

OCTOBER 2016

ACCELERATE

ADVANCING HVAC&R NATIONAL

A M E R I C A

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Adopts HFC
Phase Down

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Refrigerated
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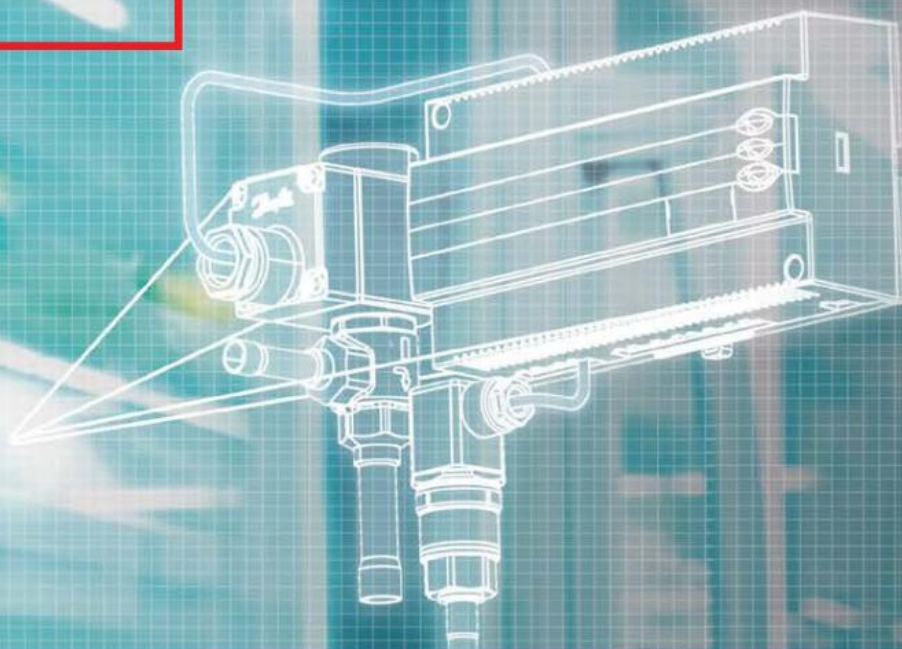
Tristam Coffin
Whole Foods Market

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Editor's note by Michael Garry

PROPANE'S NEW OPPORTUNITY

With each passing year, the regulatory pressures on HFCs grow more intense, creating new opportunities for natural refrigerants. In the U.S., the natural refrigerant that has particularly benefited from new regulations is the hydrocarbon propane (R290).

Propane's excellent heat transfer properties and its very low global warming potential (three) have enabled it to become the go-to refrigerant for self-contained display-case manufacturers in the face of new energy-efficiency requirements from the U.S. Department of Energy (scheduled to take effect next March) and delisting of HFCs by the U.S. Environmental Protection Agency.

Manufacturers like True Manufacturing and AHT Cooling Systems USA have placed hundreds of self-contained propane units in U.S. supermarkets, convenience stores and foodservice outlets. ([See story, page 30.](#)) Some supermarkets like Target are even contemplating self-contained propane cases throughout entire stores, in lieu of traditional centralized rack systems.

Propane may also be coming to the aid of end users of rack systems in supermarkets, which are facing the de-listing next January of HFCs R404A and R507A, new rules from the EPA ([see story, page 48](#)) and a global phase down of HFCs just enacted at the Montreal Protocol meeting in Kigali, Rwanda ([see story, page 10](#)).

U.S. food retailers and industrial end users have been exploring several natural refrigerant options to replace HFC rack systems, including transcritical CO₂ and ammonia/CO₂ cascade systems. Now, for the first time in the U.S., Whole Foods Market is testing a propane/CO₂ cascade system at a store in

Santa Clara, Calif., with a propane charge of about 265 lbs. ([See cover story on page 20.](#)) Even on the cold-storage side, Newark Refrigerated Warehouse has stepped forward with a plan to install a propane/brine system.

These are clearly promising days for propane, but it still has many hurdles to clear before it can realize its potential in commercial and industrial refrigeration. Chief among these is its maximum allowable charge, currently set at 150 g (5.3 oz.), which limits its use to self-contained cases.

However, the EPA is currently evaluating a proposal to raise the charge limit for propane in stand-alone cases to 1 kg, and Whole Foods, which has permission to test market its propane system, is preparing an application, in concert with Carnot Refrigeration, requesting approval to use propane in centralized cascade systems.

The reason for propane's charge limitation is its flammability. With that in mind, Whole Foods has gone to great lengths to ensure that the propane side of its system, confined to the rooftop, is extremely safe. The chain is also conducting extensive tests of the system's efficiency vis-à-vis its other refrigeration systems.

It seems likely that propane will continue its momentum in self-contained applications, but will it catch on in much larger quantities as a centralized rack refrigerant? There is certainly a precedent for safely using hundreds of pounds of propane as a fuel for energy, heating and cooking.

Whole Foods' inaugural propane/CO₂ system could tell the tale.

MG

VOLUME 2, ISSUE #19, OCTOBER 2016

ACCELERATE

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About *Accelerate America*

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

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The organic/natural food retailer, which has installed small-charge propane cases in many stores, is the first in the U.S. to test a centralized propane/CO₂ cascade system.



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Guest column by Ted Gartland



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Natural Refrigerant Systems: 'The Best of the Best'

VOLUME 2 ISSUE # 19

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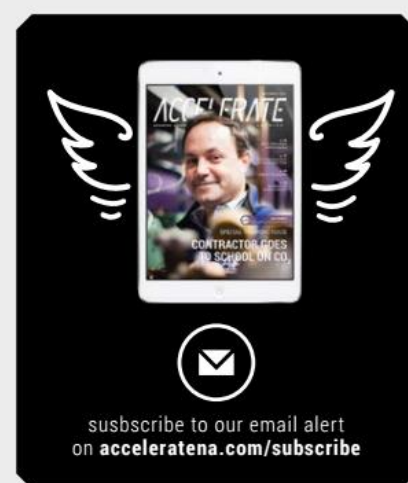
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Accelerate's network of offices stretches from New York and Brussels to Tokyo and Melbourne. Accelerate America is published monthly except for a mid-year and year-end double issue. The views expressed by the contributors are not necessarily those of the Publisher. Every care is taken to ensure the content of the magazine is accurate but we assume no responsibility for any effect from errors or omissions.

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Kysor/Warren's Different Path



- 1** October 3-5, Charlotte, NC
Critical Facilities Summit 2016
<http://www.criticalfacilitiesummit.com/>
 twitter: #CFS16 @CFSummit
- 2** October 4, Online at 2pm EDT
GreenChill Webinar: Using the Internet of Things to Manage Refrigerants
<http://epawebconferencing.acms.com/internetofthings/>
 twitter: @EPAGreenchill
- 3** October 4-7, Las Vegas, NV
RETA Annual Conference
<http://reta.com/>
- 4** October 4-8, Madison, WI
2016 World Dairy Expo
<http://worlddairyexpo.com/>
 twitter: @WDExpo
- 5** October 5-7, Los Angeles, CA
2016 Greenbuild International Conference & Expo
<https://greenbuildexpo.com/>
 twitter: #Greenbuild16 @Greenbuild
- 6** October 8-11, Las Vegas, NV
IBIE 2016
<http://www.ibie2016.com/>
 twitter: #IBIELive #IBIE2016 @BakingExpo
- 7** October 11-12, Washington, DC
Beverage Business Expo
<http://eventegg.com/bb-expo/>
- 8** October 11-12, Long Beach, CA
Cargo Logistics America (CLA) 2016
<http://cargologisticsamerica.com/>
 twitter: #cargo2016 @CargoLogistics
- 9** October 16-19, Phoenix, AZ
2016 SMACNA Annual Convention
<https://www.smacna.org/events-education/events/calendar-of-events/event-details/2016/10/16/default-calendar/2016-smacna-annual-convention>
 twitter: #SMACNA16 @SMACNA
- 10** October 18-21, Atlanta, GA
NACS Show
<http://www.nacsonline.com/NACSShow/Pages/default.aspx>
 twitter: #NACSShow @NACSonline
- 11** October 19-21, San Antonio, TX
CONNECT 2016 - Plumbing-Heating-Cooling Contractors
<http://www.phccweb.org/EducationEvents/content.cfm?ItemNumber=6714>
- 12** October 22-25, Washington, DC
2016 NFRA Convention
<https://nfraconvention.org/>
- 13** October 25-28, Orlando, FL
2016 SQF International Conference
<http://www.sqfi.com/forms/meeting/Microsite/SQFConf-2016>
 twitter: #SQFILearning @SQFI
- 14** October 26-28, Mexico City
The GREEN Exhibition and Congress 2016
<http://thegreenexpo.com.mx/en/>
 twitter: #economicircular #experienciagreen #thegreenexpo2016 @thegreenexpomx



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| <p>1 November 1, Online at 2pm EDT
 GreenChill Webinar: Transcritical CO₂ Operations in Warm Ambient Conditions
 http://epawebconferencing.acms.com/warmtranscriticalco2/</p> | <p>7 November 13-14, Scottsdale, AZ
 AHRI 2016 Annual Meeting
 http://www.ahrinet.org/News-Events/Meetings-and-Events/AHRI-2016-Annual-Meeting.aspx</p> |
| <p>2 November 1-2, Las Vegas, NV
 NFMT Vegas 2016
 http://www.nfmt.com/vegas/</p> | <p>8 November 13-15, New York, NY
 HX: The Hotel Experience
 http://thehotelexperience.com/hx2016/Public/Enter.aspx
 twitter: @HXHotel</p> |
| <p>3 November 2-3, Vancouver, BC
 CIPHEX West 2016
 http://www.ciphexwest.ca/west2016/public/enter.aspx
 twitter: #CIPH @CIPHEXwest</p> | <p>9 November 16, Pasadena, CA
 IHACI's 37th Annual Trade Show
 http://www.ihaci.org/trade-show/</p> |
| <p>4 November 3-4, Orlando, FL
 Central Florida Ammonia Refrigeration Regional Conference
 https://eventgrid.com/Events/20665
 twitter: #NFMTVegas @nfmt_conference</p> | <p>10 November 29-30, Phoenix, AZ
 ICSC RetailGreen Conference & Sustainability Showcase 2016
 http://www.icsc.org/events-and-programs/details/retailgreen-conference-sustainability-showcase/</p> |
| <p>5 November 6-9, Chicago, IL
 PACK EXPO International
 http://www.packexpointernational.com/
 twitter: #PACKEXPO #ProFoodTech @packexposhow</p> | <p>11 November 30- December 2, Toronto, ON
 The Buildings Show
 http://www.thebuildingsshow.com/</p> |
| <p>6 November 9-11, Calgary, Canada
 Buildex Calgary
 http://buildexcalgary.com/
 twitter: @BUILDEXshows</p> | |

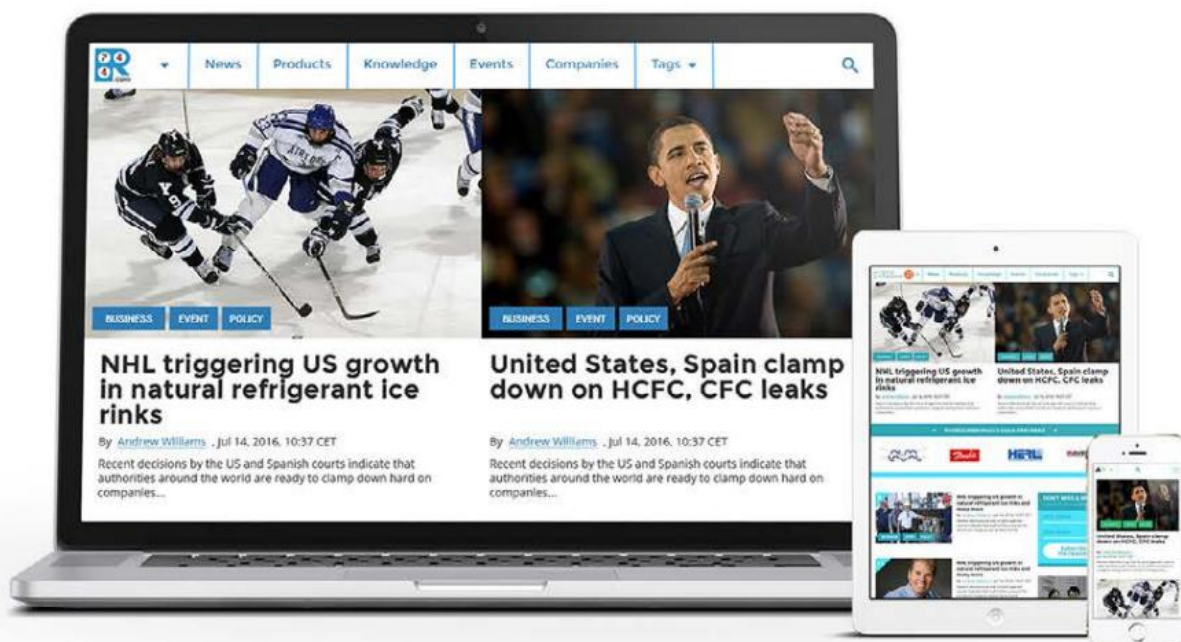


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|---|---|
| <p>1 December 1-2, Portland, OR
JLC Live Northwest 2016
https://nw.jlclive.com/</p> | <p>6 December 6, Online at 2pm Eastern
GreenChill Webinar-Case Study: Piggly Wiggly's Experiences Using a NH₃/CO₂ System
http://epawebconferencing.acms.com/pigglywiggly/</p> |
| <p>2 December 1, Santa Rosa, CA
5th Annual North Coast Wine Industry Expo
http://www.wineindustryexpo.com/
twitter: #WineIndustry #ExpoDeals #WINexpo @WINexpo</p> | <p>7 December 6-7, Indian Wells, CA
The 8th Annual NLS Food Quality Symposium
http://www.nextlevelsummits.com/index.php?page=NLS-Food-Safety-Quality-Summit&SummitID=3</p> |
| <p>3 December 3-6, Colorado Springs, CO
2016 HARDI Annual Conference CIPHEX West 2016
http://hardinet.org/hardi-annual-conference/
twitter: @HARDInews</p> | <p>8 December 13-15, Orlando, FL
Renewable Energy World International 2016
http://www.rewintl.com/index.html</p> |
| <p>4 December 4-6, Washington, DC
IEEE GLOBECOM 2016
http://globecom2016.ieee-globecom.org/
twitter: #IEEEGC16 @IEEEGlobeCom</p> | <p>9 December 19-21, San Antonio, TX
Clean Air Through Energy Efficiency Conference (CATEE), The Buildings Show
http://catee.tamu.edu/home</p> |
| <p>5 December 5-7, San Antonio, TX
10th Global Summit on Food Processing & Technology
http://foodprocessing.global-summit.com/</p> | |

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SHORT TAKES

— By Andrew Williams, Klara Skacanova and Michael Garry

CO₂ PART OF EPA'S DEAL WITH TRADER JOE'S

Trader Joe's, a specialty grocery store chain based in Monrovia, California, will conduct a pilot research project at 15 new stores or major remodels "using low-GWP refrigerants, such as CO₂" as part of a settlement with the U.S. Environmental Protection Agency (EPA) over the retailer's management of refrigerants.

The settlement stems from allegations that Trader Joe's failed to perform leak repairs and keep records for its in-store refrigeration equipment as required under Title VI of the Clean Air Act.

In addition, the deal stipulates that at all new stores and major remodels, Trader Joe's will use "only refrigerant that is non-ozone-depleting and has a low global warming potential (GWP)." The retailer had already begun installing CO₂ transcritical systems in some stores prior to the settlement, according to industry sources.

The chain, which operates about 461 stores in 43 states, will also implement a refrigerant management program and achieve a leak rate at or below 12.1% in 2017-2019. The company also agreed to pay a civil penalty of \$500,000. This is the first EPA settlement with requirements to repair leaks of HFCs. **MG**



LANDMARK HFC PHASE DOWN PASSED BY MONTREAL PROTOCOL

In a long-awaited deal having profound implications for the HVAC&R industry and the global effort to curb greenhouse gas emissions, close to 200 countries on October 15 passed an amendment to the Montreal Protocol that will phase down the production and use of HFCs.

The amendment, adopted by both developed and developing nations meeting in Kigali, Rwanda, could prevent the average global temperature from rising 0.5 °C (0.9 °F) by 2100, helping to keep the overall temperature increase since the dawn of the industrial revolution below 2 °C (3.6 °F).

HFCs, a staple refrigerant in commercial and residential air conditioners and refrigerators, are considered the world's fastest-growing greenhouse gas. Thus President Barack Obama hailed the deal as "an ambitious and far-reaching solution to this looming crisis."

The Kigali amendment – which is legally binding for all 197 Parties to the Montreal Protocol – asks developed countries to take the lead on phasing down HFCs, starting with a 10% reduction in 2019 and culminating in an 85% cut by 2036 (compared to the 2011-2013 baseline).

Developing countries are split into two groups. The first one – which includes China and African nations – will freeze consumption of HFCs by 2024, with their first reduction steps starting in 2029. A second group including India, Iran, Iraq, Pakistan and the Gulf countries will freeze their use of HFCs in 2028 and begin reducing consumption in 2032.

With a clear phase-down schedule now in place, hopes are high that the market will step up to deliver the targets set in the deal for both developed and developing countries.

"Compromises had to be made, but 85% of developing countries have committed to the early schedule starting 2024, which is a very significant achievement," said Clare Perry of the Environmental Investigation Agency.

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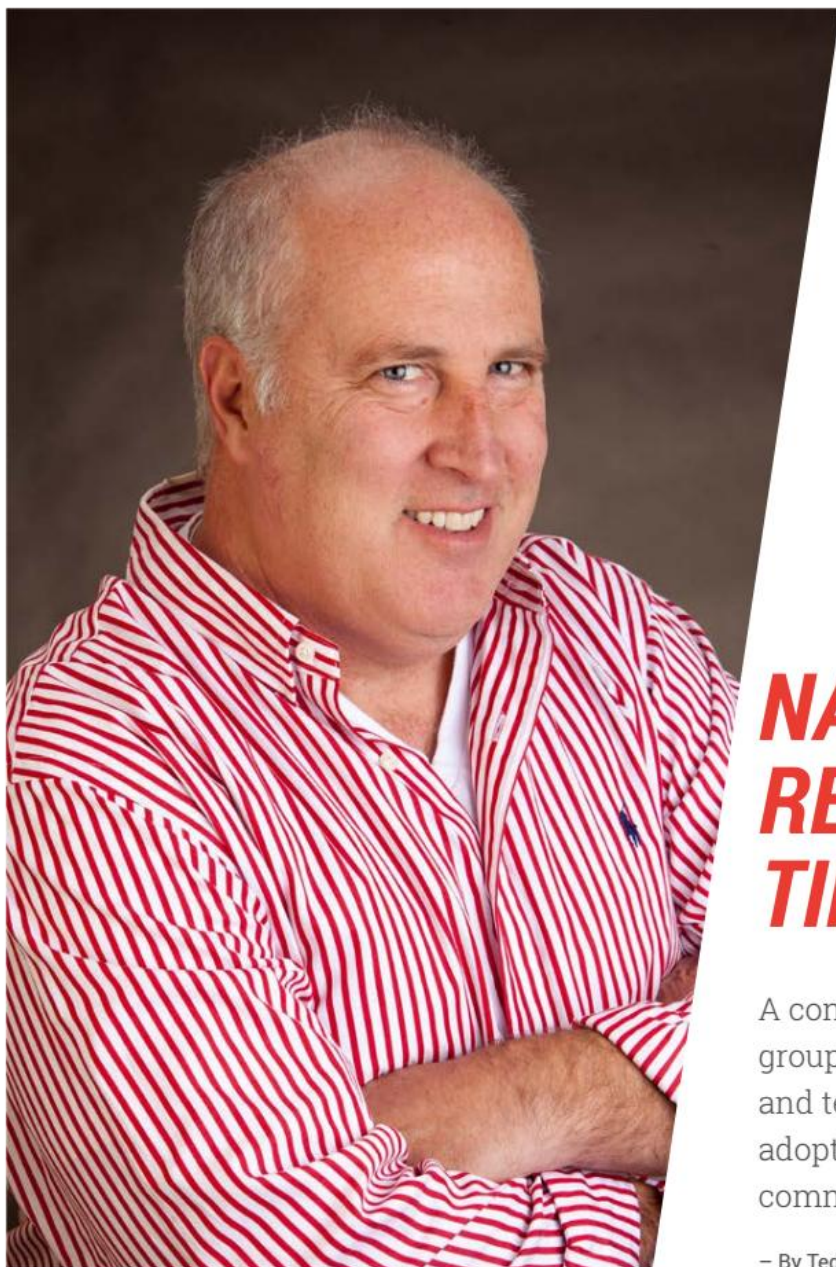
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NATURAL REFRIGERANTS' TIME HAS COME!

A confluence of factors – from grassroots groups and industry interest, to legislative and technological changes – are driving adoption of natural refrigerant systems in commercial and industrial applications

– By Ted Gartland

L started in the HVAC&R business in 1986 right out of college with a small Midwestern refrigerant manufacturer. At that time all they had were CFCs R11, R12, R502 and HCFC R22. There were no 400 series blends or chlorine-free gases. As sales people, all that we knew were the cylinder colors and prices, most of which were less than \$1.25 a pound.

Gas was so inexpensive that techs would blow out clogged drains and fill tires with CFC R12. Cigarette companies would fluff tobacco leaves with millions of pounds of CFC R11 in a liquid bath. Every spring there would be a run on CFC R11 for chillers that required air purges. CFC R12 was a propellant in aerosol cans – literally millions of pounds would be directly released into the atmosphere yearly.

But then the Montreal Protocol addressed the damaging impact of chlorine-based refrigerants on the ozone layer. Times were changing. CFCs were scheduled for a phase down while HCFCs (R22) were given a much longer tail, until 2030. Subsequent changes phased out CFCs by 1996 and moved the date of R22's demise to 2020. That all seemed so far off but is now upon us!

HFC R134a was the first "new" chlorine-free refrigerant out of the gate. It was quickly adopted by the automobile industry and in small refrigeration condensing units. HFC alternatives R507 and R404A became the go-to refrigerants for low-temperature refrigeration in the grocery and cold storage industry.

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→ A SHORT REIGN

So where are we now? HFC refrigerants rule the land. It will be a short reign, though, because the momentum is shifting towards natural refrigerants (CO₂, hydrocarbons and ammonia) that don't harm the ozone layer or contribute to global warming.

For one thing, the forces of change are more organized than they were in the 1990s. Groups like shecco/*Accelerate America*, the North American Sustainable Refrigeration Council (NASRC) and EPA GreenChill are promoting natural refrigerants and moving policy makers to recognize these refrigerants as an alternative to HFCs.

I can't emphasize enough the impact of these grassroots movements. My twitter feed is full of environmentalists describing their concerns and successes. In our industry, any change to naturals is amplified and emphasized.

Replacing HFCs with natural refrigerants helps reduce global warming and climate change. But whether you support action on climate change doesn't really matter. The industry is moving that way. Every day we see new installations of naturals. Top contractors are promoting CO₂ systems to their customers because they want to grow their businesses. The pizza shop next door to my office has a soda machine running on propane!

HFOs, the latest generation of synthetic refrigerants, are also being marketed as low-GWP alternatives to HFCs, but they will likely have an uphill fight against natural refrigerants.

Meanwhile, there is tremendous governmental pressure to make dramatic changes. President Obama's Climate Action Plan calls specifically for the curbing of HFC refrigerant emissions. To that end, the Environmental Protection Agency's SNAP (Significant New Alternatives Policy) program recently completed the process of setting dates for the de-listing of many formerly approved refrigerants, including HFC R-404A/R-507, in supermarket refrigeration systems.

Top contractors are promoting CO₂ systems to their customers because they want to grow their businesses.

The EPA recently updated HCFC refrigerant recordkeeping requirements for Section 608 of the Clean Air Act. Major changes include adding HFCs, lowering the threshold leak rate for repairs from 35% to 20%, and quarterly system inspections. Not having to keep records had been one of the attractions for companies to switch to HFCs in their designs. To be fair, most companies keep records on all refrigerants. But once the new 608 update implemented, there will be additional incentive to go to naturals, for which companies won't carry the burden of recordkeeping.

On a global level, the U.S. was one of 197 countries that just succeeded in adding HFCs to the Montreal Protocol, resulting in a phase down of the use and production of the gas. This will make high-GWP refrigerants more expensive to use.

TECHNOLOGY ADVANCES SUPPORT NATURALS

In addition to these factors, improved designs and advances in manufacturing have made it possible to safely use higher-pressure natural refrigerants like CO₂.

When HFC R410A was introduced to air-conditioning OEMs in the mid-1990s, it provided an efficiency improvement, in part because of its inherently higher pressures. Naturally OEMs would have preferred to stay with the lower pressure options (HFC R407C) but they knew future energy regulations would require major design changes anyway.

The same is true for CO₂ and other natural alternatives. Technology and controls are being utilized to maximize their efficiency, making them as good as or better than HFCs. Truly, their time has come! **TG**

Ted Gartland is the owner of E. Gartland Associates (EGA), a refrigeration and environmental consulting firm focused on food retailers. He is an adviser on the Climate Action Reserve ODS destruction working group, which recently standardized a methodology around carbon offset credits for refrigerant destruction.

A wind of change is coming...



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Johnson
Controls



From left: Mike Ellinger, Whole Foods Market; Tom Land, EPA; and Tristam Coffin, Whole Foods Market

NATURAL REFRIGERANT SYSTEMS: 'THE BEST OF THE BEST'

Among the GreenChill Partnership's certified supermarkets, two ammonia/CO₂ stores stood out from the crowd

— By Michael Garry

Two U.S. supermarkets that use ammonia/CO₂ cascade refrigeration systems — a Whole Foods Market and a Piggly Wiggly — received the GreenChill Award for “Best of the Best” certified stores from the U.S. Environmental Protection Agency’s GreenChill Partnership.

In an early morning ceremony at the Food Marketing Institute’s Energy & Store Development Conference in New Orleans last month, Tom Land, manager of the GreenChill Partnership, presented the award to Keith Milligan, CIO of JTM Corp., for a Piggly Wiggly store in Columbus, Ga; and to Tristam Coffin, director of sustainability and facilities at Whole Foods Market, and Mike Ellinger, global maintenance and refrigeration coordinator at Whole Foods, for the chain’s store in Dublin, Calif.

The “Best of the Best” “goes to the best GreenChill certified store of all stores certified in the past year,” said Land, adding that these stores feature a “notable demonstration of innovative advanced refrigeration technology.”

More than 125 supermarkets were certified silver, gold or platinum by the GreenChill program in its 2015 annual cycle (ending June 30, 2016) for reducing emissions and charge to certain levels or using refrigerants with a global warming potential (GWP) of less than 150 (platinum only). The Whole Foods and Piggly Wiggly stores were platinum-certified. Aldi and Whole Foods have the most platinum-certified stores.

Certified stores maintain their status for one year, and then need to apply to be recertified. The number of recertified stores grew from 40 in January 2014 to 75 in December 2015.

GreenChill is considering offering certification to stores that take an “all-store” distributed approach to refrigeration instead of using a centralized rack or remote system, said Land.

GreenChill is developing in-store promotional material highlighting a store’s certification status, including a decal for cases and a template for store signs, each proclaiming “It’s cool to shop here.”

continued on p.18 →

Nature Outside



Nature Inside



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THE GREENCHILL EFFECT

Since its founding in late 2007, the U.S. Environmental Protection Agency's GreenChill Partnership has helped food retailers significantly reduce their emissions of ozone-depleting and high global-warming potential (GWP) refrigerants.

GreenChill food retail partners, which account for 28% of the stores in the U.S., have an average emissions rate of 14%, compared with a national average of 25%, said Tom Land, manager of the GreenChill Partnership.

Of the 24 GreenChill partners with multiple years of emissions data reported to the program, 15 have reduced their emissions by at least 10%, 10 by at least 20%, six by at least 30%, and two by at least 40%. In 2015, there were 10 retail partners with emissions rates below 10%.

If every supermarket in the U.S. achieved the GreenChill program's average emissions rate (14%), there would be a reduction of 28 million metric tons of CO₂-equivalent greenhouse gases, and 168 ozone depletion potential tons, according to Land, who added that the savings to retailers in annual refrigerant replacement costs would be \$168 million.



From left: Tom Land, EPA; and Keith Milligan, JTM Corp. (Piggly Wiggly)

→ In addition, the program is creating an information sheet for store employees that they can use to explain the GreenChill awards to customers. The decal, template and information sheet will be available to download on <https://www.epa.gov/greenchill>

At the awards ceremony, GreenChill also announced its Distinguished Partner Award, which was given to Minneapolis-based Target as the organization "that has demonstrated extraordinary leadership and initiative in achieving GreenChill's mission in the past year," said Land, who presented the award to Paul Anderson, Target's director of engineering. Target has made a CO₂ hybrid cascade system its prototype in newly opened PFresh stores, and is actively installing self-contained display cases using propane as the refrigerant.

The other GreenChill Awards recognized retailers for superior leak reduction or store certifications. These include:

- Best Emissions Rate: Giant Eagle (retail chain) and Port Townsend Food Co-op (small-independent).
- Most Improved Emissions Rate: Dorothy Lane Market (year-to-year) and Weis Markets (since baseline year).
- Superior Goal Achievement for achieving its annual leak reduction goal: Buehler's Fresh Foods, City Market Onion River Co-op, Dorothy Lane Market, Meijer and Weis Markets.
- Store Certification Excellence (Supermarket) for the retailer that received the most GreenChill store certifications (27) in the past year: Sprouts Farmers Market.
- Store Certification Excellence (Non-Supermarket) for the commercial systems manufacturer with the most systems installed in GreenChill certified stores (95) in the past year: Hillphoenix.
- Store Re-Certification Excellence for each supermarket that has renewed its GreenChill store certification for five consecutive years: Stater Bros. Market (Chino, Grand Terrace, Lake Elsinore and Palm Desert, Calif.) and Weis Markets (Bellefonte, Pa.) **MG**

KYSOR/WARREN

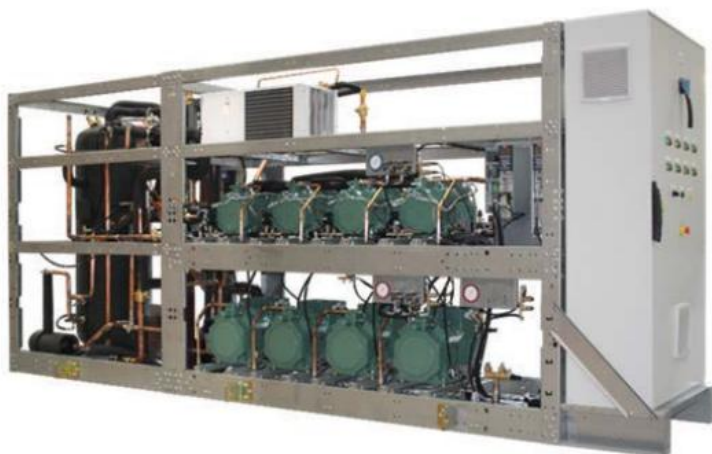
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WHOLE FOODS PUSHES THE PROPANE ENVELOPE

The organic/natural food retailer, which has installed small-charge propane cases in many stores, is the first in the U.S. to test a centralized propane/CO₂ cascade system.

— By Michael Garry



Santa Clara, Calif., location





CO₂ medium-temperature cases



→ **P**ropane, usually thought of as a fuel for everything from barbecues and portable stoves to engines and residential heating, is finding a growing niche as a natural refrigerant (R290) worldwide.

In North America, it has so far been largely limited to self-contained cases, which are able to derive cooling power from the hydrocarbon gas even though its charge is restricted by law to a maximum of 150 g (5.3 oz.) in commercial applications. Manufacturers of self-contained cases for supermarkets and foodservice operations like True Manufacturing, AHT Cooling Systems USA and Novum Refrigeration Technology are seeing growing interest in their wares ([see story, page 30](#), and ["Converting to Propane," *Accelerate America*, June 2016](#)).

Propane's miniscule global warming potential (three), its effectiveness as a working fluid, the improved efficiency of the refrigeration systems in which it operates, its relative affordability, and the safe operation of those systems despite its flammability are attracting more end users every day.

"Propane is a very, very good refrigerant," said Gerard von Dohlen, president, Newark Refrigerated Warehouse, who plans to employ propane in his cold-storage facility ([see story, page 28](#)). "It has a low compression ratio, a high COP, very good heat transfer, and is easy to get oil separation from. It's very user-friendly."

"I've never seen a [natural refrigerant] technology concept generate as much interest as fast as I have with propane systems," said Keilly Witman, owner of KW Refrigerant Management Strategy and former head of the U.S. Environmental Protection Agency's GreenChill Partnership. ([See "Hydrocarbons: The Refrigerant of the Future for Supermarkets?" *Accelerate America*, October 2015.](#))

Efforts are underway to address what is perhaps propane's biggest drawback, its charge limitation. In February, U.K. firm Carter Retail Equipment submitted an application to the EPA to increase the maximum charge of propane in commercial refrigerated stand-alone equipment to 1 kg (35.3 oz.), which would expand propane's potential to economically refrigerate many more cases in a store. The request is still pending. Other industry standards related to charge size (UL 471 and ASHRAE-15) would also need to be updated.

But what if propane could be used in much larger quantities than even 1 kg, like other refrigerants? Could it then serve as a viable primary refrigerant in a centralized supermarket rack system, emulating the performance it shows in stand-alone equipment? Whole Foods Market is about to find out.

Whole Foods, based in Austin, Texas, in August opened a 49,000-square-foot store in Santa Clara, Calif., that is the first in the U.S. to employ a propane/CO₂ cascade refrigeration system. The system, provided by Quebec-based Carnot Refrigeration, contains about 265 lbs. of propane, spread across seven separate chiller units on the roof, including three for low-temperature and four for medium-temperature applications. Whole Foods applied for and received permission from the EPA to test market the system in this store, and is preparing an application, in concert with Carnot, requesting approval to use propane in rack systems generally under the EPA's Significant New Alternatives Program (SNAP) policy.

The propane at the Santa Clara store, which never leaves the roof, is used strictly to condense its refrigeration partner, CO₂ (about 1,700 lbs. in total), which is piped up from a rack directly below, inside the building; the liquid CO₂ is then piped down to DX evaporators in low-temperature cases, and pumped to liquid-



Propane bunker cases



Description of propane/CO₂ system for consumers

overfeed coils in medium-temperature cases. "It's a very clean, sharp design," said Tristram Coffin, director of sustainability and facilities for Whole Foods' Northern California division, which encompasses 44 stores (and one distribution center) out of Whole Foods' more than 400 stores in the U.S., Canada and the U.K.

The system's structure is not unlike some other CO₂ cascade systems Whole Foods is testing except that it uses propane on the "high side" rather than NH₃ or HFCs, and the propane is spread across multiple chilling units.

Apart from being a major purveyor of organic and natural foods, a supporter of developing countries, and a retail-industry leader in sustainability and clean energy initiatives, Whole Foods has carved out a reputation as a pioneer in natural refrigerant applications in the U.S. (See ["Whole Foods' Journey to Natural Refrigerants," Accelerate America, December 2014-January 2015.](#)) Since 2009, the chain has piloted every natural refrigerant system, from transcritical CO₂ and ammonia/CO₂ to propane cases, as well as HFC/CO₂ cascade and secondary units, in an effort to see what works best in various store formats and climates.

And now it's taking its most audacious step yet, testing propane in quantities that have never been seen in U.S. commercial refrigeration. "There is precedent for this type of system in North America and Europe, but this is the first installation of the technology in the U.S.," said Coffin, who has helped lead many of Whole Foods' green initiatives since joining the company in 2008. (In Europe, propane/glycol chillers with 20-30 lbs. of propane as the primary refrigerant, are being used by supermarkets, said Kristian Ellefsen, CEO of Frascold USA.)

Like its other natural refrigerant ventures, the propane/CO₂ cascade project represents another chapter in Whole Foods'

relentless quest for real-world understanding of natural refrigerant technology. "We know there's no silver bullet for natural refrigerant systems," said Coffin. "We need different choices for climate zones and building types so that we can make an educated decision rather than rely on outside lab data that may or may not be applicable to the actual operating environment in our stores. That's my goal for the company and my personal goal."

While new technologies are making transcritical CO₂ systems more efficient in warmer climates, "we're not necessarily 100% there yet," Coffin said. That leaves ammonia – which Whole Foods is testing in an NH₃/CO₂ cascade system at a store in Dublin, Calif. – and hydrocarbons as other natural refrigerant candidates to replace synthetic refrigerants coming under growing regulatory scrutiny. "Ammonia and hydrocarbons are going to play a special role in how we go forward in the introduction of a broader natural environment in the U.S. and worldwide."

But Whole Foods needed an OEM willing to partner with it in the design of the propane cascade system. Of the six manufacturers Whole Foods contacted, only two were willing to move forward with the chain's preferred design, and Carnot was ultimately selected "for their flexibility, unique and innovative design, excitement and dedication," said Coffin. The Carnot propane system, he added, "is pretty much plug-and-play."

Whole Foods regards the Santa Clara outlet as a flagship store featuring the chain's many environmental features – reclaimed building materials, wood from Forest Stewardship Council-certified sources, and LED fixtures throughout the store, among others. The propane system represented an opportunity to "do

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CO₂ rack inside buildingPipes from CO₂ rack carrying CO₂ gas to roof for condensation

Four medium-temperature propane chillers

→ something different and be able to talk about it," said Coffin. To that end, the store features a décor board in its "beer garden" describing the system in a "cool, fun way."

Touting Whole Foods' environmental initiatives, he said, is a way to attract shoppers away from competitive stores "that aren't paying as close attention to their impact on the environment."

SAFETY MEASURES

Though propane is safely used in a host of everyday applications in larger quantities than those allowed for refrigeration, the flammability of the gas remains a concern. Thus Whole Foods has taken special pains to ensure the safety of its cascade system, especially given its relatively large charge.

For example, the chain has set up a "very comprehensive leak detection system" for the seven rooftop propane modules that has several leak sensors on each unit as well as on other "points of possible ignition," including a generator and two HVAC units, explained Coffin.

In addition, Whole Foods has conducted

"dispersion studies" with an independent company to understand the impact of a propane leak. What it found is that, given the miniscule probability of more than one of the seven propane modules leaking at the same time, the probability of the gas combusting is equally remote. "The chance of having a leak that would hit the LEL [lower explosive limit – the least amount of a flammable substance that can ignite in a given space] has too many zeroes," said Coffin. This analysis will be included in Whole Foods' EPA SNAP application.

The propane system and other equipment on the roof have also been designed to shut down in the unlikely event that a propane leak comes within 25% of the LEL, removing any source of ignition. "We are very confident that there would never be any potential for a [flammability incident] because of the R290," he said.

In addition to getting permission from the EPA to test market its propane/CO₂ cascade system, Whole Foods has cleared – and is still clearing – other hurdles. One was having the rooftop propane units vetted by a standards group. Rather than UL, the chain secured approval from the Canadian Standard

Association (CSA), which conducted a field inspection of the equipment.

What may help propane be accepted as a safe refrigerant is that the gas and other hydrocarbons have been routinely used for other applications for many generations. For example, on the roof of the Santa Clara store sits a generator tied to 200 lbs. of propane, and the building has numerous natural gas lines for heating and cooking.

"So it's a matter of helping folks understand that, yes, this is a flammable A3 refrigerant, but we have flammable gases all around the building," said Coffin. "We just have to describe the refrigeration application, how it works and what measures we have implemented to ensure occupants of the building are going to be safe."

To help support the adoption of both A3 and A2L (mildly flammable) refrigerants as HFC replacements, HVAC&R industry groups AHRI and ASHRAE are collaborating with the U.S. Department of Energy (DOE) and the state of California in a \$5.6 million research project looking into the properties and uses of flammable refrigerants; the results will be used to update ANSI/ASHRAE safety standards.



Industry sources initially alleged that A3 refrigerants were being left out of the research, a charge denied by AHRI. California's contribution of \$500,000 to the project put the controversy to rest.

VETTING EFFICIENCY

Along with addressing any concerns about propane's flammability, Whole Foods will be keen on determining the propane/CO₂ system's efficiency vs. other refrigeration options. At the self-contained level, propane has been found to be a more efficient refrigerant than HFC alternatives.

For example, True Manufacturing received the EPA's 2016 Energy Star Emerging Technology Award in the residential/commercial refrigeration category for 42 of its self-contained propane units; to qualify for the award, the 42 models had to be at least 5% more efficient than their HFC predecessors. True cites efficiency gains on average of 25%-30% for its propane units; on its website, True points out that propane's strong heat capacitance (90% greater than R134a's) allows it to absorb more heat faster.

A growing number of supermarkets and foodservice outlets have launched their investigation of propane with energy-efficient self-contained display cases. Whole Foods has as well, mostly with horizontal "bunker" units from AHT ([see story page 30](#)). Starting a few years ago, the retailer now has them installed in about 68 stores, including the new Santa Clara outlet. Self-contained cases are easy to install after a store is opened, or during specific seasons, noted Coffin. Some retailers (notably Target) are planning to

make self-contained propane cases the sole refrigeration platform in test stores.

As part of its analysis of the propane/CO₂ cascade system, Whole Foods will be comparing it to other CO₂ cascade systems it uses that employ an HFC or ammonia on the high side. "Our expectation is that it is going to more efficient than those systems," Coffin said. (Its NH₃/CO₂ system in Dublin, Calif., is "not running as efficiently as we hoped for yet," he said.) He also expects the propane system to be "in line with, if not more efficient than, a transcritical system without any [energy-improving] bells and whistles."

Whole Foods is hoping that the efficiency of the propane cascade system will be similar to that of a standard DX HFC system. "But even if the energy impact is a little more, we'll settle for that because the leak impact is going to be that much less," Coffin said. The chain considers Total Equivalent

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Three low-temperature propane chillers



Whole Foods has taken great care to ensure the safety of the propane system

A FIRST FOR COLD STORAGE: PROPANE REFRIGERATION

Gerard von Dohlen, president of Newark Refrigerated Warehouse, Newark, N.J., plans to install what may be the first cold-storage refrigeration system to employ propane as its primary refrigerant.

Von Dohlen is applying to the U.S. Environmental Protection Agency (EPA) for permission to use propane for refrigeration under the EPA's Significant New Alternatives Policy (SNAP) program.

The system, which he would like to install 12-24 months from now, will serve his two existing buildings and an additional building that will begin construction when the new refrigeration system start operation, he said.

Von Dohlen originally planned to replace the R22 currently used at his facility with low-charge ammonia systems. However, that idea fell through after the state of New Jersey abandoned a plan to relax its stringent requirements for ammonia operations. He then considered using R32 as a primary refrigerant, but decided on propane because of impending regulatory pressures on HFCs.

"EPA made it clear again that it intends to phase out F-gases at least for refrigeration by 2030 at a meeting with the IARW," von Dohlen said.

If approved, the propane system will contain 1,100 pounds of propane, which will be confined to a small one-story engine room attached to one of his two cold-storage buildings. Von Dohlen's original building has 12 freezer rooms and four medium temperature rooms, with a total capacity of 250 TR; his second building has one freezer room with a 300 TR capacity.

To ensure safe operation with a flammable refrigerant, the engine room will be IAR-2 compliant with fully automated controls, and all electrical panels will be located outside the room. "We are eliminating any potential source of ignition," said von Dohlen.

The propane will be used to cool a calcium chloride brine solution, which will serve as a secondary refrigerant; the brine, in turn will be pumped into a Kathabar conditioner where it will cool air from the refrigerated spaces; the cool air will then be blown back into the refrigerated spaces. The brine will also serve as a desiccant and disinfectant for the refrigerated air.

→ Warming Impact (TEWI), which combines direct greenhouse gas emissions from leaks with indirect emissions from electricity usage, "really the most important thing." For all evaluations, he is seeking at least one year of data to account for ambient temperature swings before coming to any conclusions.

Another energy-saving factor is the heat reclaim achieved with the propane system; waste heat captured by glycol is used to pre-heat domestic water and to supplement space heating, per Title 24 of the California Code of Regulations.

The first cost of the propane/CO₂ (as well as Whole Food's NH₃/CO₂ system) is about 50% more than that of a conventional HFC DX system, and 20% more than the cost of some of the chain's early transcritical systems, Coffin said. The marked uptick in adoption of transcritical technology, along with the greater number of suppliers, has driven down the cost of those systems significantly, but the relative newness of propane and ammonia cascade systems means their costs are still high.

"We went into this knowing that we would pay a premium for a propane system, but also knowing that if the system works – and, of course, we get SNAP approval – this could be a viable option



PROGRESS WITH TRANSCRITICAL

Whole Foods Market is moving forward with installations of transcritical CO₂ systems as it continues to collect information on their operation.

As of next month, the chain will operate transcritical systems in 10 stores, the most of any food retailer in the U.S. (Roundy's, Milwaukee, Wis., currently has seven, but plans to open five more in 2017.)

In terms of energy efficiency, the transcritical systems are "doing really well," said Tristram Coffin, director of sustainability and facilities for Whole Foods' Northern California division. "But we're still running numbers on whether this is the right solution." Next month in Walnut Creek, California, the chain will open its first store with a transcritical system that has parallel compression to improve energy in higher ambient temperatures.

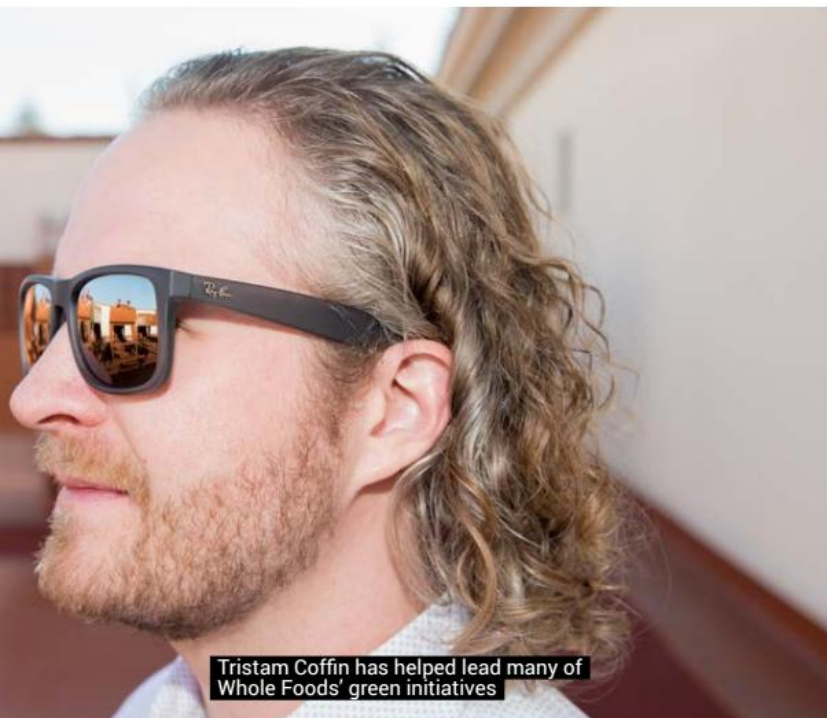
Coffin is also looking for a better understanding of leak rates, maintenance and total cost of

ownership. "Leak rates continue to be the biggest challenge for CO₂," he said.

First costs for transcritical, he said, are down significantly with the rise in deployments, though there are still opportunities to cut installation costs.

Here is a list of Whole Foods' transcritical stores, date of installation, and the system OEM:

- Victoria, B.C. (November, 2016; Hillphoenix)
- Walnut Creek, Calif. (November 2016; Green & Cool)
- Closter, N.J. (October, 2016; Carnot)
- Burnaby, B.C. (February 2016; Hillphoenix)
- Three 365 by Whole Foods Market stores (2016; Hillphoenix)
- Berkeley, Calif. (November 2014, Hillphoenix)
- San Jose, Calif. (December 2014, Hillphoenix)
- Brooklyn, N.Y. (December, 2013, Hillphoenix)



for the future, and you would expect prices to drop as they have with transcritical," said Coffin.

One of Coffin's earlier concerns about natural refrigerant systems was the cost of installations, which were driven higher by contractors who weren't familiar with the systems and wanted to budget in extra time and resources. More recently, installations costs have begun to fall as contractors have become "more comfortable" with the technology, realizing "it's just another refrigerant and most of the equipment used is almost identical" with traditional models, he said.

Still, the propane system does have certain features that needed to be respected during installation, such as the gas's flammability. "You're not going to be up there with a blow torch and start brazing pipe," he said. The installation also required a lot of on-site controls programming.

Carnot spent time at the store educating service technicians on maintaining the system. Coffin doesn't believe it will require much maintenance because it is "so straightforward." But there will be safety protocols to follow. **OMG**

SYSTEM SPECS

Whole Food Market's propane/CO₂ cascade system in a store in Santa Clara, Calif., has the following characteristics:

Capacity of MT and LT CO₂ equipment and propane cycle:

- MT CO₂ equipment: 592,000 Btuh
- LT CO₂ equipment: 158,300 Btuh
- Propane (4) MT units: 700,717 Btuh Total
- Propane (3) LT units: 230,524 Btuh Total

Temperatures of MT and LT CO₂ equipment:

- MT cases' sat.-suct.-temp. range: 20°F to 32°F, Walk-ins: 20°F
- LT cases' sat.-suct.-temp. range: -18°F to -5°F, Walk-ins: -21°F
- Propane charge in each medium-temperature module: 40-45 lbs.
- Propane charge in each low-temperature module: about 35 lbs.
- CO₂ charge: 1,730 lbs.
- Compressor in each propane module: Bitzer (reciprocating)
- Compressors in CO₂ rack: Bitzer (3 LT reciprocating)
- Sweb heat exchanger in each module
- Guntner condenser fans in each module
- Micro Thermo controls
- Heat reclaim for domestic water and space heating
- Gas defrost for LT
- CO₂ cases: Hussmann (mostly), Hillphoenix
- Engineer of record: DC Engineering
- Installation contractor: Key Mechanical





Howell Feig, AHT Cooling Systems USA

PROPANE CASES TAKE OFF

AHT's self-contained propane cases were installed in more than 600 U.S. stores this year, while Novum is starting to make inroads

— By Michael Garry

“This is what we’re doing and what we think everyone should move to.”

Boosted by the de-listing of HFC refrigerants and stricter federal efficiency standards, propane as a refrigerant for self-contained freezer and chiller cabinets in supermarkets is gaining serious traction in the U.S. market. Two manufacturers with European parents are among the companies engaged in supplying the propane equipment.

Through mid-September, AHT Cooling Systems USA, North Charleston, S.C., had installed its plug-in display cases in more than 600 U.S. stores in 2016 alone, said Howell Feig, AHT's sales director for strategic accounts, at the Food Marketing Institute's Energy & Store Development Conference in New Orleans last month. All told, more than 1,000 U.S. stores have AHT's propane cases — mostly modular islands but also spot merchandisers — usually as a supplement to remotely cooled cases.

For its modular island displays, AHT, whose world headquarters manufacturing hub is in Rottenmann, Austria, is only offering propane models. “This is what we’re doing and what we think everyone should move to,” said Feig. The cases are limited by code to 150 g of propane.

Whole Foods Market has installed AHT's propane cases in about 68 stores across the U.S., and by the end of 2016 may have them in more than 100 stores, said Feig. Wakefern's locally owned



From left: Eoin Lennon and Rick Bolibruch, Novum Refrigeration

ShopRite stores in the Northeast U.S. have them in a “fair number of stores.” Another retail chain he declined to name is using the modular islands in all of its more than 200 stores.

At least a half-dozen food retailers are considering installing self-contained propane units on a whole-store basis – in large stores as well as small – in lieu of a traditional rack system, said Feig. For complete store systems, AHT has designed multi-deck cases with top-mounted heat exchangers that rejects heat outside the store via a water-brine loop.

When AHT began marketing the propane cases in earnest in the U.S. about four years ago, end users were concerned about whether technicians were available to service them. To address that issue, AHT has established a nationwide network of external service providers as well as in-house technicians. Retailers “want to feel comfortable, even though there’s little service needed because these are integrated factory-sealed cases,” said Feig. Originally limited to 220 V, the cases have been offered in 120 V models for the past two years.

Though R290 cases are about 10% more expensive than HFC cases, energy rebates are available to offset the cost premium. In a study of propane cases conducted by Southern California Edison, they were found to offer 20% greater energy savings than R404A cases.

Feig thinks the 150 g charge limit may be raised. At a recent UN meeting, “they talked about how current charge limits are antiquated,” he said. “That should hopefully help move it along.”

HANNAFORD’S EASILY MAINTAINED CASES

Hannaford Supermarket has installed self-contained propane display islands in two stores in upstate New York that allow easy replacement of the air-cooled condensing unit.

Hannaford is using eight to 10 of the low-temperature island cases, from Novum Refrigeration Technology, to replace “worn-out” cases connected to the machine room compressor rack, said Harrison Horning, director of energy and facility services for Hannaford, based in Scarborough, Maine, at the Food Marketing Institute’s Energy & Store Development Conference in New Orleans last month.

Each case’s condensing unit, which uses 85 g of propane, “can be pulled out and replaced in minutes,” said Horning. “We bought an extra cassette [condensing unit] to put in the back room so if one dies, we pop in a new one and send the old one to the factory.”

Hannaford has had the Novum cases in one store for a year – the first U.S. store to use them – and in a second store for about a month. The chain also runs a propane beverage merchandiser from True Manufacturing in one store and in its corporate office.

Novum, a Dublin, Ireland-based manufacturer of supermarket display cases, has also installed its propane “Grand Cayman” island cases at a convenience store that is using them for its “whole freezer section,” said Rick Bolibruch, Novum’s vice president of sales, at the FMI Energy conference. In addition, Novum has installed the propane freezer cases at another grocery chain.

Novum’s primary business is in Europe, where it has produced 20,000 self-contained propane cases this year, said Eoin Lennon, Novum’s research and development manager. “All we do is hydrocarbons now. We’ve seen a huge changeover in the past year, especially in Europe, and we’re seeing the change [in the U.S.] as well.”

According to Lennon, the propane cases are 30%-40% more efficient than comparable HFC cases. The cases each consume 5.5 kWh/24 hours and have a maximum capacity of 2,915 Btuh.

MG

CO₂ PROGRESS REPORT

Hannaford plans a transcritical retrofit; Food Lion is still evaluating its transcritical system's energy usage

— By Michael Garry

Two of the food retailers that pioneered the use of CO₂ refrigeration in the U.S. are both divisions of the recently formed Ahold Delhaize, Hannaford Supermarkets and Food Lion.

Food Lion installed one of the first low-temperature CO₂ secondary loop systems in 2006 and one of the early CO₂ cascade systems in 2009. Hannaford deployed the first transcritical CO₂ systems in 2013.

At the the Food Marketing Institute's Energy & Store Development Conference in New Orleans last month, each company gave a status report on its transcritical programs.

HANNAFORD'S RETROFIT PROJECT

This December, Hannaford will begin installing a transcritical CO₂ refrigeration system in an existing store in Raymond, N.H., its first such retrofit project and one of only a few in the U.S.

"We will begin construction in November, and install the system in December and January," said Harrison Horning, director of energy and facility services for Hannaford, based in Scarborough, Maine.

Hussmann and Systemes LMP are providing the system for the Raymond, N.H., store, which will remain open throughout the installation. The existing display cases and central refrigeration system are at the end of their useful life, said Horning. "There is adequate space to install a new system while the existing system continues to run."

The biggest challenge in deploying the transcritical system in the existing store, said Horning, was planning for how the initial load would be placed on the system. "It won't be stable unless it has enough low-temperature and medium-temperature loads." He suggested that the easiest way to do this could be to start with walk-in freezer and cooler loads.



Wayne Rosa, Food Lion



Harrison Horning,
Hannaford Supermarkets

In regard to its existing transcritical systems, installed in new stores in Turner, Maine (2013) and North Berwick, Maine (2015), Horning said the Turner store's transcritical system is "running like a charm"; the North Berwick store's transcritical system is running satisfactorily following some initial equipment issues that were resolved. For both stores, "we're still in the learning mode."

MEETING FOOD LION'S NEEDS

Food Lion, Salisbury, N.C., has found its first transcritical CO₂ installation to be "very successful from a refrigeration standpoint," said Wayne Rosa, energy & maintenance manager, Food Lion.

The system, running in a store in Southport, N.C., that opened last fall, "has met our needs," said Rosa. "We've had no issue associated with the CO₂ in any shape or form. It's kept food integrity where we need it."

Rosa described the transcritical system as being "very close to a traditional refrigeration system." A lack of understanding of CO₂ can cause technicians to be "gun shy" about the technology, but upon learning about "two or three items to stay away from," they see it's the "same system" they've been accustomed to.

However, Rosa acknowledged that Food Lion is "still investigating" the energy performance of the system, especially given its location in a southern U.S. climate, where it's more exposed to warmer temperatures that reduce its efficiency. "We're trying to get more data — we want to run it a little more than a year," he said. "Our hope is energy parity [with an HFC system] at worst, and energy savings to help fund the technology."

Food Lion did not opt to install technology, such as an adiabatic gas cooler, that would help the transcritical system operate more efficiently in warmer ambient temperatures. **MG**



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NATREFS HIT THE ROAD

Several European retailers are testing CO₂ and nitrogen in trucking refrigeration, as Europe once again leads North America in a natural refrigerant application

— By Mark Hamstra



U.K. retailer Sainsbury's is testing a closed-loop CO₂ transcritical refrigerated trailer

The use of natural refrigerant technologies in the transport industry is gaining some traction in Europe, but such systems appear to have a long road to travel before they earn a significant place on the highways of the U.S.

As is the case with other applications of natural refrigerants, European F-gas regulations are steering companies away from HFCs in the transportation industry, particularly trucking, and leading many toward natural refrigerants such as CO₂ and liquid nitrogen.

U.S. companies, however, have not been as quick to adopt or even test natural refrigerants in their trucks, despite encouraging results overseas, continuing to largely employ R134a. But system manufacturers see potential for the U.S. market ([see story, page 38](#)).

Among the larger European implementations of natural refrigerants in trucks was the 2013 launch by Delhaize Group — now part of Ahold Delhaize — of the CryoTech liquid CO₂ system from Thermo King in 25 trailers in Belgium, where Delhaize is based. Delhaize has long been among the more progressive retailers in the U.S. when it comes to energy efficiency and

natural refrigerant technologies at its Hannaford Bros. and Food Lion stores.

Although Delhaize has cited multiple benefits from the CryoTech system, the small number of other end users in the Belgian market has left the company hesitant about expanding its use beyond the 25 trailers it already has in its 700-trailer fleet.

"Further fleet expansion with CryoTech trailers depends largely on the availability of filling stations and a more general usage of this technology in the market," said Jan Pijls, director of external logistics and transport at Ahold Delhaize, which operates the only filling station in Belgium.

Pijls said expansion of the technology in the market could help reduce the investment cost of the CO₂ trailers, which are about 20% to 30% higher than traditional trailers.

The lack of CO₂-refill infrastructure in Belgium is "the weak link in the system" agreed David Schalenbourg, director, technical department, Ahold Delhaize's Belgium division, who noted that



David Schalenbourg, Ahold Delhaize's Belgium division

the company's CO₂ trucks once had to be taken off the road temporarily after a truck pulled out with the CO₂ filling apparatus still attached, taking down the equipment. There was no back-up alternative station where the trucks could be refueled.

By contrast, multiple CO₂ filling stations have opened across the Netherlands and in other European countries. In the Netherlands, retailer Spar has replaced its fleet with trucks using CryoTech CO₂ refrigeration technology, and in Norway, retailer/wholesaler ASKO has done the same.

In the CryoTech system, a microprocessor controller regulates the temperature, opening valves that allow the liquid CO₂ to flow from the tank to the evaporator coils inside the cargo space. Electric fans circulate the air through the coils. As the liquid CO₂ evaporates, it cools air passing over the coils, which is circulated through the cargo.

Unlike other cryogenic systems that inject refrigerant gas into the cargo hold, which can be a safety concern for operators, the CryoTech system only circulates air into the hold.

Instead of using a diesel engine to power the refrigeration equipment like conventional refrigerated trailers, the CryoTech system is powered by the high pressure of the CO₂ charge, eliminating diesel emissions. The reservoir on the trailers holds 116 gallons of CO₂, and the tank at the company's warehouses in Zellik, near Brussels, contains 8,454 gallons of CO₂.

The truck reservoir needs to be refilled after the truck travels about 249 miles (the actual distance can vary based on ambient temperature, number of stops and other factors, according to Pijls), as CO₂ gas is discharged into the atmosphere. "The whole system creates a natural flow from high to low pressure before being vented outside," said Pijls.

The system uses reclaimed CO₂ that has been created by other industrial processes, so it is not adding to net emissions.

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David Schalenbourg, Ahold Delhaize, presenting at the ATMOsphere America Conference in June

→ PRESERVING PRODUCT QUALITY

Among the advantages of the CryoTech system, Schalenbourg explained, is that it cools the trailers quickly to optimum temperatures, so that product integrity is preserved despite the trailer doors opening and closing multiple times on a trip.

"With this technology, we can deliver product with the same quality as when we load it on the trucks, and that is very important," he said.

In addition, the CryoTech system also requires less maintenance than a traditional closed-loop as there are no moving parts, Pijls explained.

A side benefit of the CO₂ system is that it operates almost silently — at approximately 58 decibels, or quieter than a typical conversation — so that deliveries can be made at night with less disruption to surrounding residential areas.

"It's a huge advantage when you want to deliver at off-peak hours," said Schalenbourg.

The use of CO₂ trailers also helps Delhaize communicate — literally — its sustainability message to consumers. Its CO₂-cooled trailers are painted with the message (translated from the French), "This giant fridge [contributes less emissions] than yours."

"I think it speaks to people, when we have this huge trailer driving down the street with this message," said Schalenbourg.

Meanwhile Schalenbourg said he plans to meet with representatives from London-based Dearman, which has

developed a refrigeration system that uses liquid nitrogen both as a refrigerant and a power source.

"I am planning to meet the people from Dearman to see how it is going, because it looks quite interesting," said Schalenbourg. "But for the moment, I don't see us starting right away with other types of filling stations."

Delhaize remains focused on CO₂ refrigeration technologies in multiple applications, he said.

"We are quite CO₂ minded," Schalenbourg said. "You see it with our stores, with our logistics, and our warehouses. We really like the CO₂ technology. Certainly we are looking at other technologies, but I think you will meet the same limitations, and the same development issues with other technologies."

SAINSBURY'S VARIED APPROACH

U.K.-based grocer Sainsbury's is taking a different approach to CO₂ in transport refrigeration, running a three-trailer test of a closed-loop prototype transcritical CO₂ refrigeration system from Carrier Transicold that was adapted from Carrier's NaturaLINE CO₂ system for maritime shipping containers. (See "[Natural Refrigeration Sets Sail](#)," *Accelerate America*, May 2016.) Carrier's trailer system is powered by a diesel engine.

German retailer Netto Marken-Discount is also testing Carrier's prototype closed-loop CO₂ system for store deliveries in a three-year field trial.

continued on p.38 →



THE UNDISPUTED LEADER IN NATURAL REFRIGERATION SYSTEMS



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→ Meanwhile Sainsbury's is also evaluating another natural refrigerant, becoming in June the first company in the world to test Dearman liquid nitrogen refrigeration system in real-world practice, in a single refrigerated truck.

Ben Heatley, a spokesman for Dearman, told *Accelerate America* that Dearman has also been in talks with other companies to test the liquid nitrogen refrigeration system, which emits only harmless nitrogen gas into the atmosphere (which is already 78% nitrogen).

Like the CryoTech system, the Dearman system does not require a diesel engine to run the equipment. Instead, it leverages the expanding nitrogen itself to provide both power and refrigeration. The liquid nitrogen is run through a heat exchanger to cool the air that is circulated in the truck, then the nitrogen, still cold, is injected into the Dearman engine, where it is mixed with warm water so that it expands steadily and drives pistons, much like a high-pressure steam engine. The nitrogen gas is then released into the atmosphere.

"Because we are using the Dearman engine to take that second element of work out of the liquid nitrogen as it expands, we are significantly more efficient, because we are getting twice the cooling power, essentially, from each unit of liquid nitrogen, than an evaporative cooling system," said Heatley.

The Dearman system, he said, is expected to be competitive on price with diesel systems that have similar cooling power. In addition, the system costs less to operate, due to the lower costs of liquid nitrogen relative to diesel, he said. Liquid nitrogen is produced as a byproduct of other industrial processes and is in abundant supply.

"Our analysis so far has focused on European markets, but here we expect to deliver a meaningful cost saving from day one," Heatley said. **◉ MH**



German retailer Netto Marken-Discount's prototype closed-loop CO₂ refrigerated trailer

OUTLOOK FOR THE U.S.

While Europe has become the testing ground for trucking applications of natural refrigerants, makers of these systems also have their eyes on the U.S., where the Environmental Protection Agency (EPA) has listed CO₂ and cryogenic refrigeration as acceptable for transport refrigeration.

David Kiefer, director of sales, marketing and product management for the North America Truck/Trailer/Rail division of Carrier Transicold, Athens, Ga., said the company's NaturaLINE container refrigeration system, which it adapted for the Sainsbury's and Netto trailer tests, is proving that CO₂ can be used in an energy-efficient transport refrigeration application.

"While the trailer technology is still in early stages of development, with testing currently being conducted by Carrier Transicold in Europe, it is possible that customer demand in North America would potentially be driven by regulations, incentives or performance," Kiefer said.

CO₂'s global warming potential of one "serves as the benchmark for environmental sustainability, which is what Carrier Transicold continues to relentlessly pursue," he said.

Thermo King's CryoTech CO₂ system was deployed in the U.S. a few years ago with one customer, the company said. "However, it wasn't cost efficient for them to continue with the product," a Thermo King spokeswoman told *Accelerate America*. "There's nothing here in the U.S. currently, but there's nothing technologically that would prevent us from bringing it here again. However, it would have to be upon a customer's request."

London-based Dearman is also looking at the U.S. market for the potential introduction of its liquid nitrogen technology for transport refrigeration.

"We have been looking at the U.S. very closely," said Ben Heatley, a spokesman for Dearman. He cited California in particular as an attractive market because of regulations and incentives focused on reducing emissions, and also because it is a major food-producing state with high demand for refrigerated transport and storage.

"Also, the warm climate in the southern United States and in California plays well to our system," Heatley explained. "While other systems struggle as the ambient temperature goes up, Dearman is actually able to cope very effectively in that circumstance. The ambient warmth of the local area helps liquid nitrogen expand more rapidly, so it works well."

Heatley said he sees California as a starting point to launch in the U.S., "but in the long run we see America as a crucially important market for us overall," he said. "We have spoken to a number of operators in the U.S., and we don't think there are any significant obstacles in the United States."



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A BETTER MOUSETRAP

Transcritical CO₂ equipment manufacturers demonstrated at the FMI Energy Conference the strides they are making with efficiency in warm climates and installation

— By Michael Garry

The development of transcritical CO₂ technology in the North American market continued apace at the Food Marketing Institute's Energy & Store Development Conference, held in New Orleans, September 11-14.

At the conference's Manufacturer/Retailer Exchange, a number of equipment suppliers held forth on the improvements that are enabling transcritical systems to overcome their efficiency limitations in warm climates, as well as other tweaks that are making transcritical systems more efficient in general and easier to install.

PROVING METTLE IN CALIFORNIA DESERT

Hillphoenix, the Conyers, Ga.-based OEM that has installed transcritical CO₂ booster systems in about 150 food stores in North America, is making the argument that this refrigeration technology is a viable solution "across the [U.S.]," including "very warm climates," said Dustan Atkinson, Hillphoenix's manager of product strategy.



Dustan Atkinson, Hillphoenix

"We even have them in the California desert, where we've seen 120°F on the roof," Atkinson said. One of those desert locations is Palm Springs, Calif., though he declined to name the retailer operating there.

Transcritical systems typically operate less efficiently when ambient temperatures exceed the critical point of CO₂, about 88°F. So to work efficiently, the transcritical units in the desert employ a Trillium adiabatic cooler from Baltimore Aircoil Company, which applies water-assisted cooling, said Atkinson. Hillphoenix is also developing transcritical systems with other efficiency-improving technologies like parallel compression and ejectors; it has one parallel compression system in the field.

Overall, Hillphoenix is seeing "rapid growth" in transcritical adoption in North America, said Atkinson. "A lot of retailers are moving from trials to standardization."

EJECTING HIGH-AMBIENT CONCERNS

Following some test installations in Europe, Danfoss introduced an ejector for transcritical CO₂ booster systems to the North American food retail market at the FMI Energy & Store Development Conference.



Hans Matthiesen, Danfoss



Danfoss ejector, new to the North American market

"A lot of U.S. retailers say that transcritical systems are not efficient in the warmer climates in the U.S., but the ejector mitigates that issue," said Hans Matthiesen, global segment director, food retail. "It saves energy and reduces demand charges in a transcritical system on the hottest day of the year."

Over the past 1.5 years, Danfoss's ejector – called the electrically controlled multi-ejector (CTM) – has been installed in transcritical systems on a trial basis in more than 10 stores in Europe and South Africa," said Matthiesen. In the U.S. it is being tested by OEMs. "We are working on getting UL approval."

But the electrically controlled multi-ejector has already made news in the U.S., winning the 2017 AHR Expo Innovation Award in the refrigeration category.

The ejector currently operates as a gas ejector, but Danfoss is developing a liquid ejector capability as well. It works with or without a parallel compressor across a range of cooling capacities.

As a gas ejector (with a parallel compressor), it outperforms a booster system by 18% and an R404A system by 10%, according to Danfoss. In concert with a parallel compressor, and serving as a gas and liquid ejector, the ejector improves the efficiency of a transcritical booster system by 27% "on the hottest day of the year" and "outcompetes HFC systems everywhere in the world," said Matthiesen. "The warmer it gets, the more it saves; the 'CO₂ equator' is gone with this."

The ejector achieves energy savings by using energy recovered from the gas cooler to increase the pressure of gas being compressed by parallel compressors, thus reducing overall compressor load.

In cooler and more temperate climates, the ejector can optimize operational efficiency in a wide range of load conditions. In addition, the ejector also saves energy in a transcritical system that incorporates heat reclaim, Matthiesen said.

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SOURCE'S HANDS-ON TRAINING

Source Refrigeration & HVAC, a major U.S. contractor based in Anaheim, Calif., is in the process of installing a subcritical CO₂ refrigeration system at its headquarters training center to serve as a technician training tool.

"It's a used system from an abandoned store," said Bryan Beitler, vice president and chief engineer for Source. The subcritical unit employs CO₂ in low-temperature DX and pumped medium-temperature applications, in concert with a synthetic high-side refrigerant to condense the CO₂. "It's a good example of what the techs will see in the field," he said.

Source's Anaheim training center takes the form of a 12,000-square-foot grocery store "with all sorts of training opportunities," said Beitler. The contractor, which has 44 branches in the western and southeastern U.S. and employs about 1,200 technicians, will soon have another training center at its Jacksonville, Fla., office, and is building a third at its Houston office.

Source holds training classes in Anaheim for upper-level technicians. "We try to have some sort of training event for the techs at least every year," he said. "Some of it's done in Anaheim, some locally."

Source, which has been working with and servicing natural refrigerant systems over the past six years, has installed more than 30 CO₂ systems, including cascade and transcritical units, Beitler said. Source also installed and helped design an ammonia/CO₂ cascade system in an Albertsons store in Carpinteria, Calif., in 2012, the first such system in a U.S. supermarket.

But training technicians to handle natural refrigerant technology continues to be a "pain point," especially for Source's far-flung operation, he acknowledged. "We did a transcritical store in Oklahoma, then we did one in Colorado and California, but it's never the same crew. It would be nice to get two in the same county where you could train people."

→ BETTER PIPES AND COMPRESSORS

Contractor Climate Pros, which last month installed a transcritical CO₂ system at a Mariano's supermarket in the Chicago area, is eager to start using copper-iron piping from Mueller Industries for its transcritical installations, said Richard Adkins, vice president of sales for Climate Pros.

Adkins lauded Mueller's Streamline XHP copper-iron piping as a "breakthrough" for transcritical systems because it allows installers to avoid using stainless steel piping for connecting the transcritical rack to the gas cooler.

"With stainless steel, you have to 'TIG weld' it, and you need a certified welder to do that," he said. "With the new copper-iron, the techs who braze copper in DX systems can braze it and it'll hold the pressure. That's a simpler process and it cuts costs and saves labor."

Climate Pros, based in Glendale Heights, Ill., did not use the copper-iron pipes in its current installation, but expects to do so in future jobs, Adkins said.

John Hughes, product manager for Mueller subsidiary Mueller Refrigeration, Hartsville, Tenn., said the XHP copper-iron pipes are "fairly new to the U.S.," but has been marketed in Europe as K65 piping. The XHP pipes, available in either 90 Bar (1,300 psi) or 130 Bar (1,885 psi), are "designed for transcritical pressures," he said. "There's a lot of interest."

Meanwhile Bitzer is working on getting UL approval for a variable frequency drive (VFD) used with CO₂ compressors, said Kurt Bickler, director of OEM and aftermarket sales for Bitzer US. The VFD operates the compressor from 25 Hz to 87 Hz. "As you load shed at night, the compressor slows to 25 Hz to match the load, reducing the starts and stops of the compressor," he said. "It's a huge energy saver. A lot of OEMs are asking us for that every day."

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NATREFS UNDER PURDUE MICROSCOPE

The confluence of three academic conferences at Purdue University included examinations of ammonia and CO₂ refrigeration

— By Andrew Williams



Purdue University, a public research university with a strong engineering program — and the alma mater of moon astronaut Neil Armstrong — was the focal point of an HVAC&R academic discussion last July, with no less than three technical conferences converging on its campus in West Lafayette, Indiana.

This year's conference series included the 23rd International Compressor Engineering Conference, the 16th International Refrigeration and Air Conditioning Conference, and the 4th International High Performance Buildings Conference.

Six hundred participants from over 30 countries presented a record 476 papers this year, demonstrating a plethora of HVAC&R innovations that could soon find commercially viable applications. Among these were a number of natural refrigerant applications.

Conference chair and Purdue Professor of Mechanical Engineering Eckhard Groll said this year's event came "at a time when key international decisions are helping to define the direction of issues related to the environment, climate change, solar and other technologies."

Groll also referred to the rapid expansion in air conditioning and refrigeration usage across the developing world. "This expansion in air conditioning and refrigeration will drive greater needs for energy efficiency and environmental considerations," Groll said. "The question

is, where is all of the energy coming from to operate these additional systems?"

R32 NO SUBSTITUTE FOR AMMONIA

Dr. Andy Pearson, group managing director, U.K.-based Star Refrigeration, presented a comparative analysis of ammonia and gases like R32, a synthetic HFC with a GWP of 650 that some are touting as an alternative to R410A. Pearson, an ASHRAE fellow, concluded that it would not just be improbable for R32 to replace ammonia for industrial applications, but also impractical.

His Purdue paper cited the EU's F-Gas Regulation as a major barrier to swapping ammonia for R32 in industrial refrigeration.

Despite similarities between the two refrigerants, R32 is more expensive than ammonia, according to Pearson — with R32 prices only expected to increase. "In comparison, ammonia for use in industrial refrigeration systems has been very stable for many years," he said.

Ammonia and R32 are toxic and should only be used if safety precautions are respected, Pearson said. The problem with R32, he warned, is that little is known about how to run effective safety checks on it.

Ammonia, by contrast, has been used in industrial refrigeration for so long that "[it] has a good track record of safety, efficiency, ease of maintenance and reliability".

CO₂-WATER COMBINATION

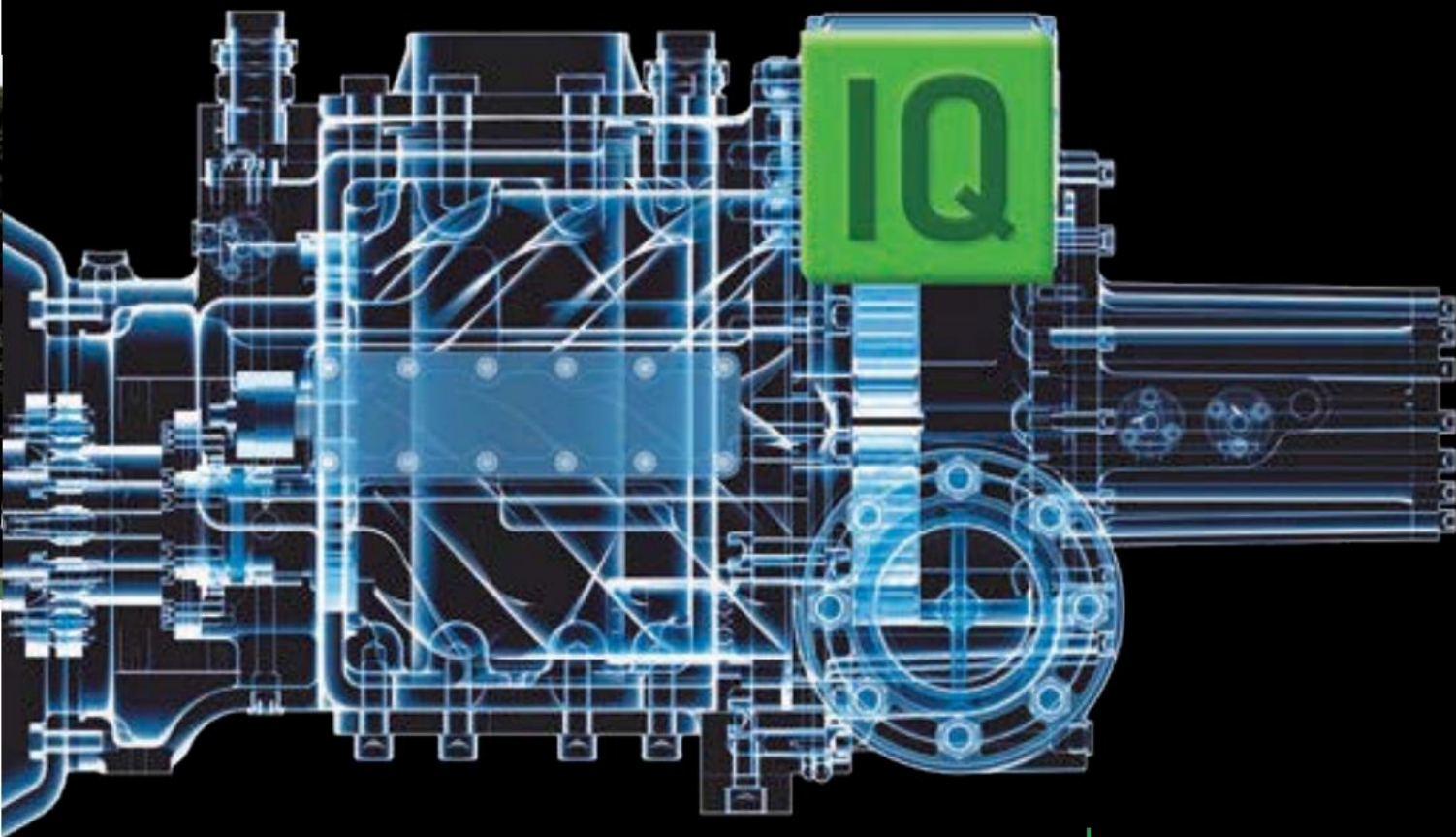
Participants at Purdue also heard how CO₂ has been successfully applied in warm ambient conditions in southern Europe as a means of meeting the demands of the F-Gas Regulation.

CO₂ can also be combined with other natural refrigerants, such as ammonia or water. Steven Lobregeti, Jan Broeze and Carlos Infante Ferreira, working in a joint research project led by three Dutch universities, found that 30% energy savings could be achieved by flash freezing via a water-CO₂ refrigeration system. Test results at a fruit and vegetable processing plant have been promising.

Environmental performance is playing an increasingly important role alongside energy efficiency and safety considerations in heat pump design, noted a Purdue paper from Miquel Pitarch and others from the University of Valencia, Spain.

The Spanish researchers set about designing a propane heat pump based on a water-to-water system to heat or cool as necessary, using the water inlet as a temperature reference point.

By operating in a subcritical cycle for sanitary hot water production and harnessing sub-cooling, their system is 31% more efficient than conventional technology. **AW**



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CONSUMER GOODS FORUM MAKES NEW PLEDGE

Building on a resolution made in 2010, the group asks consumer goods companies to phase out HFCs and expand uptake of natural refrigerants

– By Michael Garry



The Consumer Goods Forum (CGF), a group of leading food retailers and consumer brands, announced a new resolution on refrigeration earlier this month, calling on all consumer goods companies to phase out HFCs and step up adoption of natural refrigerants.

This new commitment is seen as a next step in helping to meet the Paris Climate Accord's goal of keeping the global average temperature rise to below 2°C (3.6°F) from pre-industrial levels. HFCs represent 1.5% of total warming potential today, and are expected to increase to 6%-9% of total greenhouse gases by 2050 unless action is taken.

The resolution builds on CGF's original one from 2010, which aimed to start phasing out HFC refrigerants by 2015. While the first resolution helped to shift the market towards natural refrigerants, the new pledge announced October 6 is considered necessary to help drive further uptake and ensure HFCs are permanently removed from operational systems globally.

CGF consists of CEOs and senior management from 400 retailers, manufacturers and service providers across 70 countries, including U.S. retailers like Kroger and Ahold Delhaize.

The new resolution broadens the scope of the previous pledge by addressing not just point-of-sale systems, but also all commercial and industrial refrigeration equipment.

The first point of the resolution commits CGF members to installing only natural or other "ultra-low GWP" refrigerants in new equipment in markets where this is viable, effective immediately.

The second point outlines a commitment to engage with governments, suppliers and other stakeholders to remove existing barriers in markets where the deployment of natural refrigerants or "ultra-low GWP" refrigerants faces obstacles. These barriers should be eliminated as soon as possible, but no later than 2025.

Finally, the resolution addresses total equivalent warming impact (TEWI), encouraging CGF members to work towards improving energy efficiency and reducing refrigerant leakage. Members would set individual measurable targets to reflect the three commitments and regularly publish their progress in achieving them.

The commitments adopted under the resolution are voluntary (non-legally binding) but will be treated as authoritative by CGF members.

HFO WARNING

Greenpeace hailed the adoption of the resolution as an opportunity to boost uptake of natural refrigerant technologies while warning against adoption of HFOs.

"Although there are multiple cost-effective and technically feasible natural refrigerant solutions in the commercial refrigeration sector, many CGF companies have continued to use HFCs in new equipment," said Paula Tejon Carbajal, global strategist at the environmental NGO. "This resolution is a clear commitment to change that behavior, starting now. But the change must be in favor of natural refrigerants, not a toxic alternative like HFOs. It is not only the climate we need to protect. It is the wider environment too."

The Environmental Investigation Agency (EIA) said implementation of the resolution would lead to a "massive reduction in HFC use in the commercial refrigeration sector," which represents about 25% of global HFC use. "This is a very positive and timely announcement, which should give Montreal Protocol negotiators the confidence that the global business community is behind an ambitious HFC phase-down agreement," said Clare Perry, EIA climate campaign leader. The CGF board has called for the inclusion of HFCs within the Montreal Protocol.

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THE EPA'S LATEST MOVES

The agency makes propane acceptable for new applications, renders a series of HFCs unacceptable for cold storage, and tightens leak-repair requirements – which now apply to HFCs and HFOs – for supermarkets, among other actions

– By Michael Garry

In late September, the U.S. Environmental Protection Agency's SNAP (Significant New Alternatives Policy) program issued Final Rule 21, which stipulates a series of new acceptable refrigerant alternatives to ozone-depleting substances with use conditions, unacceptable alternatives, and a change of listing status for refrigerants in several applications.

It is the latest move by the EPA to both expand and contract the refrigerants available in the U.S. marketplace, following a delisting rule issued in July 2015 that targeted R404A and R507A for removal as of January 1, 2017 in supermarket applications.

In addition, the EPA announced long-awaited changes to Section 608 of the Clean Air Act, which covers refrigerant management practices.

The EPA said the new two rules, announced on September 26, will “reduce the projected growth and emissions” of HFCs. “These two rules demonstrate the United States’ continued leadership in protecting public health and the environment,” said EPA Administrator Gina McCarthy. “We are reducing emissions of HFCs that are harmful to the climate system and showing the world that we can do this responsibly and thoughtfully by working with businesses and environmental groups.”

In developing and finalizing these two rules, EPA met with industry, environmental groups, and other interested stakeholders and considered more than 150 comments on both proposals. Avipsa Mahapatra, climate campaign lead for the Environmental Investigation Agency (EIA), a watchdog group focused on refrigerants, welcomed the EPA’s announcements as a “next step in a series of domestic actions to prepare the U.S. market for,

and build a solid foundation toward, implementing a global phase down of HFCs.”

However, the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) expressed disappointment at the EPA’s decision to decline to extend the proposed effective date of the status change of certain refrigerants used in liquid chillers.

PROPANE ACCEPTABLE FOR ICE MACHINES

Under acceptable alternatives with use conditions in refrigeration applications, the EPA now includes propane (R290) for new self-contained commercial ice machines, new water coolers and new very-low-temperature refrigeration equipment. The charge limit is 150 g, except for new water coolers, for which the limit is 60 g.

Propane has previously been deemed acceptable for other refrigeration applications, such as self-contained cases and beverage coolers, with a charge limit of 150 g. The new changes will take effect 30 days after publication of the final rule.

Under unacceptable alternatives, the EPA included all ASHRAE flammability Class 3 refrigerants for residential and light commercial air conditioning and heat pumps – unitary split AC systems and heat pumps (retrofit), 30 days after publication of final rule.

EPA changed the listing status of a number of refrigerants. Under air conditioning, the EPA deemed the following refrigerants (among others) unacceptable for centrifugal chillers and positive displacement chillers, except as otherwise allowed under a

“We are reducing emissions of HFCs that are harmful to the climate system.”



— Gina McCarthy, EPA administrator

narrowed use limit, as of January 1, 2024: HFC-134a, R-404A, R-407C, R-410A and R507A.

Under refrigeration, the EPA labeled the following refrigerants (among others) unacceptable for new cold storage warehouses and retail food refrigeration (refrigerated food processing and dispensing equipment) as of January 1, 2023 and January 1, 2021, respectively: R-404A, R-407A, R-407B, R-410A, R410B and R507A. For new household refrigerators and freezers, the EPA deemed R134a, R404A, R407C, R407F and R410A and R507A, among others, unacceptable as of January 1, 2021.

“Some of the dates for the delisting will be challenging for the industry,” said Rajan Rajendran, vice president, systems innovation center and sustainability, Emerson Climate Technologies.

For a complete summary of Final Rule 21, see https://www.epa.gov/sites/production/files/2016-09/documents/snap_action_scr_2_factsheet.pdf

SECTION 608 CHANGES

Section 608 of the Clean Air Act prohibits the deliberate release of refrigerant during the maintenance, service, repair, or disposal of air-conditioning and refrigeration equipment; it also requires proper refrigerant management practices by owners and operators of refrigeration and air-conditioning systems, technicians, and others.

In late September, the EPA updated the existing requirements related to ozone-depleting substances (ODS), such as CFCs and

HCFCs, and extended them to substitutes such as HFCs and HFOs. These regulations do not extend to substitutes that have been exempted from the venting prohibition, such as ammonia, CO₂ and propane.

The leak repair regulations under Section 608 apply to industrial process refrigeration (IPR), commercial refrigeration, and comfort cooling appliances containing 50 pounds or more of ODS or substitute refrigerant. The revised requirements will take effect January 1, 2019.

Owners/operators must identify and repair leaks that exceed 30% on an annual basis for IPR (down from 35%), 20% for commercial refrigeration (down from 35%), and 10% for comfort cooling (down from 15%) within 30 days of when the ODS or substitute refrigerant is added. Leaks must be repaired such that the leak rate is brought below the applicable leak rate.

Commercial refrigeration and IPR owners/operators with more than 500 lbs. of refrigerant must conduct leak inspections once every three months for appliances that have exceeded the applicable leak rate.

Owners/operators must submit reports to the EPA if any appliance leaks 125% or more of its full charge in one calendar year. This report must describe efforts to identify leaks and repair the appliance.

For a complete summary of Section 608 changes, see https://www.epa.gov/sites/production/files/2016-09/documents/608_fact_sheet_supermarkets_property_managers_0.pdf MG



EARNING CARBON CREDITS FOR NATREFS

Hannaford is taking advantage of a new program from EOS Climate allowing retailers to earn or buy carbon credits for recycled HFCs – and for investing in natural refrigerant equipment

– By Mark Hamstra

San Francisco-based EOS Climate has expanded its carbon-credits program to allow supermarkets to earn carbon credits by installing newly manufactured, advanced refrigeration systems – such as a natural refrigerant system – either as a complete replacement of HCFC- or HFC-based equipment, or as an installation in a new facility.

The carbon credits (formally known as verified emission reductions or VERs) could be sold in a carbon market to help offset the cost of the new equipment, providing an incentive to install environmentally friendly refrigeration systems, said Jeff Cohen, a co-founder and senior vice president, science and policy, at EOS Climate. Cohen explained the program in a recent webinar hosted by the U.S. Environmental Protection Agency's GreenChill Partnership.

New refrigeration equipment – whether store-wide systems or stand-alone units – earn credits based on the difference in emissions generated by the new system and a baseline system. The calculation incorporates leak rates, charge size, global

warming potential (GWP) of alternative refrigerant, the lifespan of the equipment and other factors.

As a pioneering end user of transcritical CO₂ technology, Hannaford Supermarkets is well positioned to earn credits through the program. “We continue to pilot advanced systems, and if there's a way to get credit for that, we'd like to pursue that,” said Harrison Horning, director of equipment purchasing, maintenance and energy at Ahold Delhaize's Hannaford division, who also participated in the webinar. “There are a number of possibilities down the road.”

As of the Sept. 20 webinar, no food retailers had yet stepped forward to sell credits earned for installing advanced refrigeration systems, Cohen said.

In July 2013, Hannaford Supermarkets gained the distinction of being the first supermarket in the U.S. to install a transcritical CO₂ system, in a supermarket in Turner, Maine. By using only CO₂,

continued on p.52 →



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→ the system reduced Hannaford's direct contribution to global warming several thousand fold compared to the HFC refrigerants that would otherwise have been used. Since then, the chain has installed a transcritical system in a new store in North Berwick, Maine and is planning to put one in an existing store in Raymond, N.H. ([See story, page 32.](#))

However, most of Hannaford's 189 stores in New England and New York State still use HFCs like R407A and R507 with a high GWP. But Scarborough, Maine-based Hannaford has taken advantage of another part of the EOS Climate program that addresses the environmental impact of the HFC emissions in those remaining stores. That is, the chain is purchasing carbon credits from retailers and others that have earned them by recycling HFC refrigerants.

The credits represent carbon reductions from the displacement of virgin HFCs with the recycled HFCs, which can refill existing equipment or be restored to virgin condition to fill new equipment. Manufacturers can also purchase credits to negate the carbon footprint of new HFC-based equipment.

Earlier this year, Hannaford acquired 4,200 carbon credits through the program, which was approved last October by the American Carbon Registry. A carbon credit represents a reduction from "business as usual" of one metric ton of carbon dioxide equivalent. The price of credits on voluntary markets can vary from \$2 or \$3 to \$10 or more per credit.

"Reclaimed HFC VERS are a promising instrument to assist our efforts to mitigate HFC emissions from our refrigeration equipment while phase-down plans are completed," said Horning.

Horning sees the new carbon-credit program as driving the industry forward environmentally. "It is a way to remove emissions from the supply chain," he said. "We can buy the credits from someone else's actions, moving the marketplace in a desired direction."

“Reclaimed HFC VERS are a promising instrument to assist our efforts to mitigate HFC emissions from our refrigeration equipment.”

“We continue to pilot advanced systems, and if there's a way to get credit for that, we'd like to pursue that.”

HELPING MEET SUSTAINABILITY GOALS

Retailers like Hannaford can apply purchased or earned credits toward corporate sustainability goals – offsetting their use of HFCs or other sources of carbon emissions – or to meet government carbon-reduction requirements should they be adopted in a company's state or nationwide. California is an example of a state that has set greenhouse-gas emission-reduction goals and a cap-and-trade system to help companies reach those goals.

Horning noted that even though the chain does not operate in California, Hannaford wants to be prepared in case an emissions-reduction regulation is adopted by states where it does operate, such as Massachusetts, which he said often follows California's lead on regulatory activity.

Horning said the company has not yet determined exactly how it will account for the purchased credits in its own carbon footprint reporting, but he noted that he sees "interesting opportunities" from the new methodology. He declined to reveal the specific price Delhaize paid for the credits.

"We could buy more credits – that depends on how our sustainability team wants to count these in our reporting – or there may be other reasons we want to buy more," said Horning.

Hannaford may also play the other side of the carbon market, earning credits for recycling its own HFC refrigerants. "We have at Hannaford a couple hundred thousand pounds of R507 that sooner or later we are going to have to deal with, and maybe [recycling them] is an opportunity," said Horning.

The generation and sale of carbon credits requires third-party verification, which food retailers can obtain through a handful of companies specializing in this service. "The carbon markets only recognize and monetize emission reductions that are proved by third parties to be real, permanent, additional and enforceable," Cohen explained. **MH**

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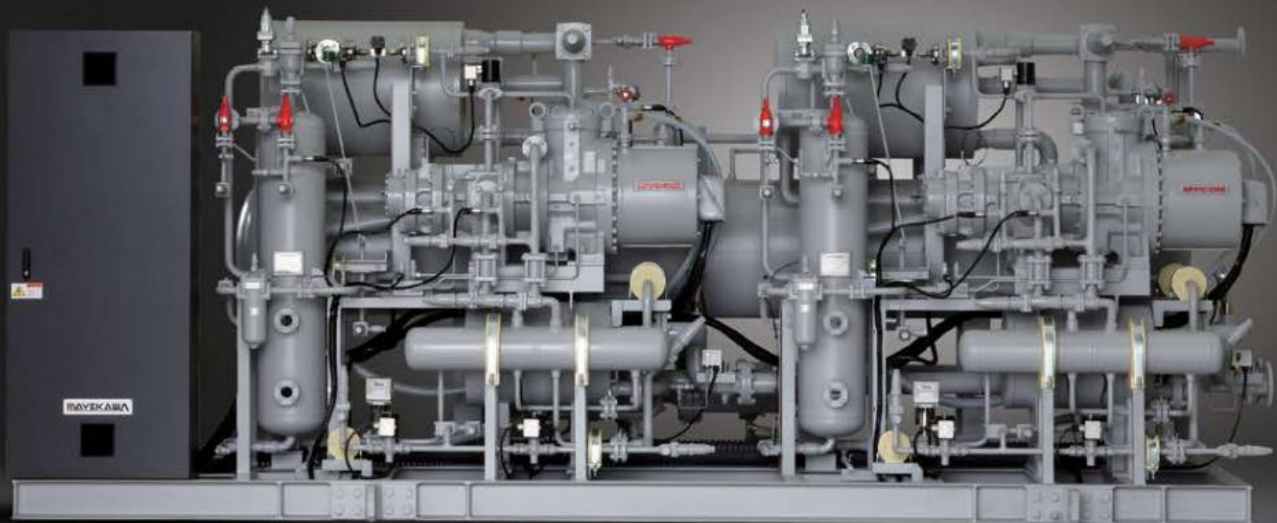
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Michael Lehtinen, Kysor/Warren

KYSOR/WARREN'S DIFFERENT PATH

The Heatcraft brand is featuring ultra-low-charge ammonia/CO₂ cascade technology along with transcritical and other cascade systems to set itself apart in the natural refrigerants market

– By Mark Hamstra and Michael Garry

Kysor/Warren, a division and brand of global refrigeration equipment maker Heatcraft Worldwide Refrigeration, is optimistic that deployment of natural refrigerant technologies will expand in the U.S., but the company admits there are some obstacles to overcome.

Over the past two years, the Columbus, Ga.-based company, which was acquired in 2011 by Stone Mountain, Ga.-based Heatcraft (itself a unit of Lennox International), has been actively promoting a variety of natural refrigerant systems, including transcritical CO₂ and CO₂ cascade systems, notably an ammonia/CO₂ cascade unit.

Kysor/Warren's 2015 placement of an ammonia/carbon dioxide cascade refrigeration system at a newly constructed Piggly Wiggly supermarket near its headquarters in Columbus was only the fourth such system installed and operating in the U.S. ([See "The Pig's NH₃/CO₂ Experiment, Accelerate America, September](#)

2016.) The company promises that another retail ammonia refrigeration installation is forthcoming. In addition, Kysor/Warren designed and manufactured an ammonia/CO₂ system for a Fresh & Easy Neighborhood Market outlet, but that chain declared bankruptcy and closed its stores a few years ago.

Kysor/Warren's CO₂ cascade systems, both the ammonia/CO₂ and HFC/CO₂ units, employ CO₂ in DX evaporators for low-temperature cases and pumped CO₂ liquid overfeed for medium-temperature cases.

The emphasis on ammonia/CO₂ technology is enabling Kysor/Warren to distinguish itself in the increasingly competitive natural refrigerants marketplace.

"There was a reason we have spent the time on ammonia technology here in the U.S., and it was to set us apart and not take a 'me-too' approach," said Michael Lehtinen, director of marketing, Kysor/Warren, in an interview with *Accelerate America*.

Kysor/Warren also wanted to provide supermarket operators with a natural refrigerant alternative that was viable in warmer climates, where CO₂ transcritical booster systems can be less efficient without new add-on technologies.

"There's got to be a better mousetrap for the people in the high ambient [temperature] environments," he said.

Turning to ammonia was an obvious solution, Lehtinen said, citing the technology's proven history as a refrigerant. "The technology used for ammonia cooling has been stable for decades," he said,

and he is confident in the safety measures employed to secure the ammonia, which is restricted to the rooftop. "We believe with the next installation, ammonia's reputation will be established, paving the way to many more opportunities."

In addition, ammonia refrigeration technology has an established base of trained technicians who have been installing and maintaining ammonia systems in industrial cold-storage applications. In fact, Lehtinen pointed out, most supermarket operators likely have a relationship with a wholesaler that already has an ammonia refrigeration system in its warehouse.

CO₂ CHALLENGES

Focusing primarily on the food retail industry, Kysor/Warren operates both independently and in tandem with its sister brands based at Heatcraft headquarters in Stone Mountain, Ga. ([see article, page 58](#)), and other Heatcraft divisions located abroad. Overall, Heatcraft is "very cohesive" on a global basis, said Lehtinen.

Kysor/Warren's CO₂ cascade and transcritical systems were developed and first commercialized by Heatcraft's business in Europe. "Then they were deployed in Australia and then we adopted them in the U.S., modified for this market," he said.

Globally, Heatcraft (including Kysor/Warren), which did \$713.3 million in refrigeration sales in 2015, has installed 249 HFC/CO₂ cascade and secondary systems, and 11 transcritical systems. More of all types are coming, said Lehtinen. Europe has the "lion's share" of installations, followed by the U.S. and Australia.

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Kysor/Warren's rooftop ammonia rack in its NH₃/CO₂ system



Kysor/Warren's CO₂ transcritical rack

→ In the U.S., about 9% of Kysor/Warren's business is in equipment that contains natural refrigerants. (Kysor/Warren has also installed one transcritical rack in Canada.)

What are the prospects for natural refrigerant systems in the U.S.? "We have found that anywhere from one to two new retailers per year dip their toes in the water and try it," said Lehtinen. "But then they want to wait about three years to see how their experience goes. That's why the growth has been slow." But he expects faster growth over the next two to three years "now that trial sites have had time to form a decision about adoption."

The negatively perceived efficiency challenge for transcritical units in warm ambient conditions, along with the lack of trained technicians for CO₂ systems, remain key obstacles that the natural refrigerant market industry has yet to fully overcome, he said.

While its transcritical CO₂ booster system has not yet used technologies designed to make it more efficient in warmer climates, such as adiabatic coolers, parallel compression and ejectors, Kysor/Warren has completed lab validation of these components on a fully functional system, said Lehtinen. In fact, he added, the company recently agreed to install within the next 12 months a system using parallel compression and ejector technology.

"In some of the initial trials, I think end users were expecting to see pretty significant gains in efficiency, and that just didn't materialize, because of the maturity level of the technology," he said. However, the development of ejectors, parallel compression, and other systems have delivered improved results, even in warm environments, over early trials, particularly in Europe. He said he expects interest in transcritical to ramp up in the U.S. in the next year or two as more trials show better results.

"Every year there seems to be more innovation to make it more efficient than — or at least on par with — any HFC systems that you would install," Lehtinen said.

Moreover, the presence of trained CO₂ technicians is growing in parts of the U.S. with more CO₂ installations, such as the Northeast, but they will need to keep up with continuing changes, he added. Kysor/Warren is helping with a new YouTube program that provides training videos, along with tips on its Facebook page.

HIGHER UPFRONT COSTS

The efficiency of natural refrigerant systems vs. that of HFC systems can often be difficult to assess because of the varying locations and conditions of the stores in which they operate. To overcome that issue, Kysor/Warren compared the ammonia rack in the Columbus Piggly Wiggly with an HFC rack housed in the same store; it found that the NH₃ rack delivered a 22% gain in energy savings.

But that still might not be enough to persuade some supermarket operators to try the ammonia/CO₂ system due to its higher upfront costs. According to Lehtinen, the NH₃/CO₂ cascade systems carries a premium of 40% to 70% over a traditional HFC system, while the premium for a transcritical system is about 20% to 40%.

Some of the more progressive retailers have been willing to trial natural refrigerants despite higher upfront payout. But others are unwilling to invest without a maximum three-year payback, despite the potential for long-term energy savings over the lifetime of the equipment, he said.

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MULTIPLE ROLES AT HEATCRAFT

Kysor/Warren, based in Columbus, Ga., functions somewhat differently from other U.S. Heatcraft Refrigeration Products brands, which are based at the Heatcraft U.S. headquarters in Stone Mountain, Ga., 126 miles away.

Kysor/Warren, an OEM, focuses on marketing its refrigeration systems as well as cases directly to supermarket customers. Heatcraft Refrigeration Products goes to market with multiple brands – including Bohn, Larkin, Climate Control and Chandler Refrigeration – largely targeting the distribution channels that serve restaurants and convenience stores, and offering products like condensing units and unit coolers, explained Michael Lehtinen, marketing director, Kysor/Warren. Heatcraft also manufactures condensing units, large unit coolers, chillers and racks for cold storage projects.

In addition, Heatcraft Refrigeration Products supplies refrigeration components such as evaporators and condensers to other supermarket OEMs.

Heatcraft units share expertise within the U.S. and globally. For example, in the U.S., Heatcraft Refrigeration Products is looking at the ultra-low-charge ammonia system Kysor/Warren developed for Piggly Wiggly, as well as supermarket transcritical technology, to see if they can be enlarged and adapted for cold storage applications.

"The stream flows in both directions," Lehtinen said. "We adopted the CO₂ technology from its origination in Europe for the U.S., but we pioneered the ammonia technology in the supermarket segment here in the U.S., and we're now we're looking at how we can deploy that in other business units of Heatcraft throughout the globe. It's fair to expect that our business units in China, Australia and Europe are considering how to deploy technology that we've developed."

“Every year there seems to be more innovation to make [transcritical] more efficient.”

→ “If you are at a supermarket chain and you put a proposal on your CFO’s desk, and say you want to go to alternative refrigerants, and your payback period is 4-1/2 or five years, they will likely say, ‘OK, come back when you get it down under three.’”

An ammonia/CO₂ cascade system is close to meeting that standard, requiring three years or more for a retailer to earn a payback on the premium over the cost of an HFC system, he said. The ROI for a transcritical system is about the same in northern climates, but longer in warmer locations.

In a cost comparison of ammonia/CO₂ with transcritical, the former is usually more efficient while the latter costs less upfront. But the further north of the Mason-Dixon line one goes, the more favorable the the total cost of ownership for transcritical becomes, Lehtinen noted. In both cases, “first costs need to come down” to stimulate adoption.

Lehtinen hopes more retailers employ total cost of ownership as their method of analysis, “but they just haven’t embraced it yet,” he said. Still, he believes there is “room for the industry to mature” around evaluation of total lifecycle costs – especially when an equipment lifecycle of 20 to 25 years is taken into consideration.

Even with increasing regulation of HFC refrigerants, many U.S. retailers have been reluctant to embrace natural alternatives. For one thing, regulations still lack “sharp enough teeth,” said Lehtinen. In addition, as long as viable drop-in artificial refrigerants – such as HFO blends – are available and affordable, retailers will “travel the path of least resistance,” he said.

But Kysor/Warren is playing its part in supporting natural solutions. “I can assure you that when we engage in discussions with retailers about what they are looking for, we make sure we put the [natural refrigerant] options in front of them and work through whatever business cases they could generate to show the opportunity.”

● MG & MH

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VOLUME #2

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- Issue #19 October 2016

Issue #19

October 2016

Publication date: Oct. 11

Focus: Transport refrigeration. Includes coverage of FMI Energy & Store Development Conference.

Ad submission deadline: Sep. 30

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- » Data Centers
- » New Technology
- » Mobile Air Conditioning
- » Buildings (residential)
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- Issue #21 January 2017
- Issue #22 February 2017
- Issue #23 March 2017
- Issue #24 April 2017
- Issue #25 May 2017
- Issue #26 June 2017
- Issue #27 July-Aug. 2017
- Issue #28 September 2017
- Issue #29 October 2017

Issue #20

Nov. - Dec. 2016

Publication date: Nov. 15

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Ad submission deadline: Nov. 4

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January 2017

Publication date: January 9

Focus: Contractors, Designers, Builders.

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Ad submission deadline: Dec. 29

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February 2017

Publication date: February 6

Focus: Foodservice, Industrial Refrigeration (Cold Storage)

Distribution at The NAFEM Show, Feb. 9-11; IIAR Expo, Feb. 26-March 1.

Ad submission deadline: Jan. 30

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March 2017

Publication date: March 7

Focus: Industrial Refrigeration (Food Processing)

Ad submission deadline: Feb. 27

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April 2017

Publication date: April 5

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Ad submission deadline: Mar. 27

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May 2017

Publication date: May 3

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