EEVs Enabling Low Condensing Refrigeration

Discover how electronic expansion valves are being used to lower head pressure in refrigeration systems and increase energy savings for customers.

BY ANDRE PATENAUTE

Images courtesy of Emerson Climate Technologies, Canada.

In the last decade, modern refrigeration and air-conditioning systems have progressed to offer the very latest mechanical and electronic component technologies. System operators and service technicians now have a variety of performance-enhancing and energy-efficiency options to precisely match system capacity with demand and better tailor operating parameters to the ambient temperatures. One often ignored method to achieve performance and energy efficiencies is through lowering the condensing (or head) pressure in refrigeration systems.

The majority of refrigeration system operators elect to run systems with fixed head pressures, which forces compressors to run at maximum output, regardless of the ambient temperature or demand. For decades, operators have been taught that maintaining fixed head pressures above 105°F was standard operating procedure. It is analogous to forcing a car engine to run at maximum rpm even when idling or driving slow—common sense tells us this is unnecessary. Unfortunately, many operators and contractors are simply unaware that low condensing operation is a viable, energy-efficient and cost-effective alternative to the fixed head pressure method.

Today, technological advances in electronic expansion valves (EEV) are enabling existing systems to operate with floating head pressures. EEVs allow operators to lower the condensing points to drastically reduced minimum levels that are more closely aligned with the fluctuations in ambient temperatures throughout the day and across the seasons.

Ben Kungl, Owner of Oxford Energy Solutions (Ontario, Canada) has been working exclusively with EEV systems for more than eight years. “In the past, we needed to maintain high head pressures to make the mechanical valves work properly. With the technology and the accuracy of today’s electronic valves, we now have expansion devices that allow us to float the head pressure and take advantage of the lower ambient temperatures.”

Definitions

“Low condensing refrigeration” refers to the practice of lowering the condensing temperature to a minimum setpoint well below typical fixed condensing pressures. The condensing temperature is commonly referred to as either the “head pressure” or the “condensing pressure” in a refrigeration or A/C system. Traditional refrigeration systems maintain a fixed head pressure above 105°F, typically relying on mechanical head-pressure control valves or fan cycling to maintain fixed pressure.

The term “floating head pressure” is synonymous with “low condensing” and describes the practice of varying (or floating) the condensing pressure in unison with fluctuations in ambient temperatures. The head pressure typically remains at 10°F–20°F above the ambient temperature and is controlled by pressure regulators or through cycling (or varying) the speed of condenser fan motors. This method requires the designation of a minimum saturated condensing temperature.
(SCT) to establish the lowest point at which the system is able to operate effectively.

As the ambient temperature rises in a floating head system, the condensing pressure will float up with it. When the ambient temperatures falls, the head pressures will also track with the decrease in temperatures—and that is where energy savings can be realized.

**Fixed head pressure operation**
Traditionally, refrigeration and A/C system operators have artificially kept head pressures high all year long to accommodate the limitations of mechanical thermal expansion valves (TXV). The TXV, which controls the refrigerant flow into the evaporator, is the main driver for maintaining these artificially high pressures and liquid quality all year.

Decades ago, when balanced-ported mechanical TXVs were used in the first attempts at lowering the condensing pressure, they were unable to maintain capacity and digest flash gas (bubbles) that formed in the liquid as the pressure floated lower. The flash gas ultimately choked the TXV, and like drinking through a straw with a hole in it, the TXV could not produce the necessary volume. As a result, system aids (such as mechanical heat exchangers, liquid pressure amplification pumps and subcooling loops) were introduced into these low condensing systems to control flash gas. However, the industry soon decided these measures were excessive and opted to bring the head pressures back up to a fixed point.

To this day, the majority of system operators in North America keep their head pressures near 105°F, which is considered acceptable because it works within the limitations of mechanical TXVs. What many operators do not realize is that technology exists now that will enable them to float their system pressures down to a 70°F (or lower) condensing temperature, thereby achieving significant energy savings.

**Reintroducing low condensing operation**
Due to today’s emphasis on energy-efficiency initiatives, the refrigeration industry is rethinking its stance on low condensing operation. Manufacturers have developed EEVs that are capable of operating within a wide range of condensing pressures. Unlike the TXVs used in fixed head pressure applications, EEVs are capable of digesting the flash gas that is produced in low condensing systems as the head pressure floats with falling ambient temperatures. EEVs can even be retrofitted into existing systems with fixed, variable-speed or digital compressors.

EEVs provide a capacity modulation range from 10%–100%, modulating in a linear, stepped fashion. As the ambient temperature starts to drop, the head pressure floats down and the compressor capacity increases, EEVs can easily handle the transition in capacity ranges. If the liquid refrigerant quality changes and causes flash gas to form, the EEV will modulate, digest the flash gas and control superheat.

Operators will find that the opportunity for energy savings increases as the ambient temperatures drop and head pressures fall. Depending on the compressor type and make, a typical system can achieve 15%–20% energy-efficiency ratio (EER) improvements on the compressor for every 10°F decrease in head pressures.

As the condensing temperature drops, the compressor wattage decreases and capacity (Btuh) increases. Because of the

![Diagram: Comparing fixed head pressure operation (dotted red line) with floating head pressures (dotted blue line), the area shaded green shows the potential energy saving opportunity in a 24-hour period.](image-url)
increased capacity, compressor runtime hours are significantly reduced, and compressor lifecycle reliability is much improved.

By lowering the minimum SCT, operators have significant opportunities for savings in North America. In Canada, the ambient temperature is 60°F or below for 90% of the year. In the central U.S., the temperature is below 60°F or 60% of the calendar year. Even in the southern tip of Florida, the ambient temperature is below 60°F for 20% of the year. Throughout the U.S., operators who allow their system head pressures to float can achieve real savings.

Kungl advised that operators should not overlook this opportunity. “Now that you don’t need to maintain a high head pressure, you can float the head down to take advantage of the low ambient conditions in the fall, winter and spring—and even summer nights. You’ll achieve a smaller compression ratio, greater capacity and less kilowatt input per Btu output.”

Benefits of low condensing
With ample opportunities to take advantage of lower condensing conditions, operators may find it increasingly difficult to justify the business case for maintaining high head pressures year-round. When it’s 35°F in December, it stands to reason that you would not want to operate your system as if it was 85°F in July. Operating at fixed head pressures places consistent mechanical stress on the system, and the many potential energy and performance benefits are left unrealized such as:

> Lower energy consumption/costs;
> Increased compressor capacity at lower condensing pressures;
> Improved sustainability by reducing system charge (refrigerant reduction);
> Maintenance costs reduced;
> An EEV prevents compressor failure from flooding; and
> Utility incentives to upgrade system before it fails.

Making a case for EEVs
For years, a Canadian food processor had been operating a 100-ton, -20°F freezer, running year-round on R-404A at a fixed 110°F SCT. When warm product was introduced into the cold-storage warehouse, operators experienced a slow pull down of temperatures. They had also grown accustomed to losing one compressor per year, on average.

Kungl recommended a system that allowed his customer to lower the condensing point and float the head pressures. By adding EEVs to each evaporator and a variable-frequency drive to condenser fan motors, he was able to drop the minimum condensing temperatures from 110°F to 70°F. Immediately, the warehouse achieved faster pull-down rates. After one year of use, his customer achieved a 50% reduction in energy costs.

In the six years since the retrofit, the contractor has not had to replace a single compressor. On one occasion, every evaporator fan motor in the facility stopped due to an outage on the
208-V power source. Since the compressor and EEVs were on a different voltage, they were unaffected by the power loss and kept running. Instead of flooding back to the compressors due to no air flow and no evaporator heat load, the EEVs throttled closed to control their superheat setpoint. As the valves continued to close, the suction pressure gradually dropped until the condensing units shut off on their low-pressure safety modes.

Kungl said this feature alone is huge cost saver. “It’s inevitable that operators or employees accidentally shut the power off, leave the doors open to the freezer, or an evaporator fan motor is lost. Normally, this would result in serious problems, such as a frozen evaporator or compressor loss. “That doesn’t happen with EEVs, because they’re able to monitor superheat very accurately. As soon as it begins to flood back, the valve simply closes because it knows there’s no heat in the evaporator. It will save the compressor by shutting it off on safety mode,” he noted.

By lowering the condensing temperatures and allowing the system to float its head pressures, the contractor also significantly reduced the amount of refrigerant used in the system—a fraction of refrigerant is needed in the condenser during low-temperature operation.

Low condensing, low energy costs
The state of California recently implemented a low condensing requirement in its Title 24 energy-reduction regulation, requiring floating head pressure systems to have a minimum setpoint of at least 70°F. If this is any indication of what the future will be for the larger North American region, the practice of low condensing refrigeration may soon be gaining wider adoption.

Lowering the minimum setpoint is the most obvious opportunity for legacy equipment to save energy, improve sustainability and reduce maintenance costs. Floating the head pressure allows the compressors to operate in a relaxed state when temperatures are low, while providing more capacity and consuming significantly less energy. Finally, the type of compressor used in the system does not matter, because EEVs are designed to control superheat of the evaporator based on a minimum setpoint.

“And at the end of the day, it’s a cheaper installation and much more efficient system. We’ve never had a system failure with an electronic expansion valve in eight years,” said Kungl.

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