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Reducing Pressure Drop in Suction Lines

Suction regulating valves, in conjunction with step motors, can reduce pressure drop in suction lines and increase efficiency

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Manufacturers of refrigerated systems and cases continuously strive to improve equipment efficiencies. One recent improvement is a case that operates more efficiently by operating at higher suction pressures. Efficiency losses are caused by a lower suction pressure at the compressor inlet, requiring more horsepower for the same net refrigeration effect.

In addition to this, you should remember that pressure drop in the suction line is an energy penalty that should not be ignored. This article will address methods for minimizing suction-line pressure drop and raising common suction set points.

Evaporator Temperature °F	R-22	R-404A	R-404A
	Suction line pressure loss		
	2 psi	2 psi	1 psi
	Percent compressor capacity loss		
40	3.1	---	---
15	5.1	3.6	1.8
-25	17.6	8.8	4.4

The chart illustrates the percent of compressor capacity loss from operating the common suction pressure below design conditions. This also can be thought of as a percent increase in required horsepower for the same load due to suction line losses.

EPR History

Evaporator pressure regulating (EPR) valves have been used for years in supermarket applications with multiplex systems where different evaporator temperatures are required to operate from a common suction pressure. The purpose of an EPR valve is to control the evaporator pressure or valve inlet pressure at a level to produce the desired discharge air temperature in the refrigerated case.

Years ago, EPRs were large, bulky, internally piloted valves and required several psi of pressure drop to drive them open to their rated capacity. The introduction of the externally piloted valves in the 1980s greatly improved system efficiencies by minimizing pressure drop in the suction line. This was accomplished by utilizing high-pressure discharge gas to pilot a normally open valve. These valves are held open by a spring and are forced closed by high-side gas pressure.

The introduction of externally piloted EPR valves allowed manufacturers and supermarket owners to realize energy savings due to the low-pressure drops at which these valves would operate. The pilot bleed to suction is minimized through a small orifice. Recent improvements to internally piloted valves have helped reduce the required pressure drop to open these valves. However, driving an EPR valve requires pressure drop for internally piloted valves, or discharge gas for externally piloted valves.

The pressure control of pilot-operated valves was such that they also improved control of the temperature of the evaporator. In addition to controlling evaporator flow, these valves also have the ability to close for defrost on systems utilizing gas defrost. Pilot-operated EPR valves also can be driven full open for dual-temperature applications with the use of small pilot solenoid valve for externally piloted valves, or an electric open feature for internally piloted valves.

The supermarket industry's ultimate desire is to control discharge air temperature instead of evaporator pressure. The U.S. Food and Drug Administration Food Code concerning product temperature is prompting further interest in close discharge air control.

A new generation of suction regulating valves has been designed for true temperature control in the supermarket display case. These valves are operated by a step motor and often are referred to as electric evaporator pressure regulators (EEPR).

Although these valves are referred to as evaporator pressure regulators, they actually control the discharge air in the refrigerated case. The EEPRs regulate the saturated pressure in the evaporator to provide the required temperature at the discharge air sensor in the refrigerated case. The valve operator currently used is a bipolar step motor. A controller that continually monitors case discharge air as well as other system parameters drives the valves.

Step Motor Operation

The step motor operates by moving the motor in discrete steps; it does not rotate continually but stops at positions predetermined by the controller algorithm. These discrete steps give the motor its name. A commonly used motor for driving valves is the bipolar motor due to its torque and efficiency for the motor's size and power input.

Bipolar step motors are constructed with two separate windings. The two windings are energized such that the permanent magnet rotor of the motor aligns with a set of electromagnetic poles and stops. Permanent magnet step motors will maintain valve position when power is removed.

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This "brake" effect allows controllers to be simple and use less energy. The controller can continue sequencing power to the windings to step-rotate the motor. Depending upon how the windings are sequenced, the motor will rotate in the clockwise or counterclockwise direction.

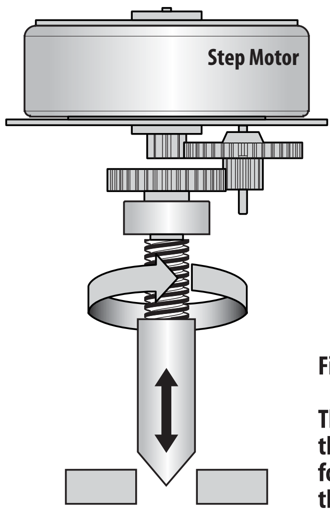


Figure 1

The lead screw is driven through gear reduction for additional power to the valve.

A step motor may have as many as 100 electromagnets around the rotor resulting in an angular rotation as small as 3.6 degrees between steps. The motor then drives a lead screw that converts the angular motion into linear motion with a resolution as fine as 0.0000783 inches per step. The lead screw may directly open or close a valve or the lead screw may be driven through a gear reduction for additional power to the valve (see Figure 1).

It should be noted that bipolar motors have four colored lead wires. The controller switches the polarity on the leads to drive the motor in the proper direction. The four colored wires represent 16 possible combinations for attaching the wires to the controller. Only four combinations will properly drive the motor. Four other combinations will reverse the direction of the motor and the other eight will prevent the motor from stepping. For proper motor wiring, refer to the service and installation manual from the controller manufacturer.

The number of steps a valve will open is stored by the controller and the controller can return the valve to any previous position at any time. Over time, the motor step position and controller step position may differ slightly by a few steps. This is due to slip found in all motors. Since the controller is still modulating the valve in response to the temperature, the valve continues to control the desired set-point temperature (see photo at right).

To prevent the controller and motor step position from differing too greatly they are periodically synchronized. This is accomplished every time the valve is instructed to close for defrost or to move to the 0 percent open position. When this occurs, the controller will overdrive the valve in the closed direction an additional 5 to 10 percent from its last known position.

The valve is designed for this overdrive feature without harm to the valve motor or drive train. Typically, step motor valves also are instructed to overdrive closed any time the controller is powered up. This allows the valve and controller to synchronize on startup or after a power failure.

Step motors have been used for many years in air conditioning chiller applications as EEVs. The step-motor driven EEPR has been used in transport refrigeration for several years on sea containers and truck/trailer units due to its corrosion resistance, robust design, and its ability to be easily controlled.

Step motor control also delivers much tighter temperature control as required in refrigerated sea containers that may hold perishables for several weeks. Step motor valves are ideal for meeting the stricter regulations on case temperature in refrigerated display cases.

Product Integrity and Store Setup

In addition to improved system efficiencies, step motor valves can improve product integrity through close temperature control and simplify store setup.

EEPR valves deliver quick pulldown since they are sensing discharge air, not pressure. EEPR valves will remain fully open until the temperature drops to the valve's set point. This means the evaporator pressure may drop below its normal modulating pressure down to as low as the common suction pressure after defrost.

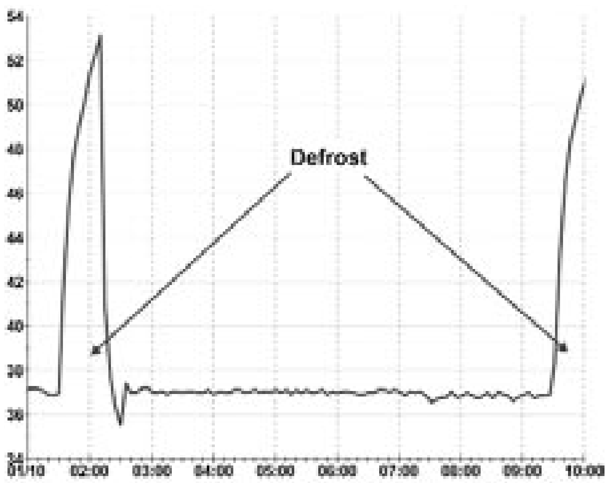
The number of steps a valve will open is stored in a controller, which can return the valve to any previous position at any time.

The mechanical EPR valve will begin to throttle to control pressure at its set point when the discharge air temperature is not yet satisfied, resulting in a slower pulldown. This ability for quicker pulldown after defrost keeps the product at more consistent temperatures.

You also can quickly change set points for dual-temperature applications by changing the controller set point. This also may be done remotely through a dial-up connection.

Controlling case discharge air using EEPRs has several benefits. From an energy-efficiency standpoint, EEPRs do not require flow or pressure drop to open. This allows EEPRs to be sized for minimal pressure drop, so the system can be operated at a higher suction pressure.

Discharge Air Temperature Curve (Set Point 37°F)



This graph illustrates a temperature curve of discharge air on an actual produce case. The spike in temperature indicates the defrost period.

System efficiencies also can be realized with EEPRs since the coil pressure and temperature is variable and the discharge air is fixed. As the coil TD decreases with a decrease in load, the EEPR valve will throttle to maintain discharge air temperature and raise the coil pressure and saturated temperature.

The rack controller then can be adjusted to automatically raise the suction set point for additional energy savings. This often is referred to as set point float. Operating at higher evaporator temperatures also may result in less moisture pick-up at the coil and fewer defrosts.

Refrigeration technicians should remember that although EEPR valves control discharge air temperature, proper air temperature does not mean that coil performance is maximized. Coil performance cannot be maximized until the TEV is set to the proper superheat. It is essential that the superheat be checked and set on all display cases to the manufacturer's recommended superheat setting. Only then will the coil surface area be maximized.

Improper superheat, if high, can lead to oil logging, high discharge temperatures, oil slugging and extended pull-down time. High superheats require the system to be operated at a lower suction pressure to overcome the lack of coil surface being utilized. This requires additional horsepower. Low superheats, for reasons of floodback and associated problems, should be avoided.

Setting EEPR valves is much simpler than setting a mechanical EPR valve. Setting EPR valves requires an accurate gauge to dial in the desired evaporator pressure for each system circuit. There also will be a delay after an adjustment is made depending on system conditions before a pressure change is reflected at the pressure gauge.

Furthermore, the EPR valve might require additional fine-tuning after setting superheats for the discharge air to be in a desirable range. The step motor valve requires only the set point to be input to the controller. The controller does the rest of the work.

Rack controllers may use a proportional integral derivative (PID) strategy within their controller to drive the valve. This type of control must have the proper PID settings to precisely maintain the temperature. Step rates and number of steps also differ between valve manufacturers. If experiencing control problems, consult the valve manufacturer for specific valve settings.

Although case controllers were the first on the market, rack controllers are gaining in popularity due to their low cost and ability to control multiple valves.

For more additional information, contact Sporlan Valve Company at 636-239-1111 or refer to Sporlan's 100-series product bulletins.

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