THE TECHNICAL TIMES

The Atherion® Advantage

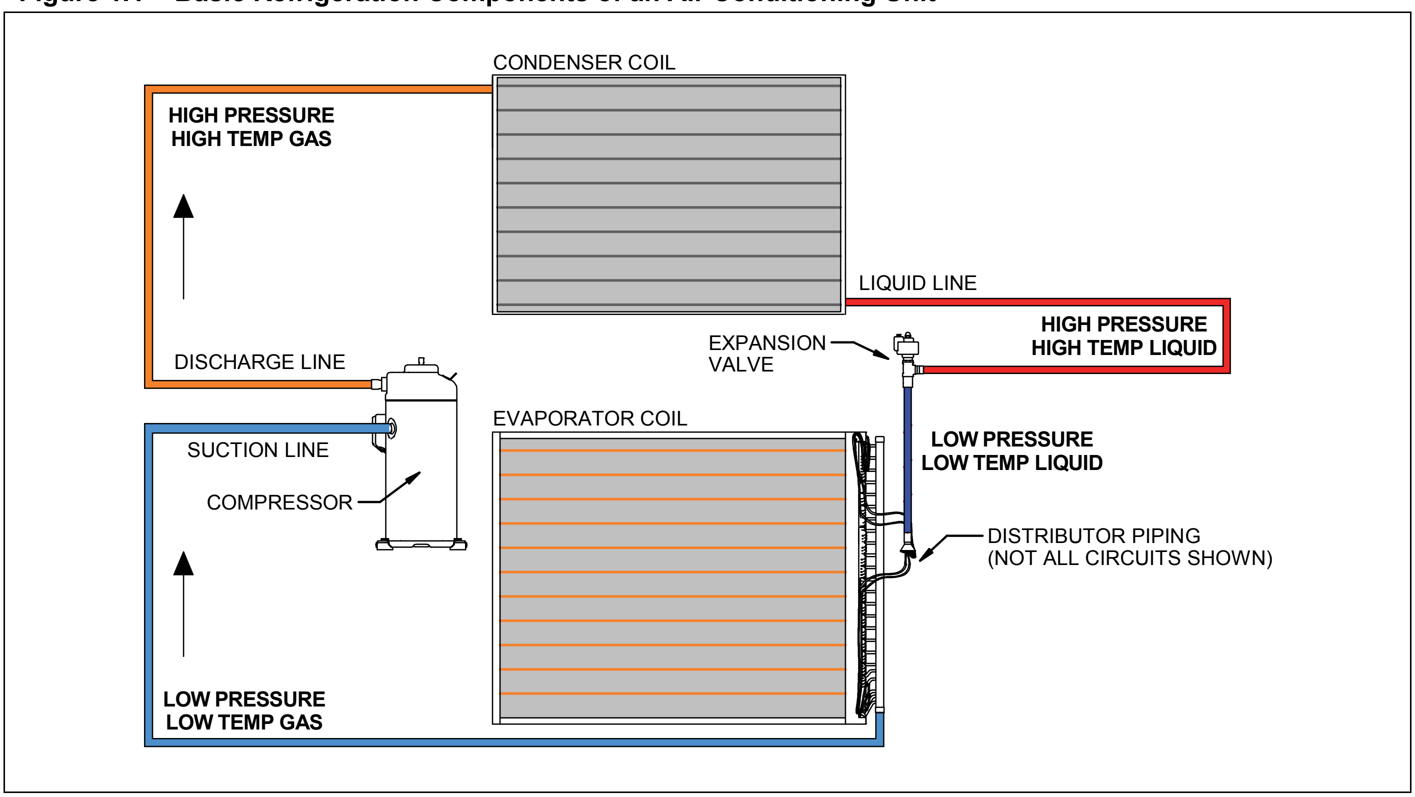
Improved System Efficiency with an Electronic Expansion Valve (EEV)

Overview of Refrigeration System Components

Electronic Expansion Valves (EEVs) can improve system performance and efficiency versus Thermostatic Expansion Valves (TEVs or TXVs), but before we examine these benefits, we must first understand the role of expansion valves in a basic refrigeration system. All direct expansion (DX) refrigeration circuits in an air conditioning unit consist of four basic components, piped together as follows (also refer to Figure 1.1):

- A compressor to move refrigerant throughout the system. The compressor takes a low pressure, low temperature gas and compresses it to a high pressure, high temperature gas which is sent to the condenser coil through the discharge line.
- A condenser coil to reject heat absorbed by the refrigerant in the evaporator coil and the heat gained from compression. The high temperature, high pressure gas is condensed to a high temperature, high pressure liquid. That liquid is sent to the expansion valve through the liquid line.
- An expansion valve to control the rate at which liquid refrigerant enters the evaporator. This will be discussed in greater depth in the next section.
- An evaporator coil to transfer heat from the conditioned airstream to the refrigerant. As the coil absorbs heat, the low temperature, low pressure liquid is evaporated to a low temperature, low pressure gas, which returns to the compressor through the suction line.

Figure 1.1 – Basic Refrigeration Components of an Air Conditioning Unit



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Role of the Expansion Valve in the System

At a given temperature and pressure, refrigerant boils. The refrigeration circuit takes advantage of this physical property of refrigerant to transfer heat energy from one location to another, either through evaporating the liquid refrigerant (absorbing heat) or condensing the vapor (rejecting heat). When cooling the air, liquid refrigerant is introduced to the evaporator, absorbing heat from the airstream passing over the coil surface to boil ("evaporate") the refrigerant inside the coil. Once the refrigerant changes state to a gaseous vapor, the temperature increases from the absorption of heat. That increase in temperature is the superheat. Measuring the evaporator's superheat value is an important part of analyzing the performance of a system to determine if the evaporator is receiving too much, too little, or just the right amount of liquid to operate efficiently and effectively. This is where the expansion valve enters the picture.

The expansion valve serves a critical role in the performance of the system, acting as a metering device to control the rate at which liquid refrigerant enters the evaporator coil. If the valve does not provide enough liquid to the evaporator, it flashes to a vapor too quickly for the coil to absorb any heat from the air. This is referred to as "starving the evaporator" and results in higher than desired superheat values. If too much liquid is provided, not all the liquid evaporates, sending liquid to the compressor and potentially causing catastrophic compressor failure. This is referred to as "flooding the evaporator" and results in lower than desired superheat values.

Most packaged rooftop units, including many dedicated or high percentage outside air units utilize thermostatic expansion valves (TXV). While simple and inexpensive, there are drawbacks that can be improved upon with the use of the more technologically advanced electronic expansion valve (EEV).

Comparison of EEV vs. TXV Characteristics

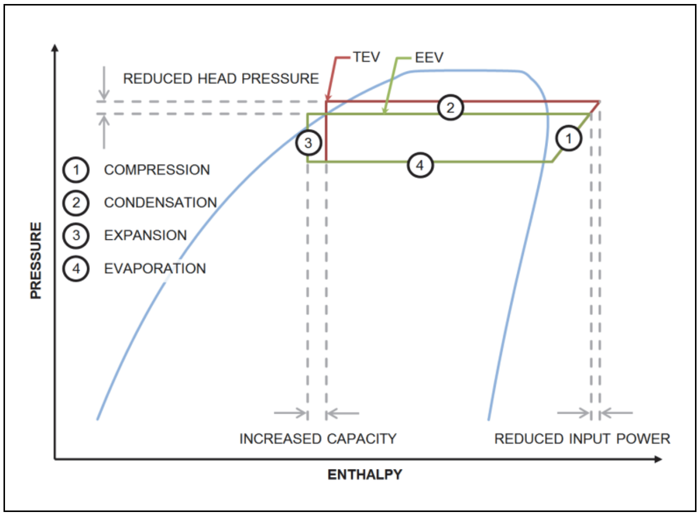
Both devices expand high pressure liquid into a low pressure liquid for evaporation. They do this by controlling superheat in the evaporator as the load changes. A well selected TXV works successfully across a relatively short design range, typically down to about 50% of full load. An EEV, however, is able to control over a much larger range, typically down to 10% of full load while holding superheat far more accurately than a TXV.

The EEV has significantly wider range of operation because of the construction of the valve and how it is actuated differently than the TXV. In the case of the TXV, this is by differing pressures acting on either side of a spring return diaphragm. It's a mechanical device whose range is limited by spring tension and diaphragm travel capability. For an EEV, a stepper motor is used, typically in the region of 480 steps of 0.00025 inch per step. In addition to a wide operating range, the EEV gives the added advantage of knowing the exact position of valve, which is not possible with the TXV.

Because the TXV is spring operated, to achieve precise control, the valve would need a "soft" spring to be sensitive to smaller changes in pressure. However, if the valve is to work over a large range of pressures, which is typical in dedicated or high percentage outside air applications, then a "hard" spring would be used which may not reach its limit at high pressures. It is difficult to have sensitivity of control over a large working range.

On the contrary the EEV is controlled to an exact position based on external temperature and pressure sensors at the outlet of the evaporator. At part load or at low ambient conditions, the liquid head pressure, or temperature at which our refrigerant is being condensed, can be reduced much lower than with a TXV. The result is overall improved system efficiency by reducing compressor power consumption (see line segment ② in Figure 2.1).

Figure 2.1
Expansion Valve Characteristics on Mollier Diagram



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Other Benefits of Electronic Expansion Valves

The Modine Atherion® Commercial Packaged Ventilation Unit uses an EEV with a feedback control loop from suction line pressure/temperature transducers to a microprocessor controller to provide a very wide and accurate range of refrigerant flow control to maintain proper superheat. Some of the key components are shown in Figure 3.1.

Figure 3.1
Electronic Expansion Valve & Superheat Controller

Because the system is microprocessor based with closed loop feedback, the system provides more system flexibility to further save energy and/or improve the performance of the equipment by adjusting the head pressure (condensing temperature) based on the operating mode. For example, the head pressure setpoint may be made higher in the dehumidification mode to increase hot gas reheat capacity, while operating at a lower pressure in a cooling only mode.

Some additional benefits of the EEV include:

- Precise control of superheat over a wide operating range protects the compressor from seeing liquid returning to the compressor, which can cause catastrophic damage.
- The EEV does not require field adjustments, as the microprocessor controller continuously monitors the pressure and temperature transducers at the evaporator outlet and controls the EEV to maintain the superheat at the optimum value by a self-adapting control algorithm.
- The EEVs used in the Atherion can fully seat and seal, eliminating the need for a solenoid valve that would be required in conjunction with a TXV to prevent refrigerant migration during unit off times in cold ambient.

Summary

Electronic expansion valves offer a number of benefits over traditional thermostatic expansion valves that can lead to energy savings and precise control. Some of the benefits of EEVs over TXVs include:

- Optimum control of superheat over a wide operating range.
- Increased efficiency by lowering head pressure, especially at part load and low ambient conditions, which reduces compressor power consumption.
- Reduced compressor power equates to lower operating costs.
- Microprocessor controller with self-adapting control algorithm to eliminate the need for field adjustments of the expansion valve.
- Control flexibility that allows for different head pressure setpoints for different applications. This can help improve hot gas reheat capacity in dehumidification modes or reduce energy use during cooling only operation.
- Prevents “flooding the evaporator” to protect the compressor from liquid refrigerant being returned to the compressor if not being fully evaporated.

EVERY Modine Atherion® Commercial Packaged Ventilation Unit uses a microprocessor controlled EEV.

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