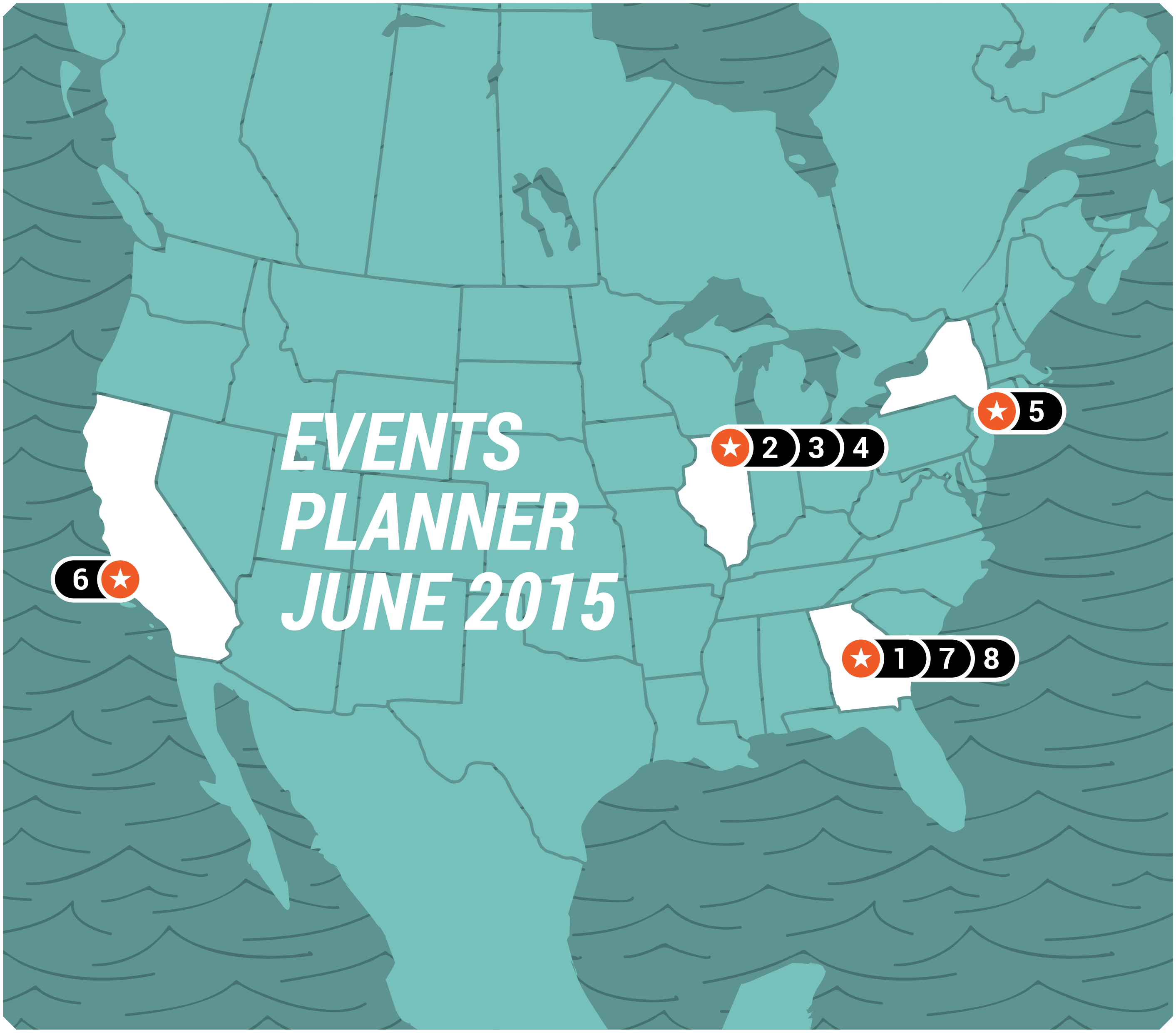
2
May 12 - 13 – Washington, DC
2015 Energy Efficiency Global Forum (EE Global)
http://eeglobalforum.org
twitter : @ToSaveEnergy / #EEGlobal

3
May 14 - 16 – Atlanta, GA
AIA Convention 2015
www.aia.org/convention
twitter : @AIANational / #AIAcon15

4
May 16 - 19 – Chicago, IL
NRA Show 2015
http://show.restaurant.org
twitter : @NRAShow / #NRAShow2015

5
May 26 - 28 – Boston, MA
2015 Ice Arena Conference & Trade Show
http://www.skateisi.com/site/sub.cfm?content=ice_arena_conference_and_tradeshow

6
May 31 - June 2 – Incline Village, NV
Food Logistics Forum, American
Frozen Food Institute
http://www.affi.org/events/2015-food-logistics-forum
twitter : @FriendsofFrozen



1
June 7 - 9 — Atlanta, GA
Dairy-Deli-Bake Seminar and Expo
https://www.iddba.org/conference.aspx
twitter : #IDDBA

2
June 8 - 10 — Chicago, IL
United Fresh, United Fresh Produce Association
http://www.unitedfreshshow.org
twitter : @UnitedFresh / #UnitedFresh2015

3
June 8 - 11 — Chicago, IL
FMI Connect
http://www.fmiconnect.net
twitter : @FMI_ORG / #FMIConnect

4
June 11 - 12 — Chicago, IL
FMI Foundation Retail Food Safety Forum
http://www.fmi.org/forms/meeting/Microsite/RFSF2015
twitter : @FMI_FoodSafety / #foodsafety

5
June 24 - 26 — NY, NY
59th Global Summit, The Consumer Goods Forum
http://www.tcgfsummit.com
twitter : @CGF_The_Forum / #CGFSummit

6
June 24 - 26 — Monterey, CA
PMA Foodservice Conference & Expo, Produce Marketing Association
https://www.pma.com/events/foodservice
twitter : @PMAFSC / #PMAFSC

7
June 25 - 26 — Atlanta, GA
ATMOsphere America 2015
http://www.atmo.org/events.details.php?eventid=30
twitter : @ATMOEvents / #ATMOAmerica

8
June 27 - July 1 — Atlanta, GA
2015 ASHRAE Annual Conference
https://www.ashrae.org/membership--conferences/conferences/2015-ashrae-annual-conference
twitter : @ashraenews / #ASHRAE

PEGA ON THE POWER OF LOW-CHARGE AMMONIA

Professor Pega Hrnjak explains why industrial systems will adopt lower and lower charges of ammonia and why other sectors may as well

– By Michael Garry

In San Diego last month at the IIAR Conference and Exhibition, *Accelerate America* was lucky enough to sit down with Professor Predrag (Pega) Hrnjak to get his take on trends in refrigeration and air conditioning, particularly low-charge ammonia systems.

Born in Belgrade, Yugoslavia, Pega is one of the pre-eminent researchers, teachers and experts in the refrigeration industry. He started his activities in the U.S. during the 1980s, and in 1993 joined the faculty of the University of Illinois, Urbana, Ill., where he is a professor in the Department of Mechanical Science and Engineering.

He is also co-director of the University of Illinois's Air Conditioning and Refrigeration Center, an NSF-founded, industry-university cooperative research center, and is president of Creative Thermal Solutions (CTS), his private research-and-development company.

The Air Conditioning and Refrigeration Center, which employs more than 100 people, offers graduate students and others an opportunity to conduct research. Its is fully funded by 30 companies who are members of the Center.

CTS is a vibrant R&D company, with almost 50 engineers, that does research primarily for industry and occasionally for governmental agencies. Its Urbana headquarters comprises 100,000 square feet of research space, including 43 environmental chambers and numerous other facilities in all areas of experimentation in thermal applications.

"I have two affairs: the university, with its academic depth, generality, intrigue, and work in the public domain; and CTS, with its focus on the realization of academic principles into a useful and effective apparatus," said Pega.

In the following wide-ranging interview, he offers insights on low-charge ammonia cooling systems – what they are, and why they are gradually transforming industrial refrigeration and potentially other sectors.

Pega Hrnjak

The origins of low-charge ammonia

Accelerate America: How did your work with low-charge ammonia come about?

Pega Hrnjak: I always say that various applications generate focus and expertise of a certain kind. We need a cross-pollination of that expertise. For example, industrial refrigeration is mostly driven by reduction of energy costs and increases in efficiency because it runs 24 hours a day, 365 days a year. It is not at all driven by the size or weight of equipment used. As we move from industrial to commercial (such as supermarkets) to residential to vehicles and aircraft applications, the same job of cooling is done differently. In cars and aircrafts, you care far less about efficiency; you care much more about compactness, size and weight because the vehicle always carries that weight. So for automobile and aircraft applications, engineers developed way better heat exchangers, with microchannel heat exchangers being the best nowadays. It took me many, many years to bring that technology of heat exchangers to industrial refrigeration. My point was not to reduce weight or size (although that is also beneficial) but to reduce the charge, which is much more important for refrigerants that are either flammable or mildly toxic (like ammonia). I am very happy to see that focus on charge reduction becoming stronger and stronger.

AA: How would you define low charge?

PH: There has been some attempt to qualify the meaning of low charge. How low is low charge? People are using 10 pounds per ton of refrigeration capacity as a threshold for low-charge systems. That is definitely much lower than typically found in conventional industrial refrigeration systems today. But 15 years ago I developed a 16 kW (5 Ton) chiller in the lab with a charge that is 100 times lower than that. Maybe that would be called ultra-low charge.

On the other hand, from a safety point of view it is the absolute value of the charge that matters, and the maximal capacity is based on that charge. Nevertheless, charge/capacity ratio is doing an excellent job of qualifying the success of technical solutions and driving them toward lower-charge options.

The real question is: What is the maximal charge of ammonia that will be below any legal concerns. In other words, what will happen if we limit the charge of a single unit not to 50 kg but to 5 kg?

I believe IIAR and other organizations should do everything possible to identify that criterion. That threshold would open unimaginable market opportunities for ammonia in the non-industrial refrigeration segment. Certainly it would quickly help push development of technologies that would deliver high-capacity units within the given limits.

AA: Can you use very-low-charge systems for industrial applications?

PH: Industrial refrigeration, it is clear, is changing the way of doing business from a technical perspective. Historically, all industrial refrigeration plants have been custom-designed and built on site. Nowadays there is a significant tendency everywhere in the world to use pre-fabricated, self-contained units with ammonia that will do the same job.

AA: Is this leading to lower costs?

PH: Its intention is to be less costly. And I am fully convinced it will be eventually less costly because of higher volume production. Whether today it is less costly remains to be seen – it will be a consequence of the market situation. The real driver today is to have reduced charge. We're not talking anymore about 10,000 pounds; we're talking about 100 or 200 pounds at most (50 – 100kg). This reduces the danger in the case of seismic events or fires or any other contemporary danger that you could easily imagine. That trend has just started. And I see that we will be going into lower and lower and lower specific charges in years to come.

AA: So these self-contained units with 100 pounds represent a good start for the low-charge movement?

PH: Yes, but it could be and should be lowered.

AA: And it's been picking up steam in the last year or two.

PH: That is correct. The support of regulations will make people even more welcoming of lower charge.

AA: But you're saying this could actually lead to even smaller charges that would still be effective in an industrial setting?

PH: Oh absolutely. With 5 kg of ammonia we can make 200kW of capacity with excellent efficiency, regardless of how remote this looks to many people at this point.

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AA: Does this exist yet?

PH: Yes, in the lab and in prototypes. At CTS we have done several prototypes of equipment with that specific charge. I have been presenting results at conferences, including the first prototype at the IIAR conference in Long Beach, Calif., 14 years ago.

AA: Why hasn't it been adopted?

PH: It was too radical. I think even today it is a big step. As long as we do not have a clear regulation specifying the lowest charge level, the reduction of refrigerant inventory will happen gradually.

Multiple units and other considerations

AA: For many low-charge systems, you would still need to deploy multiple units in industrial settings.

PH: I think that is fair to say. Capacities in industrial refrigeration vary. If you talk about huge cold storage, with freezing equipment and sizable storage capacity, the process can require something like a few megawatts of cooling capacity. You cannot do that in one self-contained system. You need several of those in place. On the other hand, this is a good opportunity because we need to reduce charge in different types of equipment.

AA: It seems odd that a small charge could do the work of a larger charge. Why do operators use such large amounts of ammonia if they can get away with less?

Paradoxically one of the reasons why ammonia has been in use continuously as a refrigerant over the last 160 years is the high charge. Ammonia is extremely inexpensive compared to synthetic refrigerants. In big industrial systems, a leak is almost inevitable - you almost always smell ammonia close to the plant. So ammonia is an affordable and extremely good refrigerant, both thermodynamically and in terms of thermo-physical properties. The pressure to reduce the charge is coming for other reasons – not to minimize the cost of the refrigerant that is already low, but to satisfy environmental concerns with safety in mind.

AA: Traditionally, industrial designers and contractors have tended to over-engineer ammonia systems. But low-charge systems lend themselves to plug-and-play.

That is correct. Overdesigning was done for a good reason. Industrial systems are expected to last for a very long time. Expectations in other applications are lower. In supermarkets, seven years is roughly the life expectancy for the display case, maybe 12-15 years for the rack. If ammonia systems are to be used in these applications, they have to be built differently to survive competition.

AA: Do you see a role for indirect systems that use secondary refrigerants along with ammonia in the machine room?

PH: Absolutely. In industrial refrigeration, CO_2 will be used in the low stage of ammonia systems. But industrial refrigeration systems don't necessarily need to have a secondary refrigeration system. The charge needs to be reduced and that will open way more opportunities than there are today. And efficiency will not suffer.

AA: Do you see a place for CO_2 transcritical systems in industrial applications?

PH: It's hard to say because of CO_2's difficulties with efficiency compared to ammonia. Ammonia provides higher efficiency for the same cost than do CO_2 transcritical systems.

AA: What will be the ultimate drivers of low-charge adoption?

PH: Economic opportunities or regulatory push. So far there hasn't been sufficient motivation to go in that direction. So most low-charge systems are coming from companies that have not been traditionally in the business of providing big custom-built systems for industrial refrigeration. And that is very logical. They see opportunity, which is a great motivation.

At some point soon a few of the traditional suppliers and contractors will see the potential to strengthen their market position with low-charge systems. And they will also start building units.

AA: So modernization through low charge is coming.

PH: Yes, I believe so. Eventually, industrial refrigeration, the way that we know it now, will have unitary equipment with lower and lower charge. It is possible to replace almost all of these big facilities with smaller, more efficient systems with a lower charge. The example of the Fukushima meltdown is very vivid to everyone. It makes much more sense to modify facilities now to prevent similar cases in a reasonable, economical way.

Other uses of low-charge ammonia

AA: What are other areas where low-charge ammonia could be applied?

PH: When below a certain charge level, other applications where ammonia is traditionally not used are easily reachable. Chillers for instance, especially those that would be on the roof of a building. Ammonia can be a replacement for R22 (and substitutes) in chillers, and then you would have a secondary refrigerant that is pumped around the building for HVAC, in industrial cooling or in a supermarket. That is very, very viable.

"Eventually, industrial refrigeration, the way that we know it now, will have unitary equipment with lower and lower charge. It is possible to replace almost all of these big facilities with smaller, more efficient systems with a lower charge."

Ammonia is the only refrigerant that is lighter than air. So if it is on the roof of a building and the charge is low, then in the case of a leak, refrigerant lighter than air will go into the atmosphere. Thanks to the low charge, the leak is small and quantities are far below the EPA-allowed daily rate for venting ammonia into the atmosphere.

I do not believe that ammonia will be used in evaporators or coolers directly exposed to populated, human-occupied areas. I don't think that ammonia can ever be used in direct air conditioning systems, but it can be in every industrial air-conditioning system that is served by ammonia today.

Ammonia in conjunction with a secondary refrigerant of some sort like glycol or CO_2 could be a very good option because of ammonia's excellent thermo-physical properties and because it is accepted as a low GWP fluid.

Of course, in my mind, not only do we need to reduce the charge of ammonia but we also need to rethink the way we design and build ammonia systems. What that means is if we just shrink the size of current systems and even significantly reduce the charge, it would probably not be sufficient to make ammonia systems competitive.

AA: How do you see supermarket refrigeration evolving?

PH: Today in the United States, the majority of supermarkets still use R22, R404A or something similar. We are witnessing a steady change to CO_2 and we will see more ammonia.

AA: You could have transcritical CO_2 systems in certain parts of the U.S and ammonia/CO_2 and hydrocarbon systems in other parts. Naturals could take the whole market.

Indirect systems with ammonia and CO_2 could be used where ammonia is not used today. I also believe that we may see CO_2 become much stronger, maybe dominant in supermarkets. In smaller supermarkets, as with every lower-capacity system, less complicated systems are closer to the overall optimum based on cost vs. performance ratios. Ammonia has a chance because of its potentially higher efficiency, especially in hotter areas, for the same cost MG

SHAKING UP INDUSTRIAL REFRIGERATION

By Michael Garry

By branching out from ammonia-only systems to an ammonia-CO_2 platform, US Cold Storage has helped make CO_2 an acceptable refrigerant for warehouse operators

Mike Lynch
United States Cold Storage

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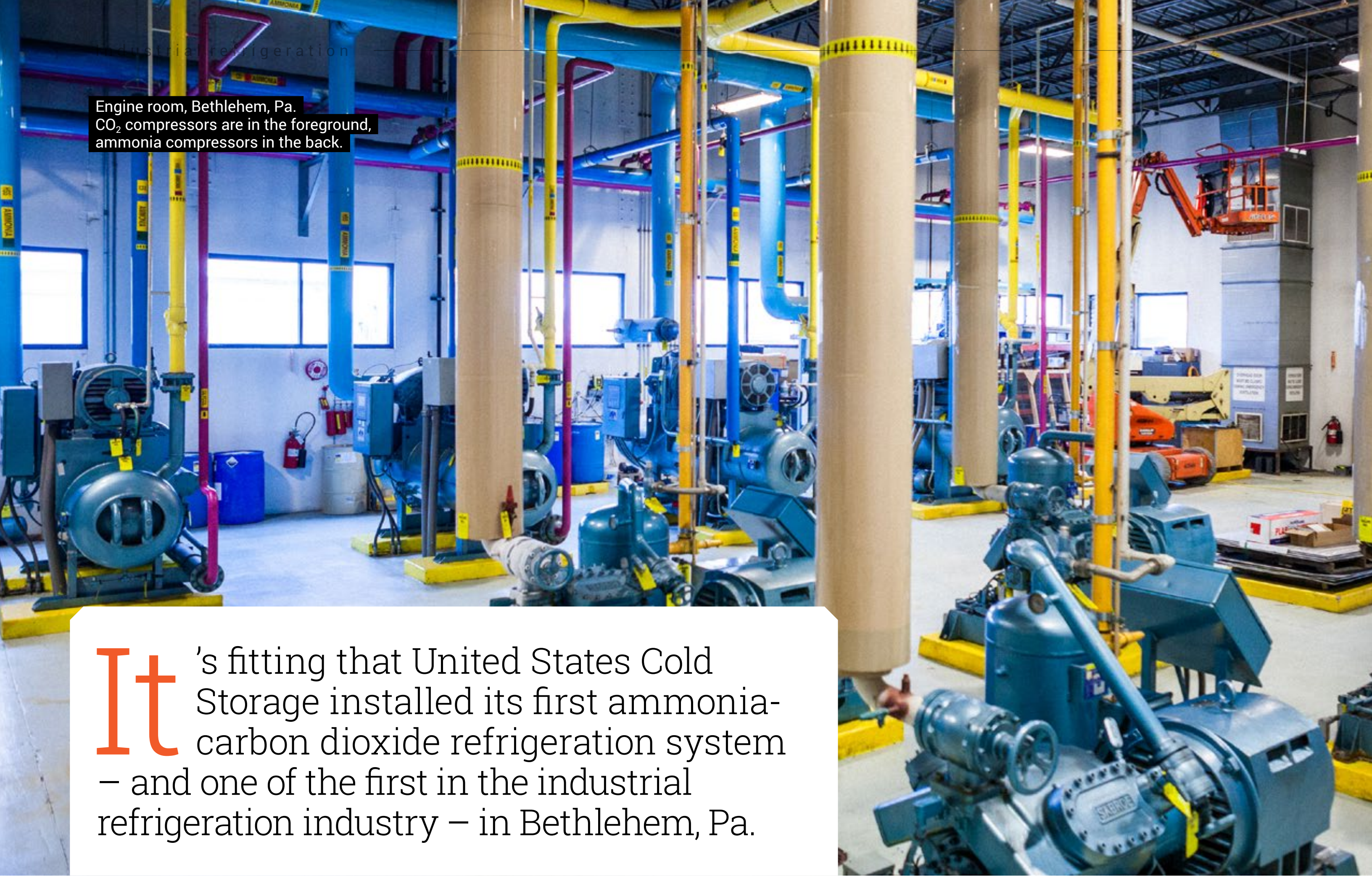

Engine room, Bethlehem, Pa. CO_2 compressors are in the foreground, ammonia compressors in the back.

It's fitting that United States Cold Storage installed its first ammonia-carbon dioxide refrigeration system – and one of the first in the industrial refrigeration industry – in Bethlehem, Pa.

US Cold Storage's 500,000-square-foot Bethlehem facility, opened in 2005, sits on a segment of the 300-acre site previously occupied by Bethlehem Steel Corp., once the second-largest steel maker in the world. In 1995 Bethlehem Steel, which produced the I-beams used to build many of Manhattan's skyscrapers, shuttered its facilities after 140 years of production, the victim of overseas competition.

The force of change, in the form of globalization, overtook Bethlehem Steel. Change – in the form of stricter governmental oversight of ammonia refrigeration -- is now sweeping over the industrial refrigeration industry, causing many companies to transition, or consider transitioning, to low-charge ammonia options.

Beginning in Bethlehem, US Cold Storage has learned how to manage change rather than be undone by it. Its Bethlehem plant, nearby the old steel mills, is a daily reminder of the need to confront current realities and not live in the past.

Rather than install a traditional two-stage pump-recirculated ammonia refrigeration system, with 20,000 to 40,000 pounds of ammonia, in Bethlehem, US Cold Storage opted for the NH_3-CO_2 cascade system, with 6,400 pounds of ammonia and 48,000 pounds of CO_2, something that was practically unheard of in 2005.

"When we started, people called us crazy," said Michael Lynch, vice president – engineering for US Cold Storage, in a recent interview with *Accelerate America* at the Bethlehem warehouse. "Even equipment manufacturers were making presentations about why you shouldn't use CO_2."

But US Cold Storage stuck to its guns. To gain more experience with NH_3-CO_2 cascade systems, the company, which was acquired by U.K.-based Swire in 1982, sent some engineers to Europe to observe the technology in action there, where it was more prevalent. "The tour gave them insight and reassurance that we could take the technology and design a system that would work here," said Lynch. At that time, Lynch, who became vice president – engineering in 2011, was more involved on the construction and installation side.

Since then, US Cold Storage – the third largest refrigerated warehousing and logistics provider in North America, with 233.5 million cubic of temperature-controlled space, according to the Global Cold Chain Alliance – has implemented ammonia-CO_2 systems at 10 more new locations in the U.S. (see map , page 25), including some that replaced outdated facilities. All together, US Cold Storage, based in Voorhees, N.J., operates 35 public refrigerated warehouses in 27 cities or towns across 13 states.

Of its 11 NH_3-CO_2 systems, 10 are cascade models, using high-pressure CO_2 compressors, while one, in Quakertown, Pa., is a critical brine unit that circulates CO_2 as a secondary coolant mostly to storage areas with a 35°F to 40°F temperature. The NH_3-CO_2 systems use between 5,000 and 8,000 pounds of ammonia and between 20,000 and 48,000 pounds of CO_2.

In a warehouse in Lumberton, N.C., US Cold Storage is installing an NH_3-CO_2 system in a second engine room to support new blast freezers – an add-on to a existing two-stage ammonia system. But the company does not plan to retrofit an entire existing ammonia system with the NH_3-CO_2 technology.

WHY CO_2?

In 2005, US Cold Storage took a risk building one of the first NH_3-CO_2 systems in the industrial refrigeration industry. Why did the company do it?

Even then, ammonia regulations were taking a toll. “We saw that [stricter] regulations were coming, so we wanted to find a way to reduce our ammonia charge,” said Lynch, who joined US Cold Storage in 2000 after a decade as a refrigeration engineer for Nestle USA.

The biggest regulatory burden on cold storage facilities that use more than 10,000 pounds of ammonia refrigerant is complying with OSHA’s PSM (process safety management) and the EPA’s RMP (risk management plan) requirements. Using an ammonia-CO_2 system, US Cold Storage stays below the 10,000-pound threshold, which removes filing protocols and puts its plants at less of a risk during an audit.

However, the company still voluntarily treats NH_3-CO_2 facilities as if the same regulations applied “because it’s the prudent and safe thing to do,” said Lynch. “And there’s still a general duty clause irrespective of the amount of ammonia you have.”

Equally as important as regulations, US Cold Storage wanted to reduce the risk of ammonia exposure to its employees and customers (delivery employees of packaged goods companies who warehouse products at US Cold Storage facilities). It could do that by taking ammonia out of the storage environment and confining it to the engine room – the scenario under an NH_3-CO_2 system.

While Lynch is not aware of any significant leaks at the ammonia-only plants, even in extremely small quantities like 15-20 PPM ammonia’s highly pungent odor is detectable to employees. “They know it’s dangerous so the slightest smell is alarming to them, and we respond accordingly,” said Lynch. With CO_2 that stress is eliminated in storage areas.

Moreover, ammonia often carries a stigma in the areas where US Cold Storage operates, and authorities and communities regard a system with less ammonia as safer.

US Cold Storage’s customers have grown to appreciate the attention it has paid to the safety of their employees, as well as to the quality of their chilled and frozen food -- everything from milk shakes to chicken fillets, eggplant to cranberry concentrate -- which could be rendered unsaleable by exposure to ammonia. “We haven’t had a CO_2 leak but the effect of CO_2 on food would be benign,” said Lynch.

“Our customers like that; our insurance company loves it,” he added in a presentation at the 2015 IIAR Conference and Exhibition.

In fact, Lynch believes that the NH_3-CO_2 system has become a competitive advantage and “helped to grow our business.”

Another factor that prodded US Cold Storage in the direction of an ammonia-CO_2 platform was its partnership with M&M Refrigeration, which had experience with CO_2 systems and exclusive rights to Sabroe’s reciprocating compressors in the U.S.

What clinched the decision for US Cold Storage was its determination that the capital cost of an NH_3-CO_2 system would be about the same as an ammonia-only system, within a margin of plus-or-minus 5%.

In addition, US Cold Storage’s ammonia-CO_2 refrigeration system, including all compressors, condensers and evaporators, was found to be on average 5.8% more energy efficient than a conventional ammonia system, according to Lynch. The greater efficiencies of the low-temperature evaporators far outweigh the lower efficiency of the warmer-temperature units (at the docks, for example).

From a maintenance standpoint, NH_3-CO_2 requires more work in certain areas (reciprocating compressors and cascade condenser) and less in others (valves) than an ammonia system. On balance, Lynch thinks costs for maintenance, as well as for installation, are about the same for both systems.

Looking at the total cost of ownership, Lynch concludes that NH_3-CO_2 cascade systems are at minimum comparable to, and in some cases less than, traditional ammonia system. The 5.8% lower energy cost – as well as intangible benefits like safety, lower regulatory burden and competitive advantage – usually tip the balance toward the cascade system.

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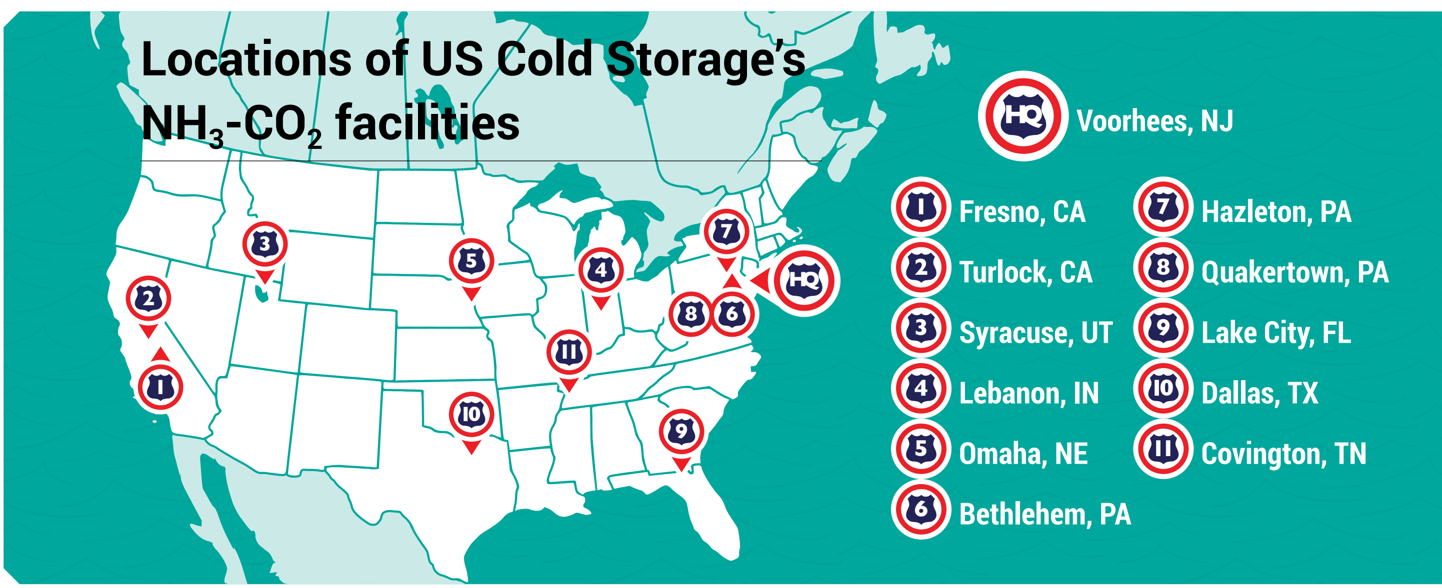
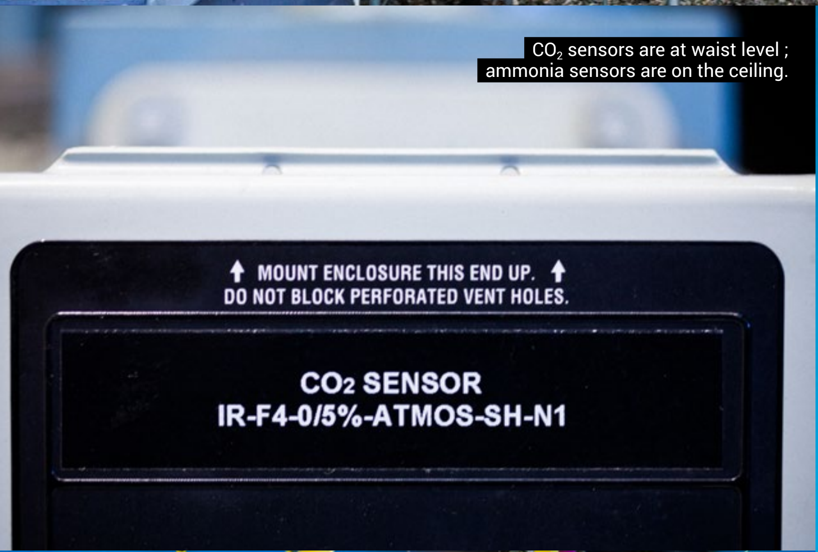
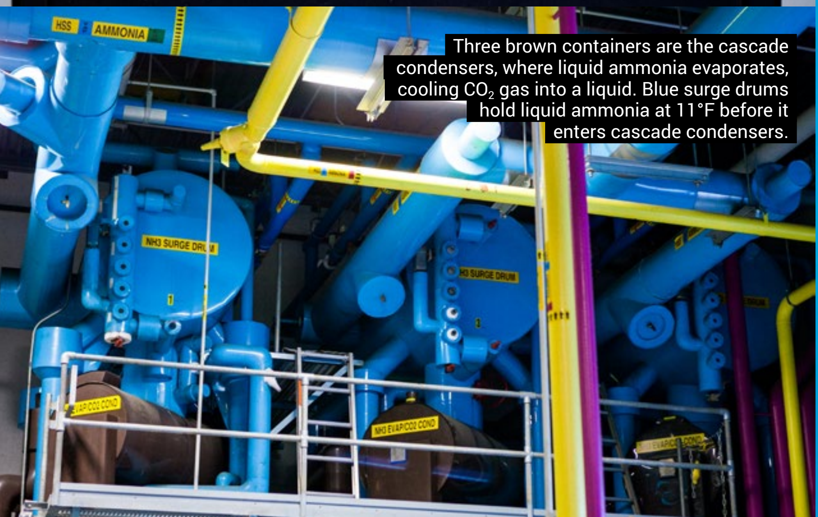


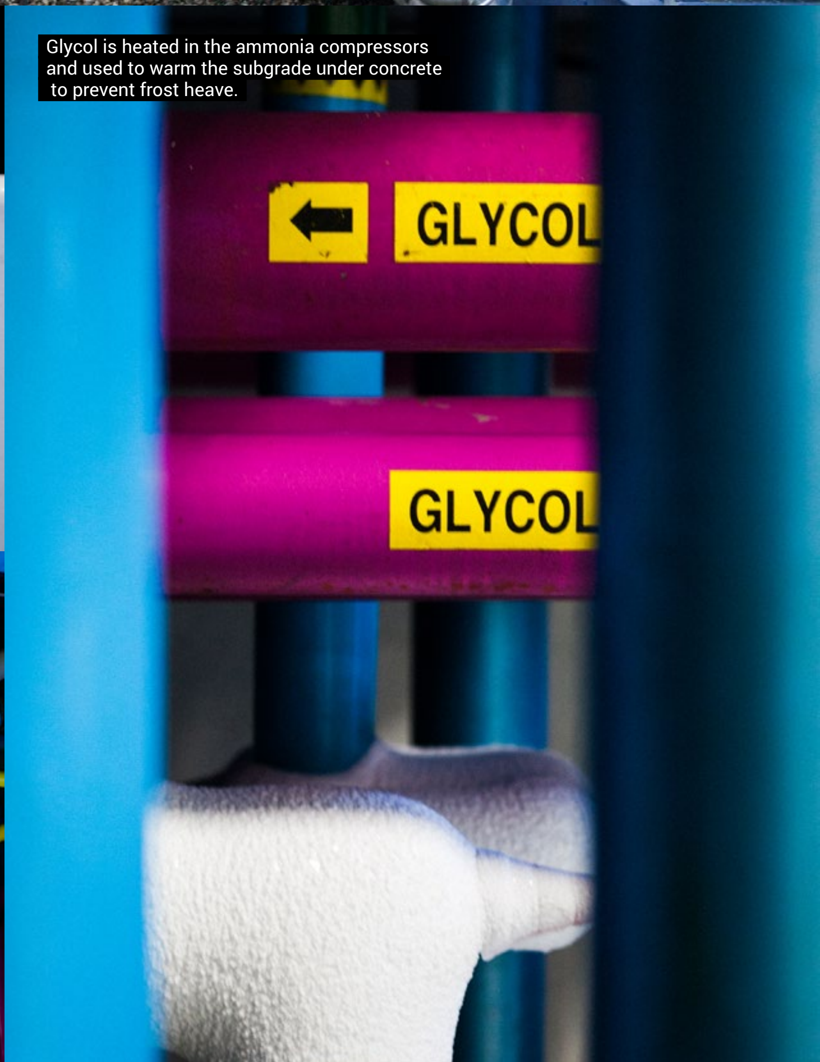
Rooftop ammonia evaporative condenser. Yellow pipes carry ammonia gas from engine room into the condenser; red pipes carry liquid ammonia to engine room.



CO_2 sensors are at waist level ; ammonia sensors are on the ceiling.



Three brown containers are the cascade condensers, where liquid ammonia evaporates, cooling CO_2 gas into a liquid. Blue surge drums hold liquid ammonia at 11°F before it enters cascade condensers.



Glycol is heated in the ammonia compressors and used to warm the subgrade under concrete to prevent frost heave.

CO_2 CHALLENGES

Of course, US Cold Storage has had to clear some hurdles, with its CO_2 system, especially at the beginning. One was its in-house refrigeration technicians' lack of experience with CO_2, though the primary difference between a two-stage ammonia system and the CO_2 cascade system is the presence of a cascade condenser.

"Knowledge transfer and training was a challenge, but we have been able to overcome that," said Lynch. Self-education has also been important, as the company's engineers conduct a post-mortem following every cascade project to discuss whether the system is operating as designed. Over the past decade the company has made "subtle changes" in equipment selection and design as part of a "continuous improvement" philosophy.

> Knowledge transfer and training was a challenge, but we have been able to overcome that."

Early on, US Cold Storage had limited options with respect to refrigeration contractors that could design and install CO_2 systems as well as to component suppliers who could provide high-pressure compressors and evaporators. Today, there are far more options on both scores "as more and more food and distribution companies embrace the technology," said Lynch. "It's gradually improving."

From a technical perspective, the NH_3-CO_2 system presents certain challenges. Perhaps most important is preventing CO_2 and NH_3 from mixing in the cascade condenser and forming ammonium carbamate, a white, powdery salt with a penchant for clumping together and clogging pipes and valves. He uses a strainer to collect any ammonium carbamate and monitor its presence, so that it can be prevented from accumulating.

It would take several days to remove a collection of ammonium carbamate, compromising a plant's operation, though that is not something US Cold Storage has experienced to date. "It's what keeps me up at night," Lynch said at the IIAR Conference.

Another technical imperative is eliminating moisture, which reacts with CO_2 to create carbonic acid that corrodes carbon steel. "Moisture management is critical," Lynch said. This includes using filter driers, leak testing with dry nitrogen, and evacuating the system down to at least 500 microns during maintenance.

The company is also relying more on acid-resistant stainless steel, which has become price-competitive with carbon steel. At its Lumberton, N.C., facility, the company is using only stainless steel in the new NH_3-CO_2 system.

Other technical challenges:

» A CO_2 system carries with it higher pressures and needs to be appropriately fitted with relief valves. But releasing saturated CO_2 gas produces dry ice, which can plug up pipes and valves. So US Cold Storage is careful to release saturated CO_2 directly to the atmosphere.

» Though CO_2, an odorless gas, is far safer than ammonia, it can be an asphyxiant in a closed space and "needs to be treated with respect," said Lynch at the IIAR Conference.

» To that end, US Cold Storage installs sensors (waist height) and alarms in all parts of the facility, as it does for ammonia (ceiling mounted). "Being odorless, CO_2 leak detection, especially small leaks, can be a challenge," said Charlie Kulp, chief engineer at the Bethlehem facility.

» At the IIAR Conference, Lynch advised anyone using CO_2 as a refrigerant in industrial plants to coordinate closely with the CO_2 supplier to ensure that the supplier is equipped to interact with a refrigeration system, since that is a new application for many of them, and that they are supplying Coleman grade CO_2 with a purity of 99.99%.

» US Cold Storage can reuse the POE oil used in the CO_2 compressor (through oil rectification) rather than discard it, which is done with NH_3 compressor oil. The CO_2 and ammonia compressor oils don't mix and have to be managed separately.

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USCS Drives Down Carbon Footprint

United States Cold Storage's adoption of energy efficient ammonia-CO_2 cascade refrigeration systems ties into the company's overall emphasis on cutting its energy consumption and carbon footprint.

Since 2008, the company's goal has been to reduce its year-over-year energy usage by 1.5%, and it has exceeded that, one year driving consumption down 5%, said Mike Lynch, vice president – engineering for US Cold Storage, who oversees the company's environmental initiatives.

The cascade system, which on average uses 5.8% less energy than a comparable ammonia system, has contributed to the overall reduction. "As a company strategy, we have decommissioned older, less efficient facilities and replaced them with more efficient buildings that have CO_2 refrigeration," Lynch said. In addition the company has retrofitted a large percentage of its warehouses with energy-efficient LED lighting.

In terms of greenhouse gas emissions, the company has also made improvements, dropping from 1,675 pounds of CO_2 per cubic feet in 2008 to 1,338 pounds in 2012, according to its 2012 Environmental, Health & Safety Annual Report. The company submits its data to the Carbon Disclosure Project.

To further reduce its emissions, the company has been testing solar energy. In 2008, it installed its first solar array, a 491.7 kW roof-mounted system at a facility in Tulare, Calif. Last month, it announced that it will deploy a 2.7 mW ground-based solar array at its Lumberton, N.C. warehouse. In the announcement, Jesse Hooks, the company's Regional V.P – Mid-Atlantic, noted that "the first array performed reliably and confirmed the ability to integrate a PV system into an existing warehouse."

OTHER OPTIONS

When US Cold Storage decided to install an NH_3-CO_2 cascade system in 2005, it was the only natural-refrigerant, low-charge alternative to all-ammonia systems for industrial applications. However, since then, low-charge self-contained ammonia units have also emerged as an option for end users. Would Lynch consider such a unit for US Cold Storage?

Possibly, but not right now, he said. "For a large industrial company like ourselves, we feel CO_2 cascade provides all the benefits we need." While low-charge ammonia systems offer benefits as well, he questions whether they are comparable from a capital cost, maintenance and efficiency standpoint. "We're not sold on it yet."

Still, there are times where a low-charge ammonia system might fit, he said, such as at a facility like the Lumberton plant that is adding an application but can't fit it into an existing engine room. "Then a rooftop [low-charge] unit could be ideal." Generally speaking, he believes smaller warehouses are better suited for low-charge units.

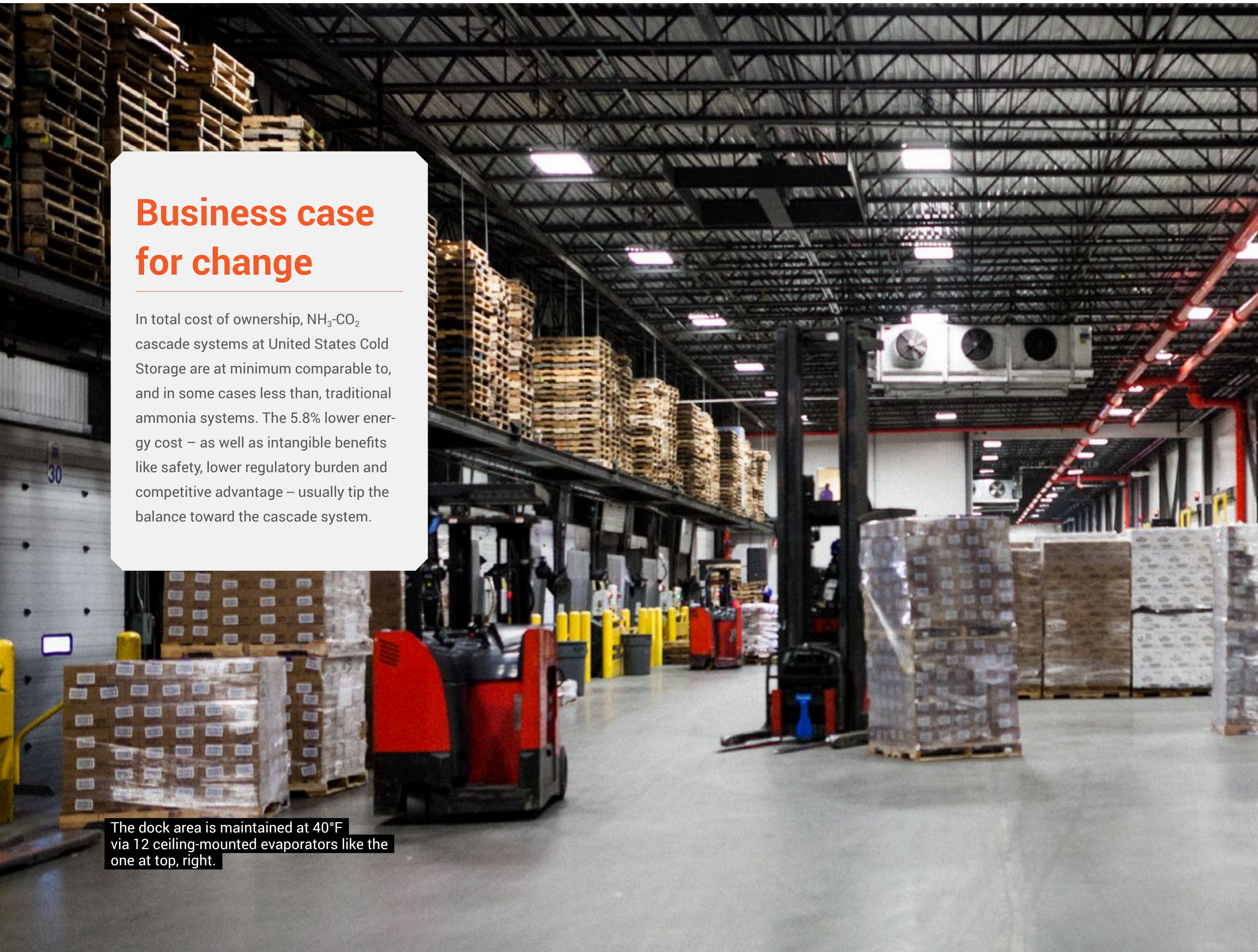
As for all-CO_2 transcritical systems, Lynch believes they are "years down the road" in industrial settings, though they are gaining traction in supermarkets.

There are occasions when Lynch still opts for a traditional high-charge ammonia system. In a facility in Wilmington, Ill., that opened in 2010, he used a single-stage ammonia system for what is an "all-cooler" building that didn't have any low-temp freezer or blast freezing for which CO_2 would be appropriate. "When you look at the life cycle costs, there are still times when traditional ammonia makes sense," he said.

But Lynch plans to continue using ammonia-CO_2 systems as his primary platform in new facilities. Already two such warehouses are in the works – one in Sacramento, Calif., and one in Atlanta, Ga.

Skeptical about NH_3-CO_2 systems in 2005, the industry has since caught up with US Cold Storage in accepting the technology as a low-charge option. The same suppliers that criticized the company are now selling CO_2 compressors and evaporators to end users that are installing cascade systems. IIAR, focused on ammonia, has incorporated CO_2 educational sessions into its conference agenda.

Lynch believes the tipping point came in 2010, when he saw "a change in thinking and acceptance," which has been growing since then.



Business case for change

In total cost of ownership, NH_3-CO_2 cascade systems at United States Cold Storage are at minimum comparable to, and in some cases less than, traditional ammonia systems. The 5.8% lower energy cost – as well as intangible benefits like safety, lower regulatory burden and competitive advantage – usually tip the balance toward the cascade system.

The dock area is maintained at 40°F via 12 ceiling-mounted evaporators like the one at top, right.

LOOKING AT THE WORLD DIFFERENTLY

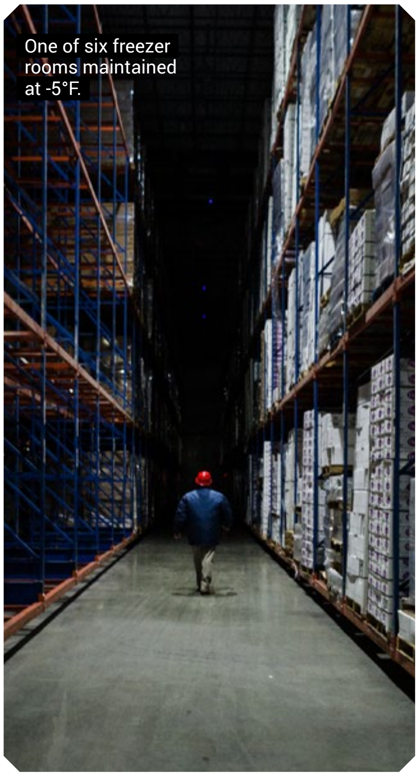
Lynch regards his job as personally gratifying on several levels. First, he enjoys overseeing construction of US Cold Storage buildings from conception to completion, and then watching them become profitable parts of the business. He is also responsible for the company's environmental strategy, which includes installing NH_3-CO2 refrigeration systems, and he finds that aspect fulfilling as well.

"As a parent" – Lynch is the father of three teenagers, two boys and a girl – "you look at the world differently," he said. "You want a better environment for your kids. So being able to do my share in helping control how our company affects the environment is rewarding."

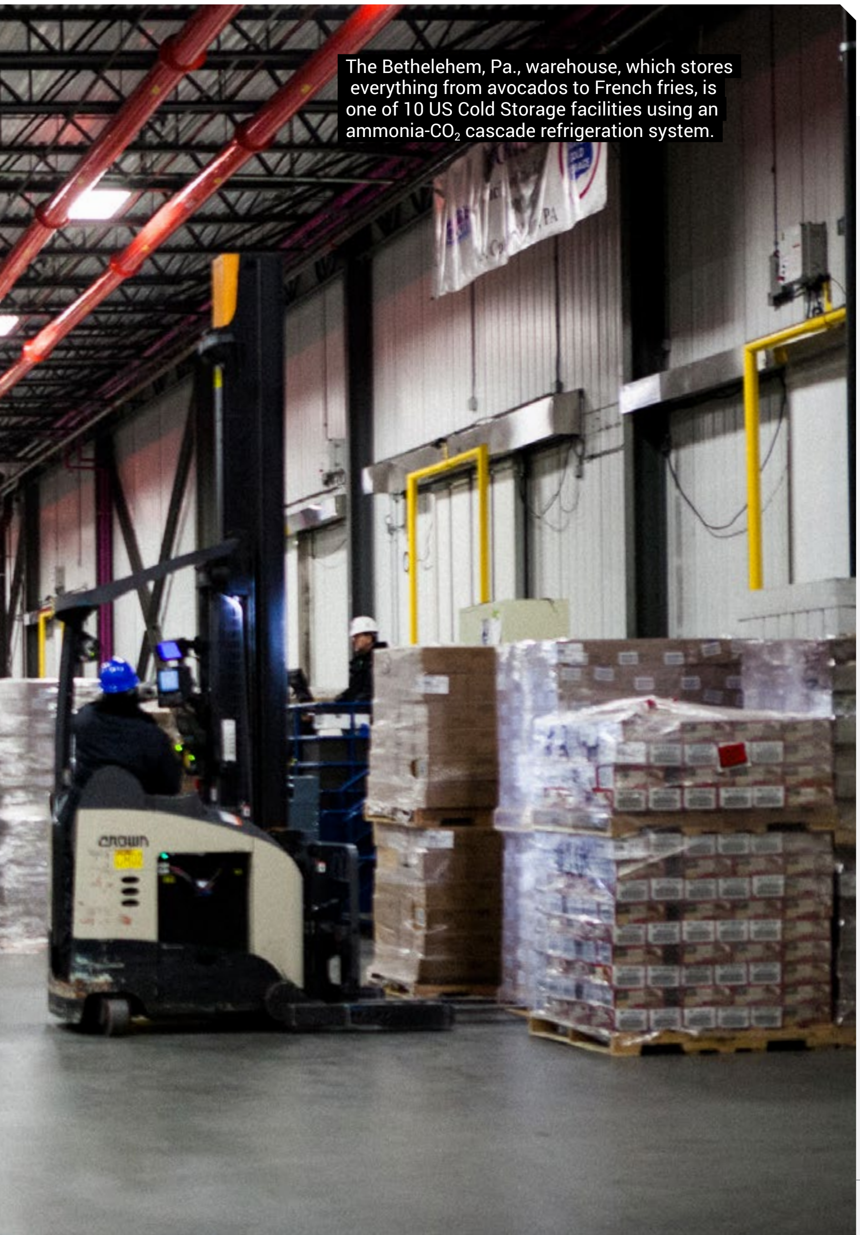
Lynch has also been trying to influence the environmental direction of the industrial refrigeration industry as a whole through speaking engagements at industry events and consultations with customers. "I spend a lot of time enlightening our customers about CO_2 and how they can embrace it in their facilities," he said. "That helps grow [CO_2 adoption] in the industry and increase awareness and demand."

US Cold Storage's customers include major brands like Unilever and Nestle that want to project a sustainable position to consumers by reducing their carbon footprint. Energy-efficient NH_3-CO_2 systems offer them one way to do that.

Moreover, since US Cold Storage is part of their supply chain, the company's sustainability efforts can be incorporated into the brands' own carbon calculation MG



One of six freezer rooms maintained at -5°F.



The Bethelehem, Pa., warehouse, which stores everything from avocados to French fries, is one of 10 US Cold Storage facilities using an ammonia-CO_2 cascade refrigeration system.

System Specs

At US Cold Storage's public refrigerated warehouse in Bethlehem, Pa., the NH_3-CO_2 cascade refrigeration system has the following characteristics:

- M&M Refrigeration designed and installed the system
- Temperatures: 40°F (docks); -5°F (storage freezers). Other warehouses may include -48°F or below (blast freezer) and/or convertible freezer (40°F to -20°F)
- Capacities : Similar to those of an ammonia-only system.
- Charges: 6,400 pounds of NH_3; 48,000 pounds of CO_2.
- Six freezer rooms, cooled by CO_2
- Vahterus three-part cascade condenser (plate and shell heat exchanger)
- Pump recirculated CO_2 system
- Four Sabroe high-pressure reciprocating compressors, plus one Frick high-pressure screw compressor, for CO_2
- Penthouse-mounted Guntner and Evapco CO_2 evaporators above each freezer room
- Two CO_2 receivers 19.4°F and -36.4°F
- Danfoss valve station on CO_2 evaporators
- Danfoss level controls on CO_2 receivers
- Four M&M high-temp screw compressors for NH_3
- Roof-mounted Evapco NH_3 evaporative condenser (air- and water-cooled)
- NH_3 controlled pressure receiver
- NH_3 surge drums
- Electric defrost (glycol and CO_2 hot gas used at other locations)
- The ventilated and monitored engine room is equipped with eye wash , an emergency shunt trip switch and remote emergency fan control outside control room

Members of ASHRAE's Los Angeles chapter touring NXTCOLD low-charge unit on the roof of LA Cold Storage's Fourth St. facility in downtown LA.

BREAKING WITH TRADITION

— By Michael Garry

NXTCOLD'S low-charge ammonia system, created and first installed at Los Angeles Cold Storage, challenges industrial refrigeration orthodoxy

> "Just for a moment, let us recognize a strange phenomenon – the ironic tendency to resist change. This is one natural tendency we must strive to overcome."
>
> — John Scherer, ASHRAE presentation, 1991

Nearly a quarter of a century ago, refrigeration engineer John Scherer, speaking to the Los Angeles chapter of ASHRAE about the history of ammonia refrigeration, captured quite eloquently the industry's penchant for sticking with the tried-and-true rather than venturing into new vistas.

One of the ASHRAE members was so impressed with Scherer's comments that he made a framed poster out of them, signed by Scherer.

But little did Scherer know at the time the role he would be playing in 2015 to help the ammonia refrigeration industry overcome the forces of inertia and embrace change.

For more than 36 years, Scherer has been manager of engineering at Los Angeles Cold Storage, a public refrigerated warehousing company. In 2010, he added a second title: chief technology officer for NXTCOLD LLC, a startup owned by Scherer and LA Cold Storage. Scherer's brother, Jerome Scherer, who recently retired from United States Cold Storage, serves as president of NXTCOLD.

At NXTCOLD Scherer developed an industrial refrigeration ammonia system with what he describes as a "very low" refrigerant charge of less than 50 pounds (usually under 50 pounds), or less than a pound per TR (ton of refrigeration),, compared to the charges of traditional systems that can reach 50,000 pounds and more.

The system can be applied to a wide range of refrigerated warehouses, including very large ones. It can work in facilities with capacities ranging from 5 TR to 150 TR, replacing ammonia charges in excess of the regulatory threshold of 10,000 pounds. The system's operating temperatures -60°F to 60°F, serving blast freezers, freezer or coolers. Defrost is handled with air, water, electricity, or some combination.

Factory-tested units can be installed and commissioned in one day on the roof or on the ground outside a new or existing facility. NXTCOLD's units facilitate the move "to distributed systems from a central machine room," said Scherer.

At a time when the refrigeration industry is moving in the direction of lower and lower ammonia charge, and away from F-gases, NXTCOLD's unit represents the change that

Scherer was alluding to in 1991. But making the move to lower-charge technology likely won't be resisted as much as it was in the past, given the increasingly stringent regulatory environment in which the industry has been operating over the past few years.

By reducing the ammonia charge so dramatically, NXTCOLD's low-charge unit enables end users to improve safety, reduce their regulatory responsibilities, and focus on their core business, Scherer said. It does this, he added, at a reduced cost and greater energy efficiency than traditional ammonia systems.

STARTING IN LA

Scherer developed NXTCOLD's first low-charge equipment for his own company, Los Angeles Cold Storage, which operates three cold-storage warehouses adjacent to each other in downtown LA. Together they encompass 400,000 square feet of freezers currently using 32,000 pounds of ammonia, and take up 10 acres.

In January 2012, a test cell began operation at LA Cold Storage's Central plant, followed 14 months later by the installation of a rooftop "penthouse" unit (5 pounds of refrigerant with 15 TR capacity) at the company's Fourth St. facility. LA Cold Storage, which specializes in handling seafood from around the globe, "kind of had the inside track" on getting the first system, Scherer quipped.

LA Cold Storage cut its ammonia charge by 1,000 pounds with the NXTCOLD unit, and removed another 7,000 pounds from its central systems through other means.

Many industry associations, including IIAR, AHSRAE and RETA, have sent representatives to LA Cold Storage to view the low-charge units in action. The company is in the planning stages to install several more units at its plants.

Safety was the big driver behind Scherer's invention of a low-charge system for LA Cold Storage. "This system was developed by an end user because we couldn't handle big ammonia charges anymore," he said.

Because of LA Cold Storage's proximity to downtown LA, a major ammonia leak would be simply untenable for the company. "I couldn't sleep," said Scherer. "It became an obsession to develop a low-charge system." It took him four years, working nights and weekends, to come up with the design.

The regulatory burden on LA Cold Storage has also become problematic. The company employs a full-time regulatory affairs director, but "he can't really keep up with everything," said Scherer. "We're being hit continuously, over and over, with audits." But the low-charge units can lift "the vast majority" of that burden, he said.

In addition to LA Cold Storage, NXTCOLD is installing multiple units at a facility in Oxnard, Calif., run by Lineage Logistics, the second-largest U.S. cold storage provider. NXTCOLD also has a backlog of 70 units it is building for additional customers. Most of its installations have been retrofits.

"There are hundreds of other people who want the equipment," said Scherer. "We're gearing up to handle those." NXTCOLD uses Hillphoenix, Conyers, Ga., and a Phoenix-based company to assemble the units.

NXTCOLD regards thousands of facilities in California with more than 2,000 pounds of HFCs or HCFCs – which are regulated under the state's AB32 climate chang e law -- as potential customers. And the company is also seeking to install its units at craft beer facilities, which range from 5,000 to 10,000 square feet. Other potential customers include supermarkets and ice rinks.

While NXTCOLD has focused so far on ammonia-only refrigeration, it plans to venture into ammonia-CO_2 cascade systems, which could also be applied to supermarkets.

Because of its roots in the cold storage business, NXTCOLD's largest customers are friends of longstanding. "When we talk to them it's different than sales people selling wares," said Scherer. And by selling its systems directly to end users, NXTCOLD is changing the traditional business dynamic in industrial refrigeration whereby refrigeration contractors purchase equipment and assemble large systems for end users. "Normally the contractor knows the owner but in this case we know the owner," said Scherer.

But contractors hired to install NXTCOLD equipment can do so in less than a day as opposed to the six months to a year taken up by a traditional ammonia system, with its myriad of

continued on p.32

Cost Analysis

NXTCOLD has estimated the cost savings of its system when 18 of its units are used in place of a traditional pumped-liquid ammonia-overfeed system at a 400,000-square-foot generic facility.

With the NXTCOLD system, the plant has one fewer operating engineer, a savings of $100,000 annually. By not building and maintaining an engine room, it saves $650,000 the first year and $45,500 annually thereafter. And by putting food products in what would have been an engine room, the facility is able to generate an estimated $270,000 in additional revenue annually.

In addition, an 8% energy savings with the NXTCOLD units saves $205,597 annually. And a 90% reduction in ammonia refrigerant costs results in a savings of $21,600 in the first year, and $1,920 annually thereafter.

Other costs that are reduced: regulatory compliance measures, ammonia training for employees, and pollution and product liability insurance.

In addition, the facility received a utility energy-reduction incentive of $206,000 and a peak-energy reduction incentive of $20,000.

The total savings, including incentives, amounts to $1.6 million in the first year, and $708,000 annually thereafter. All other costs are assumed to be the same, though the first cost of NXTCOLD's system is actually about 10% less than that of a traditional system, and maintenance costs are projected to be lower, said NXTCOLD.

permitting and pipefitting. "They can do a couple of projects a week and make a much better margin," Scherer said. "At the end of the year, they're going to hold onto a lot more money and have a better quality of life. And they'll have the environmental people and utilities behind them."

CONTROLLING REFRIGERANT

To reduce its ammonia charge to under a pound per ton, NXTCOLD's unit dispenses with many of the refrigerant-holding components typically found in ammonia systems, such as receivers and accumulators. Instead, the refrigerant travels directly from the condenser to the evaporator to a DX compressor. "We're able to control the refrigerant mass within the evaporator by keeping the quality level at the level it needs to be," said Scherer. This allows for fully wetted circuits lengths, maximizing the evaporator coils' heat transfer without the restrictions of superheat-based control.

NXTCOLD's evaporator achieves that high level of refrigerant quality by means of an electronic refrigerant injection control (ERIC) mechanism, which uses multiple-point liquid injection with varying tube diameters. (The system is patented with more patents pending.) "We inject liquid [ammonia] into the evaporator circuits," explained Scherer. "We build the same amount of vapor but we don't have the pressure drop because the mass isn't in there. We inject it when we need it, not when we don't need it. That's how we get to ounces of charge per ton."

How many NXTCOLD units are needed to refrigerate a large cold warehouse? A 100,000 square foot building that is 50 feet tall can be refrigerated by two of NXTCOLD's largest units. (It has four sizes, ranging from 5 to 20 TR up to 50 to 150 TR.) If a facility has two separate areas, then each area would have two units, with each unit comprising two compressors. But larger facilities would use more units.

For example, in one facility NXTCOLD has installed 18 units for a 400,000-square-foot refrigerated space. The space includes eight different applications, from ice cream at -20°F to produce/candy at 55°F. The 18 NXTCOLD units are equivalent to the number of evaporator coils in a traditional ammonia setup with an engine room.

NXTCOLD's units have several energy-saving features, such as being close-coupled with open-drive ammonia equipment that has substantial heat-absorbing properties. The energy efficiency improvement over traditional ammonia systems is typically 8%, though "it's not unusual for it to run anywhere from 15% to 35%, particularly when compared with HFC and HCFC systems," said Scherer.

The system's energy savings have piqued the interest of utilities. NXTCOLD has been collaborating closely with Southern California Edison to gain significant energy incentives for a number of test sites, including Lineage's Oxnard facility. The company is also working with the Electric Power Research Institute and other utilities. "The utilities are keenly interested in this," said Scherer MG

Los Angeles Cold Storage developed its NXTCOLD low-charge-ammonia system because of the company's proximity to downtown Los Angeles.

System Specs

The NXTCOLD low-charge refrigeration unit comprises one or two compressors, an evaporator and a condenser in one tightly configured package. In addition it has the following characteristics:

» Electronic refrigerant injection control
» Less than 50 pounds, or less than a pound per ton of capacity, of ammonia
» Handles capacities ranging from 5 TR to 150 TR
» Produces operating temperatures ranging from -60°F to 60°F.
» Defrost with air, water, electricity or some combination.

REFRIGERATED WAREHOUSE GOES NATURAL WITH CO_2 AND ICE

Systemes LMP is replacing Plaisirs Gastronomiques' R22 system with a hybrid of refrigeration technologies

— By Elke Milner

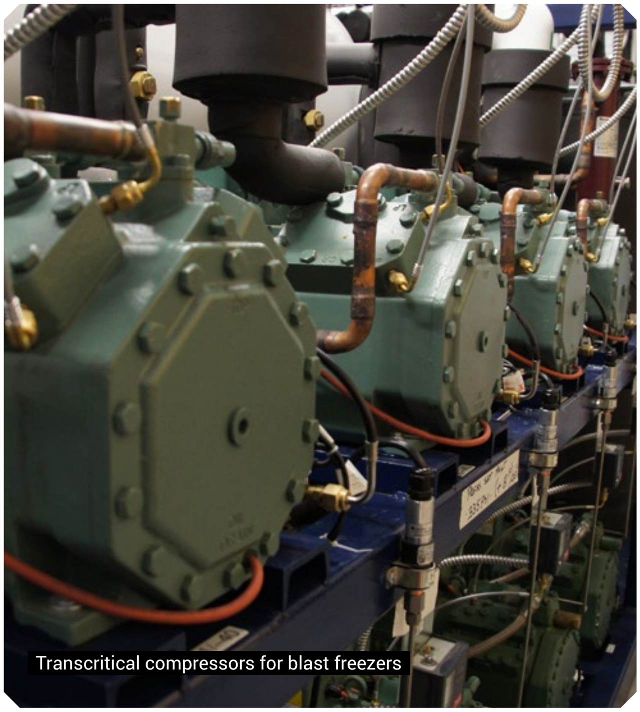
Jeff Gringas of Systemes LMP, standing next to CO_2 cascade system at Plaisirs Gastronomiques

When the three Beauvais brothers who operate Plaisirs Gastronomiques decided in 2013 to remove the R22 refrigerant from their 132,000-square-foot refrigerated warehouse in Broisbriand, just outside of Montreal, they devised a plan to do that — and more.

The brothers chose a hybrid solution that combines ice slurry, a CO_2 cascade system and two transcritical CO_2 systems, using the four existing compressor rooms.

The project, financed in part by a government grant, began in April 2013 and will be completed in July. At that point, Plaisirs Gastronomiques — which makes a wide array of frozen and refrigerated foods, including pot pies, sandwiches, pizza, quiches and more for major Canadian food retailers — will have removed all 12,000 pounds of its R22, replacing it with 3,000 pounds of R507 confined to the compressor rooms. The rest of the system will consist of natural refrigerants.

In this exclusive interview, Jeffrey Gingras, vice president of sales for Systemes LMP, explains how his company is renovating the 16-year-old warehouse with the new refrigeration systems.



Transcritical compressors for blast freezers

How did this project get started?

Plaisirs Gastronomiques felt it was necessary to find a solution to reduce the amount of R22 without risking any downtime of the plant, as this would impact their business. We worked with them to try to find ways to achieve what they where asking for and not stop any coolers during this very complex renovation.

What is Systemes LMP installing?

We approached them with a solution to reduce the amount of R22 they have and replace it with a natural solution. Our goal was to use as much of the existing equipment as possible.

For the medium temperature side, we opted for our ICE SLURRY solution, which allowed us to use the existing evaporators and add a pumping station for the ice slurry. The refrigerant charge (R507A) would be restricted to the compressor rooms. By using this technology, Plaisirs Gastronomiques would not need to change all their compressors and their evaporators; they would just need to be adapted to the ice slurry solution.

All the low temperature freezers are running with a CO_2 cascade system that [uses] two screw compressors, which also act as subcoolers for one of the ice slurry racks. The freezers were retrofitted to [the] cascade CO_2 technology. We were able to reuse the evaporators in all the freezers. All the other components had to be changed, as CO_2 compressors and line sizing are not the same as those using R22. For both the medium-temp and freezer applications we changed all of the condensers to fluid coolers.

The major goals of the project are to reduce the amount of synthetic refrigerant in the system, increase the capacity by using subcooling, reduce the cost of maintenance, simplify the control system, ensure the system is user-friendly, provide energy savings, and install technology that can be adaptable to many different applications

What are the new all-CO_2 additions to the facility?

We really wanted try something new, so when Plaisirs Gastronomiques wanted a spiral freezer that runs at -40°C, we thought this would be a good place to try something that has not yet been done. We developed a very low-temperature transcritical system that runs with a CO_2 recirculation pump. The temperatures requested have been achieved, and the pizza is completely frozen after its cycle. It is a very innovative technology that runs solely with a natural solution. The results are amazing.

We also installed three blast coolers that work as DX CO_2 transcritical systems. We are able to achieve our set points and are very happy with the results. Achieving the correct temperatures that Plaisirs Gastronomiques needed was very important.

What are the expected energy savings?

For the moment we have not looked into the energy savings. Heat reclaim and hot water preheat will be installed before the end of the project. Monitoring the energy will be easily done thanks our Micro Thermo controller.

Is the demand for CO_2 refrigeration in warehouses growing in North America?

The demand for CO_2 warehouses has dramatically risen in 2015; we have had many requests already this year. People are starting to look into ways to get rid of the R22 they currently have in their systems. Ammonia is not the solution for everyone when doing a warehousing retrofit, as some people feel more comfortable using CO_2.

AA: What are your expectations for the industry overall for the coming year?

I think public perception is changing for natural refrigerants. The upcoming year will be a time of evolution and many new systems will be built with new technologies EM

Ice slurry holding bin (left) and mixing bin

SHORT TAKES

— By James Ranson

All-CO_2 Kroger Store Gets GreenChill Platinum

U.S. grocery giant Kroger has been given the highest certification award in the U.S. Environment Protection Agency's GreenChill Partnership, following the installation of a CO_2 transcritical refrigeration system from Hillphoenix at its store in Holland, Ohio.

In a ceremony at the store on April 21, Kroger was presented with GreenChill's platinum certification, which recognizes the company's efforts to minimize the creation and emission of greenhouse gases at the Holland store by deploying state-of-the-art refrigeration systems.

Kroger is one of only a few retailers in the country to achieve platinum certification.

"Kroger can be very proud of this accomplishment," said Janet McCabe, acting assistant administrator for EPA's Office of Air and Radiation. "By installing an EPA GreenChill certified advanced refrigeration system, Kroger is demonstrating how smart, innovative design can work to better protect our climate and the earth's ozone layer."

The Holland store is the first of Kroger's 2,625 outlets to employ an all-CO_2 refrigeration system.

"Kroger is taking steps to protect the environment, and this store's GreenChill-certified system helps us reduce our carbon footprint while still serving our customers' needs for fresh products in a healthy and friendly atmosphere," said Keith Oliver, Kroger's vice president of facility engineering

CO_2 Ice Rink Cuts Energy Costs

The first CO_2 transcritical ice rink in the U.S. is reaping rewards just three months after opening, achieving reduced energy and refrigerant costs while benefiting the environment.

The city of Anchorage, Alaska, operates the renovated ice rink, called the Harry J. McDonald Recreational Center, which was opened in January with a Hillphoenix Advansor all-CO_2 transcritical system.

"We are already seeing savings, and we're anticipating energy savings of 25% to 40% when all the results are in," said John Rodda, Parks and Recreation Director for Anchorage.

Anchorage Mayor Dan Sullivan cut the ribbon on the new facility after a nine-month renovation and $3.5 million investment in the project. Hillphoenix Industrial Programs Manager Tim Henderson said that the company "anticipates public and private ice rinks around the country will follow Anchorage's lead."

As U.S. ice rinks comply with federal regulations phasing out R22, the successful test case at the McDonald Center could lead to increased demand for transcritical systems. "We've got ice rinks calling us from all over the country to see how it's going," Rodda said.

Obama unveils plan to cut U.S. emissions

The Obama Administration last month released its plan to cut U.S. greenhouse gas emissions by 26% to 28% by 2025, meeting a March 31 deadline for countries to submit their climate-change commitments to the United Nations in advance of a major international meeting in Paris in December.

The plan includes various initiatives undertaken by the White House, including pollution limits on power plants, higher fuel efficiency standards, and new rules targeting methane and hydrofluorocarbons.

With less than two years remaining on his term President Obama is intent on leaving an environmental legacy that would see the U.S. significantly cut its emissions over the next decade.

"We can achieve this goal using laws that are already on the books, and it will be in place by the time the president leaves office," said Brian C. Deese, President Obama's senior adviser on climate change.

Yet there has been opposition from Republicans, with 13 states vowing to fight the clean power plan.

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MAKING SENSE OF AMMONIA REGS

IIAR experts weigh in on the ever-evolving world of ammonia regulations and codes

— By James Ranson

The explosion at the West, Texas, fertilizer plant in 2013

On April 17, 2013, an ammonium nitrate explosion obliterated the West Fertilizer Company storage and distribution facility in West, Texas, near Waco. Fifteen people were killed, more than 160 were injured and more than 150 buildings were damaged or destroyed.

This horrific event set off a chain of regulatory actions that have heavily impacted the industrial refrigeration industry and will continue to do so for the foreseeable future. In addition to increasing the number of inspections and fines levied on warehouses, the new regulatory climate has sparked considerable interest in a variety of low-charge ammonia systems that improve safety while relieving some of the oversight burden.

At the International Institute of Ammonia Refrigeration (IIAR) Conference & Exhibition in San Diego CA last month, these issues were all high on the agenda in presentations by regulatory and code experts, who advised attendees on impending developments.

The regulatory climate abruptly changed on August 1, 2013, when, in the wake of the West Fertilizer disaster, President Obama issued Executive Order 13650 – "Improving Chemical Facility Safety and Security." The order directed a bevy of federal agencies – the Environmental Protection Agency, Department of Labor and the Department of Homeland Security among them – to identify ways to improve operational coordination with state and local authorities, enhance federal agency coordination, modernize policies, regulations and standards to enhance safety and security in chemical facilities, and work with stakeholders to identify best practices. To this end, the order established a Chemical Facility Safety and Security Working Group.

And this past February, the EPA issued an "enforcement alert" to refrigeration facilities using anhydrous ammonia. Given evidence that some facilities were failing to follow safety procedures, the alert warned companies to "take responsibility to prevent accidental releases of dangerous chemicals like anhydrous ammonia."

Lowell Randel, Vice President of Government and Legal Affairs for Global Climate Change Alliance (GCCA), acknowledged in a luncheon presentation at the IIAR Conference that executive order 13650 is leading to regulatory activity with respect to "improving chemical facility safety and security."

With regard to the EPA's February enforcement alert, Randel said it was triggered by "inspection findings of imminent danger at a few facilities" and intended to "alert industry to hazards and lessons learned." Yet, he added, the enforcement alert raised concerns with the negative spin it put on the use of ammonia, "while largely ignoring the environmental benefits of ammonia – namely that it does not deplete the ozone and it is self-alarming, as we all know."

But executive order 13650 could lead to some constructive changes, Randel said. "It includes improved coordination with federal agencies and improved information sharing, also improved coordination between state and local officials, including the first response community."

Randel described the executive order as "a real chance for OSHA and the EPA to advance some policy issues they've been thinking about for quite some time." This includes expanding the elements that underlie OSHA's Process Safety Management (PSM) standard, including "different metrics that might be useful," he said.

In addition, with the increasing adoption rate of indirect (secondary) refrigeration systems that confine ammonia to the engine room, OSHA is reviewing the PSM regulation on charge limits. In another presentation at the IIAR Conference, Evapco Vice President Kurt Liebendorfer said that while OSHA was unlikely to change charge limits as part of the current review, it may do so in future.

Meanwhile, as part of its Risk Management Program, EPA has put out a request for information relating to formal rule-making changes. The IIAR has responded by forming a task force that includes the Global Cold Chain Alliance, International Association of Refrigerated Warehouses, American Frozen Food Institute, American Meat Institute, North American Meat Institute and the US Poultry and Egg Association.

Randel believes some of the potential changes could be costly. "We feel you know your facility better than the federal government," he said. "We're communicating back to the agencies that micro-management is not the intention of these standards."

Randel expects a lengthy process. "I think the EPA is going to move more quickly; their stated goal is to have a proposal by this fall and a final rule by the end of 2016, as they're trying to get things done before the end of the Obama administration," he said. "OSHA is going to move more slowly and part of that is the procedures that they have to go through, including what they call a panel for small business impacts. The IIAR has a big role to play there too."

Meanwhile. IIAR-2 – IIAR's industry standard on equipment, design, and installation of closed-circuit ammonia mechanical refrigeration systems – is under major revision and out for public review through mid-2015. One of the reasons the standard has undergone a major rewrite is to help close the gaps with ASHRAE-15, Uniform Mechanical Code (UMC), NFPA-1, International Mechanical Code (IMC) and the International Fire Code (IFC). The results will have implications for packaged and low-ammonia-charge systems, and include new definitions for equipment enclosures and secondary coolants.

Following Randel's presentation, IIAR code consultant Jeff Shapiro urged attendees to support the IIAR as its first source for 2015 model codes and standards. "There are some minimum requirements you should meet if you're operating an ammonia facility and we should be the ones to prescribe that, not another organization."

Codes and Low-Charge

At the IIAR Conference, Liebendorfer of Evapco, which supplies its own range of low-charge-ammonia refrigeration systems, summarized his paper, "Regulatory and Code Implications for Low-Charge Ammonia Systems."

Liebendorfer said the main reason low-charge systems are becoming so important is that the threat of ammonia releases still drives the regulatory burden. Codes and standards such as OSHA, IIAR, ASHRAE, International Building Code, IMC and UMC all have various design references to the quantity of refrigerant in a system. Yet despite impressive coordination as a whole, there remains a lack of consistency on the definition of low-charge size.

"The regulations and the codes have been coordinated over the years and I found in reading all these codes that they contain many common requirements and this is a good thing," Liebendorfer said. "However, there is a real lack of [a common threshold-quantity definition] related to ammonia charge size or ammonia charge management. Therefore, an effort should be made between all major code writing bodies to communicate and coordinate better support of charge reduction, which I think is what everyone is after because it should reduce the risk and it should reduce the regulatory burden."

continued on p.40

In the meantime, it is generally agreed that a low-charge ammonia system should hold no more than 10 pounds of ammonia per ton of refrigeration and contain no more than 50% of the charge of the optimized PRL (Pumped Recirculated Liquid) system. Types of low-charge ammonia systems that are being increasingly adopted in the industry include electronic DX systems, ammonia-CO_2 cascade systems, ammonia secondary fluid systems (including brine/CO_2), and modular based packages.

Due to the safety issues with ammonia, a common theme throughout the codes is the requirement to maintain sufficient access for operations, maintenance and emergency activities. Since some of the new low-charge technologies involve packaged or enclosed modular systems, where space is at a premium, it is important that the required access be provided.

Another key element for reducing charge in ammonia systems is the use of a secondary coolant. “There’s a big open door for ammonia to move into the HVACR industry if you’re able to provide cooling to a space via a secondary fluid,” Liebendorfer said. “That’s why a lot of our industry is based around secondary fluids to reduce charge.”

In regards to the public review of IIAR-2, Liebendorfer suggested there could be some significant additions to the code relative to low-charge systems, notably the 100 HP compressor threshold, outline of equipment enclosures, and a detailed set of criteria for packaged systems and ventilation design criteria for limited-charge systems. The specification of the different locations that refrigeration equipment can be located in a facility, along with the relevant thresholds, is particularly pertinent for low-charge packaged systems, which often arrange equipment in different locations than typical field-erected ammonia systems.

In particular, the IIAR-2 draft states that ammonia equipment does not have to be located in a machine room if the charge is less than 6.6 pounds -- a standard already established in ASHRAE-15.

“As the industry continues to successfully develop low- and lower-charge ammonia systems, the application of these products can expand into other air-conditioning and process cooling applications, provided the relevant code writing bodies allow it,” Liebendorfer said. “Where this will have great benefit is for owners that require or desire a natural refrigerant but have limited solutions currently available. Low-charge packaged ammonia cooling systems are the solution that can serve this need” JR

EPA Shares Lessons Learned

In the Environmental Protection Agency’s Enforcement Alert published in February, it listed lessons learned from recent inspections of ammonia refrigerated systems.

Here are some key examples:

» Operators should understand the gap between the safety requirements of new industry codes and standards and the standards to which its facility was built, and develop a plan to address safety deficiencies. This may include making upgrades.

» Refrigeration systems that are missing key controls, such as emergency shutoff valves, need to be upgraded.

» Halting corrosion of pipes and equipment should be a priority.

» Hammering and shaking of equipment and pipes risks breakage and ammonia releases.

» Ability to shut down the system without entering the machinery room is necessary.

» Ammonia pressure relief valves should not be located where they could spray ammonia onto people.

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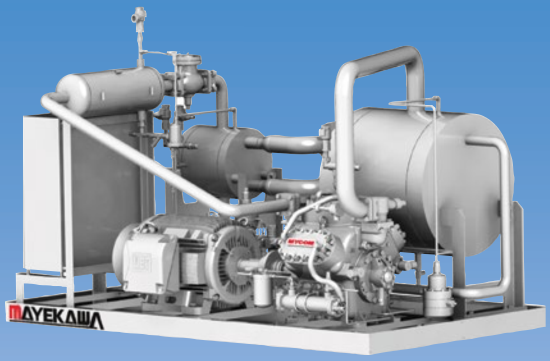

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LOW CHARGE TAKES CHARGE AT IIAR SHOW

The need to cut ammonia charge was reflected in numerous systems on display, from modular units to NH_3/CO_2 cascade systems – By Michael Garry

There was near unanimity at the IIAR (International Institute of Ammonia Refrigeration) 2015 Conference & Exhibition, which took place in San Diego last month, that "the times they are a-changin'," as Bob Dylan sang in the 1960s.

Those changes are focused particularly on reducing the ammonia charge in industrial refrigeration, both to improve safety and to avoid the strict regulatory requirements that apply to ammonia charges exceeding 10,000 pounds. Low-charge ammonia systems were the talk of the exhibit floor, including those that also pair up with carbon dioxide.

"Everybody and his brother are into these low-charge schemes," said Virgil Gulley, market development manager, Asia Pacific, Parker Hannifin, which showcased temperature and pressure gauges that transmit their readings via Bluetooth to a mobile phone app. He attributed this trend to strict enforcement of federal and local safety codes, especially in California. "They're writing them up for having a period in the wrong place," he said. "But if end users get under 10,000 pounds of ammonia, they win."

Being "plug-and-play," low-charge systems are great for technicians with less technical skills, Gulley said. But he also pointed out some of the potential issues associated with low-charge systems, including efficiency challenges at lower temperatures, the weight of the systems on roofs, and the absence of controls to communicate problems to technicians.

"I'm not saying it's a bad idea, just that there are still things to be worked out," particularly for larger applications, he said. "These small-charge systems are about 60 tons [of refrigeration capacity]. In our business we don't start thinking about refrigeration until you get to 300 tons. That's a radical shift there."

San Francisco-based Azane, a division of Star Refrigeration, promoted its low-charge ammonia units – the Azanefreezer, a low-charge air-cooled ammonia condensing unit for freezer warehouses, and the Azanechiller, a low-charge ammonia chiller. The total ammonia charge for the former ranges from 163 pounds to 484 pounds, while the ammonia charge for the latter runs from 98 pounds to 250 pounds.

Another factor pushing companies, particularly smaller warehouses, towards low-charge ammonia systems is the phaseout of R22 and impending restrictions on HFCs, said Derek Hamilton, Azane's business development manager, at an IIAR Conference & Exhibition workshop. "For facilities moving away from R22, low-charge ammonia, along with other natural refrigerant technology, is going to be the best option if they are looking to invest in technology that's going to service them for the next 20 to 25 years," he said. "The R22 phaseout is a massive opportunity for the ammonia refrigeration industry to enter new markets."

At the IIAR event, EVAPCO, Taneytown, Md., introduced the Evapcold Packaged Low-Charge Refrigeration System. It requires 2.5 to 3 pounds of ammonia per ton of refrigeration, "a fraction of the refrigerant charge associated with traditional field-built systems," the company said in a statement.

EVAPCO's low-charge system comes in one- or two-piece rooftop modules, water-cooled or air-cooled condensing, 10 TR to 100 TR capacity and -20°F to 50°F room temperature applications. It can be applied to retrofits, building expansions or new facilities.

The Evapcold system comprises all of the key elements of a refrigeration system – a first for EVAPCO -- including the evaporator, condenser and compressor, along with piping, valves and controls, noted Kurt Liebendorfer, vice president, EVAPCO. For a typical 100,000-square-foot refrigerated facility, an end user would employ 6-7 units, placed near the refrigerated areas. The evaporator is a pump liquid-feed system.

Transcritical CO_2 Coming to Industrial Refrigeration

Carbon dioxide, which is making progress as a refrigerant in the North American supermarket sector, is also increasingly infiltrating its way into the industrial sector as well.

At the IIAR Conference & Exhibition in San Diego last month, CO_2 was not only discussed as a refrigerant in ammonia cascade and secondary systems, but also as a solitary refrigerant in transcritical systems, at least for smaller facilities.

Known for its transcritical CO_2 systems for supermarkets, Quebec-based Carnot Refrigeration has two DX NH_3-CO_2 cascade systems installed in industrial settings as well as a transcritical industrial installation on the way, said Tommy Dolbec, design engineer for Carnot.

In general, Carnot recommends NH_3-CO_2 for larger warehouses and CO_2 transcritical for smaller ones (under 100,000 square feet).

Hillphoenix – also known for its extensive installations in supermarkets – was at the IIAR show discussing the opportunity to use its transcritical CO_2 racks in small warehouses.

Hillphoenix has installed one such system in a pharmaceutical facility and another in a produce storage warehouse in Canada, said John Gallaher, vice president, industrial applications, declining to name the companies without their permission. Industrial refrigeration end users are now more open to considering transcritical systems, particularly as an alternative to HFC units, he added.

Zero Zone continues to pursue applications for CO_2 refrigeration in both the supermarket sector (which comprises 75% of its business) and industrial settings, noted Dan O'Brien, vice president of sales and manufacturing for Zero Zone, North Prairie, Wis.

For example, last month, Zero Zone's first transcritical CO_2 system went live at a commissary in a pharmaceutical facility for both low- and medium-temperature applications.

Vilter Manufacturing, a division of Emerson Climate Technologies, is developing screw and reciprocating compressors for transcritical CO_2 applications in industrial plants. "CO_2 is on our radar," said Tom Melotik, district sales manager for Vilter. "There's not a lot of CO_2 [refrigeration] in the U.S., but it's starting to grow, even at a conference like this."

Liebendorfer noted that the fertilizer plant explosion in West, Texas in 2013 precipitated the Obama Administration's executive order 13650, which has "ramped up" enforcement of safety rules at chemical facilities. The result has been an upsurge in violations and fines at cold storage facilities over the last few years, providing greater impetus to transition to low-charge systems, he said.

NH_3/CO_2 UNITS OFFER LOW-CHARGE OPTION

M&M Refrigeration, which designs complete systems for industrial end users, about 75% of them ammonia-CO_2 cascade models, "is seeing more interest in ammonia-CO_2 cascade to get the charge down," said Ole Christensen, vice president, engineering.

In its cascade systems, the ammonia charge is 15% to 20% of what it would be in an ammonia-only system, Christensen said. In one 700,000-square-foot cold storage facility, the ammonia charge in a cascade system is less than 8,000 pounds while the CO_2 charge is 60,000 pounds. "None of our CO_2 installations have more than 10,000 pounds of ammonia," he noted.

The M&M cascade systems typically features 2-3 temperature levels, one at -50°F for blast freezing, one at -25°F for freezing and one at +20°F for docks and cooler rooms.

The energy consumption of the cascade systems is about the same as for a two-stage ammonia system at -25°F, but under that it uses 10% to 15% less energy. The first cost of the cascade system is also about the same as for a two-stage ammonia system.

Mayekawa promoted its NewTon 3000 hybrid cooling system, which employs low-charge ammonia (under 200 pounds) in the mechanical room and delivers carbon dioxide as a secondary fluid to cool cold storage areas. It features a semi-hermetic compressor, which combines an IPM motor (running between 37 KW and 55 KW) and screw rotors to cut energy consumption by 20% compared with conventional systems, the company says.

The unit also contains an ammonia condenser and evaporator, and a CO_2 receiver/condenser, which is hooked up to another company's CO_2 evaporator in the cold storage area. Its capacity ranges from 12.8 TR to 32.1 TR.

Mayekawa has successfully marketed the NewTon in its home market, Japan, over the past seven years, and is now bringing it to the U.S., said Mark Tomooka, Mayekawa' director, applied technology development. A test facility, under construction in Nashville, Tenn., is slated to open by the end of the summer. "We have worked hard to make elements [of the NewTon] more suited to the U.S. market," he noted.

As a large designer, builder and contractor, Cimco Refrigeration elicited a lot of interest at its booth in Mayakawa's NewTon ammonia-CO_2 unit following a presentation on CO_2 given by its director of business development, Benoit Rodier.

"CO_2 is starting to perk up in industrial and recreational (ice rinks) in the U.S.," said Jose Mergulhao, vice president, US operations for Cimco. "NewTon is one of the pieces – a small dedicated package built for smaller facilities, maybe 5,000 to 10,000 square feet with three evaporators."

COMPONENT MAKERS SUPPORT LOW CHARGE

In support of low-charge ammonia systems, a number of manufacturers showcased components like separators, heat exchangers, wireless temperature gauges and valve stations. Much of it is suited for both ammonia and carbon dioxide, given the interest in cascade NH_3/CO_2 systems.

For example, Alfa Laval, based in Lund, Sweden, showcased its U-Turn liquid separator, which sits above one of its M10 semi-welded plate heat exchangers (generally used as an evaporator), which together can support low-charge ammonia applications in industrial settings.

"Alfa Laval has more focus on natural refrigerants, and we're developing products with low-charge such as the U-Turn, said Alireza Rasti, market manager, industrial refrigeration, at the company's IIAR booth. "We could see the market need for low charge."

The combined unit is compact enough to fit through a standard door, he noted. This also helps in making the system energy efficient, added Jesper Olsen, market manager, industrial refrigeration. Its capacity ranges from 150 KW to 10 MW.

The system is designed to handle pressures up to 900 PSI, making it suitable for carbon dioxide-

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ammonia cascade applications. To date, 4-5 cascade systems incorporating the system have been installed in the U.S. The U.S. market tends to be slow to make changes, Olsen said. “Some say they can’t do it just yet. We tell them they’re not the first and they’re happy.”

Danfoss, based in Nordborg, Denmark, unveiled a new valve station, which links multiple valves into a single unit to reduce the number of weldings required for individual valves, thereby reducing leaks and improving safety in ammonia systems.

In the new unit (ICF 15-4), which can be used in a liquid line to an evaporator, four standard valves are combined into a single housing, reducing the number of weldings from six or eight to two. The valves include a solenoid, stop valve, filter and manual opener. The units are rated to 52 bar, making them suitable for CO_2 applications. They can also be used in low-charge systems.

“The focus of the market is on safety and that’s where the valve station comes in,” said Carsten Dahlgaard, global marketing director, industrial refrigeration.

Colmac Coil Manufacturing’s mission “is to make the world a safer place for the people in the industrial refrigeration industry by minimizing the risk of exposure to ammonia,” said Bruce Nelson, president of the company, based in Colville, Wash.

To that end, Colmac has developed a DX (direct expansion) ammonia evaporator, which employs aluminum tubes, distributes ammonia equally to all tubes, and is able to work at freezer temperatures. It requires 30 to 50 times less ammonia than a pumped ammonia system, while costing less as well, said Nelson “We can design a large refrigeration system with significantly less than 10,000 pounds of ammonia.”

So far six large U.S. plants have implemented the low-charge evaporator. “We’ve only been on the market with it for two or three years, but we’re really accelerating the number of projects,” said Nelson.

For low-charge ammonia systems, Baltimore Aircoil, Jessup, Md., offers its Trillium Series hybrid air/evaporative condensers, which use as little as 13 pounds of ammonia. The microchannel condenser “uses so much surface area that you don’t need as much refrigerant,” said Huseyin Koca, sales engineer, refrigeration.

EVAPCO’s low-charge ammonia Evapcold unit.

Jeremy Williams, directing manager/lead instructor for Garden City Ammonia Program (GCAP), is well positioned to observe trends in the industry, given his company’s longtime position as a training school for industrial refrigeration, particularly systems using ammonia and carbon dioxide. The school trains about 2,400 students per year.

Williams sees interest in ammonia-CO_2 systems for new facilities that reduce the ammonia charge compared to traditional systems. “Guys want to keep ammonia in the engine room and CO_2 in the plant,” he said at his IIAR booth. But the change from large-charge ammonia systems will not happen overnight. “It will take 30-40 years to get to that in all new plants.”

In the meantime, he does not expect existing ammonia plants with, say, 350,000 pounds of ammonia and 48 screw compressors, to get under 10,000 pounds, the threshold for PSM (process safety management) plans. He also doesn’t believe the industrial sector will gravitate to CO_2-only systems. “Industrial means killing 20,000 hogs a day,” he said. “Ammonia is better than CO_2 for that.”

Still, he acknowledges that many industrial operators are keen on reducing the risks posed by large quantities of ammonia. “Safety is huge and government regulations are huge,” he said. “To reduce risk with lower charges is one option, but it won’t work for everybody” JR

Ammonia Heat Pump Finding U.S. Users

High-pressure ammonia heat pumps are beginning to catch on in the U.S. for industrial applications, said Sam Gladis, business director, heat pumps, for Vilter Manufacturing, which makes the single-screw, single-rotor compressor used in this heat pump. Vilter is a division of Emerson Climate Technologies.

The ammonia heat pumps have 16 installations in Europe. In the U.S., they are installed at a major food processing plant and at a cheese processor, both retrofit operations. Gladis declined to name the companies without their permission.

“With the EPA’s regulations on emissions, [energy-saving] ammonia heat pumps serve that very well,” he said, adding that the ammonia replaces an HFC like R134a. “People in the U.S. are waking up to what we’re doing.”

The heat pumps, used for cooking, sanitizing and other applications, take advantage of the waste heat from a facility’s refrigeration system, and can be employed instead of fossil-fuel boilers. The energy savings offered by the heat pump usually produces a three-year ROI on the cost of the unit, said Gladis.

Naturals a Major Catch at Seafood Expo

Not just ammonia equipment, but ammonia-CO_2 systems stand out amid the crabs and flounder

— By Michael Garry

In Boston last month, the North American seafood industry showed the wide range of natural-refrigerant technologies it uses to keep its perishable products fresh.

A variety of ammonia refrigeration applications, from cold storage to quick-freezing to ice making, were showcased amid displays of shrimp, halibut, tilapia and every other conceivable fish at the Seafood Expo North America/Seafood Processing North America shows, co-located at the Boston Convention and Exhibition Center.

In addition, a number of exhibitors featured equipment tapping carbon dioxide, including ammonia-carbon dioxide systems, which reduce the ammonia charge and improve safety.

For example, Mayekawa's freezer division was at the Seafood Expo as part of its effort to enter the North American market. (Its refrigeration division is already well established in North America.) The freezer division markets process freezers that quick-freeze seafood products.

While most of Mayekawa's end users employ ammonia in quick-freeze applications, closed ammonia-CO_2 systems are now being more widely used. "Processors want to eliminate ammonia in the processing area and use CO_2 there," said Bud Martinson, Mayekawa's sales manager, freezer division. "The ammonia can then be isolated in the refrigeration room." The dual-refrigerant system also can go to lower temperatures.

Lineage Logistics, Richmond, Va., a six-year-old company that has grown its network of 111 temperature-controlled warehouses through the acquisition of 16 companies, recently began installing ammonia/CO_2 refrigeration systems, in lieu of ammonia-only or HFC refrigeration, in a few of its newer facilities.

Skaginn, based in Iceland, also offers ammonia/CO_2 refrigeration systems. Its latest customer for this technology is Eastern Fisheries, which uses a closed-loop mechanical system for an IQF (individually quick freeing) application, said Sigurour Skulason, sales and service. The system combines frosting and freezing.

"It's a new refrigeration system in an existing plant," he said. "They took out a nitrogen (cryogenic) system and put in an ammonia/CO_2mechanical freezer." He called this type of transition "unusual."

Because of their lower running costs, ammonia/CO_2 systems are "getting popular" for cold-temperature applications, he said. Other Skaginn customers have been using ammonia/CO_2 for a few years in plate freezers.

Differing Ice Makers Displayed

Chicago-based Howe Corp.'s industrial ice flake makers typically tie into a facility's ammonia refrigeration system or to a dedicated condensing unit using an HFC (hydrofluorocarbon) gas. However, two years ago, Freshwater Fish Marketing installed a 20-tons-per-day ice flake maker linked to a dedicated condensing unit using ammonia.

"It's unusual to put in a condensing unit with ammonia to run an ice machine," said Andrew Ortman, Howe's vice president, sales & marketing, at the Expo. The reason for that is the ammonia condensing unit requires steel rather than copper piping, boosting the cost.

Howe Corp. also showcased a CO_2 icemaker machine, which produces ice flakes in supermarkets. It has been installed in the seafood department of a new 33,000-square-foot Roche Bros. store opening in Boston at the end of April. The machine (2000-RLE-CO_2), which makes 2,000 pounds of ice flakes daily, is connected to the store's carbon dioxide liquid-overfeed refrigeration system, which pumps liquid CO_2 to refrigerated and frozen-food applications throughout the store.

"We're seeing more use of CO_2," said Ortman. "Sobeys in Canada uses our machine [with CO_2] and we're seeing more from them, as well as from Whole Foods." Currently, about 90% of Howe's supermarket icemakers are connected to HFC refrigeration systems, and 10% to CO_2 systems.

"Now that more information is out there about natural refrigerants, people are more comfortable with it and trying it," he added. "But some customers say, 'No, we'll wait and see a little more what the others do."

Howe's icemakers that work with CO_2 are slightly more expensive than those that operate with HFCs because the CO_2 units have more electronics. On the other hand, the CO_2 models are less expensive to install because of smaller line sizes. Considering first cost and installation, the cost difference between the two system types is "close to a wash," said Ortman.

At its booth, Linde displayed its new Cryowave IQF tunnel freezer, which uses a rolling wave action in concert with liquid carbon dioxide or nitrogen to cryogenically freeze individual shrimp, scallops, meatballs and other foods. It is designed to replace a traditional flighted freezer.

"The flighted freezer is difficult to control," said Mark DiMaggio, Linde's head of food & beverage industry. "With our new [Cryowave] freezer, you get more heat transfer, higher production and lower cost to operate." In CO_2 operations, the new system eliminates CO_2 "snow" carryover and is easier to clean.

Pocino Foods, City of Industry, Calif., uses the Cryowave freezer with CO_2 to quick-freeze its meatballs, pizza crumble and sliced and diced meat. "It was time to replace the flighted freezer," said Jerry Pocino, vice president, in a case study prepared by Linde MG

EUROPE FORGES AHEAD

ATMOsphere Europe 2015 found an HVAC&R market well prepared for the new EU F-Gas Regulation on HFCs, with new technologies available to improve the efficiency of CO_2 in warm climates, and increased investment in training

– By Janaina Topley Lira

As it adapts to tough new restrictions on HFC refrigerants, Europe continues to lead the world in natural refrigerant adoption, setting an example for other countries to follow.

That was the message heard at ATMOsphere Europe 2015, which returned to Brussels, Belgium, on March 16 and 17 for its 6th and largest edition. Attended by 230 participants, the shecco-hosted event featured 60 international speakers, who presented on the very latest natural refrigerant trends in and around Europe.

"Here in Europe we really are at the forefront of natural refrigerant technologies; we are leading the world," said Marc Chasserot, conference chairman and shecco's Managing Director, in his opening remarks. "We see that policy has been a big driver of this, setting the framework, but playing an equally important role are the customers who want these technologies. We are seeing now more and more solutions, even for warmer climates, and using a variety of natural refrigerants."

The breadth of natural refrigerant applications presented at ATMOsphere Europe 2015 made it clear that in nearly all sectors the natural refrigerant market in Europe is expanding. For example, the supply of CO_2 transcritical systems continues to grow, with new players entering the market, and new technologies increasing the efficiency of systems in warm climates. The European market for hydrocarbons is also experiencing growth, spurred on by green procurement strategies in the foodservice and retail sectors. Leading end users, such as McDonald's and Red Bull, have invested in over half a million pieces of propane refrigeration equipment.

In the commercial refrigeration sector, Stuart Webb, Carrier's International Sales Support for CO_2, noted that year-on-year growth of cascade systems in Europe was an impressive 51% but that this increase was being outstripped by transcritical refrigeration systems, which have increased by 63% from 2013 to 2014.

CO_2 system supplier Advansor, whose CO_2 transcritical booster systems are available in the U.S., following the company's acquisition by Hillphoenix, is experiencing a similar upturn in European business. Director Torben Hansen reported that "Advansor has had a tripling in inquiries" over the last two years. For Hansen this shows that the growth is not just in the north of Europe but also the south.

A key focus of many presentations was the evolution of CO_2 technology for southern European countries, where higher ambient temperatures previously had an undesirable effect on the efficiency of R744 units. Ejectors, economizers and parallel-compression were just some of the solutions cited as capable of boosting transcritical efficiency in warmer climates, putting to rest the so-called "CO_2 equator."

According to Nina Masson, shecco's Deputy Managing Director, developments in Europe are having reverberations all around the world, with an increase in uptake of CO_2 in North America, China and Japan. In Canada for example, retailer Sobeys has 72 stores using CO_2 transcritical systems, and is opening 15-20 CO_2 stores every year.

Masson also predicted a "growing appetite" for hydrocarbons (HCs) in the North American foodservice industry. The EPA's approval of HCs in six AC&R (air conditioning and refrigeration) applications, including stand alone commercial refrigerators and freezers, will certainly help to cement this trend.

"We can expect that with upcoming regulations and standards, the number of light commercial hydrocarbon systems will increase," said Masson.

CHANGE DRIVERS IN INDUSTRIAL REFRIGERATION AND HEATING

In Europe's industrial sector, taxation on emissions, customer demand for sustainability and accountability, as well as high operational efficiency, are all driving the uptake of both ammonia and CO_2. Technology providers are responding with wider equipment availability, less complexity and greater accessibility. "There are many more industry players on the market today, and an increased variety of applications for natural refrigerants," said Eric Delforge, Corporate Business & Policy Officer, Mayekawa Europe. "Because there is more competition and equipment on the market, the capital costs of these systems can decrease."

An Industrial Refrigeration session collected a number of natural refrigerant technology case studies, including the first CO_2 transcritical ice rink in Europe, installed in Gimo, Sweden.

Kent Hofmann, Sales Engineer at Green & Cool, and Jörgen Rogstam, Managing Director of Energi & Kylanalys, reported that, thanks to the CO_2 transcritical installation, the daily average energy usage at the Gimo ice rink was reduced to 1,500 kWh, from 4,200 kWh. This translates to seasonal energy usage of about 350,000 kWh, with the municipality achieving savings of about 600,000 kWh a year, corresponding to more than a 60% reduction in energy costs.

Another CO_2 case study, presented by Paul Rivet, Manager of AF Consulting, focused on a CO_2 transcritical system in a frozen fish factory in France. The system is made up of two continuous freezers with capacities of 350 kW at -40°C, as well as frozen storage rooms with a 100 kW capacity at -25°C, and working areas of 150 kW at +8/+10°C.

Although usually a project of this nature would use ammonia as the refrigerant, in this case a complete CO_2 transcritical system was installed due to the strict constraints on ammonia refrigeration in France. In addition, a comparison with direct pumped NH_3, direct pumped HFC, and a hybrid CO_2/NH_3 system revealed the transcritical unit to be an energy-efficient solution.

In Spain, the FRIBIN meat processing facility benefitted from the installation of a centralized CO_2 industrial refrigeration system for tunnels and cold rooms. Juan Carlos Rodríguez, Engineering Manager at Johnson Controls España, explained that the solution provided a saving up to 2,600,000 kW per year, which translates to a 32% energy reduction and a $406,000 cost savings.

Further north, in the UK, Johnson Controls installed an ammonia heat pump solution at the Cranswick abattoir, one of the main suppliers of pork products to supermarkets in the UK. The aim of the project was to phase-out its R22 and HFC dependency, improve product yield, and reduce utility costs.

Thanks to the installation of Sabroe's NH_3 industrial-refrigeration heat pump with reciprocating compressors, Cranswick was able to reduce energy costs by $736,500 per year, increase the productivity by 30% and decrease the weight loss of the carcasses from 2.3% to 1.4%. The installation set a new industry standard, as it not only monitors the performance of the plant, but also actively hunts for optimal set points to reduce energy usage.

Lastly, in Belgium an ammonia heat pump installation enabled a bakery to achieve annual savings in energy costs of $60,000 and a return on investment of 3 years.

EU F-GAS REGULATION SPARKS NEW OPPORTUNITIES FOR NATURAL REFRIGERANTS

Organized for the first time in Brussels since the EU F-Gas Regulation came into force, ATMOsphere Europe 2015 provided a timely platform for key policymakers, industry representatives and stakeholders to exchange views and updates on its implementation.

Bente Tranholm-Schwarz, Deputy Head of Unit of DG Climate Action at the European Commission, provided a snapshot of the key measures under the EU F-Gas Regulation that entered into force in January 2015. The HFC phase down, which will require reducing the average GWP of refrigerants from 2,000 to 400 by 2030, gives a clear signal to the manufacturers and buyers of refrigeration and AC equipment to avoid the use of HFCs as much as possible.

However, the positive effects of the EU F-Gas Regulation on increased demand and availability of natural refrigerant equipment will need to be accompanied by an updating of national codes and standards. To help eliminate any regulatory barriers to the introduction of natural refrigerants, Tranholm-Schwarz noted that the European Commission has initiated a study that will identify codes, standards and legislation that limit or prevent the use of HFC alternatives at the EU and national level.

In a similar vein, in the summer of 2015, the French government will update certain regulations to alleviate the burden on ammonia installations, allowing a wider introduction of such technology in France JTL

Pushing For a Global HFC Phase Down

On the heels of its new EU F-Gas Regulation, the European Union has made the case for a phase down of HFCs at the international level. But the proposal contrasts with that made by the United States, Canada and Mexico, and presented by Philippe Chemouny, Manager of the Montreal Protocol Program at Environment Canada, at ATMOsphere Europe 2015.

Chemouny indicated that the countries are currently working on the 2015 version, which should be submitted at a meeting later in 2015.

To come to an agreement on a global HFC phase down, Chemouny believes that the vast differences in consumption levels among developing countries, in addition to differing opinions with regard to the technical feasibility of alternatives to HFCs, need to be addressed. In addition, questions relating to adequate financial support for developing countries and the role of the Multilateral Fund (MLF) must be clarified.

Canada is also taking action to reduce HFC emissions domestically. In September 2014, the government issued a notice of intent to regulate the import and use of certain HFCs and is currently considering a variety of options in consultation with the industry. Chemouny hinted that possible measures could include an HFC phase down, sector-specific bans, as well as a combination of both approaches.

HIGHLY EFFICIENT HEAT PUMP DEBUTS AT ATMOSPHERE EUROPE

The TripleAqua, a patented natural refrigerant heat pump system using propaene, can achieve up to a 50% reduction in energy consumption

– By Janaina Topley Lira

Heating and cooling is responsible for around 40% of a building's CO_2 emissions, providing a great opportunity for energy savings. The TripleAqua heat pump, created by the Dutch firm Coolmark, aims to capitalize on that opportunity.

Unveiled in Brussels, Belgium, last month at ATMOsphere Europe by Menno Van der Hoff, manager of research and development HVAC for Dutch supplier Uniechemie (Union Chemicals), the TripleAqua goes further than traditional heat pumps. As befits its name, the system offers three water-related elements for medium and large buildings – heating, cooling and (unlike standard technology) passive storage of heat and cold that can later be used for heating and cooling instead of being wasted. In addition, it is can provide heating and cooling simultaneously.

The upshot: a 50% reduction in energy consumption compared to traditional heat pumps, according to Van der Hoff. In addition, he said, the TripleAqua employs a VRF (variable refrigerant flow) fan coil system and can cut construction costs by 25%. It is also easy to install and use and incorporates standard components that are readily available on the market.

The TripleAqua builds on the efficiency advantages inherent in heat pumps. In general heat pumps represent an excellent alternative to furnaces and air conditioners by providing three to six units of useful thermal energy for each unit of energy consumed. By contrast, combustion-based heating systems provide less than one unit of thermal energy for each unit of energy consumed.

An outdoor heat pump, the TripleAqua operates with climate-friendly refrigerant propaene (R433A) – a mix of hydrocarbon refrigerants propane (R290) and propene (R1270) – with a GWP (global warming potential) of three. The refrigerant charge of the system is less than 5 kg, and to ensure safety a water-based loop design is used to transport heating or cooling from room to room. This means the hydrocarbon coolant does not have to enter the building.

The system uses three pipelines: one provides hot water (28°C – 36°C), one provides cool water (12°C - 18°C), and once these have fully released their energy a return pipe receives ambient temperature water from the hot and cold loops.

Although it is becoming more and more common to find systems operating in parallel for the provision of cold water for cooling, and hot water for heating, the TripleAqua is rare in that it uses the heat released during the cooling process to feed the hot water loop, while cold released from the heating process is used to feed to the cold water loop.

This simultaneous heating and cooling is ideal for buildings with extensive glazed facades where rooms with a large share of window glazing must be cooled owing to incident solar radiation, while rooms with small glazed areas must be heated.

Inside a building, the TripleAqua's water-loop system includes linked slim-line horizontally and vertically installed units, equipped with self-regulating water control valves. The design of the units, which come in eight different sizes from 1.1 to 5.8 kW, makes them suitable for a variety of buildings, such as hotels, office buildings, and medical centers. The indoor units feature a specially designed heat exchanger with copper-aluminum mini-tube technology, dual ball-bearing, direct-current fans, and a micro-cassette filer to block fine dust, pollen and other pollutants.

For ease of operation, control panels allow personal temperature and function preferences for the indoor units to be set in different rooms; up to six separate controls can be used in conjunction with each other to control an entire group of units.

An external unit provides overall system control using an arithmetic processor to autonomously control all tasks. The full package of controls (provided without purchasing additional options) include functions such as speed and capacity, energy measurements, sensors, door surveillance, CO_2 measurement, clock, day/night/weekend, emergency heating, communication with GBS, VING card, fresh air, CO_2 control, and more.

The TripleAqua will be sold by Beijer Ref, one of the largest distributors of HVAC&R units in Europe , which owns Coolmark and Uniechemie. The initial sales focus will be on the EU. JTL

TRIPLEAQUA SPECS

- COP (Coefficient of Performance) ranging from 4.5 to 10
- 1.4 meters (4.5 feet) high
- Two Bitzer compressors that work with the natural gas propaene.
- Emerson control system that can be read via the internet
- VLT Danfoss inverters and four electronic expansion valves
- A slow turning EC fan specially developed for TripleAqua, which has a diameter of over 1 meter (3 feet) and fan blades inspired by bird wings for high efficiency and quiet operation.
- Small-diameter pipes in the heat exchanger to use the least possible amount of propaene
- The underside of the heat exchanger is drip-free, so that in winter defrost moisture or condensation cannot form

THE TRIPLEAQUA CAN BE CONNECTED TO

- Floor heating/ cooling
- Chill beams
- Low temperature heating / convectors
- Heat recovery
- Air curtains
- District heating
- Free cooling

AZANE HAS BIG PLANS FOR LOW CHARGE

The U.S. subsidiary of Star Refrigeration is rolling out low-charge ammonia freezers and chillers for small- to medium warehouses this year, positioning them as natural alternatives to R22 and HFCs

— By Michael Garry

Derek Hamilton, Azane

When computers first came on the scene in the 1950s and 1960s they were big, clunky boxes that took up a lot of space. Today, of course, far more powerful computing devices fit into your pocket.

The industrial cold storage industry is beginning to undergo a similar transition with ammonia refrigeration systems. Low-charge ammonia systems have figured out how to do the work of much larger systems, vastly reducing the amount of required ammonia.

This development comes at a time when at least three regulatory changes are converging to create a need for low-charge ammonia systems: the increasingly restrictive regulation of systems with more than 10,000 pounds of ammonia, the phaseout of R22 by 2020, and the impending limitations on HFCs.

Azane, a San Francisco-based subsidiary of UK-based Star Refrigeration, aims to take advantage of this regulatory climate with its two low-charge ammonia units – the Azanefreezer, a condensing unit for freezer and cooler applications, and the Azanechiller, designed for a wide variety of uses. Manufactured in Chambersburg, Pa., both are slated for their first U.S. installations this year, said Derek Hamilton, business development manager for Azane.

In terms of ammonia charge, Azane's condensing units have about five pounds per TR and the chillers two pounds per TR. By contrast, a recirculated overfeed central ammonia system would have 20 pounds per ton. In total pounds, the condensing unit's ammonia charge is in the hundreds, compared with traditional systems in the thousands or tens of thousands of pounds.

Azanefreezer

The condensing units have cooling capacities ranging from 26 to 107 TR, the chillers from 60 to 294 TR.

In the low-charge ammonia arena, Azane is competing with companies like NXTCOLD and Evapco that also provide modular units.

Azane comes to this task with the backing of a parent company, Star, that has been producing low-charge packaged ammonia systems in the UK for five years, and other low-charge systems much longer. Now the time seems right for a British invasion. “We’re seeing that the US will have to do things differently and low-charge ammonia will be part of that,” said Hamilton. “Over the past 18 months there’s been a real buzz surrounding this at the trade shows.”

Hamilton acknowledges that, even with regulatory pressures bearing down, the US industrial refrigeration industry will not change its traditional approach to ammonia refrigeration overnight. For Azane, lower-hanging fruit may be smaller refrigerated warehouses – 10,000 square feet or less – that employ R22 or HFCs.

“The phaseout of R22 is having a larger and larger effect on the industry,” Hamilton said during a presentation at the IIAR Conference and Expo last month in San Diego. “The amount of R22 that’s available is going down and the price is going up. Facilities are at risk if they have a large leak and can’t find refrigerant.”

Meanwhile, HFCs, which used to be regarded as a good replacement for R22, are facing their own gradual phasedown in the US due to their high global warming potentials.

By offering low-charge ammonia units to these small- to medium-sized warehouses, Azane is trying to “carve out a new market that didn’t previously exist,” said Hamilton. Azane has a compelling economic argument: Though its units are more expensive than comparable HFC equipment, they are 15% to 20% higher in efficiency and their total cost of ownership is lower, said Hamilton.

For end users trying to phase out of R22 or HFCs who are unaccustomed to ammonia, Azane is positioning its low-charge condensing units in a way that overcomes the stigma of ammonia as a dangerous refrigerant. “This is not like a central machine room with massive amounts of ammonia,” said Hamilton. “We’re trying to make the transition to ammonia a much easier thing.”

Azane’s low-charge modular units can be effectively used in large-scale refrigerated warehouses, but are more “cost-effective” in smaller facilities, Hamilton noted. Meanwhile, larger facilities that prefer traditional ammonia systems are also employing technology to reduce the charge, he added. “There’s a general drive to reduce ammonia charge.”

For example, in his IIAR presentation, he described an optimized pumped liquid receiver solution that uses an advanced evaporator design to achieve a charge of 9.4 pounds per TR; and an advanced DX ammonia system that has a charge of 10.5 pounds per TR.

“There are strengths and weaknesses to all [low-charge] systems,” he said. “The best system for the job will depend on various factors, including the location of the plant, climate and layout.”

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Simple Design

Azane's low-charge-ammonia condensing unit comprises two or three screw compressors, a condenser and control valves in a single package. Its condenser is cooled by air, a less expensive and simpler option than water, which is "becoming an issue now in a lot of areas," said Hamilton. The condensing unit can be placed on a rooftop or at the side of a building and connected to two evaporators (also supplied by Azane) in the cooling space. "It's close to plug and play," he said.

Unlike many evaporators, Azane's has no control valves, which instead are housed in the condensing unit. "This reduces the potential for leaks and makes the system simpler to operate and maintain," said Hamilton. The evaporators use efficiency-enhancing aluminum coils supplied by Colmac Coil. They employ reverse-cycle defrost.

Azane has what it calls a "low-pressure receiver" design in its condensing unit, which takes the place of an expansion valve in front of an evaporator as in a DX system. "We take high-pressure liquid from the condenser and subcool it, then expand the liquid to low pressure and send the low-pressure liquid to the evaporator coils," said Hamilton.

How is the condensing unit able to operate with relatively small amounts of ammonia?

"We reduce the charge by eliminating all non-useful refrigerant from the system," said Hamilton. This includes vessels with buffer volumes of refrigerant in the overfeed system. In addition, Colmac's aluminum coils are designed to operate with a refrigerant charge that is a fraction of what you would need in a traditional system. "So you don't have to pump all this extra liquid," he noted. "This is a key technological development for low-charge systems at freezer temperatures."

Can Azane's condensing units still leak out of the evaporators in the storage areas? "The risk is all but eliminated," said Hamilton. "We don't have any mechanical joints or flanges [in the evaporator] – nothing except fully welded pipework. The only place where a leak is conceivable would be in the condensing unit on the roof."

"We have an excellent safety record as an industry but the fact that [leaks] are in the news means there's still room for improvement," said Hamilton in his IIAR presentation. "Low charge addresses this by greatly reducing the risk of leakage."

For facilities requiring temperatures of 32°F or higher, Azane is marketing its low-charge, air-cooled ammonia chiller, which uses two screw compressors and an air-cooled condenser. It can also be used for central air-conditioning, process cooling and ice rinks, among other areas. The chiller circulates a secondary fluid like water or glycol to absorb heat in the premises. The units are being manufactured and will be installed this year in the US.

"There's a huge amount of interest in chillers," he said, adding that R22 and HFC phaseouts are also driving this trend MG

What Is Low-Charge Ammonia?

At his IIAR Conference and Exhibition presentation last month, Derek Hamilton, Business Development Manager for Azane, listed eight characteristics of an optimum low-charge ammonia system. It would:

- Have the lowest possible charge while ensuring reliable operation.
- Be reliable across a range of operating conditions.
- Have the maximum possible efficiency.
- Be leak-free.
- Require the lowest possible level of maintenance.
- Be low cost.
- Pose zero (or close to zero) risk to employees.
- Not require special permits or reporting.

Azanechiller on its way to installation.

Bitzer's Approach to Ammonia: **All of the Above**

Bitzer's U.S. headquarters in Flowery Branch, Ga.

The German compressor giant launched an ammonia package for large systems but its compressors are also being used by low-charge ammonia units

— By Janaina Topley Lira and Marc Chasserot


Joe Sanchez, Bitzer U.S.

Ammonia and carbon dioxide compressors represent less than 10% of sales for Bitzer U.S., the third largest subsidiary of German compressor maker Bitzer.

But sales are going to get much larger, as ammonia keeps expanding its application range while CO_2 becomes the choice for supermarkets in the future, believes Joe Sanchez, application engineering manager at Bitzer U.S. He shared his views recently with *Accelerate America* a the subsidiary's headquarters in Flowery Branch, Ga., where Bitzer manufactures most of its reciprocating compressor line, from fractional up to 50 HP units, for all refrigerants.

A year ago, Bitzer launched its modular ammonia compressor package (ACP) for large industrial applications, which comprises three compressors. (See story page 55) On top of that, OEMs specializing in low-charge industrial ammonia systems are using Bitzer compressors.

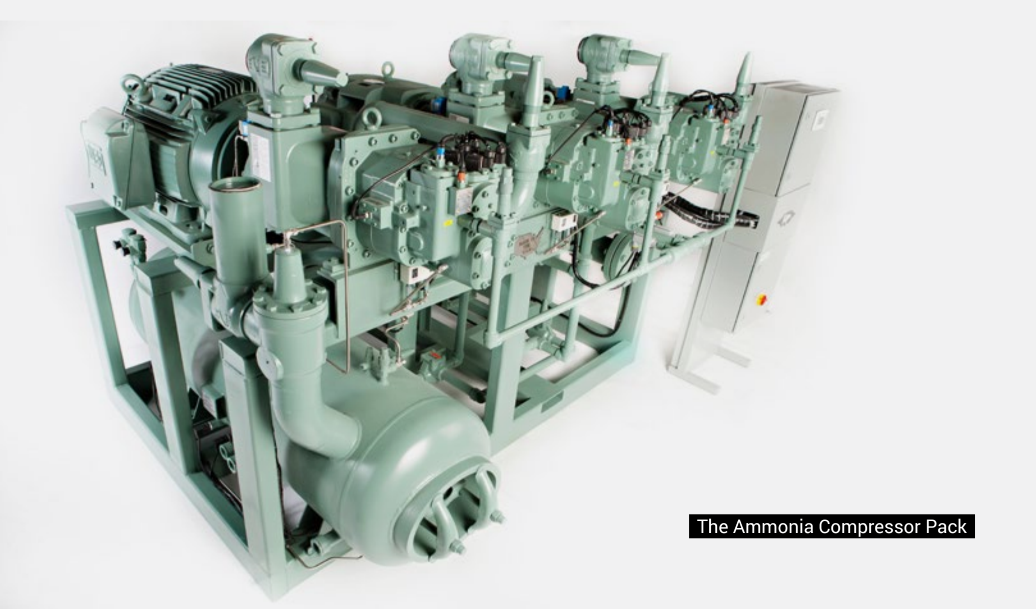
Not content to rest on its laurels, Bitzer is expanding its range, revamping its smaller compressors, and adding larger compressors and ammonia packages. This strategy will enable it to approach the market from many different angles and support both low-charge innovations and more traditional systems.

For 80 years, BITZER has been manufacturing refrigeration compressors, the "heart" of refrigeration and air conditioning systems. The company is considered a global leader in the production of screw, scroll and semi-hermetic reciprocating compressors for refrigeration applications and commercial air conditioning, with models specifically designed for natural refrigerants such as CO_2 and ammonia.

Predicting exactly how quickly the natural refrigerant market will grow in the U.S. is difficult. CO_2 in Europe for example, grew from a few hundred installations to several thousand in the space of three years. What is clear, however, is that the low-charge ammonia revolution is the first step in expanding ammonia to other applications.

Currently the industrial sector is focused on replacing the conventional 10,000-pound-and-more ammonia cold storage systems with solutions that have only a few hundred pounds. There are only a handful of low-charge ammonia systems currently in operation in the U.S., but as the technology continues to evolve ammonia could increasingly be used for both industrial air-conditioning systems and commercial refrigeration.

For Sanchez, the switch to low charge is a trend that will take off in a big way, along with similar growth for CO_2 transcritical solutions in commercial refrigeration. Particularly in New Jersey, where R22 is the dominant refrigerant, low-charge ammonia could take away significant market share from fluorinated refrigerants.


The Ammonia Compressor Pack

Cost considerations

Initial cost is a potential barrier that could slow low-charge's uptake, but Sanchez is confident that one of the larger facilities will sooner or later take a gamble on this kind of equipment. What will really determine the success of low-charge systems is their efficiency savings.

Sanchez was full of praise for a simple but comprehensive dollars-and-cents comparison to evaluate the performance of a pilot CO_2 transcritical installation by Delhaize's Harrison Horning. Cold storages will likely have to do something similar. For example, who knows what savings are possible by addressing long piping rounds and parasitic heat gains?

Generally speaking, for the low-charge ammonia market to succeed it needs to come close to breaking even on total cost of ownership and efficiency. It already reduces much of the regulatory burdens from OSHA and EPA, which is a big bonus.

Although ammonia refrigeration represents 90% of the U.S. industrial refrigeration market, there are still some companies that are switching to HFCs (even R507a, which could be delisted) rather than ammonia. Their argument is that they do not need to worry about future legislation and not being able to source the refrigerant in the future as long as the refrigeration system is leak proof. Ammonia component and system suppliers thus need to keep innovating to change their mind.

Outside of the low-charge innovations, the industrial refrigeration sector is beginning to look at and adopt technologies used in commercial applications, such as DX (direct expansion). Engineers are asking themselves what the commercial world does that makes sense and can be adapted to an industrial installation.

The blending of commercial and industrial solutions requires changes in what Sanchez describes as "style". Whereas industrial systems use open-drive ammonia compressors, commercial systems use semi-hermetic compressors. Commercial systems also use copper piping, which is not considered for many industrial systems.

For carbon dioxide specifically, what is interesting is that its volumetric cooling capacity makes it compatible with small compressors. Bitzer will soon be starting up its first semi-hermetic industrial CO_2 installation at a cold storage facility. The plant will use twelve 30-HP compressors as opposed to two or three large industrial compressors. This installation will enable the facility to reap benefits the commercial world is already familiar with: no shaft seals, high part- load efficiency, no slide valve, among others.

Looking beyond climate-friendly refrigerants, Bitzer is also reducing its carbon footprint by having a manufacturing facility in Georgia, which allows it to more readily supply many local customers. Other green initiatives include using returnable pallets and investing in recycling, particularly for metals.

"I am excited about the changes ahead," said Sanchez. "I would love to tell my grandkids that I was part of reducing the carbon footprint of the world" JTL + MC

A Trio of Compressors

First presented at the 2014 IIAR Industrial Refrigeration Conference & Heavy Equipment Show, Bitzer's ammonia compressor pack (ACP) features three plug-and-play ammonia compressors with high system part-load efficiency.

Bitzer's compressor package is positioned to replace a 400 HP ammonia compressor, but it can be used for low charge chiller applications, such as the prototype running in Germany on a half pound per TR.

The ACP line is available with a capacity range of 100 to 450 TR. For higher capacities up 1200 TR, as many as three compressor packs (up to 9 compressors) can be connected to a single controller.

The ACP also offers a low-charge economizing option, which consists of a small, flooded, closed economizer system.

The system's main compressor uses a variable speed drive, which is able to operate at part load. This means that individual compressors can be turned on and off depending on requirements, ensuring the unit always operates at an optimum level.

Every aspect of the ACP has a backup system, including the controller, which has an extra CPU. This ensures that if something fails it is possible to simply start the backup, so the system is up and running within just a few seconds.

A double oil filter means that in addition to the main oil filter, there is an individual filter in each of the compressors. This simplifies maintenance, as any one of the filters may be worked on without having to shut down the entire system.

A special oil cooler system allows the unit to operate at very low head pressure, an important feature for colder regions, because it allows the unit to be started up even when the condenser units are very cold.

Finally, an electrical panel means that this "plug and play" system is easy to start up.