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Maximizing refrigeration system efficiencies

Strategies for improving energy efficiency and reliability in your existing system.

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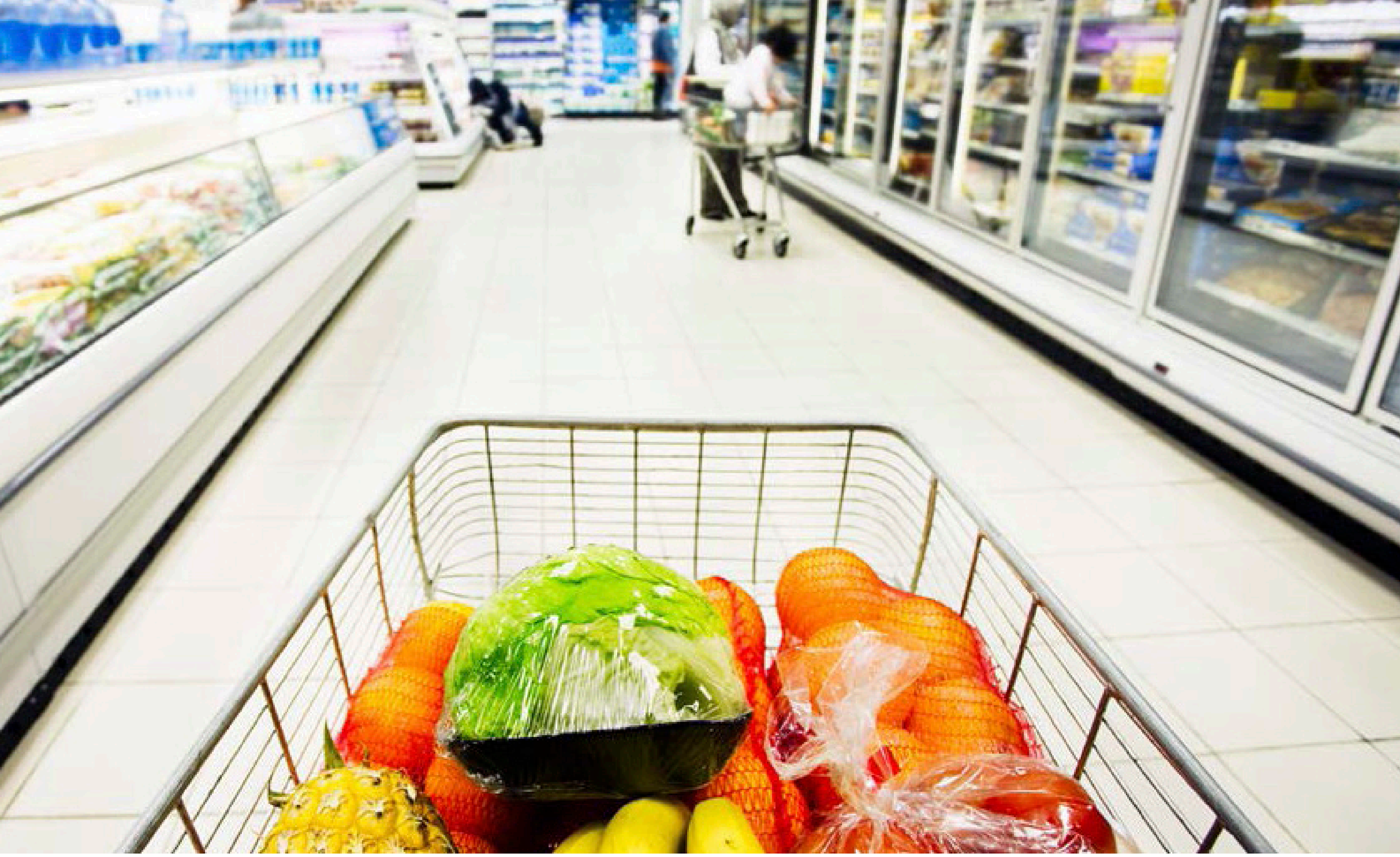

For most supermarket operators, reducing energy spend is a key component of their overall sustainability objectives. As the system typically responsible for the greatest energy consumption, refrigeration should be among the first areas of focus for achieving these goals. But as is often the case with many refrigeration systems, they begin to drift from their original commissioned state over a period of time. Setpoints are changed, mechanical subcooling strategies become ineffective, condensing pressures increase, and overall system energy consumption rises. And in many instances, maintaining consistent case temperatures becomes a constant struggle.

This performance drift is an all-too-common occurrence that slowly degrades energy efficiency and refrigeration reliability.

Fortunately for many supermarket operators, this inefficient state neither has to be the status quo, nor does it necessarily mean that it is time to replace their existing refrigeration system. In fact, there are a variety of tools and techniques for taking back control of a supermarket refrigeration system. Combined, many of these techniques can not only restore the system to close to its original commissioned state, but also greatly improve its efficiency, capacity and reliability.

Efficient liquid subcooling

Many supermarket refrigeration systems are designed to enable liquid subcooling on low-temperature (LT) racks to deliver 50 °F liquid to the case. Subcooling results in denser liquid, which packs more BTUs per pound and maximizes system capacity and performance. These systems typically utilize a plate heat exchanger (as an evaporator) to cool the refrigerant with mechanical expansion valves sized to handle the subcooling load. This strategy is intended to drive higher efficiencies, use smaller liquid lines, and therefore maintain a lower refrigerant charge.

While this strategy appears great on paper, one of its challenges is that it is designed for operation during the hottest anticipated summer day. But for all other weather conditions—which, in some regions, represent more than 95% of the year—the system operates outside of its design parameters. As ambient temperatures drop, the condenser operates more efficiently, thus decreasing the subcooling load requirements. The net effect is that the plate heat exchanger for subcooling is oversized for most of the year.

As the system tries to adapt to changing weather conditions by modulating refrigerant flow into a heat exchanger, the liquid quality output can become more

erratic. And as this lower-quality refrigerant then travels down long liquid lines to cases located in the farthest regions of the store, the system's smaller liquid lines originally sized for a specific amount of subcooling become undersized—causing liquid line flash gas, which can starve the evaporator. System designers often use electronic evaporator pressure regulators (EPRs) at the outlet of the subcooler to manage load variability; therefore, these controls must be properly set to maintain target liquid-out temperatures.

If they aren't, the conditions can combine to create a perpetual state of fluctuation as the system "hunts" for the liquid quality for which it was designed. Ultimately, the constant hunting and flash gas bubbles can result in poor temperature control in cases brought on by a domino effect of system issues that potentially impact energy efficiency and reliability:

- Inability for mechanical expansion valves to maintain flow in the evaporator
- Oversized, underutilized heat exchangers and/or compressors
- Drop in liquid suction pressure
- Undersized liquid lines due to sub-par liquid quality
- Rising superheat in cases
- High return gas temperatures and resultant higher than normal discharge temperatures
- Higher compression ratios and energy consumption

When service technicians don't fully understand the cause of these effects, they often make matters worse by changing setpoints or increasing condensing pressures. But while these steps may temporarily improve liquid quality, they can also significantly increase energy consumption—while potentially decreasing overall system efficiency and capacity.

Install electronic expansion valves

Replacing the system's mechanical expansion valves with electronic expansion valves (EEVs) is the key to helping operators overcome these subcooling challenges and restoring system efficiencies. EEVs modulate refrigerant flow to the heat exchanger, regardless of whether it is the hottest or coldest day of the year. As temperatures and liquid quality fluctuate, EEVs at the inlet of the subcooler control the refrigerant flow much more effectively—which in turn allows the system to run at maximum capacity and deliver the performance advantages for which it was originally designed.

Advantages of efficient liquid subcooling include:

- Higher BTUs per pound of circulating refrigerant
- Reduced liquid line size and charge reduction
- Improved efficiency for energy savings

For optimum control of a subcooling heat exchanger equipped with an EEV, using a variable-capacity compressor like the Copeland™ scroll digital compressor or adding a variable-frequency drive (VFD) to a Copeland Discus™ compressor can provide a balanced load approach.

Raise system suction pressures

System suction pressures are inversely proportionate to the system's overall energy efficiency. The higher the system suction pressures are, the lower the associated compressor power consumption. Therefore, any increases in suction pressure should result in higher energy savings—particularly for lower-temperature refrigeration systems compared to medium-temperature systems.

A common rule of thumb for this relationship is as follows: for every 1 PSI increase in suction pressure, a compressor's energy-efficiency ratio (EER) is improved by approximately 2%. Electronic EPRs are commonly used in centralized racks to maintain evaporator temperatures within various suction groups and optimize suction pressure to its highest possible point based on case demand. To save additional energy, technicians may "float the suction pressure" by allowing it to rise slightly when the lowest temperature case is satisfied. This can only be achieved if the EPRs are properly set.

Low-condensing operation

Another leading technique for offsetting the inefficiencies of a system designed for the hottest day of the year is to implement low-condensing operation (aka "floating the head pressure"). Low-condensing operation also relies on the mass flow control capabilities enabled by EEVs to allow the system to operate efficiently year-round—especially during non-peak conditions.

The concept is relatively simple: instead of artificially keeping head pressures near 105 °F with the use of head pressure control valves, case EEVs allow systems to float head pressures down as the temperatures drop. This can reduce system stress during non-peak conditions, provide increased compressor capacity, and result in significant energy-efficiency improvements.

In low-condensing systems, head pressures are usually maintained 10–20 °F above ambient temperatures. On average, a system can achieve 15–20% energy efficiency ratio (EER) improvements on compressor performance for every 10 °F decrease in head pressure. EEVs are designed to modulate with fluctuations in capacity and liquid quality to digest flash gas and control superheat. Using this technique, supermarket operators can reliably float system pressures to 70 °F or lower.

Advantages of lowering condensing pressures typically include:

- 15–20% EER improvements on compressor performance
- Increased compressor capacity for faster pull-down rates
- Lower pressure, which reduces system stress
- Higher system reliability, which lowers total cost of ownership

Due to its energy-saving benefits, low-condensing operation has been written into a variety of environmental regulations and guidelines. California's Title 24 regulation requires a minimum setpoint of at least 70 °F in floating head pressure systems. In addition, low-condensing operation was cited as a design option in the Department of Energy's guidelines for meeting 2017 energy-reduction targets in walk-in units.

Helping you take back control of your system

Copeland provides the tools, technologies and expertise to help operators implement efficient liquid subcooling and low-condensing pressure strategies. Our EX series EEVs feature a patented ceramic gate port design that can manage a wide range of liquid quality and condensing pressures—and deliver precise refrigerant control via variable-capacity modulation from 10–100%.

The companion EXD-SH1 or SH2 superheat controller regulates evaporator superheat to optimize system performance, regardless of ambient conditions. Its integrated display allows operators to check a variety of system conditions, such as superheat, percentage of valve opening, pressure and temperature values.

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