Pioneering Natural Refrigeration

Whole Foods Market makes R-290 a cornerstone of its refrigeration strategy

PAGE 2

P. 8   More retailers opt for natural refrigerant systems

P. 12  Regulations bringing refrigerant change to commercial HVAC market

P. 18  Keys to servicing CO₂ systems
Diverse Priorities Continue to Influence Refrigeration Landscape

When Emerson started its E360 stewardship platform in 2014, we set out to balance an equation comprised of four primary factors: energy, environment, economics and equipment. At the time, the commercial refrigeration industry was in the early phases of a momentous transition shaped by new regulations, emerging technologies and changing technician demographics. As this ecosystem continues to evolve, it has become more and more apparent that there is tremendous diversity among end user priorities.

There are many factors influencing refrigeration decisions as there are system architectures. From first costs, refrigerant considerations and sustainability goals to environmental regulations, energy-efficiency targets and maintenance requirements, end users have more selection criteria to consider today than ever before. What we’ve found is that each end user values these factors individually depending on their priorities, and the order of importance of these criteria differs widely from one customer to the next.

Take our cover story, for example. With corporate sustainability goals stated publicly and leveraged as a marketing position, Whole Foods is an American food retailer pioneering the use of all-natural refrigeration systems. By using CO₂ and R-290 instead of synthetic hydrofluorocarbon (HFC) refrigerants in their Santa Clara, Calif., location, the grocer is seeking to leave the smallest possible carbon footprint while meeting its energy-efficiency targets. All other criteria are secondary. Be sure to read the full story to learn how they’ve incorporated natural refrigerants into their centralized and stand-alone systems.

But for operators in other parts of the country, where energy costs are lower and environmental mandates are less demanding, a more traditional HFC system with lower first costs and more familiar maintenance protocols may be preferred. The same may be said for those who are intimidated by the increased complexities or relative “unknowns” of new system architectures.

You may have read the recent ruling by the U.S. Court of Appeals for the District of Columbia pertaining to the Environmental Protection Agency’s (EPA) efforts to limit HFCs in commercial refrigeration. The court ruled in favor of an HFC refrigerant manufacturer, stating that the EPA’s 2015 ruling had exceeded the authority of its Clean Air Act — a legislation originally intended to address ozone depletion. And while some may applaud the court’s ruling, others believe the process of phasing down HFCs is already well underway. We’ll have to wait and see what the true implications of this ruling will be.

If there’s anything we can be certain of, it’s that the refrigeration landscape will continue to change. Already in Europe, where F-gas regulations limit the use of high global warming refrigerants, the price of HFCs is on the rise as supplies dwindle. This is also indicative of how regional idiosyncrasies throughout the world also factor into the refrigeration decision, as the potential of carbon taxes, refrigerant price hikes and local climates must also be considered.

To be sure, there currently is no one-size-fits-all approach to commercial refrigeration. Our goal is not to favor one architecture over another, but to help end users balance this difficult equation for themselves — and based on their unique priorities, take the best approach. With our deep portfolio of refrigeration components and technology, we’re uniquely positioned to help you balance that equation.
Pioneering Natural Refrigeration

Whole Foods Market makes R-290 a cornerstone of its refrigeration strategy

By Allen Wicher
Director, Marketing — Foodservice
Emerson
When it comes to the use of natural refrigerants in commercial refrigeration, Whole Foods Market (WFM) is a true pioneer in the U.S. food retail space. Even before the recent wave of regulations prompted retailers to look for more eco-friendly alternatives, WFM was deploying sustainable refrigeration systems with the intent of reducing harmful environmental impacts and improving energy efficiencies. Today, 22 of its 465 stores utilize all-natural refrigerant systems, with most of them moving to the hydrocarbon R-290 (propane) for their self-contained cases.

WFM’s Director of Sustainability & Facilities for its Northern California region, Tristam Coffin, has been dedicated to fulfilling the company’s green refrigeration vision.

“Refrigeration makes up roughly one-third of our total energy consumption, and we’re committed to natural refrigerants,” Coffin said.

WFM sought to open its first “natural store” in Brooklyn, N.Y., with zero synthetic refrigerants on premises, they went on the hunt for a more efficient, self-contained natural refrigerant option.

“We didn’t want to just drop a bunch of inefficient, synthetic refrigerant cases on our sales floors, because they would negatively impact our energy usage and go against our sustainability efforts,” especially in stores where we are utilizing all-natural refrigerants,” explained Coffin.

Although R-290 was becoming the refrigerant of choice for retailers looking for a natural, self-contained case option, at the time there were very few U.S. refrigeration equipment manufacturers that offered R-290 units. But AHT Cooling Systems USA was on this short list. AHT National Sales Manager Howell Feig said that developing R-290 products for the European market enabled AHT to help early adopters in the U.S.

“We had been manufacturing bunker-style cases for our European customers since 2002, and around 2010 some of our environmentally-driven U.S. customers started asking for self-contained, R-290 based equipment,” Feig said.

Since the 2013 Brooklyn installation, Coffin said that R-290 self-contained cases have been deployed across the company’s entire network of stores. He estimated that 50 to 60 stores a year are installing new cases — as replacements to HFC units, in new stores, or in new programs being rolled out by WFM.

“When these units make up less than 10 percent of our overall refrigeration footprint, they have hit a home run for us in that they’re 10 percent more efficient in most instances, and they’re using a natural refrigerant,” Coffin said.

Both Feig and Coffin believe that the U.S. food retail industry is slowly shifting toward R-290 use in self-contained cases. From AHT’s perspective, Feig explained that early adopters like Whole Foods Market have served as a proof of concept for less progressive retailers. As a result, adoption has increased to the point where AHT will transition its entire equipment platform to R-290 by the end of this year.

While many retailers have been at the forefront of this shift, AHT’s perspective, Feig explained that early adopters like Whole Foods Market (WFM) was a more efficient, self-contained natural refrigerant option.

Sustainability commitment drives innovation

Sustainability is a core value that has driven WFM since its inception. As a member of the Department of Energy’s Better Buildings Challenge Alliance, they are participating in a challenge which is focused on reducing their overall energy use intensity (EUI) footprint 20 percent by 2020. This initiative comes on the heels of their previous 2010 goal to reduce energy-use-per-square-foot 25 percent by 2015 — a target Coffin says they nearly hit.

“We’re also a founding partner of GreenChill in support of what we do around refrigerants, seeking to reduce both direct refrigerant emissions and overall GWP using natural alternatives,” added Coffin.

WFM’s mission to provide healthy food with a passion for preserving the planet has led to experimentation with innovative system architectures. Coffin explained that there’s no “one-size-fits-all” solution and every store is evaluated individually based on the facility’s characteristics and climate impacts.

In 2016, this spirit of innovation led to the opening of their facility in Santa Clara, Calif. It features what’s arguably the most environmentally friendly refrigeration system in the U.S. The system is based on an R-290/CO₂ cascade architecture that reduces the environmental impacts of refrigerants to near-zero, while greatly improving energy efficiency.

This unique system uses R-290 to condense CO₂ — the most eco-friendly refrigerant available with a climate impact that is thousands of times smaller than typical HFCs — which is then distributed to connected cases throughout the store. CO₂’s high
heat-carrying properties reduce both the amount of refrigerant needed and the energy required to run the refrigeration system. Simultaneously, a heat reclaim system captures the heat generated by the system, and uses it to preheat the store’s hot water supply and supplement space heating—a strategy that enables the store to greatly reduce the amount of natural gas burned to heat water.

“The system uses the least possible amount of the most climate-friendly refrigerants, while reducing the energy it takes to operate it and re-using the heat it generates,” said Coffin. The Santa Clara store also features 10 of AHT’s self-contained cases for product showcases on the floor.

Safety, serviceability and charge limits

From a safety and servicing perspective, Coffin believes that the novelty of R-290 in the U.S. brings with it a degree of apprehension about its impacts to service technicians and end users. While safety protocols are mandatory with the use of the class A3 (flammable) refrigerant, Coffin feels that the perceived risks are often not proportionate to the actual risks.

“The reality is we use natural gas and propane to heat and cook for residential and commercial purposes all the time in this country. It’s simply a matter of educating end users and technicians about proper safety protocols,” Coffin said. “Plus, self-contained OEMs have done an excellent job of making these systems safe and user-friendly, and training their service technician base,” he added.

Coffin and Feig concur that increasing the charge limit of R-290 systems (currently at 150g) would open new opportunities that aren’t currently possible. Coffin said that an increase to 500g would allow R-290 to be used in open-door cases as well as walk-in coolers and freezers. This prospect could potentially even allow for a full-store solution of self-contained R-290 cases, which would be particularly advantageous in smaller urban locations where space constraints prevent the use of centralized racks.

“Increasing the charge limits would enable significant advances in system design and efficiencies,” said Feig.

Even at the current charge limit, Coffin said that the R-290 cases are a solution they plan on using for many years to come.
By Andre Patenaude
Director, CO₂ Business Development
Emerson

In an era driven by the necessity to deploy more environmentally responsible refrigeration systems, very few refrigerants can achieve regulatory compliance and meet corporate sustainability objectives. On this short list are three natural refrigerant options: carbon dioxide (CO₂ or refrigerant name R-744), the hydrocarbon propane (refrigerant name R-290), and ammonia (NH₃ or refrigerant name R-717).

With all the debate about which synthetic refrigerant blends will replace common hydrofluorocarbons (HFCs) targeted for phase-down by the Environmental Protection Agency (EPA), some consider these natural refrigerant alternatives to be not only the best current options, but also “future-proof” in their ability to support the next generation of system architectures. Make no mistake: these refrigerants are by no means perfect — each has its own caveats — but in terms of thermodynamic properties, operational efficiencies and eco-friendliness, natural refrigerants are truly in a class by themselves.

The term natural refrigerant refers to substances that naturally occur in the environment. From a historical perspective, natural refrigerants were among the first to be used in refrigeration applications. In recent decades, as synthetic chlorofluorocarbon (CFC) and HFC refrigerants were found to have either ozone depletion potential (ODP) or global warming potential (GWP), natural refrigerants have made their way back into the commercial refrigeration conversation.

While new synthetic refrigerants are being developed that offer lower GWP levels and much reduced environmental threats, many of these substances have yet to be fully vetted or deemed as acceptable substitutes by regulatory bodies. In contrast, natural refrigerants are not only the benchmark for ultra-low GWP and ODP, they’re also listed as acceptable for use in most refrigeration applications (subject to use conditions).

**AMMONIA**

R-717 was among the first refrigerants to be used in refrigeration applications. Its superior thermodynamic properties made it a logical first choice, but its toxicity (classified as B2L: low flammability and high toxicity) has been a deterrent to operators unwilling to risk potential leaks. The advent of CFC refrigerants in the mid-twentieth century drove the refrigeration industry away from R-717 toward lower-risk synthetic alternatives.

To this day, ammonia’s suitability in low-temperature applications has made it a mainstay in industrial, process cooling, cold storage and ice rink applications. Through leak detection protocols, careful adherence to safe application procedures and lower refrigerant charges, R-717 systems can be used safely and effectively in a broad range of refrigeration applications.

**PROPANE**

Propylene is a hydrocarbon that was also identified in the early days of refrigeration as an effective refrigerant. Its high capacity, energy-efficient performance and very low GWP are offset by its classification as an A3 (highly flammable) substance. But, as synthetic refrigerants became available for many refrigeration applications, R-290 was largely abandoned in lieu of its CFC-based counterparts. Since the 2000s, R-290 has been regaining global popularity as a lower-GWP, effective alternative to HFCs like R-404A and HFC-134a — especially in a wide range of low-charge, reach-in displays.

**CARBON DIOXIDE**

Non-toxic and non-flammable, CO₂ has proved to be a very effective alternative to HFCs in both low- and medium-temperature applications. CO₂-based refrigeration systems have been successfully deployed in commercial and industrial applications in Europe for nearly two decades.

Because of its low critical point (87.8 °F) and high operating pressure (around 1,500 psig or 103 bar), CO₂ refrigeration strategies — such as cascade, secondary and transcritical booster — must be designed to account for its unique characteristics. In light of current environmental regulations, the popularity of these systems has increased significantly in North America in recent years.

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**Know Your Naturals**

### Natural Refrigerant | GW | ODP | Special Considerations | Trends in Refrigeration System
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**Ammonia (R-717)**

- 0
- 0
- • Potentially toxic
- • Slightly flammable
- • Very low charge requirements
- • Used in the high stage to absorb heat and/or cool R-744
- • Far removed from occupied spaces

**Carbon dioxide (R-744)**

- 1
- 0
- • High pressure
- • Low critical point
- • High triple point
- • Very little danger to occupants in the event of leaks
- • Used in medium and low stages
- • Pumped into the fixtures used in occupied spaces, rather than R-717

**Propane (R-290)**

- 3
- 0
- • Highly flammable
- • Very low charge requirements (currently 150 grams is the max)
Emerson has developed a useful tool to help retailers make the transition from higher-GWP HFC refrigerants to lower-GWP natural and synthetic refrigerant alternatives. The web app helps decision-makers forecast the life cycle climate performance (LCCP) of a franchise or store based on their preferred refrigeration architectures and refrigerant choices. As CO₂ systems become more common in larger food retail applications, this tool will help retailers demonstrate the impacts of phasing down their current carbon footprint impacts while phasing in lower-GWP options.

End users start by inputting key information about their current and proposed system architectures, such as: design temperatures for stores; store counts of current and future architectures; leak rates; and refrigerant choice. Then, the end user can calculate the phase-down impacts and download graphical charts that will help them demonstrate the impacts. The refrigerant phase-down calculator provides grocers with the following insights:

- Total carbon footprint impacts and LCCP in individual stores and across an enterprise
- Forecasts the impacts of phase-down and phase-in of new refrigerants and system architectures
- Key metrics that can be downloaded as charts, including: total LCCP per franchise; total LCCP per store; weighted GWP per store; and total weighted GWP

Grocers can use Emerson’s refrigerant phase-down tool to forecast the impacts of phasing down higher-GWP systems and phasing in new refrigerant architectures.

Innovative installations

Today, the use of natural refrigerants is on the rise. As technologies improve, equipment manufacturers are working closely with early adopters to develop innovative solutions. This has resulted in several creative natural refrigeration applications that belie their traditional uses — like ammonia being used in supermarket systems and CO₂ playing a larger role in industrial process cooling.

Ammonia trials in food retail

In September 2015, the Piggly Wiggly supermarket company opened a new 36,000 square-foot store in Columbus, Ga., that utilizes an NH₃/CO₂ cascade system manufactured by Heatcraft Worldwide Refrigeration. The all-natural refrigerant system uses an ultra-low charge of ammonia (53 pounds) located away from occupied spaces (on the facility’s roof). The ammonia condenses the CO₂ and is circulated to the store’s low-temperature cases via direct expansion; the medium-temperature circuit is cooled by a CO₂ liquid pump overfeed. Since the total refrigerant charge of the system has a GWP under 150, this store is one of 10 supermarkets in the U.S. to receive the highest certification level (platinum) from the EPA’s GreenChill Partnership. It’s also the fourth supermarket in the U.S. to use this NH₃/CO₂ cascade architecture.

CO₂ adoption in industrial cooling

In cold storage applications, where ammonia has been the preferred refrigerant for decades, companies are also seeking lower ammonia charges. As older ammonia systems near replacement, many operators are evaluating the best option to expand their facility’s low-temperature capabilities. They’re accomplishing this by adopting NH₃/CO₂ cascade systems that not only utilize very low charges of ammonia, but also keep the R-717 circuit out of occupied spaces. There’s also a regulatory driver behind this trend.

Propane in food retail

When major retailers like Target publicly announce their intentions to use only propane in their self-contained units, it’s an indication that the perceptions about the mainstream viability of R-290 are shifting. The smaller charge limits make R-290 a logical fit for Target’s smaller, stand-alone refrigerated display cases and coolers. All of this is part of the retailer’s pledge to become a sustainability leader in the food retail space.

While efforts are needed to mitigate their associated risks and ensure their safe use, natural refrigerants represent true sustainable alternatives without sacrificing performance. As regulatory bodies and industry organizations work to refine these standards, natural refrigerants will continue to play a key role in the future of commercial and industrial refrigeration.

Evolving safety standards

There are currently several global efforts in effect and underway to evaluate refrigerant classifications, ensure safety standards, and govern the charge limits of R-290 and R-717.

R-290

- International Electrotechnical Commission (IEC) has formed a working group to evaluate the potential of raising the charge limit from 118g to 300g–500g in the U.S. This has broad implications for expanding the size and efficiency of self-contained applications.
- SSEC with AHRI, ASHRAE and the DOE to study flammable refrigerant behavior in real-world applications

R-717

- Occupational Safety and Health Association (OSHA) created the Process Safety Management of Highly Hazardous Chemicals (29 CFR 1910.119) standard to ensure the safety of systems that require more than 10,000 pounds of ammonia.
- OSHA’s National Emphasis Program (NEP) on process safety management-regulated industries has recently stepped up enforcement, requiring owners and operators of large ammonia systems to maintain continuous record keeping in preparation for NEP inspections.
Regulations Bringing Refrigerant Change to Commercial HVAC Market

By David Hules
Director of Commercial Marketing, Air Conditioning
Emerson

There are a number of well-known factors driving change in the commercial HVAC market, including advances in building automation and connectivity, and increasing focus on comfort and air quality. One factor that might not be on the radar of many of our readers is a U.S. regulation that will have a major impact on the type of refrigerants used in commercial HVAC equipment, specifically chillers. While this regulation is not in effect yet, as a key supplier to equipment manufacturers it is important that Emerson prepare now to help the industry transition. For instance, we have to “work backward” from the implementation dates to adequately design, test and supply the components needed to work with potential new refrigerants.

Part of that preparation also involves helping ensure our customers stay informed and understand the coming changes and how they impact their operations and infrastructure. As part of that effort, this article provides a quick snapshot of where the industry currently is regarding pending refrigerant changes.

Under the U.S. Environmental Protection Agency’s (EPA’s) Significant New Alternatives Policy (SNAP) program, current popular refrigerants R-410A, R-407C, R-134A and others will be delisted in chiller applications effective January 1, 2024. This is prompting the evaluation of low global warming potential (GWP) replacement refrigerants for use in commercial chiller applications.

In this ongoing industry effort to identify low-GWP replacements for R-410A and other refrigerants, four main criteria are being considered. When combined with technology, a viable alternate refrigerant must:

- Have proven safety properties and conform to building codes and safety standards
- Be environmentally friendly with zero ozone depletion and low GWP
- Offer long-term availability at reasonable capital cost
- Provide performance equal to or better than current refrigerants to keep energy consumption low

While there are a few low-GWP, high-performance natural refrigerants listed as acceptable by the EPA (i.e., ammonia, propane and CO2), they are rarely used in chiller applications, primarily because of toxicity, flammability and efficiency concerns, respectively. Currently, the most viable, low-GWP replacements approved by the EPA fall into the A2L safety classification.

Of course, A2Ls present their own set of challenges that the industry is working to solve or minimize. The main challenge being that the refrigerants are mildly flammable (although not as flammable as propane). As a result, there is an effort underway to update safety standards (e.g., UL standards) that will necessitate an update to building codes. To be included in the next building code cycle, these updates need to be ideally finalized and approved by the beginning of 2018. Any delay in approval likely delays the timeline by which A2L-compatible new equipment becomes available in the market.

With an eye on all these moving pieces, equipment manufacturers are diligently redesigning systems to utilize these new refrigerants. While safety and building codes are still being drafted, the delisting deadline of January 1, 2024, is a known quantity that is driving the chiller design cycle, including the optimization of components around A2L use.

So at this stage, what should end users do to prepare for the coming refrigeration transition in commercial chiller applications? For right now, the best thing you can do is stay informed and be aware that this transition is coming. Know that depending on the refrigerant options and building code updates, the equipment will be changing.

Industry experts and equipment manufacturers are working closely together to ensure that the transition is seamless and viable refrigerant options are supported. The hope is that this process will better position the industry and each individual end user to reduce carbon footprints and minimize the impact of climate change through responsible energy use.

Key Events and Regulations

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Regulations are driving the need for compressors and other components to be optimized for new low-GWP refrigerants.
Apprenticeship Opportunities

Mining this largely untapped resource to bridge the refrigeration gap

My colleague Bob Labbett and I have talked at length in these pages about the growing technician shortage facing our industry. It’s what we call the refrigeration gap. Through our E360 Forums, we’ve assembled stakeholders to develop strategies that address this very real challenge. Already, we’ve formed the basis of a solution that focuses on four key areas: awareness, recruitment, training and retention — and we are always looking for creative ways to achieve these objectives.

A recent announcement by the Trump administration about doubling the budget of the federal apprenticeship program piqued our curiosity. Not only were we largely unaware of the program, we were intrigued by its potential for addressing our industry’s technician shortage. But we needed to learn more about this program before determining its feasibility. So, we put two summer interns at The Helix to research the opportunity. It was the UVCC (Upper Valley Career Center) program. Under Trapp’s guidance, UVCC has theUVCC program is revolutionary. We’re on the cutting edge of this exciting opportunity, and we’re excited to share our experience with our E360 community. The UVCC program is a Registered Apprenticeship Program (RAP) that focuses on the HVAC field.

What is a Registered Apprentice?

An RA program typically starts with a business sponsor to provide on-the-job training. It incorporates technical education and culminates in national certification — all while giving the apprentice an opportunity to earn a competitive wage. Source: Department of Labor

Registered Apprentice-able occupation. A credential that validates proficiency in an apprentice-able occupation.

Apprentice benefits:

• Provides opportunities for tax credits and employee tuition benefits in some states
• Reduces turnover costs and increases employee retention
• Creates industry-driven and flexible training solutions to meet national and local needs

Recent data from the DOL indicates a steady increase in participation and sponsorship over the past five years:

• In FY 2016, more than 206,000 individuals nationwide entered the apprenticeship system.
• Nationwide, there are over 505,000 apprentices currently obtaining the skills they need to succeed while earning the wages they need to build financial security.
• 49,000 participants graduated from the apprenticeship system in FY 2016
• There are more than the 21,000 registered apprenticeship programs across the nation.

The UVCC pre-apprenticeship program is also recognized by the Department of Education’s career and technical education (CTE) program.

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• Upon graduation, our students can continue their apprenticeship in a registered apprenticeship program, starting as second-year apprentices,” Trapp added.

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The UVCC pre-apprenticeship program is also recognized by the Department of Education’s career and technical education (CTE) program.

• We went through the process to become one of two career centers in Ohio to be approved as registered pre-apprenticeship programs,” said Trapp.
• Upon graduation, our students can continue their apprenticeship in a registered apprenticeship program, starting as second-year apprentices,” Trapp added.

Under Trapp’s guidance, UVCC has theUVCC program is revolutionary. We’re on the cutting edge of this exciting opportunity, and we’re excited to share our experience with our E360 community. The UVCC program is a Registered Apprenticeship Program (RAP) that focuses on the HVAC field.
Less Is More

Copeland Scroll™ compressors now available in fractional horsepower range

When it comes to regulatory compliance, foodservice refrigeration equipment manufacturers have their work cut out for them over the next few years. In 2018, the Environmental Protection Agency (EPA) will be phasing out the use of R-404A in new remote condensing units for walk-in coolers and freezers (WICF). Then, the Department of Energy (DOE) has proposed the enforcement of its new WICF efficiency mandate in 2020, as measured by the annual walk-in efficiency (AWEF) standard. The challenge for foodservice OEMs is to design new condensing units and stand-alone equipment that comply with both requirements.

Our new 1/4 to 1 1/2 horsepower (HP) offerings extend the existing Copeland Scroll ZF*KA and ZB*KA compressor lines, allowing OEMs to combine compliance into a single design cycle for smaller low- and medium-temperature applications. As with any Copeland Scroll compressor, these smaller offerings deliver high efficiencies and reliable performance.

As the EPA phases down the use of hydrofluorocarbons (HFCs) with higher global warming potential (GWP), new refrigeration platforms must be designed to accommodate the performance characteristics of lower-GWP alternatives. The new fractional HP Copeland Scroll compressors are rated for use with new alternatives R-448A/449-A as well as existing lower-GWP HFCs such as R-407A.

Liquid-injected for low-temperature efficiencies
Walk-in freezers that rely on outdoor condensing units will require compressors that can mitigate the higher discharge temperatures produced when using new refrigerant alternatives in low-temperature applications. The Copeland Scroll ZF*KA fractional HP models utilize liquid-injection technology to cool discharge temperatures and reduce compressor stress. Traditional hermetic reciprocating models will require additional modifications and heat-reduction strategies in these low-temperature scenarios that can’t match the inherent simplicity and efficiency advantages of Copeland Scroll technology.

Copeland Scroll ZF*KA fractional HP compressors are the basis of Emerson’s X-Line outdoor condensing unit, enabling it to simultaneously meet both DOE (AWEF efficiency) and EPA (lower-GWP refrigerant) requirements in low-temperature scenarios. Other condensing unit manufacturers can achieve similar benefits with the expansion of Copeland Scroll into smaller HP ranges.

Wide applicability in medium temperatures
For medium-temperature, walk-in coolers, the new fractional HP ZB*KA compressors deliver enhanced AWEF efficiencies in WICF condensing units. It’s important to note that incumbent hermetic reciprocating compressors cannot achieve the same efficiencies without modifications to other system components (e.g., coils, cooling fans, etc.). Patented Copeland Scroll technology enables significant efficiency improvements in medium-temperature WICF applications without the investments in additional components or engineering, design and development (ED&D) costs.

The new ZB*KA compressors represent an extension of the medium-temperature line of compressors to better serve today’s wide range of walk-in cooler requirements. OEMs can now integrate reliable Copeland Scroll technology into their complete lineup of walk-in refrigeration equipment, while achieving compliance with environmental and energy efficiency regulations.

Simplify the design cycle
As foodservice refrigeration OEMs complete the design cycles needed to comply with EPA and DOE regulations over the next few years, the new fractional HP Copeland Scroll compressors will offer them many distinct advantages. In low-temperature, walk-in applications, the liquid-injected ZF*KA models will enable reliable operation without the need for complex heat-mitigation techniques. And in medium temperatures, where larger coils, evaporator fans and other components may be needed to meet AWEF targets, the efficiency of Scroll technology alone will often get the job done. Compared to its hermetic reciprocating counterparts, Copeland Scroll is simpler to incorporate into new designs without additional engineering, development and design costs.
Keys to Servicing CO₂ Systems

The global implementation of CO₂ systems in food retail has grown significantly in the past two decades. Sustainability objectives and regional regulations have given retailers renewed motivation to explore greener commercial refrigeration strategies. A recent study on natural refrigerant adoption estimates there are upwards of 9,000 CO₂ installations in Europe, and more than 260 CO₂ stores currently in the United States. With zero ozone-depletion potential (ODP) and a global warming potential (GWP) of 1, all-natural CO₂ (or refrigerant name R-744) has become a leading alternative to higher-GWP hydrofluorocarbons (HFC) refrigerants. But from a service technician’s perspective, CO₂ has unique performance characteristics and operating peculiarities that dictate system design and impact maintenance requirements. Following are the key considerations to be aware of when servicing CO₂ systems.

Low critical point (subcritical vs. transcritical) — R-744 has a relatively low critical point (1,005 psig or 87.8 °F) that determines its mode of operation. Subcritical mode refers to systems operating in regions with colder climates and lower ambient temperatures where the refrigeration cycle takes place below 87.8 °F. Transcritical mode takes place above this point (also referred to as supercritical), which is common in warmer regions or periods during the summer heat.

Higher operating pressure — one of the common reservations when using CO₂ is its relatively high operating pressure. But, it’s important to realize that high pressure only takes place in the beginning stages of the refrigeration cycle. Refer to the enthalpy diagram and accompanying transcritical booster system architecture. Point 1 is the start of the refrigeration cycle and the suction of medium-temperature compressors. As R-744 compresses on a hot day in a supercritical zone, pressures can reach 1,400 psig at 240 °F (Point 2), where the refrigerant goes through the gas cooler/condenser up on the roof. From there, it returns to the machine room where a high-pressure valve (Point 3) reduces the pressure to 400–500 psig and stores the liquid in a flash tank (Point 4). The rest of the refrigeration cycle operates at pressures like that of a traditional R-410A high-side system. In most instances, the only true high pressures are during the heat of the summer and even then, it’s generally confined to the roof. To handle these high pressures, piping is typically stainless steel, although high-pressure ferrous alloy copper piping has recently been introduced.

High triple point (possibility of dry ice formation) — triple point is the point at which the three phases of CO₂ coexist (69.4 psig or -69.8 °F). While the temperature seems low, the pressure is relatively high by refrigerant standards. As the pressure approaches that point in CO₂ systems, the refrigerant will turn to dry ice (an unusable state for most applications). It is so unlike traditional HFCs, it’s a best practice to manage this storage requirement and plan accordingly to deliver refrigerant to keep pressures low and maintain volume in the system.

Resumption of power — the electronic expansion valve (EEV) on every CO₂ case utilizes a stepper motor or a pulse-width-modulated (PWM) type of valve. When the power goes out, the stepper motor is frozen in that exact position, leaving the system’s CO₂ evaporators susceptible to flooding. R-744 naturally migrates quickly to these cold evaporators, and when the system resumes, this can cause considerable damage to compressors. To avoid this, liquid line solenoids placed upstream of the EEV, supercapacitors or battery back-ups are often used on case controls to force the valves closed during a power outage. Many contractors perform power outage trials to give their technicians a chance to practice and understand the different issues that can occur before the store opens.

Form a refrigerant plan — managing CO₂ is different than what contractors may be accustomed to with traditional HCFCs. Operators and contractors alike need to understand the local codes for storing R-744 cylinders (inside or outside the building), and develop an appropriate strategy. In a typical store that requires 2,000 pounds of refrigerant charge, contractors must make sure the facility can handle this storage requirement and plan accordingly to deliver refrigerant when needed.

System charging — the high triple point affects R-744’s charging procedure. After pulling a vacuum, the internal pressures of the system will be well below 60.4 psig. Since standard atmospheric pressure is 14.696 psig, the process cannot start with liquid charging. Instead, contractors must vapor charge the system (roughly to around 145 psig), and then wait until the system has equilibrated with 145 psig of vapor before charging with liquid. This ensures that no dry ice will form in the charging lines or anywhere of your system.

Managing scheduled shutdowns and power outages — when a CO₂ system shuts down for longer periods of time, pressures will build more quickly than in an HFC system. There are strategies to preserve the system charge if you don’t want to evacuate R-744 through pressure release valves. The most reliable method is to install a generator with a standby condensing unit until the power goes out, the generator powers a condensing unit that has a loop within the flash tank (i.e., receiver) designed to cool the volume of liquid within the tank and keep pressures down. Smaller systems may utilize a fade-out vessel, which is essentially a large container that can accommodate the refrigerant to keep pressures low and maintain volume in the system.

Improving the efficiencies of CO₂ transcritical booster systems

Because CO₂ transcritical booster systems are prone to declining efficiencies in warmer climates, equipment manufacturers have developed several techniques to offset the impacts of high ambient air temperatures.

Spray nozzles — condenser that mixes water to cool air across condenser coils

Adiabatic gas cooler — wet pads that line the outside of the condenser are used to cool air and keep the system from going into transcritical mode

Parallel compression — the flash tank feeds refrigerant to an independent compressor with increased suction pressure and smaller motor

Sub-cooling — cools the gas to reduce the BTU/lb. on the enthalpy curve and increase overall system efficiency

Gas ejectors — a means of using high-pressure gas energy to redirect medium pressure suction gas to the parallel compressors via the flash tank

Other peculiarities

Aside from the aforementioned scenarios, there are also other idiosyncrasies to consider when dealing with CO₂.

• Since CO₂ is already abundant in the atmosphere, it can be difficult to detect refrigerant leaks.

• Because CO₂ is so unlike traditional HCFCs, it’s a best practice to keep a dedicated set of CO₂ gauges, high-pressure hoses and miscellaneous CO₂ parts at each installation.

• Like any system, preventative maintenance is critical to managing the total cost of ownership.

• It’s important to understand the consequences of trapping R-744, always have a pressure relief or check valve in place in the event R-744 gets trapped in the system.

• For contractors, training of service personnel is critical. For end users and facility operators, using a company with CO₂ expertise is equally as important.

• System cleanliness and dryness are keys to efficient operation.

• CO₂ systems require the use of high-pressure controllers, electronic expansion valves, pressure transducers and temperature sensors to optimize pressures and refrigerant quality to the extent possible.
Applying Machine Learning for Facility Management

Advanced machine data combined with expert insights yield actionable results

by JOHN WALLACE

Machine learning is a subfield of computer science that refers to a computer’s ability to learn without being programmed. In theory, machines should be able to learn and adapt through experience, but human interaction is still needed to produce the desired results. There are two primary types of machine learning: supervised learning that utilizes historical data to train an algorithm and predict an outcome from a series of inputs and unsupervised learning based on algorithms that operate by picking out relationships in the data and lead to specific conclusions. Today, most applications utilize a supervised learning approach. In either case, the output of a machine-learning algorithm is entirely dependent on available data and used to train the machine-learning model. More, learn by studying data to detect patterns or by applying known rules. Typical machine learning objectives include:

- **Categorizing or cataloguing like people or things**
- **Predicting likely outcomes or actions based on identified patterns and relationships**
- **Detecting irregular or unexpected behaviors**

The processes by which machines learn are known as algorithms. Different algorithms learn in diverse ways. As new data regarding observed responses or changes to the environment is provided, machine learning becomes more accessible, the question is how to apply this technology to generate a competitive advantage.

Leveraging valuable data can help businesses evolve from a reactive stance to a more proactive and predictive one. Most businesses have an abundance of data available to them that is not being used or is difficult to access. With the advent of the Internet of Things (IoT) and the wealth of sensor data, this information is now more readily available. But how can businesses effectively use this data? By harnessing its potential, operators can uncover opportunities for value creation such as driving increased efficiencies or creating new revenue streams.

**How to create a machine-learning model in your enterprise**

Businesses can take some relatively simple steps to create a supervised learning model. This process can be summarized in six steps:

1. **Have a keen idea of what problem you are trying to predict or solve.**
2. **Develop a data collection strategy.** Data is made up of inputs from gathering a variety of sensors, including temperatures, pressures, on-off activities (from motors, etc.) as well as the actions that result from these inputs. Your goal will be to predict the action that will occur for a given set of inputs. The more relevant data you can gather, the better. The data you have gathered will be used to both train the learning model and validate the model’s performance; these data sets are typically separated.
3. **Use training data to create a machine-learning model.** This is where math is used to create a model that predicts an action based on inputs. There are different types of models that perform better or worse for a particular data set, so you might need to create multiple models (different math) and then pick the one that performs best based on your data.
4. **How closely does your model predict the action or result that came out of your training data?** A perfect model would anticipate the result every time. While that usually doesn’t happen, the goal is to get as close as possible to that result. Once you develop a standard and are achieving the desired results, use that model moving forward.
5. **Test the validation data from step two.** That validation data contains the inputs and the actions that occurred, but it’s completely independent from the training data. You used the training data in step four to select and train the model. In step five, use the validation data to see how good the model performs based on the data set. If the validation data doesn’t match up, you may need to step back and select a different training model, and then confirm it with the validation data. This is an intricate process. When and if the results do not match expectations, you may have to start from the beginning. Make sure you are collecting the right types of data before running the process again.
6. **Let the machine learning begin.** Upon completion of your efforts, you should have a model that can be used to predict an action or result based on the available inputs. At some point, input parameters may change or another system modification may be required; in this event, you will need to go back periodically and update the model based on new data.

**HVAC example**

Large many food retailers use numerous roof top units (RTUs) to maintain a comfortable in-store environment. Typically, these operate independently without any coordination among them. During typical operation, all the units may or may not be operating simultaneously. This situation can create unwanted energy demand spikes. By capturing the data being generated in that space, such as ambient air temperature, space temperatures, compressor staging (on and off the individual RTUs), we should be able to create a machine-learning model that can predict when the RTUs are turning on or off. Once the model establishes this pattern, we can use that data to better coordinate multiple RTUs coming on at the same time. The key is to compare the data streaming into the model’s predictions and decide the best action to take. If you have multiple RTUs running simultaneously, you’re likely to have higher demand charges and use more electricity. Being able to better control the RTUs will result in lower demand charges.
The New Emerson Commercial and Residential Solutions

Emerson has boldly transformed itself to create value for our customers and innovate the solutions that will become their successes. We will continue to offer the technologies and services that keep homes and businesses running smoothly while creating comfortable, controllable environments with our energy-efficient HVACR solutions. Look to Emerson to solve the toughest industry challenges with our market-proven compressors, controls, thermostats and related equipment. Learn more at Emerson.com.

Emerson Climate Technologies is now part of the Emerson Commercial & Residential Solutions business platform. Leading product brands include: Copeland Scroll™, ProAct™, Sensi™, RIDGID® and InSinkErator®.

Commercial & Residential Solutions is focused on delivering value through:
• Ensuring human comfort
• Protecting food quality and sustainability
• Advancing energy efficiency and environmental conservation
• Creating sustainable infrastructure
• Innovating at The Helix

We’d like to hear your feedback.

Thank you for reading this edition of E360 Outlook! At Emerson, we believe the challenges faced by the refrigeration industry cannot be solved in a vacuum. Only through collaboration and a commitment to innovation will we discover answers to the difficult questions before us.

We hope the information provided here will spark conversations and open all of our eyes to new perspectives. But for that to happen, we all need to contribute. And that starts with you. Feel free to contact us with your feedback, questions and insights. We look forward to hearing from you.