NOVEMBER / DECEMBER 2018

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JUNE 17-18, 2019
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The Truly Green Option

— by Michael Garry

Accelerate America focuses much of its attention on natural refrigerant-based HVAC&R systems used in the food industry, especially by supermarkets and cold storage facilities. But this technology has a broader reach – which we also cover – from residential homes and motor vehicles to commercial/institutional buildings and sporting arenas, and more.

This issue's cover story (page 34) examines ice rink refrigeration systems. It was inspired by the National Hockey League's decision in May to partner with Chemours in promoting the use of the chemical producer's HFO blends R449A and R513A in rinks across North America. Notably, the NHL and Chemours said that this partnership supports the league's "Greener Rinks Initiative," dedicated to sharing sustainable practices with community rinks.

While this partnership pertains specifically to the ice rink industry, it really relates to all users of HVAC&R equipment. That's because it raises general questions about looking at HFO blends as "green alternatives" when unquestionably green natural refrigerant alternatives are available.

At shecco, publisher of *Accelerate America,* we consider sustainability to be about conserving the environment for current and future generations as well as delivering regulation-proof business solutions that save money and perform well over time. In both of these regards, as delineated in the cover story, the natural refrigerants ammonia and CO_2, separately and in combination, serve ice rink owners better than any synthetic refrigerant, including HFO blends.

From an environmental perspective, the HFO blends R449A and R513A – like their halogenated predecessors – fall short. First, because they combine high-GWP HFCs with the low-GWP R1234yf, their overall GWP remains high, particularly for R449A (1,282). This makes it bad for the environment and ultimately subject to regulation. Even R513A's GWP (573) is nearly 600 times that of CO_2.

Moreover, the Kigali Amendment, an extension of the Montreal Protocol, will start phasing down HFCs next year in many countries – not a good prospect for any refrigerant that depends on them.

Then there's the fact that R1234yf readily degrades in the atmosphere into trifluoroacetic acid (TFA), a very durable chemical that is brought down to ground level in the form of "acid rain."

TFA is also produced naturally in the environment, and at current levels is not regarded as a threat to the environment or human health. The key phrase here is "at current levels"; if HFO products proliferate, they will produce orders of magnitude more TFA, with future impacts not yet understood.

Already a number of studies are sounding the alarm. A 2017 report commissioned by the Norwegian Environmental Agency pointed to a number of "knowledge gaps" about TFA's ultimate environmental effects; the German Federal Environment Agency (UBA) warns that TFA could contaminate fresh water supplies.

I agree with Janos Maté, a senior consultant for Greenpeace, who urges that the large-scale uptake of HFOs should be avoided until there is a full comprehension of the impact of peak-production levels. I also endorse his suggestion that HFOs should be listed in the Annex of Controlled Substances of the Kigali Amendment, enabling accurate accounting of the amount being produced, consumed and released into the atmosphere.

For ice rinks and other HVAC&R applications, natural refrigerants are the truly green option.

Michael Garry
Editor

In this issue

NOVEMBER-DECEMBER 2018

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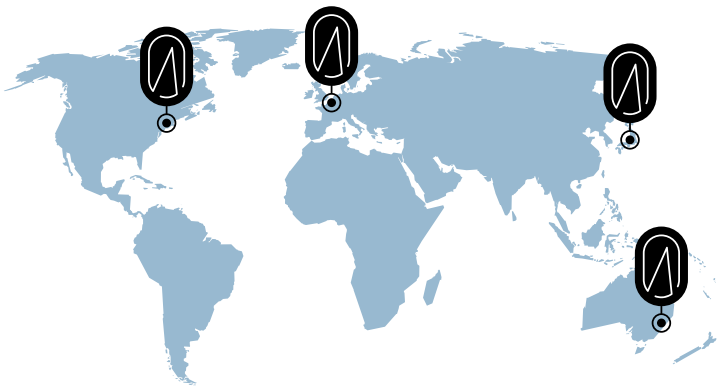

About *Accelerate America*

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

http://acceleratena.com

Accelerate America publisher shecco's network spans the globe with offices in Brussels, Tokyo, New York and Sydney.

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July 3

// ISSUE #47
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* Publisher reserves the right to modify the calendar.

LETTERS TO THE EDITOR

CO_2 IS CHANGING INDUSTRIAL REFRIGERATION

In regard to "Taking on Transcritical in Cold Storage" (*Accelerate America*, October 2018), I have had the pleasure of not only knowing Pete Lepschat of Henningsen Cold Storage for many years but also visiting the Grandview, Wash., transcritical CO_2 facility just prior to pulldown. As usual, the Henningsen facility was well thought out and planned not only for current business but future business expansion as well.

Five or six years ago, if someone had told me that transcritical CO_2 refrigeration had a place in industrial refrigeration, I would have been highly skeptical. However, three or four years ago my friend Bob Hampson told me that he had just installed a system in a facility in Quebec (Canneberges Becancour) and couldn't have been happier with the results. I accepted Bob's invitation to visit the facility. After my visit, it was obvious that this technology merited a "deeper dive."

Since this first visit, I've traveled throughout North America visiting other sites and hearing similar accolades from owners and contractors alike. I've been working on a white paper on this subject for well over a year, and have had to stop and reset several times due to the rapidly evolving technological advances in this area.

The evidence for transcritical CO_2 has been extraordinarily positive in virtually every category including total cost of ownership (TCO). As noted in one of the article's sidebars, it is clear that there are major investments being made to further improve the technology by many companies, both large and small. It is not hard to imagine that we are only at the precipice of a major shift in our thinking when it comes to industrial refrigeration systems.

Terry L. Chapp
North American Business Development Manager
Danfoss Industrial Refrigeration, Baltimore, Md.

KEEP HFC LEAK REPAIR RULES

In response to "EPA Proposes to Rescind Leak Repair Rules for HFC Equipment" (*Accelerate America*, October 2018), I view the exclusion of HFCs from Section 608 as a step in the wrong direction. Since these refrigerants carry a very high global warming potential, and play a significant role in many current commercial refrigeration systems, including HFCs in the regulations was logical.

Many high-volume refrigerant users, like grocery retailers, have already invested significantly in refrigerant leak-reduction programs that include HFCs; changing back would create confusion. In addition, expenses related to refrigerant leaks and leak repair are one of the highest maintenance cost categories that a grocery retailer faces, and many have seen the benefit of employing a thorough and responsible leak-reduction program.

Section 608 requirements support the need to establish these programs. With some of the recent scientific reports that have been published on climate change, it seems appropriate that HFCs continue to be included in regulations going forward.

Bryan Beitler
Vice President, Chief Engineer
Coolsys, Brea, Calif.

LETTERS ARE WELCOMED!

Accelerate America invites readers to submit letters to the editor at michael.garry@shecco.com. They can be about a recent article; an industry issue that readers would like us to cover in greater detail; or the value of *Accelerate America* and ATMOsphere America in educating the industry about natural refrigerants, including what we can do better. Letters may be edited for clarity or length.

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AMERICA'S PLEDGE

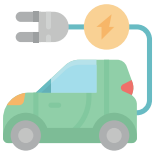
10 CLIMATE-ACTION STRATEGIES, INCLUDING HFC REDUCTION

1 Double down on renewable energy targets

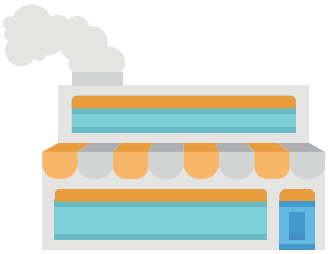
2 Accelerate the retirement of coal power

3 Encourage residential and commercial building efficiency retrofits

4 Electrify building energy use



5 Accelerate electric vehicle adoption



6 PHASE DOWN SUPER-POLLUTING HFCS

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- **Implementing HFC-reduction** at all 16 state members (and growing) and Puerto Rico in the U.S. Climate Alliance;
- Broadening EPA GreenChill program;
- Extending HFC-reduction to aerosols

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- **Enhanced engagement** (40% reduction from 2013 levels by 2030 in U.S. Climate Alliance states and Puerto Rico).

7 Stop methane leaks at oil and gas facilities

8 Reduce methane leaks in urban gas distribution

9 Develop regional strategies for carbon sequestration on natural and working lands

10 Form state coalitions for carbon pricing

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DEC – JAN

12.11-12

Bitzer 2-Day Natural Refrigerants Seminar, Oakwood, Ga.

Day 1 will cover CO_2 and Bitzer Reciprocating Compressors. Day 2 will cover NH_3 and Bitzer OS Open-Drive Screw Compressors

https://bit.ly/2AinpVK

@BITZERGroup

12.12-13

Emerson Natural Refrigerants Training, Brantford, Ontario

Training will cover major trends in $C0_2$, NH_3, and R290; terminology; mapping a CO_2 system; best practices in servicing; charging of CO_2 systems; start-up and shutdown sequences; and more.

https://bit.ly/2DLzg1Z

@Emerson_News

01.10

Danfoss Natural Refrigerant Seminar And Live CO_2 Demo, Baltimore, Md.

Free seminar on natural refrigerant applications in supermarkets, geared to food retailers, service contractors and environmental stakeholders. Agenda includes: incentives for low-GWP refrigerants; refrigerant regulations at the international, federal, and state level; and a live demonstration of a CO_2 transcritical system.

https://bit.ly/2TDzjSZ

@Danfoss_US

01.12-16

ASHRAE 2019 Winter Conference, Atlanta, Ga.

The ASHRAE Winter Conference technical program includes refrigeration, HVAC&R fundamentals and applications, systems and equipment, common system misapplications, and achieving high-performance building operation after design.

https://bit.ly/2Bv9Wvq

@ashraenews

01.14-16

AHR Expo, Atlanta, Ga.

Co-sponsored by ASHRAE and AHRI, the AHR Expo bills itself as the world's largest HVACR event, with more than 2,100 exhibitors and over 120 educational sessions. Attendees include OEMs, engineers, contractors, facility operators, architects, educators and other industry professionals.

https://ahrexpo.com

@ahrexpo

JAN – FEB

01.15 2PM

EPA GreenChill Webinar: Supermarket Experiences with Micro-Distributed Systems, Online

Webinar featuring Rich Gilles of Hussmann and Paul Anderson and Charlie Wernette of HEB Grocery.

https://bit.ly/2FGErmp

@EPAgreenchill

01.16-17

Emerson CO_2 Learning Sessions, Atlanta, Ga.

Designed for service technicians, manufacturers and end users, this event covers terminology, mapping of casacade and transcritical systems, efficiency optimization in warm ambient climates, and more.

https://bit.ly/2P0maQf

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01.29 2PM

EPA GreenChill Webinar: Market Trends for Carbon Dioxide, Ammonia and Hydrocarbon Refrigerants in North America, Online

Webinar features Klara Zolcer Skacanova and Marc Chasserot, shecco.

https://bit.ly/2DIF77T

@EPAgreenchill

01.30-31

Emerson CO_2 Learning Sessions, Orlando, Fla.

Designed for service technicians, manufacturers and end users, this event covers terminology, mapping of casacade and transcritical systems, efficiency optimization in warm ambient climates, and more.

https://bit.ly/2P0maQf

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02.07-09

The NAFEM Show, Orlando, Fla.

Every-other-year event for foodservice operators features more than 500 exhibits by equipment and supplies manufacturers and myriad educational sessions.

https://bit.ly/2FC1lLz

@TheNAFEMSHow

02.12 2PM

EPA GreenChill Webinar: Benefits of Partnering with GreenChill for Small and Independent Grocers, Online

Webinar features Rene Tanner and Scott Marble of the Port Townsend Food Co-op.

https://bit.ly/2S8csNy

@EPAgreenchill

AHR Expo Returns to Atlanta

The giant trade show will take place in the Georgia capitol – near several manufacturers of natural refrigerant equipment – for the first time since 2001

– By Michael Garry

The AHR Expo, which bills itself as the world's largest HVACR marketplace, will return to Atlanta, Ga., for the first time since 2001 for its 2019 event, January 14-16 at the Georgia World Congress Center.

The Atlanta area is home to several of the OEMs and component makers serving the natural refrigeration industry, including Hillphoenix, Bitzer, Hussmann, Heatcraft, Nidec-Secop and Carlyle.

The AHR Expo will feature more than 2,100 exhibitors and over 120 educational sessions, including an overview by shecco of global market and policy trends for CO_2 and ammonia in refrigeration. The show's more than 60,000 attendees include OEMs, engineers, contractors, component manufacturers, distributors, and facility operators spanning the commercial, industrial and institutional sectors.

Exhibitors offering natural refrigerant-related equipment include: Stellar (booth B244), Blissfield Manufacturing (B851), Tecumseh Products (B1327), Emerson (B2219), Carel USA (B2255), Keeprite Refrigeration (B2260), Parker Hannifin (B2349), Carlyle Compressor (B2931), SWEP North America (B2953), Super Radiator Coils (B3735), Modine Commercial and Industrial Solutions (B3275), Wieland Copper Products (B5770), ebm-papst (C5819) Baltimore Aircoil (C6531) and Embraco North America (C7431).

In the refrigeration category, the AHR Expo Innovation Award will go to Emerson for its Copeland Scroll fractional-horsepower low-temperature compressors, which use liquid injection technology and cooling discharge temperatures to reduce compressor stress and meet federal regulatory requirements. Finalists include Baltimore Aircoil for its TrilliumSeries adiabatic condenser and DunAn Microstaq for its Silicon Refrigeration Valve,

The following educational sessions are related to natural refrigerants:

- Trends in the Global HVAC Market, Jan.14, 9-11 am, room B312. BSRIA executives will present the latest global trends from HVAC markets, including a detailed look at the U.S.

- DOE Regulations and the HVAC&R Industry, Jan. 14, 10:45-11:05 am, Theater A-room C101. Nidec Motor will discuss upcoming changes in Department of Energy regulations and their impact on the HVAC&R industry.

- Low-GWP Refrigerants: Components and System Designs, Jan. 14, 11 am-noon, B313a. This seminar will present the performances of a variety of lower-GWP alternatives at various temperatures, and how to adopt them in system design. Speakers include Pega Hrnjak, Creative Thermal Solutions and the University of Illinois; Paul de Larminat, Johnson Control Industries; and Craig Bradshaw, Oklahoma State University.

- Update on Global Policies and Programs for Best Use of Refrigerants, Jan. 14, 2:15-3:45 pm, B313b. This session provides updates on global refrigerant regulations and efforts to support the best use of refrigerants. Speakers include Antonio Bouza, Department of Energy; Didier Coulomb, International Institute of Refrigeration; Ayman Eltalouny, UNEP; and Yunho Hwang, University of Maryland.

- Global Market and Policy Trends for CO_2 and Ammonia in Refrigeration, Jan. 15, 10:30-11 am, B316. Marc Chasserot, CEO of shecco (publisher of *Accelerate America*), will evaluate the key market, technology and policy trends for CO_2 and ammonia, presenting data on the number of installed applications and comparing the evolution globally.

- Low-GWP Alternative Refrigerants for Cooling – Skills, Needs and Solutions, Jan. 15, 2:30-4:30, B315. This session will draw from the EU's "Real Alternatives 4 Life," which provides training materials to address the skills barriers to the widespread adoption of natural refrigerants. Speakers include Didier Coulomb, International Institute of Refrigeration; Marco Buoni, AREA Association of European Contractors and ATF Training; and Graeme Maidment, London South Bank University and the Institute of Refrigeration. ■ MG

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AMERICA IN BRIEF

EPA Announces NH_3 Settlements

Last month the U.S. Environmental Protection Agency (EPA) announced seven settlements with companies in four New England states for alleged violations of chemical accident prevention and reporting laws. All the cases address the safe use of anhydrous ammonia in refrigeration and cooling units.

The companies all cooperated with EPA's New England regional office. Two of the settlements were with companies that EPA inspected after ammonia releases occurred, and five cases were undertaken to prevent such releases.

Collectively, the seven companies have spent more than $750,000 to comply with the laws, and will pay more than $580,000 in penalties to settle EPA's claims of alleged violations.

"These agreements will improve compliance with important laws that help protect communities and provide critical resources for local emergency responders and communities," said EPA New England Regional Administrator Alexandra Dunn.

The settlements were with the following companies: Finicky Pet Food, New Bedford, Mass.; McCain Foods USA, Easton, Maine; Twenty-Five Commerce, Norwalk, Conn.; Guida-Seibert Dairy Company, New Britain, Conn.; The Maine Wild Blueberry Company, Machias, Maine; New England Sports Management Corporation, Marlborough, Mass.; and High Liner Foods (USA), Portsmouth, N.H. MG

Bacharach Issues Section 608 Guide

HVAC&R instrumentation manufacturer Bacharach, New Kensington, Pa., has issued a free guide to revisions in the U.S. Environmental Protection Agency's Section 608 Refrigerant Recycling and Emissions Reduction Program.

The revisions are set to take effect in January.

The guide, called "EPA Section 608 2019 Refrigerant Compliance: checklist & guidelines," is designed for equipment owners within the food retail sector.

Section 608 applies to the maintenance and leak repair of stationary refrigeration and air conditioning equipment.

The free guide can be downloaded at https://bit.ly/2G7Re1k.

Section 608 requirements were revised in 2016, extending from ozone-depleting refrigerants to include HFCs as well. However, the EPA is currently engaged in rule-making to rescind the leak repair and maintenance requirements for HFC equipment. It is not known whether a new rule will be finalized before January. MG

Montreal Protocol Targets CFC-11

At the 30th Meeting of the Parties to the Montreal Protocol (MOP 30) in Quito, Ecuador, last month, the 197 Parties (countries) committed to providing all available data on the illegal use and production of ozone-depleting CFC-11.

The Montreal Protocol, originally signed in 1987, phased out the use of CFC-11 and other ozone-depleting substances. Use of CFC-11 would be in violation of the treaty, which in 2016 added an HFC phase-down under the Kigali Amendment.

The CFC-11 agreement followed the presentation at MOP 30 of the Environmental Investigation Agency's (EIA) latest report on the potential impact of ozone-depleting CFC-11 use in China on the ozone layer, called "Tip of the Iceberg: Implications of Illegal CFC Production and Use." It includes recommendations for action aimed at the meeting's participants.

Under the agreement, each Party will take measures to ensure the phase-out of CFC-11 in their countries is maintained, and to share information on any illegal use or production of CFC-11 to the relevant bodies of the Montreal Protocol.

For its part, China contended that it has "taken action to investigate and enforce its laws regarding Ozone Depleting Substance (ODS) production and use," said Zeng Rong, spokesperson for the Chinese embassy in the United Kingdom, in an open letter to *The Guardian*, a U.K. newspaper.

Also at MOP 30, two developing countries that are still phasing down HCFCs – Cameroon and Chile – expressed interest in leapfrogging HFCs by adopting natural refrigerants. "There is definitely very high interest in natural refrigerants in Africa," said a delegate from Cameroon. MB

Daikin acquires AHT Cooling Systems

In another sign of its interest in the natural refrigerants sector, Japanese multinational air-conditioning giant Daikin has announced the acquisition of Austrian commercial refrigeration firm AHT Cooling Systems for $999 million.

Daikin, the world's largest manufacturer of air conditioning equipment, expects to complete the acquisition in January 2019. The Japanese firm said the deal would enable it to "propose total systems that cover the entire cold chain," while also expanding its refrigeration business in the U.S. and Asia.

Having opted for propane in the 1990s, AHT remains committed to this natural refrigerant as a means of reducing the energy consumption and environmental impact of its refrigerated and frozen food display cabinets.

AHT already has over one million propane-based cabinets operating worldwide. "We think propane is the best solution on the market for supermarket units," Reinhold Resch, AHT's vice president for R&D, said last year.

In North America, where it is based in Ladson, S.C., AHT has signficantly grown sales of its propane self-contained commercial display cases.

Last February, Daikin Europe NV acquired Spanish CO_2 system developer Tewis. AW

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Build Credibility for NatRefs via Energy Analysis

A proper energy comparison between a natural refrigerant and an HFC system needs to include ambient conditions, load, heat recovery, an updated baseline and good commissioning

– By Klas Berglöf

All new technologies create uncertainty in the marketplace, as there are often strong believers but also opponents. To reduce this uncertainty, we need well-documented field tests that present sufficient system data and can be validated by a third party.

In particular, measuring energy efficiency is a key to introducing new supermarket-sector technologies such as CO_2 refrigeration.

Many articles claim high efficiency for CO_2 systems but many others report the opposite. In many cases the published test documentation does not make it possible to evaluate how the new solution saved energy.

Well-documented tests are required to enable a new technology to become accepted as well as to learn how the solution can be improved. Field tests are necessary because laboratory tests do not give the full picture, and properly done field tests build experience and allow the best use of a technology in future installations. But there are obvious challenges to performing real-life tests that allow new systems to be compared with HFC technologies.

Normalized energy signatures

The following are some examples of major challenges to evaluating the efficiency of a new solution.

First, the ambient conditions before and after a technology change will never be the same. Therefore, data must be adjusted to reflect changes in ambient conditions; otherwise results cannot be compared over time or between two locations.

Normalized "energy signatures" with kWh consumption per hour at each ambient temperature for different time periods or locations are a powerful tool for comparing the energy efficiency of two technologies while considering variation in climate.

There may be a desire to make the test period as short as possible if it is urgent to reach full commercialization. But if relevant factors are not considered and reported, the uncertainty will increase and those opposing the technology may discredit the test. A poorly planned and executed test may be worthless.

Avoid comparing previous and new equipment at disparate times during the year if the expectation is to analyze annual energy consumption. To compare February and June seldom makes sense for most locations. The test must cover a representative range of ambient conditions occurring over a "normalized year" to eliminate the impact of normal variations.

The load during a pre- and post-installation evaluation period, or between two sites, will rarely be the same as there are no accepted benchmarking methods. But this can be solved if energy signatures are normalized for significant load factors. Some supermarkets chains use meter display, while others use the floor area of a store; no method is perfect but they work well.

A normalized energy signature also requires factors like heat recovery to be taken into account. This is particularly true for CO_2 systems where heat recovery often is important for overall efficiency.

Controls and commissioning can also have a major impact on efficiency and reliability. To compare the efficiency of two systems with different controls and levels of commissioning makes little sense.

In addition, evaluations should identify and quantify what caused a difference in efficiency; otherwise a comparison to another system can't be understood .

A LEGEND IN PROGRESS

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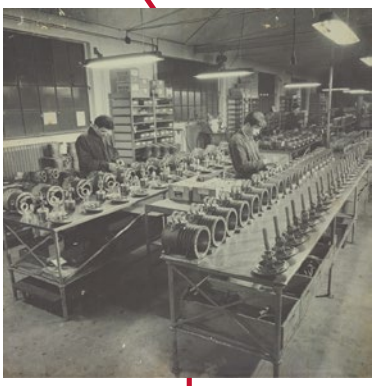

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CRH2019 | 9-11 April 2019 – Shanghai (CN)
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Proper baselines and commissioning

Historical energy consumption of a plant should not be used as a baseline of comparison without validating details of the plant's operation.

Most old plants are not operating as well as they could. It is of limited value to have a team of engineers make a new solution run better than a bad old system – maybe they could have improved the old plant. A baseline performance should be documented and understood. If there are faults/inefficient operations, these should be fixed before baseline data is collected. If a reference plant is not properly described, then any comparison will be discredited.

It is also often taken for granted by those involved in a new solution that it will be operating well since everything is new and state-of-the-art. Commissioning of plants is often done before the plant is in full operation and often at one ambient condition. This does not result in good efficiency, and often things happen during the test period that reduce efficiency without causing alarms.

It is important to monitor relevant data points to evaluate performance of a plant in real time during commissioning tests. Deviations can then be detected to avoid valuable test time being destroyed by mistakes in commissioning or while faults are occurring.

For example, in a Bonneville Power Authority (BPA) test, a pressure sensor became defective, causing excessive energy consumption at the evaluated plant. Without proper instrumentation and continuous monitoring, this excess energy consumption would have destroyed the evaluation of the new technology.

Early detection of faults is always cost effective and prevents long test periods from becoming useless. The period over which the faulty sensor operated can be removed from an evaluation since it was not related to the technology under consideration.

It is good advice to do your homework and ensure that operation of your plant is well understood and efficiency is maintained over the test period.

The cost of executing a test is significant, but measuring and validation are a minor expense. Most of the required sensors are installed as standard practice, but not all; so it's necessary to analyze what sensors are needed. It's important to learn as much as possible from the pilot result so that corrections to design can be made, and the results can be used to improve cost effectiveness for future plants.

For a transcritical CO_2 or hydrocarbon system at a supermarket, only a few more sensors than what is standard are required to facilitate complete performance analyses and energy reporting via System Efficiency Index (SEI), a normalized unit of efficiency.

With proper instrumentation, it is possible to follow performance dynamically over time and detect deviations in performance before they result in increased energy consumption or failures. SEI and sub efficiencies for compressor, condenser and evaporator are powerful tools for visualizing performance and detecting changes in a refrigeration or air conditioning plant.

Finally, do not neglect the importance of good commissioning of controls for all operating conditions. Many existing and new plants operate with poorly adjusted controls, causing excessive energy consumption and premature failures.

In most cases the focus has been on maintaining a set temperature. Poor setup and erratic operation caused by controls poorly adjusted to the conditions and requirements of a particular plant frequently increases energy consumption 20%-30% and systems operate with excess start-stop without anyone considering it a "fault."

These problems might not show up during commissioning conditions, and the cost in energy efficiency and failures caused by start and stop in plants seem to be almost neglected in the industry. ■ KB

Klas Berglöf is managing director of ClimaCheck Sweden. He has been active since 1984 in the Swedish refrigeration, air conditioning and heat pump industry. In 2004, he started ClimaCheck to develop performance analysis methods for RAC systems.

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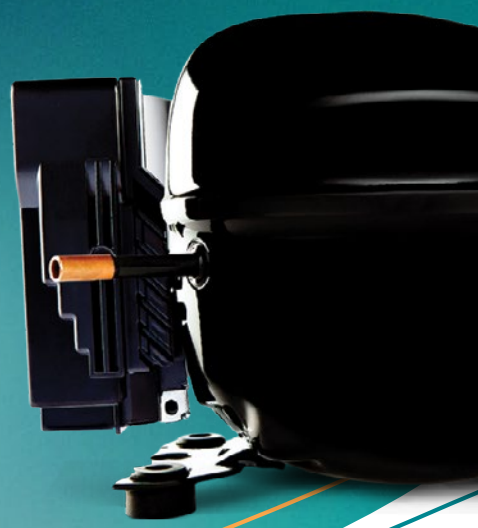
LEADING NATURAL REFRIGERATION



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NATURAL REFRIGERANTS

PAYING ATTENTION TO LEAKS

Food retailers in the EPA's GreenChill program explain how investing in detection technology and focusing on maintenance can dramatically cut refrigerant leaks, saving dollars and helping the environment

– By Eda Isaksson and Michael Garry

From left: Tom Land, EPA; Wayne Rosa, Food Lion, receiving an EPA GreenChill 2018 Superior Goal Achievement award for reaching leak-reduction goal

Photography by: Ted Gartland

The best way large users of refrigerants like supermarkets can help the environment is to switch to natural refrigerants that don't contribute to climate change or deplete the ozone layer.

Short of that, food retailers that continue to use synthetic refrigerants can take steps to reduce how much leaks into the atmosphere. To that end, the GreenChill Partnership, a decade-old voluntary program run by the U.S. Environmental Protection Agency,, has helped numerous chains significantly cut their leak rates. About 11,000 U.S. supermarkets operated by 45 companies from all 50 states are in the program, representing about 29% of U.S. stores.

The GreenChill recipe for success is disarmingly simple. "It's really all about focus – just paying attention," along with setting corporate leak-rate goals, said Tom Land, GreenChill's program manager, at a session on leak reduction at the Food Marketing Institute's Energy & Store Development Conference in September. He was joined by representatives of two GreenChill partner retailers, Meijer and Food Lion, who shared strategies for cutting leaks. At a GreenChill-hosted webinar earlier in September, executives of Kroger ran through their approach.

GreenChill's retail partners' leak rates averaged 12.9% in 2017 – far below what is thought to be the industry rate of 25%. Eleven companies cut their leak rates to below 10%. "The 'under 10% club' continues to grow," said Land.

Leak reduction gives a decided boost to retailers' bottom lines. The average annual replacement cost for refrigerants that leak at a 25% rate is $8,000, but that drops to $2,500 when the rate is 12.9%, said Land.

KROGER'S LEAK DETECTION SYSTEMS

Leak detection technology has helped Cincinnati, Ohio-based Kroger – the largest supermarket chain by revenue in the U.S. – cut its refrigerant emissions by 44% in 43 stores that use the devices compared to 78 without them, said Jerry Rumple, manager of maintenance during the GreenChill webinar.

Leak detection systems, which are integrated into the building automation system, are standard now for remodels, expansions and new stores, he noted. The chain uses both stationary and portable leak detection devices.

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The detection systems used by Kroger come in both electronic and infrared versions. The less sophisticated electronic devices are less accurate and are susceptible to false alarms; they also require calibration.

By contrast, infrared devices, which identify specific gas molecules, are "extremely accurate, self-calibrating and have no false alarms," said Rumple, who has over 30 years of experience working in commercial building maintenance. Infrared systems should be set at very low ppm – they detect as little as 1 ppm of a gas – "to find the smallest of leaks."

To improve detector operation, Rumple recommended understanding the air patterns in a store by using "smoke testing."

Kroger technicians look for leaks in coolers, freezers, prep rooms and compressor systems in enclosed spaces, among other spots. In addition to leaks, they target safety and code compliance.

A preventative maintenance (PM) program is also in place throughout the company, said Michael Dellecave, manager of mechanical services at Kroger, during the webinar. This includes semi-annual visual inspection focused on system operation, tubing condition, filters, settings and reporting via building automation.

On an annual basis, Kroger inspects and replaces line end filters and moisture filters, and uses a product that simulates halogen gas to test gas pick-up and notifications.

MEIJER'S AGGRESSIVE APPROACH

Grand Rapids, Mich.-based Meijer, which joined GreenChill in 2012, slashed its leak rate from 19% in 2009 to 8.5% in 2017, said Jason Flanigan, the chain's senior mechanical engineer, at the FMI Energy Conference. "We're very proud of that."

During that period, Meijer, which runs 242 supercenter stores in six states, reduced the amount of refrigerant it purchased by 19% despite growing by 12%, he said.

Meijer takes an aggressive approach to leak prevention and maintenance. "We don't consider the EPA leak threshold when addressing leaks; we fix all leaks regardless of the leak size," said Flanigan.

Meijer employs infrared leak detection systems in about 119 stores, with plans to complete a chain-wide rollout, said Flanigan. The precision of the devices gives Meijer the opportunity to find leaks and fix them before they become significant enough to cause downtime or temperature issues. Detecting has down to 1 ppm, the device alerts a technicians at 3 ppm and sounds an alarm at 5 ppm.

In Meijer's preventative maintenance program, all store racks are checked for leaks every quarter with hand-held devices. "PMs are automatically generated through the refrigerant management system," said Flanigan.

The chain keeps small refrigerant stocks in every store, and conducts an inventory every quarter in order to track its refrigerant usage.

To cut the amount of refrigerant charge in a store by 35%, in 2010 Meijer began a switch from a central rack design to distributed systems, installing six per store, he said. The design also cut leaks by 41%.

FOOD LION RATES TECHNICIANS

Salisbury, N.C.-based Food Lion, which joined GreenChill at its inception in 2007, slashed its leak rates over the next decade by 23.4%, said Wayne Rosa, director of maintenance for Food Lion, at the FMI Energy Conference. "GreenChill brings out a competitive spirit" among partners with respect to leak reduction, he noted.

When it comes to sustainability initiatives, Food Lion, a division of Ahold Delhaize, decided years ago to "be good at the basics – energy consumption and leak rates," Rosa said.

To that end, the 1,029-store chain tracks all refrigerant use, even equipment with less than 50 lbs of refrigerant.

Food Lion employs more than 100 in-house refrigeration technicians. Technicians are evaluated on "score cards," which incorporate leak rates and lbs of refrigerant use. Their bonus structure is based on the results. "It gives them an incentive to control leaks," said Rosa.

The chain does quarterly inventory and leak checks and annual compressor room checks.

Food Lion also does "condition-based maintenance," tracking receiver levels in racks. "If there's any divergence from what it should be, an alarm is sent out to do a leak check," said Rosa. The accuracy rate of the alarms has been in the upper 90th percentile.

In 2017, Food Lion added leak detection systems in motor rooms "where larger leaks occur," said Rosa. "It's rare there will be a large loss on the sale floor."

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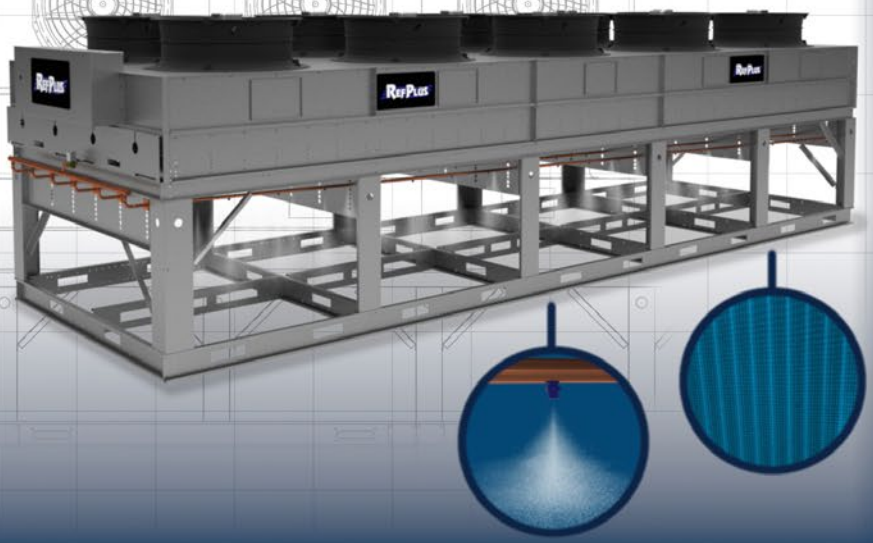

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NEW HC CHARGE LIMIT NEARS FINAL IEC VOTE

A proposed increase in the IEC's hydrocarbon charge limit to 500 g from 150 g got approval to go to a final vote, which is expected in mid-March

– By Marie Battesti and Michael Garry

Marek Zgliczynski, chair of IEC's SC61C subcommittee

In a move that could widen the use of hydrocarbons as natural refrigerants worldwide, the International Electrotechnical Commission (IEC) in October approved advancing to a final vote on whether to increase the charge limit for A3 (flammable) refrigerants like propane in commercial refrigeration equipment to 500 g from 150 g under the IEC standard 60335-2-89.

The final vote, expected by mid-March 2019, represents the last step in a lengthy standards process that will determine whether the higher charge limit is ultimately employed throughout the world.

The final vote under IEC rules is called the Final Draft International Standard (FDIS) phase. The FDIS vote had been expected by the end of 2018 but "is not ready yet," said Marek Zgliczynski, Embraco's manager of commercial refrigeration product engineering, who chairs the IEC SC61C subcommittee. "It will go to IEC's Central Office for translation and editorial revision by mid-December. So the vote will happen probably in mid- March, not earlier than this."

To get to this stage, national committees in the IEC agreed in July by a 75% "yes" vote in what was called the CDV (Committee Draft for Vote) to increase the charge limit to 500 g. (See "HC Charge-Limit Increase Approved in Interim IEC Vote," *Accelerate America*, August 2018.)

That was followed by the approval from the SC61C subcommittee in October at a meeting in Busan, South Korea, where the subcommittee analyzed comments received from the national committees during the CDV stage.

In the FDIS phase, the charge-limit document is circulated to the national committees for a two-month voting period. An FDIS is approved if at least a two-third majority of P (Participating)-members vote positively, and less than 25% of votes are negative. If the document is approved, it progresses to the final publication stage and could be published in the first half 2019; if it is not approved, it is referred back to a technical committee or subcommittee to be reconsidered.

Four-year process

It is commonly accepted by experts that the 150 g limit does not allow manufacturers and end users to fully exploit the safe application of hydrocarbon refrigerants in this sector.

To address the charge limit issue, in 2014 Subcommittee SC61C created a working group (WG4)., which comprises experts from major global manufacturers like AHT, Epta, True Manufacturing, Emerson and Hussmann, among others.

At the Busan meeting, "most of the CDV comments proposed by WG4 were accepted, except the maximum charge of A2L, which will remain 1.2 kg," said Zgliczynski.

Standards from the IEC, a worldwide body that proposes rules governing how to use electrical, electronic and related technologies, influence the development of the market by providing manufacturers and customers with guidelines as to what is safe to use and buy. "But to be mandatory, [the standard] has to be adopted by region," said Zgliczynski.

In the European Union, CEN/CENELEC tends to harmonize their standards with IEC and ISO benchmarks as much as possible.

In the U.S., a new IEC charge limit for hydrocarbons in commercial refrigeration cases would need to be adopted by standards bodies, including UL, ASHRAE and the Environmental Protection Agency, as well as ICC and state building codes, before it would go into effect. ■ MB & MG

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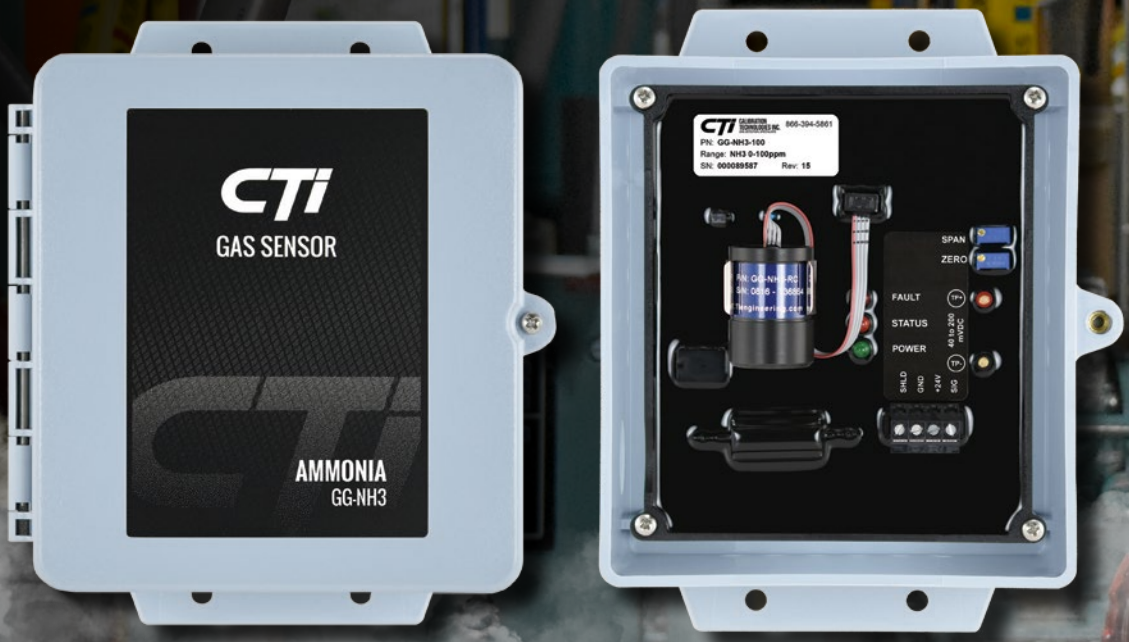

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Three New Governors to Join U.S. Climate Alliance

Evers of Wisconsin, Pritzker of Illinois and Whitmer of Michigan will enter group committed to cutting HFCs.

– By Michael Garry

Three Democratic governors elected in the U.S. midterm elections on November 6 have said they plan to join the U.S. Climate Alliance, a bipartisan coalition of governors from 16 states and Puerto Rico committed to reducing short-lived climate pollutants (SLCPs), including HFCs.

The governors are Tony Evers of Wisconsin, J.B. Pritzker of Illinois and Gretchen Whitmer of Michigan.

The U.S. Climate Alliance formed in 2017 in reaction to the absence of national leadership on climate change from the Trump administration. Alliance states are committed to implementing policies that advance the U.S. goal for the Paris Agreement, set by the Obama administration, to reduce greenhouse gas emission by at least 26%-28% below 2005 levels by 2025.

"When the federal government withdrew the United States from the Climate Agreement, I called on [then Michigan] Governor Snyder to join hundreds of mayors and a dozen governors across the nation in committing to lowering carbon emissions," said Whitmer on her campaign website. "He refused, but I won't. I am committed to fighting for our air and water."

$9 TRILLION ECONOMY

The U.S. Climate Alliance currently includes California, Colorado, Connecticut, Delaware, Hawaii, Maryland, Massachusetts, Minnesota, New Jersey, New York, North Carolina, Oregon, Rhode Island, Vermont, Virginia, Washington and Puerto Rico. In total, the alliance represents 40% of the U.S. population and a $9 trillion economy, greater than the third largest country in the world.

Already, four of the states in the alliance – California, New York, Maryland and Connecticut – have announced plans to reduce HFC emissions. (See "Three States Follow California's Lead on HFCs, *Accelerate America*, October 2018.)

California, which has been the leader in this area, passed a Cooling Act targeting HFCs in August. New York, Maryland and Connecticut made their announcements in concert with the Global Climate Action Summit in San Francisco in September.

In June, the alliance committed to reducing emissions of SLCPs, including HFCs, which would provide "outsized global climate benefits in the near-term, along with significant health, agricultural, and ecosystem benefits," the group said. The alliance also invited national and subnational jurisdictions, businesses and other actors to bring commitments to reduce SLCPs to the Global Climate Action Summit.

The alliance said that strategies to reduce HFC emissions "promote more energy-efficient systems that lower costs for businesses and households, support the leadership of U.S. businesses developing alternatives to HFCs, and increase the need for skilled technicians and system designers."

The action by the states stands in contrast to the unwillingness to date by the Trump administration to refer the Kigali Amendment on phasing down HFCs to the Senate for approval. "The only resort we have is to rely on the power of states' rights," wrote Alec Johnson, in his RefrigerantHQ.com blog.

In addition to the wins at the state level in the midterm elections, Democrats gained control of the U.S. House of Representatives, where they can exercise oversight of the Environmental Protection Agency. Newly elected House Democrats include Alexandria Ocasio-Cortez of New York, who supports transitioning to 100% renewable energy by 2035, and Sean Casten of Illinois, who ran on a platform to fight climate change.

There were electoral setbacks as well, notably the failure of a carbon-tax initiative in Washington State. ■ MG

U.S. States Oppose EPA Proposal on HFC Leaks

Fifteen states and the District of Columbia urge the agency to stick with Obama-era rule extending ODS leak repairs to HFCs

– By Michael Garry

Fifteen U.S. states and the District of Columbia last month sent a letter to the U.S. Environmental Protection Agency (EPA) "strongly opposing" its proposed revisions to updated leak repair and maintenance regulations that were extended to HFCs.

The states, mostly represented by their attorneys general, include Massachusetts, Delaware, Illinois, Iowa, Maine, Maryland, New Jersey, New York, North Carolina, Oregon, Vermont, Virginia, Washington, and California. California was also represented by its Air Resources Board.

The states' letter was issued on November 15, the deadline the EPA set to receive comments on the proposed revisions.

All of the states but Illinois, Iowa and Maine belong to the U.S. Climate Alliance, which is committed to reducing short-lived climate pollutants (SLCPs), including HFCs, in the absence of federal leadership. (Illinois plans to join; see page 28.) Four of the states in the alliance – California, New York, Maryland and Connecticut – have announced HFC-reduction plans. (See "Three States Follow California's Lead on HFCs, *Accelerate America*, October 2018.)

The letter objected to the EPA's September proposal, called "Protection of Stratospheric Ozone: Revisions to the Refrigerant Management Program's Extension to Substitutes," which the letter said would limit the scope of the EPA's refrigerant management program and "thereby increase emissions of dangerous chemicals." (See "EPA Proposes to Rescind Leak Repair Rules for HFC equipment," *Accelerate America*, October 2018.)

The States instead urged the EPA to withdraw the proposed rule and fully embrace the appliance-maintenance and leak-repair provisions that apply to high-GWP HFCs.

Section 608 update

The EPA's proposed rule takes aim at an update to Section 608 of the Clean Air Act issued on November 18, 2016. Under the update, the EPA extended the refrigerant management rules for supermarkets and industrial facilities – originally designed for ozone-depleting substances (ODS) – to common ODS substitutes like HFCs. But in the proposed rule the EPA would revert to the original language of Section 608, which pertains only to leak repair and maintenance of ODS equipment.

The agency is also weighing whether it should also rescind additional requirements set forth in the 2016 rule pertaining to HFCs, such as the provision requiring purchasers or handlers to be Section 608-certified technicians.

The letter said the proposed rule "reflects an arbitrary, capricious and inadequately explained departure from EPA's 2016 Rule."

The letter also called the EPA's proposed rule "unlawful and misguided," adding that the Clean Air Act "gives EPA broad authority to promulgate regulations to prevent the knowing ventilation of both ODS refrigerants and their substitutes and to reduce ODS emissions to the lowest achievable level."

The letter also said the EPA had not "adequately analyzed the costs and benefits of the proposed rule, including the significant public harm associated with increased emissions of greenhouse gases and ODSs."

By contrast, extension of appliance-maintenance and leak-repair requirements to HFCs provides "a sensible and consistent regulatory scheme that prevents knowing ventilation and emissions of both ODSs and dangerous ODS substitutes," the letter added. ■ MG

Entrance to Chillventa 2018, Nuremberg, Germany
Source: NürnbergMesse

CHILLVENTA REFLECTS EUROPE'S NATREF LEADERSHIP

The giant German trade show features advances in heat pumps and chillers along with new CO_2 condensing units

– By Andrew Williams & Charlotte McLaughlin

> *"Natural refrigerants are the trend going forward."*
>
> – Luis Felipe Dau, Embraco

In all the applications and markets in which Embraco is active, "natural refrigerants are the trend going forward," said Luis Felipe Dau, president and CEO of the Brazilian compressor maker, at Chillventa 2018 in October.

Dau was talking about hydrocarbons, and about the focus of Embraco in particular. But his words captured the spirit of this year's Chillventa, which saw a record number of companies offer natural refrigerant-based HVAC&R solutions.

Chillventa, which takes place in Nuremberg, Germany, every other year, broke a number of records in 2018. For example, the event attracted 35,490 visitors from 125 countries – up 10% from the previous edition in 2016. The exhibition hall held 1,019 booths – an increase of 4% from 2016 – from 45 nations.

NatRefs spreading in HVAC market

Natural refrigerants have steadily been gaining market share in refrigeration and HVAC markets around the world. This is particularly true in Chillventa's home continent of Europe, where the new EU F-Gas Regulation – in force since 2015 – aims to reduce the European Union's use of HFCs by 79% by 2030.

The EU phase-down, in fact, has already led to HFC price rises – creating more opportunities in Europe for natural refrigerant-based technologies to replace HFC systems as market-ready, environmentally friendly and less expensive alternatives.

Commercial refrigeration end users are already adopting natural refrigerants at a promising rate. In Europe, with an estimated 16,000+ supermarkets in Europe using CO_2 transcritical systems, according to sheccoBase, the market development arm of *Accelerate America* publisher shecco. That compares to over 500 in North America.

The HVAC market, however, has been slower to pick up speed. But at Chillventa 2018, there were signs that this is beginning to change.

For example, Euroklimat, an Italian manufacturer of commercial and industrial heating and cooling solutions, displayed its new propane (R290)-based heat pump at the show. With a propane charge of 5.5 kg, it has a heating capacity of 60 kW (17 TR) and is designed for outdoor installation. The unit on display at Chillventa targeted commercial buildings.

Euroklimat is currently testing the new unit in the laboratory and in the field, with a view to putting it on the market in January-February 2019. "This is a prototype," said Giulia Fava, Euroklimat's product developer.

Euroklimat is aiming "to have ready next year a range of propane heat pumps from 30 kW (8.5 TR) up to 150 kW (43 TR)," she added.

The heat pump uses Frascold compressors, an ATEX-certified pressure transducer and pressure transmitter, and CAREL's microprocessor. Asked how the prototype had performed in testing, Fava said, "it is working well, down to -20°C (-4°F)."

Euroklimat decided to invest in the propane heat pump after receiving many requests from customers. "Most of our customers for propane are from northern countries," Fava said. "Two years ago they started asking us, 'Please, we need a heat pump down to -20°C!' and we didn't have it. So now we are trying to answer their requests."

CO_2 heat pump/chiller

Propane wasn't the only natural refrigerant to be employed in HVAC equipment on display at Chillventa. The Yukon CO_2 chiller range, displayed for the first time by Italian system manufacturer Enex, can be used as a reversible heat pump and air conditioner in commercial buildings.

"We are now installing the first versions with reversible operations," said Sergio Girotto, president of Enex. "It means they work as heat pump in winter and as a chiller in summer."

The Yukon line, designed as plug-and-play, medium-sized water/brine chillers, comes in two offerings. One uses a pressure receiver with a capacity of up to 60 kW (17 TR) and permits a capacity increase while assuring redundancy. The second unit, which uses gravity-fed evaporators, has a larger capacity of up to 450 kW (128 TR), and can be used with Enex's "enjector" ejector.

"Nobody believed so far that CO_2 could be a good refrigerant for water chillers, but [with the Yukon chiller range] we proved that it is efficient," Girotto said. "[The enjector] makes the chiller efficient at 35°C (95°F) ambient temperature."

The Yukon is particularly suited to space cooling in medium and large commercial buildings with a significant hot water demand, such as hotels, hospitals, gyms and wineries.

> *"The ejector gives us that extra energy efficiency we need to operate in warm climates."*
>
> – Kenneth Bank Madsen, Advansor

CO_2 transcritical for all climates

Market interest in CO_2 transcritical systems has grown dramatically in the past four years as technology developments such as ejectors help to overcome their operational limitations in warm climates, noted Kenneth Bank Madsen, business development manager at Danish multinational Advansor.

At Chillventa, Madsen presented Advansor's CO_2 transcritical systems for industrial and commercial applications. "Interest in our transcritical CO_2 racks has been huge," he said. "We can clearly see a development since the last Chillventa in 2016."

Advansor's CO_2 systems have been installed "from northern to southern Europe – we cover all climates," Madsen said.

Ejector technology helps in this regard. "The ejector gives us that extra energy efficiency we need to operate in warm climates," said Madsen, presenting a rack designed for Portugal that is capable of operating in temperatures of up to 43°C (109°F).

Meanwhile, Italian multinational compressor manufacturer Dorin, believes CO_2 transcritical is poised to take off in industrial applications within the next three to five years as larger compressors hit the market, said Giovanni Dorin, the firm's marketing manager. "We're ready to ride that wave."

Asked how the market for CO_2-based HVAC&R technologies had changed since the last Chillventa in 2016, Dorin said, "component availability and access to technology is more widespread".

CO_2 condensing unit

Compressor manufacturer Tecumseh, based in Ann Arbor, Mich., announced at Chillventa the launch in 18 months of its first CO_2 condensing unit.

> *"For CO_2, component availability and access to technology is more widespread."*
>
> – Giovanni Dorin, Dorin

Tecumseh is developing the CO_2 condensing unit "to extend its product range that is compliant with European regulations" such as the EU's F-Gas Regulation and Eco-Design Directive.

Tecumseh exhibited a prototype of the new condensing unit at its Chillventa booth. The firm will face competition from Japanese multinational Panasonic, which pushed its new VF Series of CO_2 condensing units for refrigerated and frozen goods at the show.

Panasonic launched a 15 kW (4.3 TR) model for the European market this summer. A 4 kW (1.1 TR) unit has been available in Europe since last year.

Panasonic's VF Series is geared to small to medium-capacity cooling and freezing applications at retail and food service sectors, such as small supermarkets and convenience stores, said Shigeru Dohno, managing officer (food retail and commercial equipment business) at the Panasonic Corporation's appliance company branch. It also serves the restaurant and hotel sectors.

Since the European launch in 2017, Panasonic has installed its 4 kW units in 250 stores in Europe, from Iceland in the north to Italy and Spain in the south.

With so many new products on show at Chillventa, the future looks bright for natural refrigerant-based HVAC&R solutions. ■ AW & CM

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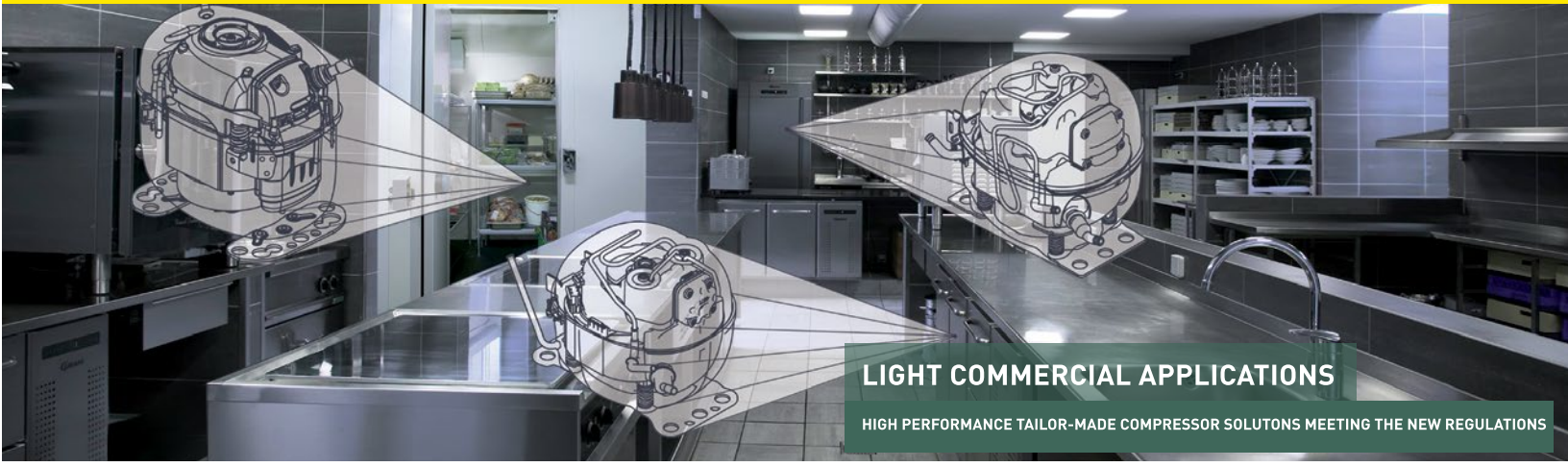

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ICE RINKS: ***WHICH REFRIGERANT IS BEST?***

The National Hockey League has partnered with Chemours to promote HFO blends R449A and R513A as green refrigerants for North American ice rinks, though so far no NHL team is using them. A more sustainable choice would be natural refrigerants ammonia and/or CO_2, industry stakeholders told *Accelerate America.*

– By Michael Garry

Ice hockey was first played on frozen ponds, which are freezing later and melting earlier as a result of climate change.

Acknowledging the sport's fundamental link to the environment and its preservation, the National Hockey League (NHL) – the 101-year-old organization now consisting of 31 professional ice hockey teams across Canada and the U.S. – launched the NHL Green initiative (https://www.nhl.com/info/nhl-green) in 2010.

"Most of our players learned to skate on outdoor rinks," said NHL Commissioner Gary Bettman, in announcing the program. "For that magnificent tradition to continue through future generations, we need winter weather – and as a league we are uniquely positioned to promote that message."

For help in "greening" league games and operations, the NHL consulted with the National Resources Defense Council (NRDC). Each NHL team appointed one or more sustainability representatives to liaise with the league.

In 2014, the NHL released its first sustainability report, which provided data on its environmental impact. This was followed two years later by a program focusing specifically on ice rinks – the Greener Rinks Initiative; its mandate is to measure and evaluate the combined environmental impact of approximately 4,800 indoor ice rinks across North America, which have an average age of over 30 years.

The Greener Rinks Initiative is "committed to sharing sustainable business practices with community rink owners and operators," according to the NHL,

In March of this year, the NHL released its second sustainability report, which reported that the majority of NHL arenas still use R22 or HFCs as refrigerants, with about 20% using ammonia.

R22's days are numbered as production and import of the gas in North America are slated to end in January 2020. In May, the NHL promoted what could be a replacement refrigerant for R22, announcing a multi-year partnership with The Chemours Company to provide Opteon XP40 (R449A) and Opteon XP10 (R513A) to rinks across North America. (The announcement did not disclose any financial terms.)

The NHL and Chemours view this partnership as continuing the league's environmental stewardship, saying in the announcement that it "supports the NHL Greener Rinks Initiative."

But are R449A and R513A the most environmentally sustainable refrigerants to use in ice rink systems, particularly in new facilities?

A number of industry stakeholders contacted by *Accelerate America* point to natural refrigerants ammonia and CO_2 as more sustainable and future-proof for ice rinks than the Opteon refrigerants being promoted by the NHL. This mirrors a similar discussion going on in other HVAC&R-related sectors like food retail and cold storage.

Art Sutherland, Accent Refrigeration Systems

Benoit Rodier, CIMCO

Best green solutions

Art Sutherland, president and CEO of Accent Refrigeration Systems, Victoria, B.C., a major designer and installer of ice rink refrigeration systems, strongly endorses the use of natural refrigerants in ice rink systems. "The whole world is going this way, moving away from [HCFCs] and HFCs, and now there's concern about HFOs and their acidic nature," he said. "Ammonia and CO_2 are the best true green solutions."

"It would be a shame if the NHL bypasses any opportunities to adopt truly low-GWP alternatives such as CO_2 and ammonia," said Christina Starr, Climate Policy Analyst for the Washington, D.C.-based Environmental Investigation Agency (EIA). "Particularly for new rinks and systems, these alternatives are available, proven, and offer opportunities for energy improvements over HFCs as well as direct climate benefits."

Toronto-based CIMCO Refrigeration (a division of Toromont Industries) is a major designer and installer of ice rinks that claims to have installed more than half of the world's rinks. The company offers a range of refrigerant options

for ice rinks, including ammonia/CO_2, ammonia/glycol, CO_2 and "Freon," which is Chemours' trademark for a number of halocarbon refrigerants. (Information on CIMCO's CO_2 ice rink patents for the Canadian market can be found here: https://bit.ly/2B6NGqc.)

For each project, CIMCO looks at initial cost, energy consumption and maintenance, and calculates total cost of ownership. "Generally low-charge ammonia/glycol or CO_2 are a better choice over a 20-30 year time frame," said Benoit Rodier, CIMCO's director of business development. "We present the business case and the customer takes a decision."

Customers who choose Freon "are looking for the lowest initial investment and are not so concerned about efficiency over time," he added.

In Canada, the government of Quebec is giving an incentive to ice rinks that replace R22 with either ammonia or CO_2, and one-third of that incentive if HFO blends are used, noted Rodier. "The government recognizes the value natural refrigerants bring to the table."

Given that previous generations of synthetic refrigerants – CFCs, HCFCs and HFCs – have prompted environmental regulations, "it makes no sense to use a fourth-generation synthetic molecule," said Marc-André Lesmerises, a CO_2 refrigeration pioneer who is president and founder of Carnot Refrigeration, Trois-Rivières, Quebec.

In Europe, "the cost [of HFOs] and potential environmental issues put an end to the discussion fairly quick," said Jörgen Rogstam, managing director for EKA (Energi & Kylanalys), a Swedish firm focused on ice rink efficiency.

Operationally, natural refrigerants have performed well in studies of ice rink systems. A 2013 study by the Canadian government's CanmetENERGY research group found that CO_2 systems had the best COP (coefficient of performance) for refrigeration and heating (3.9), followed by NH_3 (3.0) and HFCs (2.6); and the lowest annual energy consumption (393 MWh), followed by ammonia (525) and HFCs (611).

A report by CIMCO that included measures of horsepower expended per 100 tons of refrigerant, listed CO_2 as the lowest (123.1) followed by ammonia (123.5), R513A (144.2) and R449A (168.8), among other refrigerants. CO_2 was evaluated under a 65°F condensing temperature.

On the issue of "glide," natural refrigerants also have advantages. For example, CO_2 boils at a constant temperature, whereas R449A is a zeotrope, or a blend of refrigerants that boil at different temperatures. This temperature range, or glide, is a factor in evaluating refrigerants, with a potential impact on efficiency, said Tim Henderson, Hillphoenix's industrial program manager.

In contrast with R449A, R513A is an "azeotropic refrigerant with zero glide," according to Chemours.

Linde AG, a distributor of R449A, states in promotional literature that the refrigerant "has a moderate glide of approximately 4K that can be easily managed by a minor adjustment in the expansion device." In addition, as a zeotrope, R449A "must be charged in the liquid phase to prevent fractionation."

But Henderson pointed out that refrigerants with glide may require larger

condensers and possibly larger evaporators with more surface area "to make up for the glide." He has also heard of problems with "expansion valve sizing."

Moreover, glide "has been proven to have a negative effect on the heat transfer performance of the refrigerant and may result in the chemical breaking down over a period of time," said Dave Rule, president, International Institute of Ammonia Refrigeration (IIAR), Alexandria, Va.

Outreach to the community

The NHL declined to be interviewed for this article, deferring questions to Chemours, a Wilmington, Del.-based chemical producer formed in 2015 as a spinoff of DuPont.

Allison Skidd, Chemours' North America marketing manager, fluorochemicals, described the NHL-Chemours partnership as providing "options for community rinks across North America that are faced with the need to address environmental regulations as well as economic sustainability concerns."

Chemours and the NHL are working on outreach to community rink owners, operators and mechanical contractors "to offer resources for selection of safe, operationally cost-effective, environmental and financially sustainable alternatives, such as Opteon refrigerants which are non-ozone depleting and have low global warming potential," Skidd said. The effort covers both retrofits of refrigerants in existing systems as well as equipment replacement in new and existing locations.

As to which refrigerant or system the 31 NHL teams will ultimately employ, "each team or arena owner will be the final decision maker after considering the many factors for their situation," said Skidd. No NHL arena is known to have used Opteon refrigerants to date.

Meanwhile, NHL players have given an endorsement to ammonia. Last month the *Edmonton* (Alberta) *Sun* reported that Rogers Place, home to the NHL's Edmonton Oilers, ranked second in ice rink quality in a poll of NHL players, coming in only behind the Montreal Canadiens. Both teams use ammonia-based ice rink systems.

Opteon refrigerants have been employed in "numerous systems across North America before and since the partnership began," said Skidd. These include retrofits of R22, R507 and R134a, replacement of ammonia systems, and new rink installations. For example, the MARS Lakeview Arena in St. Cloud, Minn., has successfully operated "with lower operating cost and improved energy efficiency" since converting to R449A, she said. The facility uses R449A in a DX chiller (that replaced a flooded R22 chiller) with a glycol secondary fluid.

Meanwhile, many ice rink operators are using ammonia as a primary refrigerant coupled with a brine or glycol as a secondary refrigerant. CO_2, both in direct and indirect (secondary) systems, is increasingly being employed by ice rink arenas in North America and Europe.

Asked to compare Opteon refrigerants with ammonia and CO_2, Skidd said, "As A1 ASHRAE safety class refrigerants, Opteon XP10 and XP40 offer improved safety—with respect to toxicity and flammability—versus R717 [ammonia]. They also operate at lower pressures than R744 [CO_2], which favorably impacts chiller efficiency, system reliability, and operating cost."

The NHL and Chemours noted in their announcement of the partnership that many community rinks across North America continue to use soon-to-be-phased-out R22. R449A has become an alternative to R22 in some ice rink systems because "older R22 systems can be retrofitted to accept [R449A]," thereby avoiding the cost of a new system, wrote Alec Johnson on his RefrigerantsHQ.com blog.

Accent Refrigeration's Sutherland acknowledged that that R449A and Honeywell's R448A could be "drop-in" replacements for R22 while ammonia and CO_2 could not.

Many rinks, noted Chemours and the NHL, also use high global warming potential (GWP) HFCs like R507 and R134a, which are being phased down globally via the Kigali Amendment to the Montreal Protocol. (The U.S. has yet to ratify the amendment.)

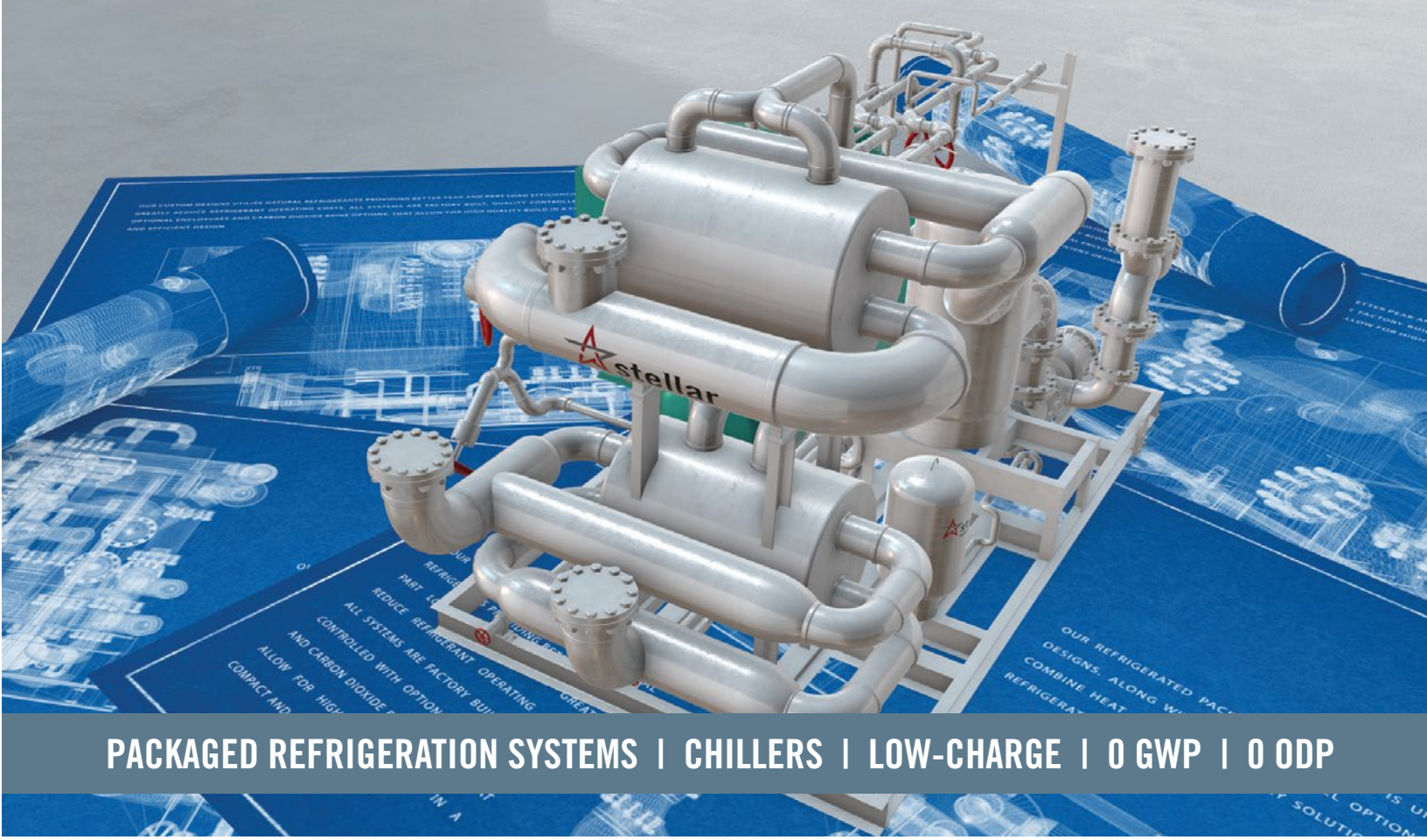
While Chemours promotes R449A as having a "low GWP," Johnson called its GWP of 1,282 "a high GWP number." At a time when high-GWP refrigerants are being targeted by regulatory bodies throughout the world, "a high GWP number means tha [R449A] very well may be targeted for phase down or phase out," he observed.

CIMCO's Rodier views R449A, with its near-1300 GWP, as a "transitional solution."

R513A's GWP (573) is about half that R449A, but it still considerably higher than the GWP of ammonia (zero) and CO_2 (one), making it vulnerable to phase outs in regions like California that are looking at capping GWP in non-residential refrigeration systems at 150.

R449A and R513A both contain HFCs: R449A includes the HFCs R32 (24.3%), R125 (24.7%) and R134a (25.7%), while R513A includes R134a (44%).

Asked about how the phase-down of HFCs would impact Opteon refrigerants, Skidd replied, "In order to meet goals of the Kigali Amendment, the global HVACR (and other) industries will need to adopt a wide array of solutions,



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"These solutions offer a range of lower-GWP options and involve trade-offs between performance, safety classifications, and total cost of ownership," she added. "The Opteon portfolio of solutions will play an integral role in the industries we serve for the long term."

Aside from the GWP question, R449A and R513A also contain R1234yf, which degrades readily in the atmosphere into trifluoroacetic acid (TFA), a very durable substance whose long-term environmental impact is still being investigated. (See page 43.)

Natural refrigerant technology is "the only method that will ensure that future refrigerant phase-out regulations are avoided due to both current and unknown environmental issues," said IIAR's Rule.

Sabres and Oilers tout ammonia

Ammonia systems have a big head start on other ice rink options. In Canada, about 90% of the rinks use ammonia, except in Quebec, where it's split roughly 50/50 between ammonia and R22, said Rodier.

Ammonia continues to be a refrigerant employed by NHL teams, including recent installations by the Detroit Red Wings, Buffalo Sabres, Edmonton Oilers, and the Las Vegas Golden Knights. (The Los Angeles Kings recently installed a CO_2 ice rink system.)

The NHL has also employed an ammonia/glycol system to support its annual outdoor games played on temporary rinks in baseball and football stadiums across North America. (See, "Turning Stadiums into Hockey Rinks, *Accelerate America*, March 2018.)

Last year, the NHL's Buffalo Sabres replaced its 21-year-old R22 system with an ammonia-based system, which uses less electricity, said Ian Ott, senior manager of media relations for the team.

"It's been performing very well," he added. "Our ice quality is excellent. We haven't had much in the way of maintenance costs."

The Edmonton Oilers' Rogers Place opened two years ago with an ammonia/glycol system supporting two rinks with 400 TR of capacity. The ice has been endorsed by such NHL stars as Sidney Crosby of the Pittsburgh Penguins and the Oilers' Connor McDavid. The Oilers previously played at the Northlands Coliseum, where they used an ammonia/brine system.

"I'm a fan of ammonia refrigeration," said Jason Rimmer, director of engineering and ice operation at Rogers Place. "Even for the simple fact that if there's a leak, you know it. Freon is colorless and odorless, so if your detector is not working properly, you won't notice a leak."

Rimmer also prefers ammonia to Freon from an efficiency point of view. His energy costs are also reduced by virtue of the NH_3 system's heat recovery, which serves an indoor garage at Rogers Place and its hot water supply. "It's capable of generating 6.25 million BTUs per hour," he said.

The Rogers Place low-charge system uses only 550 lbs of ammonia. "I feel comfortable using it as there are many safeties in play," Rimmer said. "Additionally, we ensure all of our department is trained in different situations by both classroom training as well as performing drills."

Fernie accident

Sutherland of Accent Refrigeration, who has installed systems with HFO blends like R513A and R448A (from Honeywell), nonetheless always promotes ammonia as "the greenest and most efficient choice for ice rinks," he said. "And for years that view was unopposed."

But then a tragic accident happened in 2017 at the Fernie Memorial Arena in Fernie, B.C., where a catastrophic leak in a chiller with 1,000 lbs of ammonia took the lives of three technicians. The Fernie arena recently reopened after installation of a new ice rink chiller that uses Opteon refrigerant.

As horrible as it was, the accident has created what Sutherland and others in the ammonia refrigeration industry believe is an unfair perception of ammonia as an unsafe refrigerant. "It created a lot of fear among municipalities and rink operators," he said, "and thrown a wrench into the whole industry."

However, he pointed out, the fatalities at Fernie were the first related to ammonia in the ice rink industry's 125-year history. (Other fatal accidents were the result of R22 leaks.) "And the reason for it is that this system was really old and had been leaking for years," he said. "The chiller should have been changed years before."

With current technology, he added, the accident would not have occurred. As minor an addition as a $200 pressure relief valve on the secondary side of the system "would have saved these three people."

Sutherland pointed out that there have been major advances in ammonia refrigeration that have rendered the technology vastly safer. One is lower ammonia charges, which have been cut to as low as 0.5 lb/TR. Modern ammonia ice rink chillers, he said, have less than 15% of the refrigerant charge used in shell-and-tube chillers of the past.

Sutherland remains confident that low-charge ammonia systems represents the direction in which the ice rink industry in British Columbia is headed, despite the Fernie incident.

Another safety advance is better airflow in buildings. "So if there is a leak you can get the ammonia out of the air quickly," Sutherland said.

Next summer, Sutherland plans to install a "new style" ammonia system at a rink in Port Alberni, B.C., with innovative safety features. The system will contain only 60 lbs of ammonia and use calcium chloride brine as a secondary refrigerant; it will employ a low-charge "spray chiller" in which the liquid ammonia "vaporizes as soon as it hits the [evaporator] tubes," he said.

In addition, in the event of a 25 ppm ammonia leak, a high-speed exhaust fan would be initiated; if a leak reaches 300 ppm, the Port Alberni system would close the solenoid valve on the outlet of the condenser and pump ammonia out of the machine room and into the condenser "in less than a minute," he said. "It will safely contain the ammonia in the condenser."

First NH_3/CO_2 system

Ammonia in combination with CO_2 has also proved to be an effective refrigerant solution for ice rinks.

Three years ago, Sutherland designed North America's first ammonia/CO_2 system for the Wells Fargo Sports Complex practice ice rink at University of Alaska's arena in Anchorage, replacing a leaky direct system with 6,000 lbs of R22. (See "Double Duty," *Accelerate America*, June 2016.) A separate machine house was built for the NH_3/CO_2 system.

"It's a great system," said Glenn Thomas, refrigeration technician for the University of Alaska. "It will last a long time and produce much better ice."

Thomas likes the lower amount of CO_2 (350 lbs) used in a secondary system compared to a transcritical direct system (over 1,000 lbs). The systems also uses a low ammonia charge (400 lbs), and serves a capacity of 130 TR.

Ammonia/CO_2 is a more expensive option than other systems but offers the best total cost of ownership, said Sutherland. "It's a fairly long payback – over 10 years – but [the energy efficiency] gives you a payback over the lifetime of the system," he said. Thomas noted that maintenance cost savings alone were considerable.

Sutherland believes an ammonia/CO_2 system is more efficient than a CO_2 system, though CO_2 produces high-grade heat for reclaim while NH_3/CO_2 generates low-grade heat.

But Rodier contends that in Canada, with its cooler northern climate, transcritical CO_2 would be "a little more efficient than ammonia/CO_2," as well as less expensive. But for larger capacity rinks, NH_3/CO_2 would be needed, he added.

In any event, the NH_3/CO_2 systems uses less energy than its predecessor at the University of Alaska, said Sutherland, though he acknowledged it was an old system. Energy is saved in several ways: the NH_3/CO_2 system employs an adiabatic condenser rather than an air-cooled condenser; and it reclaims more heat than the older model.

In addition, the R22 compressors had to be run "full-tilt, all the time," while the ammonia compressor runs "half the time, about 12 hours a day," said Thomas.

Growing CO_2 market

CO_2 refrigeration is a relative newcomer to the ice rink market, with the first installation in 2010 at an arena in Saint Gédéon, Canada. But it is gaining traction as a green alternative in the U.S. and especially in Canada, where there are more than 40 CO_2 ice rink systems, according to Carnot's Lesmerises. Quebec has the most installations though "there is a lot of interest coast to coast," said CIMCO's Rodier.

EKA's Rogstam describes CO_2 ice rink development in Northern Europe, especially in Sweden and Norway, as "fantastic," adding that "the cost is lower than ammonia." In February, he estimated that there were 20 CO_2 systems in Europe. European CO_2 ice rink suppliers include Green & Cool, Advansor and SCM Frigo.

Carnot Refrigeration is supplying CO_2 systems to ice rink arenas in the U.S. Lesmerises believes CO_2 transcritical systems, direct or using a secondary brine/glycol, save more energy in ice rinks than any other system, including those using ammonia.

That's for two reasons, said Lesmerises: CO_2 generates the most heat reclaim; in addition, it is thermodynamically the most efficient system, especially for the many ice rinks that operate for nine months – not during the hot summer months when CO_2 may operate less efficiently.

Combining heat recovery and system efficiently makes CO_2 "a no brainer," he said.

Last month, a transcritical CO_2/glycol secondary system that will support two ice rinks – one existing and one new – went live for the new rink at the St. Michael-Albertville Arena, in Albertville, Minn., used by local high school hockey teams.

The system supplied by Zero Zone, Ramsey, Minn., replaced an aging R22/glycol system.

A CO_2 direct system, which distributes CO_2 under the rink rather than a secondary fluid, "didn't fit" because the arena did not want to replace the existing glycol piping under the original rink with CO_2-ready steel or copper pipes, noted John Collins, industrial sales manager for Zero Zone.

Hillphoenix, the Conyers, Ga.-based manufacturer of transcritical CO_2 systems for supermarkets and industrial plants, has installed direct transcritical CO_2 systems at four ice rinks operated by the Municipality of Anchorage, Alaska. (See Skating on CO_2-Made Ice," *Accelerate America*, May 2016.) The units, which were installed between 2014 and 2017 in place of R22 systems, generate between 100 TR and 130 TR of cooling capacity.

Hillphoenix's Henderson also believes CO_2 transcritical direct is the most efficient ice rink system available today.

One reason he gave is the much lower power needed to pump CO_2 under the rink vs. secondary fluids like brine or glycol. According to Rodier, in a secondary system CO_2 requires a 2 kW pump, compared to a 15-20 kW pump for a glycol.

In addition, said Henderson, a direct system has greater efficiency than a secondary system that expends energy in the primary/secondary heat exchanger; and a direct system runs higher suction pressures. Rodier pointed out that CO_2 operates "10°F-12°F higher than any system," which enables it to consume "way less energy."

Like Lesmerises, Henderson acknowledged that the considerable heat reclaim offered by a CO_2 system is part of its efficiency gain. "CO_2 is a great heat pump; you get a lot of heat out of it for a little additional kW input," he said.

Rogstam said recent studies indicate that large arenas can save 80%-90% on heating costs by using recovered heat from a CO_2 system.

In 2013, Concordia University in Montreal, Canada, installed a transcritical CO_2 direct system supplied by CIMCO. The system generates high-grade heat reclaim, which is above 140°F and suitable for boiler replacement, as well as low-grade heat reclaim, at 100°F, for under-floor heating, potable water and a snow-melting pit.

"When you add all of this up, you come up with the fact that [CO_2] is the most efficient way to do it," Henderson said.

Henderson acknowledged that ambient climate is a factor in a CO_2 ice rink's efficiency, though the installation of an adiabatic condenser has been shown to enable a transcritical system to run efficiently in most of the U.S. In Anchorage, because of its far-north location, the CO_2 ice rinks can operate efficiently with air-cooled condensers, though "that's the exception," he said.

In terms of installed cost, a transcritical CO_2 direct ice rink system can run higher than systems using synthetic refrigerants or ammonia, mostly due to the stainless-steel piping required under the rink, said Henderson. The installed price of an ammonia system, he added, is impacted by safety requirements, while its operational cost is boosted by the use of an evaporative condenser.

In replacing an R22 system, the CanmetENERGY study found that for a CO_2 system the cost would range from $207,000 with an unchanged brine loop to $685,000 with a new CO_2 loop under the ice.

But energy savings with a CO_2 transcritical direct system can result in a better lifecycle cost, said Henderson.

As a direct system, CO_2 produces better quality ice than a secondary glycol system, said Rodier. That's because CO_2 changes from liquid to gas under the rink, cooling the rink at a constant temperature throughout, in contrast with glycol, which produces slightly different temperatures across the rink, he said. "Skaters and operators notice. Even the Zamboni is quicker with a direct floor."

The only operational challenge with a CO_2 transcritical direct ice rink system is the potential for compressor oil leakage at start-up due to higher initial suction pressures, noted Henderson. "But if you control the start-up properly, it's a non-issue," he said.

Though it is classified as an A1 nontoxic refrigerant, CO_2, like any refrigerant, is capable of displacing air in an enclosed area, and requires CO_2 detectors to warn technicians of a leak. CO_2 systems, especially the direct version, need to adhere to the ASHRAE-15 safety standard that limits the amount of CO_2 to 3.6 lbs per thousand cubic feet of occupied space, noted Rodier.

Lesmerises explained that because direct CO_2 systems use much more CO_2 charge than indirect systems, in small arenas direct systems may exceed the allowable charge standard unless additional ventilation or other safety adjustments are made, making indirect systems the better choice. On the other hand, direct systems conserve the most energy, producing the most heat reclaim.

Henderson dismisses the notion that the high pressures under which CO_2 systems operate present a safety problem. "It's a non-issue," he said. "The equipment is designed to operate up to 1,750 psi. It's misinformation makes people afraid of higher pressures."

Which means CO_2 – and its natural refrigerant cousin ammonia – are well-positioned to become the de facto future-proof alternatives for ice rinks. ■ MG

What About TFA?

Both R449A and R513A contain R1234yf (25.3% and 56%, respectively), which degrades readily in the atmosphere into trifluoroacetic acid (TFA), a very durable substance whose long-term environmental impact is still being investigated.

TFA descends to the earth in rain. It is found in a wide range of water bodies, including rivers, streams, lakes and wetlands, with the highest concentrations in terminal water bodies such as salt lakes, playas and oceans. In freshwaters, TFA is thought to be solely human-made (anthropogenic). For one type of algae, Raphidocelis subcapitata (freshwater green alga), scientists have determined the "Predicted No Effect Concentration" (NOEC) – the limit of what it can tolerate with no adverse effects – to be 0.12 mg/l of TFA.

Asked if the continued investigation into TFA's potential environmental impact raises uncertainty about the long-term viability of Opteon, Skidd replied, "We do not see any uncertainty about the long-term viability of our Opteon portfolio. Numerous independent, scientific and peer-reviewed studies have been published on this matter over the past decade, noting that more than 95% of TFA found in oceans is naturally occurring, and TFA generated from current and future use of fluorinated materials will add only fractionally to amounts already present from natural sources such as undersea vents and volcanic activity.

"In addition, she said, '…projected future increased loadings of TFA to playas, land-locked lakes and oceans due to continued use of HCFCs, HFCs, and replacement products are still judged to present negligible risks for aquatic organisms and humans,' according to an article in Photochemical & Photobiological Sciences, Issue 1, 2015, called 'Changes in air quality and tropospheric composition due to depletion of stratospheric ozone and interactions with changing climate: implications for human and environmental health.'" (See https://rsc.li/2zWcvFw for article.)

But there are a number of studies raising questions about TFA.

A December 2017 report commissioned by the Norwegian Environment Agency on the environmental impact of TFA recommended that a number of "knowledge gaps" needed to be addressed before TFA's ultimate effect on the environment can be determined. (See https://bit.ly/2QFqxoK for full report.)

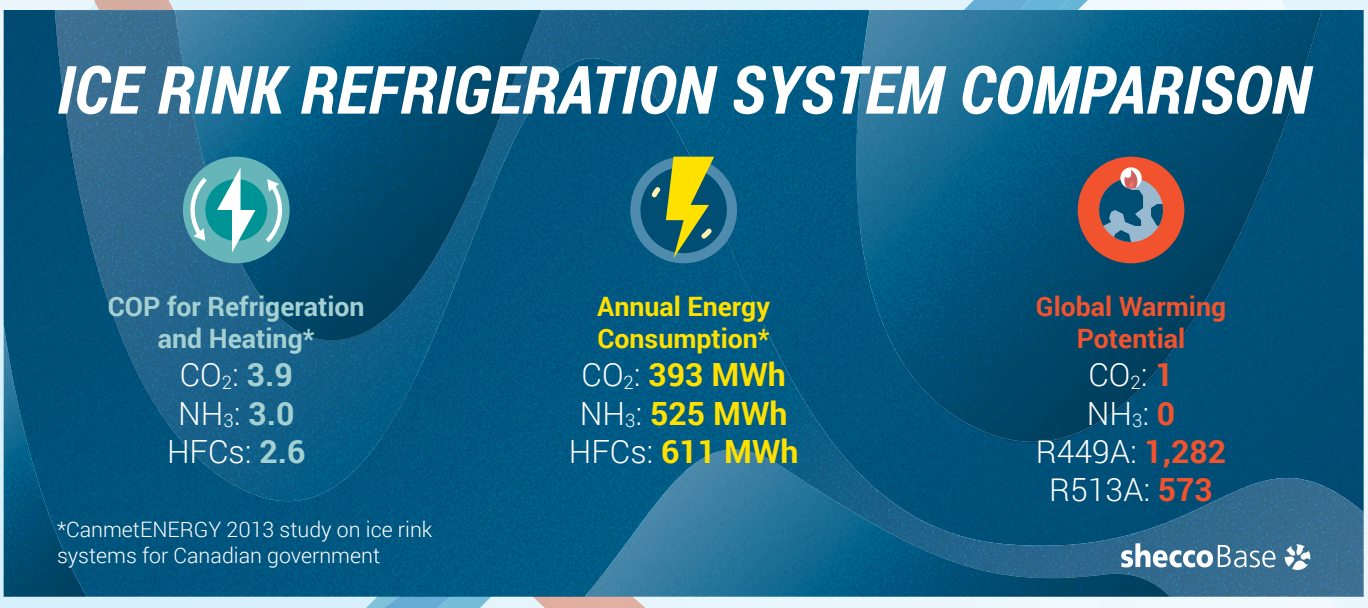
Moreover, HFOs' environmental risks will grow with use, the report said, adding that phasing out HFOs and other measures would reduce those risks.

In July the German Federal Environment Agency (UBA) warned, in an interview with Frankfurt-based newspaper *Frankfurter Rundschau*, that the degradation of R1234yf into TFA could contaminate drinking water. (See https://bit.ly/2EmDApg for article.)

"We are watching with concern the increased use of the refrigerant R1234yf in car air conditioning systems and stationary refrigeration systems," said Maria Krautzberger, UBA's president.

So far the concentrations in some German water supplies are at the 'precautionary level' (3 micrograms per liter of drinking water) recommended by the UBA. Ten micrograms per liter would be considered a "preliminary action value" but the goal is to stay below three.

Reacting to the uncertainty about TFA's ultimate environmental impact, Janos Maté, senior consultant with Greenpeace, said the NGO calls on governments to list HFOs in the Annex of Controlled Substances of the Kigali Amendment in order to track HFO production, consumption and the amount released to the atmosphere, among other steps.



HUSSMANN DEBUTS SELF-CONTAINED PROPANE CASES

OEM's microDS line, coupled with a water loop, can serve a store's complete refrigeration footprint

– By Michael Garry

Schematic of Hussmann self-contained propane cases

Hussmann, a St. Louis, Mo.-based manufacturer of refrigeration equipment for the food retail industry, has unveiled a new complete-store refrigeration system based on self-contained display cases that employ environmentally safe propane (R290).

The new line, called microDS, encompasses low- and medium-temperature merchandisers suitable across a wide range of supercenter, dollar, convenience and drug stores.

In this new offering, Hussmann joins the growing North American market for self-contained hydrocarbon cases and refrigerator/freezers supplied by such OEMs as AHT, True Manufacturing, MTL Cool and QBD Cooling Systems. (See "The Rise of Hydrocarbon Refrigeration in Stores and Homes," Accelerate America," May 2018.)

While many stores are using self-contained cases from these companies as spot merchandisers to complement remote systems, not many are employing them on a full-store basis, which Hussmann is supporting with the microDS line.

The merchandisers in the microDS line include full-sized grocery cases – such as five-door reach-ins and open multidecks up to 12-ft long.

Waste heat from the cases is withdrawn by a closed water loop with water-inlet temperatures up to 115, which is cooled by a roof-mounted dry fluid cooler. Walk-in coolers and freezers utilize propane units that also connect to the water-loop system.

> *"Many realize the long-term benefits of propane as a sustainable solution."*

To complete an entire store, air-cooled, self-contained propane merchandisers are used.

Tim Figge, CEO of Hussmann (a subsidiary of Panasonic), said microDS represents "an excellent option for customers to use natural refrigerants with lower installation costs and increased merchandising visibility."

Hussmann has installed the new propane units in several grocery stores operated by multiple retailers (who could not be named without their permission), said Richard Gilles, senior product leader for Hussmann's Distributed Systems Group, adding, "A lot more are planned for 2019."

So far, the units are being used in mid-sized stores (about 35,000 sq ft), though the system's scalability makes it suitable for larger or smaller stores as well, he said.

The self-contained cases utilize circuits charged with up to 150 g, or just 5.3 oz, of propane -- slightly more than a half-cup. One circuit serves up to three doors of a reach-in lineup and four feet of an open multi-deck configuration, said Gilles.

The small amount of propane used in the microDS full-store system is 90% to 95% less refrigerant than typically required in remote refrigeration systems using HFCs.

Propane also has a negligible GWP (three), compared to that of commonly used HFC refrigerants with GWPs exceeding 1,300. This makes the system virtually "future-proof" – not subject to evolving state and federal environmental regulations, said Gilles.

Moreover, the easy-to-install self-contained cases are pre-charged and hermetically sealed to prevent propane from leaking into the atmosphere, Gilles said.

Preparing for charge increase

The International Electrotechnical Commission (IEC) has approved advancing to a final vote on whether to boost the charge limit on A3 (flammable) refrigerants from 150g to 500g. (See page 26.)

"We support the current charge limit of 150 g, but will of course be prepared to support our customers if the charge increase occurs," Gilles said.

Gilles anticipates growing interest in propane cases in North America among food retailers, who recognize the safety and performance of the units.

He does not see the movement toward sustainable refrigeration deterred by the recent rollback of federal regulations on HFCs. "Retailers don't build for two years; they build for decades," he said. "And many realize the long-term benefits of propane as a sustainable solution."

Moreover, sustainable technology has become "engrained in the culture, especially with young shoppers, who want to shop with companies that are responsible and sustainable," he said.

Installing the propane system and water loop requires only "a garden hose connection and plugging in the cases," he said. "It's as simple as it gets."

The new line is not Hussmann's first self-contained propane offering. In 2013, a new H.E. Butt Grocery store in Austin, Texas, installed 70 of Hussmann's self-contained low- and medium-temperature cases using propane refrigerant and cooled by an HFC glycol-loop system; these cases covered the majority of the store's refrigeration.

Two years, later, another Texas chain, Lowe's Markets, installed Hussmann's self-contained frozen-food cases using propane and an HFC water/glycol loop.

Since then Hussmann has been able to design "more and better features" for propane cases, including "intrinsically safe" components that dispense with the need for propane sensors, said Gilles.

Hussmann, in partnership with Systemes LMP, also markets another natural refrigeration system – transcritical CO_2. The new microDS propane offering gives the company "another arrow in our quiver," allowing its customers a wider selection of systems to fit their particular needs, Gilles said. MG

LOW-CHARGE AMMONIA: PACKAGED OR CENTRAL?

The development of low-charge ammonia in North America is heading in two directions – packaged units and central systems; two case studies from Canada show the differences

– By Devin Yoshimoto and Michael Garry

The benefits of lowering the ammonia charge in industrial refrigeration are clear: improved safety, less stringent government regulations, improved efficiency and faster installation.

However, the road to these benefits has split into two directions: a packaged system, often installed on a rooftop over the refrigerated rooms, sometimes with multiple packages at one site; or a central system with a machine room, similar to traditional setups but altered to enable significant charge reduction. Each has been installed at cold-storage and food-processing plants.

At ATMOsphere America 2018, held in Long Beach, Calif., in June, industry stakeholders had an opportunity to hear about each system type, installed at facilities in Canada. (ATMOsphere America is organized by shecco, publisher of *Accelerate America*.)

Low charge at a high rise

Equipment manufacturer Evapco, Taneytown, Md., is one of the pioneers in North America of packaged low-charge ammonia systems. (See "Research + Sustainability = Low-Charge Ammonia," Accelerate America, December 2015-January 2016.)

One of Evapco's latest projects has been installing four of the company's Evapcold packaged units at a high-rise cold-storage freezer (-10°F) warehouse in Alberta, Canada. The system, providing 266 TR of capacity, is scheduled to be commissioned in February 2019.

High-rise cold-storage facilities are becoming more popular in North America due to their high storage capacities and use of automated storage and retrieval systems (ASRS), said Kurt Liebendorfer, vice president for Evapco, at ATMOsphere America.

"These are the latest technologies coming into the warehouse industry to eliminate the largest cost component, which is labor," said Liebendorfer. "These warehouses are essentially 100% automated for material handling."

The Alberta facility is 110 ft tall and has three air-cooled low-charge ammonia packaged systems installed on the roof, with one additional unit installed above the warehouse's dock/staging area (35°F).

> *"If this were to have been stick-built, it would have easily been 10,000 pounds."*

Kurt Liebendorfer, Evapco

Jeff Buxton, PermaCold Engineering

> *"There's some room for debate, but overall I calculated about 14% savings."*

The system's low charge of ammonia was one of its key selling points, said Liebendorfer. Each of the three units uses 490 lbs of ammonia, for a total of 1,470 lbs. "If this were to have been stick-built, it would have easily been 10,000 pounds, so there is a great reduction in charge for no sacrifice in performance."

Liebendorfer described the penthouse design as a "perfect application for this type of building" because it takes advantage of "eliminating field piping to the top of the roof that would come from a central plant."

This scenario offers energy benefits, he said. "By eliminating those long hundreds of feet of pipe runs, you're eliminating the associated pressure drops and temperature losses. [That] really does improve your system efficiencies."

The rooftop packaged units enable additional energy efficiency through better management of "suction levels."

In a traditional central ammonia plant, with "house" suction temperature levels, "whatever your room temperatures are, they have to regulate down to that nearest suction level," which causes energy losses, he explained.

"With these packaged units, you have a suction level for every room per unit, minimizing your temperature approaches and raising your suction as high as possible, which optimizes your performance."

PermaCold Engineering, Portland, Ore., which served as the main design and installation contractor for this project, used SolidWorks Fluid Flow Analysis Software to avoid short circuiting the air flow and determine optimum air distribution. "The target is to keep up air velocity and cover the freezer," said Jeff Buxton, mechanical engineer for PermaCold.

Buxton also presented a projected annual system operating cost comparison between the Evapcold system and a central system with evaporative cooling; this looked at power for compressors, receivers and condensers, as well as water treatment (none for the air-cooled Evapcold units).

"There's some room for debate, but overall I calculated about 14% savings against a well built, stick-built ammonia refrigeration system" ($161,888 vs. $183,412), he said. Annual energy savings alone for the Evapcold system was close to 100,000 kWh/yr. The installed system cost of the units was not provided.

Liebendorfer acknowledged that the heavy weight of the systems on the roof was a concern, but added that this was balanced by the strength of the high-rise facility's supporting structure.

"These Evapcold units [are] pretty big, weighing around 48,000 lbs," he said. "The ability to support that on a traditional building certainly has to be addressed, but with these high-rise buildings, the rack structure is so robust, it was told to me that our units equate to about 17 pallet positions. [That's] not much given the quantity of pallet positions already in there."

Frick's remote condensing units

In 2017, Frick Industrial Refrigeration, a division of Milwaukee, Wis.-based Johnson Controls, unveiled a novel low-charge centralized system (LCCS) that limits the liquid ammonia to rooftop condensers – "remote distributed condensers" (RDCs) – located close to the cooling loads; they feed a small amount of liquid to a vessel that supplies multiple evaporators in or near the storage space. The system employs an engine room containing only compressors and a control panel.

The RDCs could be adiabatic, plate-and-frame, dry or evaporative. Sensors monitor the RDCs to make sure a sufficient quantity of ammonia is fed to the evaporators. In this scenario, ammonia vapor, not liquid, is distributed throughout the plant.

The ammonia charge in the system ranges from 1.5 to 3 lbs/TR; industrial systems commonly have charge ratios of 20-23 lbs/TR.

The RDCs are what distinguish the Frick system, said Darryl Stauffer, product manager for Frick, at the ATMOsphere America conference.

"In a traditional system, you have liquid vessels throughout," he said. "We've introduced what we call the RDC where you only have vapor being distributed through the plant – not liquid – so that the condensing [fluid] is now [only] being distributed to the point of use." At the same time, the system retains familiar industrial procedures and components.

Frick's low-charge central system was installed this year at a new 178,000-sq-ft Congebec cold-storage facility in Ontario, Canada, which calls for a refrigerating capacity of 430 TR. Congebec, based in Quebec City, Quebec, is one of the largest refrigerated cold-storage providers in Canada, with 13 facilities.

The Congebec system operates with about 1,000 lbs of ammonia, which translates to about 2.3 lbs/TR. With five adiabatic condensers, the system supports two 0°F freezer rooms, two freezer/cooler rooms (0°F or 36°F) and a 39°F dock. Eight rooftop freezer (RTF) penthouse evaporators are used in the freezer and freezer/cooler rooms, and eight ceiling-hung air evaporators are employed in the dock area.

Current regulations in Ontario require 24/7 coverage of ammonia-based refrigeration facilities, but the low amount of ammonia in the Frick system may enable Congebec to avoid that cost, said Jean-Francois Labelle, vice president of engineering for Congebec, who spoke with Stauffer at the conference.

"Due to both the low ammonia charge and the full automation of the system that Frick is providing us, we have the chance to reduce the costs of adding an employee to monitor our facility on the refrigeration site to zero," said Labelle "That's very important for us."

The Frick system also allows Congebec "to very easily adapt and expand our warehouse," said Labelle. "That is, by the way, what we are going to do in the next two years. We are adding 70,000 square feet with an additional unit on the roof, so it is important to us to have that flexibility with the system."

Energy efficiency data on Congebec installation was not available at the conference, but Stauffer said that the system offers the "flexibility and the efficiency of a central system."

Stauffer also provided data on Frick's first installation of the low-charge central system at a food processing plant in Nebraska. In phase one (2016), the system provided 660 TR using 1,268 lbs of ammonia (1.9 lbs/TR). It included plate-and-frame heat exchangers serving ceiling-hung evaporators at the loading dock, holding cooler and process room.

From left: Jean-Francois Labelle, Congebec; Darryl Stauffer, Frick

> *"We've introduced what we call the RDC where you only have vapor being distributed through the plant."*

In 2017 the Nebraska system added 112 TR and 202 lbs of ammonia, as well as two adiabatic condensers. A 40 TR extension was planned for 2018 with one adiabatic condenser added to an existing central ammonia system in a remote location.

This year, Frick planned to install the low-charge central system at a cold-storage facility in Pennsylvania, supplying 250 TR of capacity. Three adiabatic condensers will feed six ceiling-hung evaporators in freezer and cooling rooms. MG

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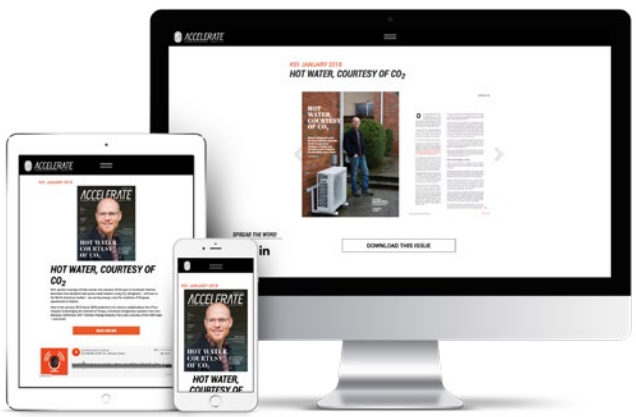

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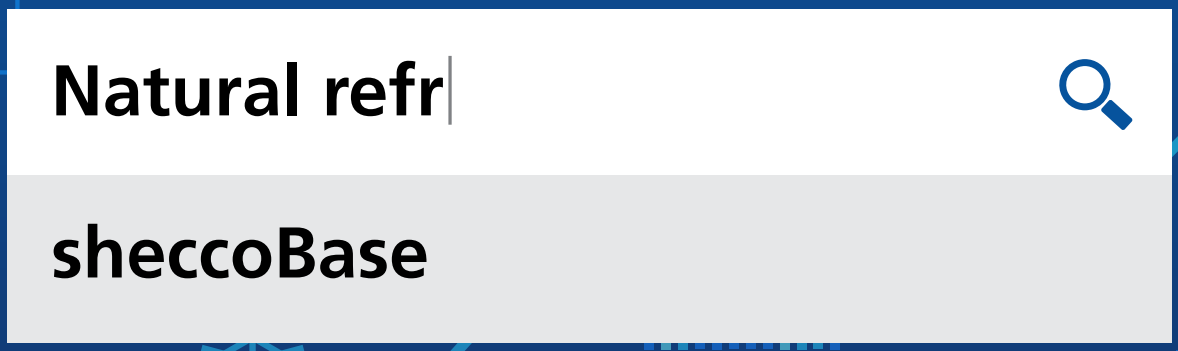

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