Everything You NEED to KNOW About TXVs

With the higher SEER air conditioners, technicians need to reacquaint themselves with thermostatic expansion valves

BY AL MAIER

Before the 13 SEER minimum efficiency standard, thermostatic expansion valves (TXVs) were rarely seen in residential air-conditioning systems. They were used on some high SEER systems and on heat pumps (usually on the outdoor coil), but these represented a relatively small portion of the overall market.

However, that has changed dramatically now that virtually all new 13 SEER equipment will be manufactured with TXVs. As a result, there is a growing need for many service technicians to reacquaint themselves with TXVs in terms of operation, troubleshooting and replacement.

Refrigerant flow

Metering the flow of refrigerant to the evaporator is the sole function of a TXV. It must meter this flow at precisely the same rate the refrigerant is being vaporized by the heat load. The TXV does this by keeping the coil supplied with enough refrigerant to maintain the right superheat of the suction gas leaving the evaporator coil.

There are three forces that govern the TXV operation. Refer to Figure 1, which shows the basic force balance diagram of a TXV. In the chart:

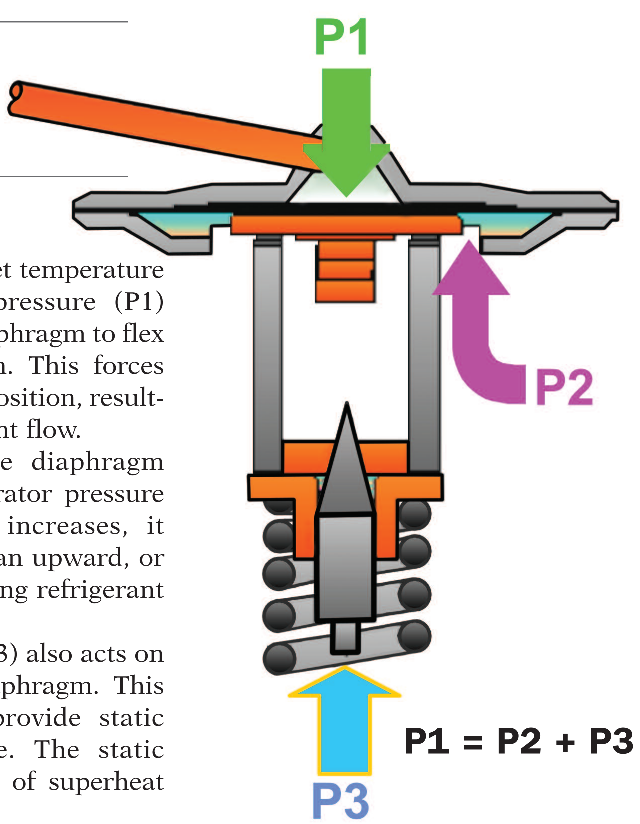
P1: Power element and remote bulb pressure.

P2: Evaporator pressure.

P3: Superheat spring equivalent pressure.

For the valve to be stable, the forces need to be balanced, or P1 = P2 + P3.

Figure 1
In a TXV, the forces need to be balanced for it to be stable.



As the evaporator outlet temperature becomes warmer, the pressure (P1) increases, causing the diaphragm to flex in a downward direction. This forces the valve pin in an open position, resulting in increased refrigerant flow.

The underside of the diaphragm always senses the evaporator pressure (P2). As this pressure increases, it forces the diaphragm in an upward, or closing position, decreasing refrigerant flow.

The spring pressure (P3) also acts on the underside of the diaphragm. This spring is adjusted to provide static superheat for the valve. The static superheat is the amount of superheat needed to initiate movement of the valve pin to just start to move. This is defined as .002-inch of stroke.

➤ **Gradient.** The amount of superheat required to move the pin from the static set point to the rated stroke is called gradient. Figure 2 depicts how a TXV regulates flow in response to changing superheat.

Starting from the origin, no change in valve stroke occurs as the superheat slowly increases. It is not until the static setpoint is reached that the valve begins to open. From this point forward, further increase in superheat results in a proportional

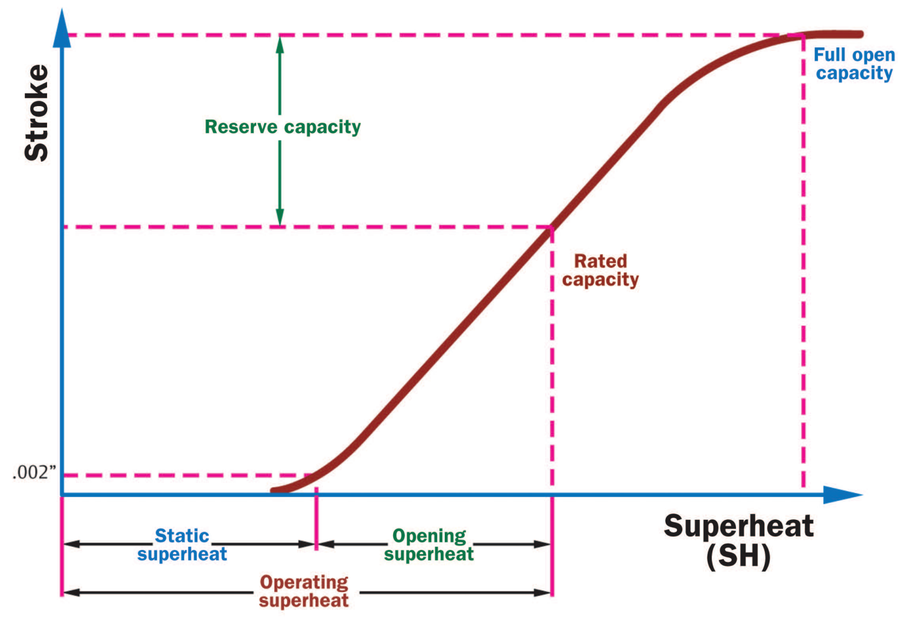


Figure 2
A TXV regulates flow in response to charging superheat.

increase in valve stroke until the maximum stroke position is attained.

Gradient is an important aspect to TXV performance in a system. Too low a gradient and the valve will be unstable and tend to "hunt" (more on this later). If the gradient is too high, more superheat will be needed for the valve to open, resulting in high operating superheat and poor evaporator efficiency.

➤ **Measuring superheat.** Since good superheat control is the criterion of TXV performance, accurate measurement of the superheat is vital. This involves four steps, as shown in Figure 3. They are:

1. Measure the suction pressure at the evaporator outlet with an accurate gauge. If a gauge connection is not available, a tee can be installed in the equalizer line.

2. Referring to a P/T chart for the refrigerant used in the system, find the saturation temperature that corresponds to the pressure observed in step 1.

3. Measure the temperature of the suction line at the remote sensing bulb. This can be done with a strap-on type thermometer or an electronic device.

4. Subtract the saturation temperature determined in step 2 from the suction gas temperature measured in step 3. The difference is the operating superheat.

➤ **Internally and externally equalized TXVs.** In a system with a relatively small evaporator, the pressure drop across that evaporator is so small you can assume it is zero. Therefore, the TXV outlet pressure and evaporator outlet pressure are equal.

In most a/c systems, the evaporators are quite large and, therefore, have significant pressure drop across them

By drilling a small bleed passage between the underside of the diaphragm and the outlet of the valve, you can sense the pressure internally and eliminate the need for an external connection. Valves produced in this manner are termed internally equalized valves.

In most a/c systems, the evaporators are quite large and, therefore, have significant pressure drop across them. For the TXV to sense the evaporator outlet pressure, a separate line is needed from the suction line (near the TXV bulb location) to the external equalizer connection on the valve body.

If a distributor is used to supply refrigerant to various evaporator circuits, an externally equalized valve must be used. Distributors typically have between 15 psi and 30 psi pressure drop across them. Hence, use them only with externally equalized valves.

➤ **Balanced-ported valves.** With a conventional TXV, the pressure differential across the valve results in a force that tends to "open" the valve. As operating conditions vary, this pressure differential changes and results in a variation of the original superheat. Engineers have developed the balance-ported TXV to compensate for this (Figure 4).

In this design, the inlet pressure is applied across the valve pin as well as an undercut on the push-rod. Since these forces are in opposite directions, they cancel or balance one another resulting in no change in superheat, regardless of operating conditions.

Balanced-ported valves are ideal for use in systems that operate over large changes in operating conditions. An example of this is a commercial a/c system that must operate both winter and summer, resulting in system operation under widely varying head pressures.

Troubleshooting TXVs

There are really only three failure modes that a TXV can experience:

1. Starving. This is defined as insufficient refrigerant flow causing high superheat at the evaporator outlet. Symptoms include high superheat at the compressor inlet, high discharge temperature and possibly compressor overheating (the protector trips).

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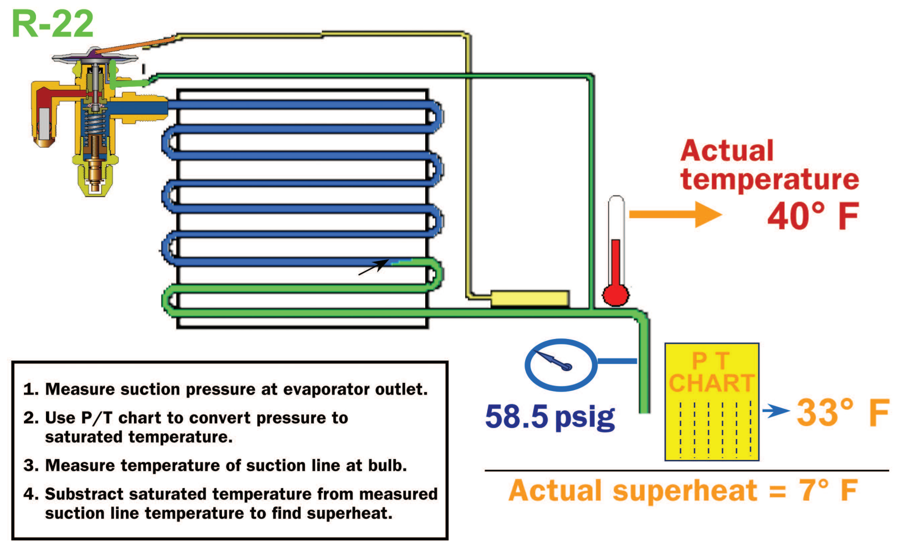


Figure 3
Four steps are required to accurately measure superheat.

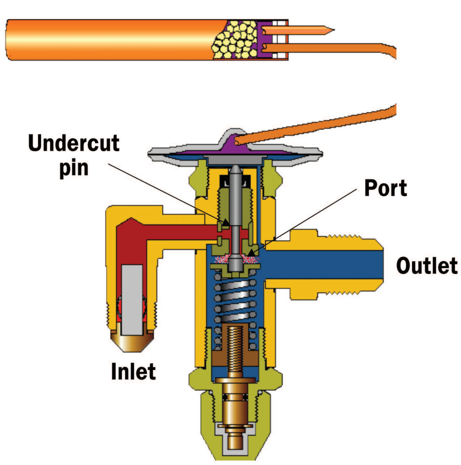


Figure 4
The balanced port TXV compensates for varying operating conditions.

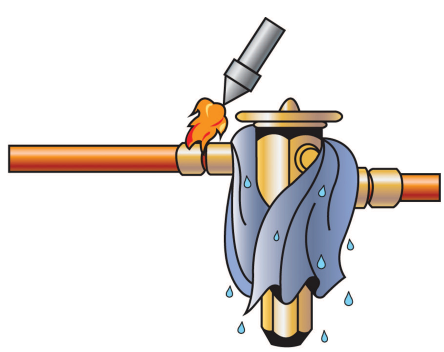


Figure 5
Wrap the valve with wet rags to avoid overheating.

2. Flooding. This occurs when the refrigerant flow to the evaporator is so high that all of it can't evaporate within the coil. The result is liquid refrigerant getting back to the compressor. Symptoms include low evaporator superheat, diluted oil and noisy compressors. If not corrected, this can lead to permanent compressor damage.

3. Hunting. When the superheat in an operating system is constantly changing from little or no superheat to very high superheat, it is called hunting. You can easily recognize this by noting extreme cyclic changes in the evaporator or suction pressure.

Hunting is caused by many factors, but usually occurs when the valve is oversized for the load. Before condemning a valve for this symptom, make certain the evaporator is clear of frost and has proper airflow since these conditions will result in very low loads potentially resulting in a "good" valve hunt.

Checking TXV operation

If a TXV is suspected of working properly, checking the superheat is the only way to know for sure. Do this with accurate instrumentation to get meaningful results.

Check the a/c equipment manufacturer's installation and service manual to verify the acceptable superheat for that particular model. As a rule of thumb, operating superheats between 8° F to 12° F is considered normal.

Some "tips" to help in troubleshooting TXV performance follow:

• Check the bulb to assure it is properly connected to the suction line. If you can move the bulb by hand, then it is not secured adequately.

• Some manufacturers insulate the bulb to protect it from the effects of an airstream. If this was done by the oem, make sure the insulation is still intact.

• Check the equalizer line for restrictions (kinks) or signs of frost. A frosted equalizer line indicates internal leakage and will require replacement of the valve. You will need to repair or replace a kinked equalizer as well for the valve to operate properly.

A TXV is designed to meter the flow of liquid refrigerant. If the refrigerant at the valve inlet contains flash gas the capacity of the valve will be reduced. Make certain the system is properly charged and that some subcooling exists at the inlet of the valve before condemning the TXV.

With the use of R-410A and POE oils, there is a greater risk of dirt and contaminants being circulated within the system. Some manufacturers use inlet strainers or screens to prevent debris from clogging the valve.

If such a condition is found, clean and replace the strainer. It would also be wise to install a large filter/drier at the inlet of the TXV to prevent a recall.

Replacing a TXV

If you determine that you need to replace the valve after checking the superheat, here are some tips to assure proper replacement:

1. Whenever possible, use the valve recommended by the manufacturer of the equipment. If this is not possible, be sure the replacement has the same:

• Rated capacity.
• Refrigerant designation.
• Charge type.
• Internal/external equalizer style.

- Internal check valve (if supplied on original valve).
- Inlet/outlet connection size and type.

2. To maintain system cleanliness, replace the filter-drier whenever opening the sealed system. While this always has been a recommended service procedure, it is of even greater importance with HFC/POE systems due to the hygroscopic nature of the POE oils and their greater solvency.

3. Do not overheat the valve during the brazing process. Overheating can cause deterioration of the internal seals, which could lead to frosted equalizer lines. To avoid this:

- Wrap the valve with wet rags as shown in Figure 5.
- Keep the torch flame pointed away from the valve body.
- Never allow the torch to come in contact with the bulb.

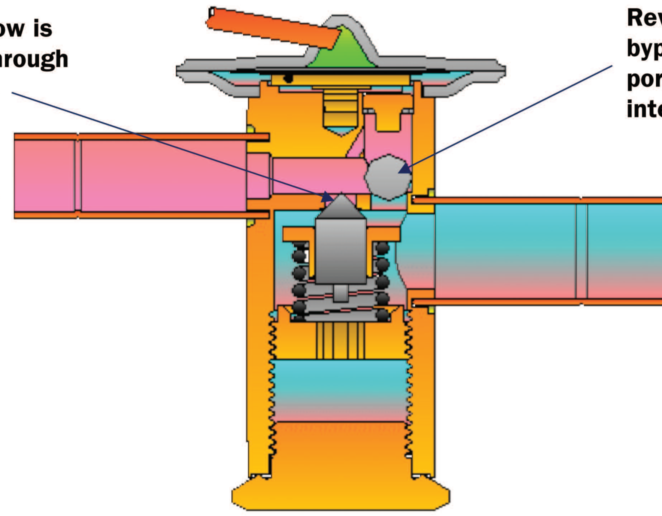


Figure 6
Here is a diagram of an internal check valve.

TXVs in heat pumps

In heat pump applications, the liquid refrigerant must flow through or around the TXV when operating in the reverse direction. Historically, this was accomplished by installing a check valve around the valve.

However, in recent years TXV manufacturers have modified their products with internal check valves. Many oems have adopted these since they eliminate joints and the potential for leaks.

Figure 6 is a cross-sectional drawing of one such valve. In the forward flow direction, inlet pressure pushes the ball against the seat, forcing it closed. All the flow must then pass through the main valve port and the valve operates as a normal valve.

When the flow is reversed the inlet pressure pushes the ball up, allowing flow through the check port. In this mode, the flow bypasses the main port and liquid will flow through the valve with only a small pressure drop.

When replacing a valve in a heat pump verify if the original valve had an internal check. If it did, be sure the replacement has one too. If none is available, use a standard valve. You must install a check valve to bypass the TXV when reverse flow is encountered.

Systems using TXVs are quickly becoming the norm in this post 13-SEER world. Understanding their function and operation will enable you to properly service systems using these devices. Follow the basic troubleshooting and replacement guidelines discussed here, to ensure optimal system performance and prevent permanent compressor damage.◆

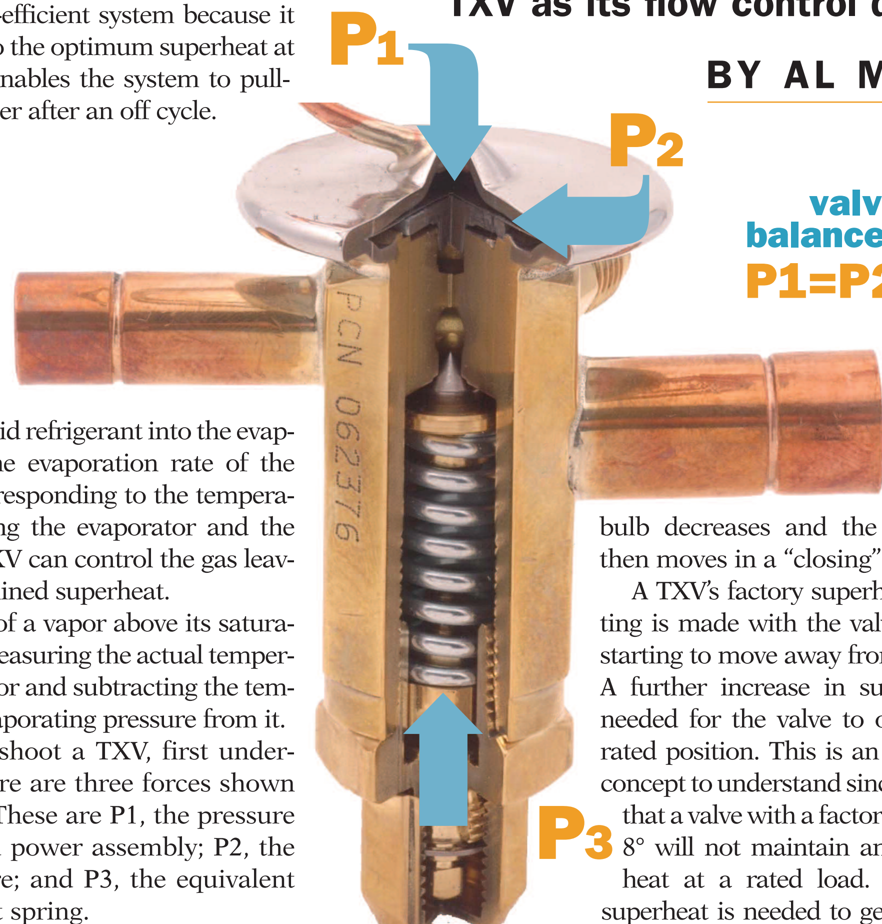
Al Maier has over 30 years of refrigeration system and component design experience. He is currently vice president of application engineering for Emerson Climate Technologies, Flow Controls Division.

TROUBLESHOOTING Thermal Expansion Valves

Here is the correct way to diagnose and troubleshoot a system with a TXV as its flow control device.

BY AL MAIER

With the advent of the 13 SEER regulations in January 2007, nearly every manufacturer of split residential air-conditioning equipment changed their designs from using flow raters to using thermal expansion valves (TXVs) for controlling the rate at which refrigerant is fed to the evaporator. The TXV enables a more energy-efficient system because it maintains the evaporator closer to the optimum superheat at all operating conditions, and it enables the system to pull-down to optimum conditions faster after an off cycle.



TXV function and operation

Although TXVs offer many operating advantages, they are viewed as a somewhat mysterious device by those not familiar with them and as a result are often replaced needlessly. The TXV has only one function. It meters the flow of liquid refrigerant into the evaporator in exact proportion to the evaporation rate of the refrigerant in the evaporator. By responding to the temperature of the refrigerant gas leaving the evaporator and the pressure of the evaporator, the TXV can control the gas leaving the evaporator at a predetermined superheat.

Superheat is the temperature of a vapor above its saturation temperature. It is found by measuring the actual temperature at the outlet of the evaporator and subtracting the temperature corresponding to the evaporating pressure from it.

In order to correctly troubleshoot a TXV, first understand how the valve works. There are three forces shown that govern a TXV's operation. These are P1, the pressure created by the remote bulb and power assembly; P2, the evaporator or equalizer pressure; and P3, the equivalent spring pressure of the superheat spring.

The pressure in the remote bulb assembly (P1) corresponds to the refrigerant temperature leaving the evaporator. As this pressure increases, it tends to move the valve in an "opening" direction. Opposed to this force on the diaphragm's underside and acting in a closing direction is the force exerted by the evaporator pressure and the pressure exerted by the superheat spring. The valve will assume a stable position when these forces are in equilibrium (P1=P2+P3).

As the temperature of the refrigerant leaving the evaporator increases above its saturation temperature—corresponding to the evaporator pressure—the pressure in the remote bulb in-creases, causing the valve pin to move in an "opening" direction. Conversely, as the refrigerant gas temperature leaving the evaporator decreases, the pressure in the remote bulb decreases and the valve pin then moves in a "closing" direction.

A TXV's factory superheating setting is made with the valve pin just starting to move away from the seat. A further increase in superheat is needed for the valve to open to its rated position. This is an important concept to understand since it means that a valve with a factory setting of 8° will not maintain an 8° superheat at a rated load. Additional superheat is needed to get the valve to "stroke" to its rated capacity.

Troubleshooting TXVs

There are three principle modes of failure of a TXV. The valve may feed too much refrigerant (flooding); it may not feed enough refrigerant (starving); or can alternately feed too much and then too little (hunting). Each of these will be discussed in greater detail:

Flooding

Flooding occurs when the refrigerant amount being fed to the evaporator is more than can be evaporated, resulting in liquid refrigerant going back to the compressor. Symptoms of flooding include frosting of the compressor shell, noisy compressors, low superheat at the evaporator, and normal- or higher-than-normal suction pressures. Causes of flooding include:

- **Undersized or inefficient compressor.** If the compressor capacity is low, the suction pressure will be higher than normal and the superheat will be low. If this condition is suspected, consult with the compressor manufacturer;
- **Low superheat setting.** On externally adjustable valves, turn the adjusting stem clockwise to increase the superheat;
- **Moisture.** Any moisture in the system can freeze in the TXV, preventing the valve from functioning as intended. If this is suspected, install a high-quality liquid-line filter drier. It also is advisable to install a liquid-line moisture indicator to enable the technician to monitor the moisture level within the operating system;
- **Dirt or debris.** Any foreign material that gets past the inlet strainer can become lodged between the pin and the port of the TXV, preventing it from properly closing. Here again, a high-quality filter drier should be installed in the system to prevent the circulation of dirt and debris and cause system malfunctions;
- **TXV seat leak.** If the pin and port do not seat properly, liquid refrigerant will flow through the valve when there should be none. Inspecting the valve may reveal dirt and debris, in which case the TXV can be cleaned and put back into service. Inspection may also reveal damage to the pin or port due to wire drawing or erosion of the pin. In such a case, the valve should be replaced;
- **Oversized valve.** Make certain the correct valve specified by the equipment manufacturer is installed in the system. A valve too large for the capacity of the system will tend to overfeed; and
- **Incorrect bulb position.** Ideally, the power element bulb should be attached to a horizontal run of suction line—immediately after the evaporator outlet. It should be in close proximity to the equalizer connection, but upstream of it. The bulb needs to be firmly attached to the suction line to maintain good thermal contact. Additionally, the bulb must not be influenced by external sources of heat.

Measuring/adjusting superheat steps

To measure superheat:

1. Determine suction pressure at the evaporator outlet;
2. Use a pressure/temperature chart for the appropriate refrigerant, and determine the saturation temperature corresponding to the pressure measured in step 1;
3. Measure the temperature of the suction line at the remote bulb location; and
4. Subtract the saturation temperature determined in step 2 from the temperature measured in step 3. The difference is the superheat.

Adjusting superheat for externally adjustable TXVs only:

1. Remove the seal cap from the bottom of the valve, exposing the adjusting stem;
2. Rotate the stem clockwise to increase the superheat—decreases flow of refrigerant; and
3. Rotate the stem counterclockwise to decrease the superheat—increases flow of refrigerant.

Starving

Starving occurs when the refrigerant amount feeding the evaporator is fully evaporated long before the outlet. Symptoms of starving include insufficient refrigeration effect—warmer than desired load temperature—high superheat at the evaporator outlet and low-suction pressure. Causes of starving include:

- **Moisture.** Any moisture in the system can freeze in the TXV, preventing the valve from functioning as intended. If this is suspected, install a high-quality liquid-line filter drier. It is also advisable to install a liquid-line moisture indicator so the technician can monitor the moisture level within the operating system;
- **Dirt or debris.** Any foreign material that gets past the inlet strainer can become lodged between the pin and the TXV's port, preventing it from correctly closing. Here again, a high-quality filter drier should be installed in the system to prevent the circulation of dirt and debris that cause system malfunctions;
- **Insufficient Delta P across valve.** If the pressure drop across the valve is too low the valve's capacity is reduced. This sometimes happens during low ambient operation when the head pressure is allowed to "float" with the ambient. To correct for this, raise the head pressure or replace the valve with one that has a larger capacity;
- **Undercharged system.** If a system is low on charge then the superheat will be high, the suction pressure low, but the system still will not provide sufficient cooling. A sight glass installed in the liquid line immediately before the TXV is the best way to determine this. "Bubbles" in the sight glass are a clear indication that the system is low on charge. On residential A/C systems, the manufacturers include a chart indicating what the correct pressures are in different operating conditions. These tables can be used to determine if the system charge is correct. Additionally, measure the subcooling at the inlet of the TXV. If there is no subcooling, that too is an indication that the system charge is low;
- **Flash gas at inlet to TXV.** Any restrictions in the liquid line leading to the TXV inlet will cause a pressure drop and result in flash-gas formation. Because the gas density is much less than that of liquid refrigerant, having flash gas feeding the TXV will reduce the valve's capacity and cause high superheat and starving. Flash gas can be found in the following ways:

1. Look for frost or moisture on the liquid line. As the flash gas is formed, it causes a refrigeration effect making the area around it cold. Since the liquid line is normally warm to the touch, a cold spot is usually a sure sign that a restriction exists at that point;

2. If a sight glass is installed,

look for bubbles. A steady stream of bubbles indicates either a low charge or vapor in the liquid line; and

3. Check for subcooling. If subcooled liquid is present at the outlet of the condenser, but not at the inlet of the evaporator, then determine where you have lost the subcooling. In some cases, the liquid line may be undersized, or liquid-to-suction heat exchange may have been lost, resulting in a loss of subcooling.

• **Plugged equalizer line.** If the equalizer line is plugged, the pressure underneath the diaphragm can be higher than the actual evaporator pressure, resulting in a valve that tends to be in a more "closed" position. To correct this, replace or repair the equalizer line;

• **Valve too small.** Check that the valve is correctly sized for the system. Replace with the proper sized valve;

• **Superheat adjusted too high.** On externally adjustable valves, turn the adjusting stem counterclockwise to decrease the superheat;

• **Power assembly failure or partial loss of charge.** If the power assembly has lost all or part of its charge, it will not generate sufficient pressure to cause the valve to "open." A tech can verify this in the field by holding the bulb in his hand while monitoring the system operating conditions. Hand warmth should cause the pressure to increase, resulting in increased refrigerant flow and an increase in suction pressure. If no change is noted, the valve may have lost its charge. This technique is only valid if the system is correctly charged and the valve has high-quality liquid refrigerant at its inlet. If it is found that the valve has lost its charge, the power assembly must be replaced. In some cases, the power assembly is an integral part of the TXV, in which case the entire valve must be replaced.

• **Cross ambient effect.** Some TXVs have special charges designed to limit the maximum operating pressure of the system. These are designated with a "W" in the charge code followed by a number—for example HW100. With charges of this type, the bulb must always be colder than the power element or the valve's body. If not, the charge can migrate from the bulb to the power element with a resultant loss of control. If this is suspected, replace the valve with a non-maximum evaporator pressure type charge—in this example, an R-22 refrigerant medium temperature (HC) or R-22 heat pump (HCA); and

• **Strainer clogged.** Dirt or debris in the refrigerant leading to the valve can result in the strainer becoming clogged. Remove and clean the strainers and add a high-capacity liquid-line filter drier to prevent recurrence.

Hunting

Hunting occurs when the TXV alternately opens and closes, causing large fluctuations in superheat. This can be caused by the difference in the time response of the system versus the TXV. Different type charges have been designed with various time constants to minimize this effect, but other factors—such as sudden changes in load or operation at low-load conditions—also can impact this. Causes of hunting include:

• **Valve oversized for application.** A valve that is too large for the application will tend to hunt. If this is suspected, replace the valve with one that is correctly sized for the application;

• **Bulb location.** Verify that the bulb is not located downstream of a P trap on the suction line. Relocate the bulb if this is found. It may also be helpful to insulate the bulb to make certain it is not affected by an air stream;

• **Refrigerant distribution.** On systems with distributors, it is not uncommon to have different circuits with largely differing loads. This can result in some circuits occasionally overfeeding sufficiently to allow liquid to reach the bulb. This, of course, will force the TXV closed until superheat is again achieved; at which time it will open. To correct this requires elimination of the distribution problem;

• **Superheat adjustment.** TXVs have their superheat set at the factory to operate correctly on most systems. At times, however, the factory setting may need to be adjusted. In most cases, increasing the superheat will minimize hunting. Turning the adjustment screw clockwise will increase the superheat; and

• **Moisture.** Any moisture in the system can freeze in the TXV, preventing the valve from functioning as intended. As the moisture freezes and then thaws, the superheat will vary erratically. The use of a high-quality liquid-line filter drier is recommended to prevent this.◆

Al Maier is vice president of application engineering at Emerson Climate Technologies Flow Controls Div. For more information call 314-569-4680 or e-mail al.maier@emersonclimate.com.