TEV & AEV Theory and Application
Catalog E-1a, January 2012
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## TEV & AEV Theory and Application

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Catalog E-1a, January 2012, supersedes Catalog E-1a, October 2007 and all prior publications.
Applications and General Information

Applications

Bi-Directional Valves

The conventional means of applying thermostatic expansion valves to a split system heat pump is shown in the schematic to the right. This system employs two thermostatic expansion valves and two check valves and could be simplified by using a single thermostatic expansion valve as depicted in the schematic at the right labeled “Bi-directional TEV.”

The drawing at the bottom right is a schematic of a heat pump employing a single externally equalized bi-directional thermostatic expansion valve controlling superheat in both the cooling and heating modes. The balanced port valve is ideally suited for this application since its internal construction prevents liquid by-pass through the external equalizer connection in both modes of operation. Only externally equalized valves can be used for this application.

When the bi-directional valve is used on a split system and installed on the condensing unit, it may be necessary to insulate the tubing between the expansion valve and the indoor heat exchanger. To decrease the pressure drop, it may also be necessary to increase the diameter of the insulated tubing. These system modifications are not necessary when the valve is applied to a single packaged heat pump.

Note: The schematics at the right show the air conditioning systems in the cooling mode. By switching the 4-way valve, flow from the compressor will be directed from the outdoor coil to the indoor coil changing the systems from cooling to heating.

General Information

Operation

The thermostatic expansion valve is a metering device designed to regulate the flow of liquid to the evaporator, at a rate equal to the evaporation of the liquid in the evaporator. This is accomplished by maintaining a predetermined superheat at the evaporator outlet (suction line) which ensures that all liquid refrigerant vaporizes in the evaporator with only refrigerant gas returning to the compressor.

The thermostatic expansion valve (see the schematic above) is installed in the liquid line at the evaporator inlet separating the high and low pressure side of the system. The thermal bulb is connected to the outlet of the evaporator, sensing the evaporator outlet temperature. The expansion valve will remain in the closed position until the superheat increases to its setpoint. Subsequently, refrigerant flow through the valve orifice will maintain a flow rate consistent with the heat load and the valve superheat setting.
General Information

If the temperature sensed by the thermal bulb increases, the flow rate will increase, maintaining the proper evaporator outlet superheat. If the temperature decreases, the valve will stroke in the closing direction in response to the reduced heat load on the evaporator, again maintaining the proper evaporator outlet superheat.

The superheated suction gas flows to the compressor where its pressure and temperature are increased due to compression. The superheated discharge gas from the compressor then flows to the condenser where heat is rejected, changing the gas into a high pressure subcooled liquid. The liquid refrigerant then flows to the expansion valve’s inlet and is metered into the evaporator at a flow rate necessary to maintain proper evaporator superheat.

How To Determine Superheat
1. Determine suction pressure at evaporator outlet with gauge. On close coupled installations, suction pressure may be read at compressor suction connection.
2. Use Pressure-Temperature Chart to determine saturation temperature at observed suction pressure. For example, with an R-22 system: 54.9 psig = 30°F.
3. Measure temperature of suction gas at the expansion valve’s remote bulb location. For example: 40°F.
4. Subtract saturation temperature of 30°F (Step 2) from suction gas temperature of 40°F (Step 3). The difference, 10°F, is the superheat of the suction gas.

Superheat
Superheat is the temperature of refrigerant gas above its saturated vapor (dewpoint) temperature. Superheat as it relates to thermostatic expansion valves, can be broken down into three categories:

- Static Superheat – The amount of superheat necessary to overcome the superheat spring force biased in a closed position. Any additional superheat (force) would open the valve.
- Opening Superheat – The amount of superheat necessary to open the valve to its rated capacity.
- Operating Superheat – The superheat at which the valve operates at normal running conditions or normal capacity. The operating superheat is the sum of the static and opening superheat. The figure below illustrates the three superheat categories. The reserve capacity, as shown in the graph, is important since it provides the ability to compensate for occasional substantial increases in evaporator load, intermittent flash gas, reduction in high side pressure due to low ambient conditions, shortage of refrigerant, etc.

Valve Setting
Parker “sets” the thermostatic expansion valve superheat at the static condition described above. Turning the adjusting screw clockwise will increase the static superheat. Conversely, turning the adjusting screw counterclockwise will decrease the superheat. Parker valves can also be adjusted at the operating point, indicated above. When a system is operating, any adjustments made will change the operating superheat. The static superheat range of adjustment is 3°F to 18°F. One full turn clockwise will typically increase superheat 2°F to 4°F.

Note: Refer to the valve’s installation bulletin for specific directions on superheat adjustment.

“W” Charge
The Parker “W” liquid cross charge can be used with evaporator temperatures from -40°F to +60°F (-40°C to +15°C). Unlike conventional cross charges, the “W” charge maintains a nearly constant superheat throughout this range of evaporator temperatures. A liquid charged bulb maintains control even when the power element is colder than the bulb.
General Information

“Z” Charge
The Parker “Z” low temperature liquid cross charge can be used with evaporator temperatures from -40°F to 0°F (-40°C to -20°C). The “Z” cross charge is designed specifically for low temperature applications; therefore, it can control the system so that the desired evaporator conditions are achieved more rapidly than the all purpose “W” liquid charge. Additionally, the “Z” charge prevents the possibility for compressor floodback on startup due to higher operating superheats at higher evaporator temperatures. Like the “W” charge, the “Z” liquid charged bulb maintains control even when the valve power element is colder than the bulb.

Since the “Z” charge is designed specifically for low temperature applications, it does not exhibit “flat” superheat control over the entire operating range. This characteristic decrease in superheat as the evaporator temperature decreases allows the system to reach the desired operating conditions quickly. Due to this “slope” in superheat control (see graph at the right above), it is possible to optimize the operating superheat for any particular application by adjusting the valve after operating conditions are achieved.

The graph above illustrates the typical superheat control characteristics of Parker thermostatic valve bulb charges.

“X” Charge
The Parker “X” anti-hunt gas cross charge can be used with evaporator temperatures from -40°F to +60°F (-40°C to +15°C). Every “X” charge is a pressure limiting, or MOP (Maximum Operating Pressure), type charge which limits flow on startup to prevent flooding and/or compressor overload. The approximate maximum evaporator operating pressure is designated in psig by the numbers which follow the “X”, e.g. “X60” has an approximate pressure limit of 60 psig. Due to the pressure limiting characteristics of these charges, each charge is usable over a specific evaporator temperature range which can be determined by referencing the MOP number and refrigerant type in the table below.

Valves with an “X” type charge should not be used where the power element could get colder than the thermal bulb. Migration of the bulb charge to the power element can occur causing a loss of valve control.

Recommended thermostatic valve charges are listed in the table below. A “-” indicates that a charge is not available for an application.

### Recommended Thermostatic Valve Charges

<table>
<thead>
<tr>
<th>Application</th>
<th>Applicable Evaporator Temperature Range °F (°C)</th>
<th>R-22/R-407C</th>
<th>R-12/R-134a</th>
<th>R-502/R-404A</th>
<th>R-410A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Temp Refrigeration</td>
<td>-40°F to 0°F (-40°C to -20°C)</td>
<td>VZ</td>
<td>—</td>
<td>SZ</td>
<td>—</td>
</tr>
<tr>
<td>Commercial Refrigeration</td>
<td>-40°F to +60°F (-40°C to +15°C)</td>
<td>VW</td>
<td>JW</td>
<td>SW</td>
<td>—</td>
</tr>
<tr>
<td>Low Temp Pressure Limiting</td>
<td>-40°F to 0°F (-40°C to -20°C)</td>
<td>VX35</td>
<td>—</td>
<td>SX35</td>
<td>—</td>
</tr>
<tr>
<td>Commercial Pressure Limiting</td>
<td>-10°F to +60°F (-20°C to +15°C)</td>
<td>VX100</td>
<td>JX60</td>
<td>SX110</td>
<td>KX200</td>
</tr>
<tr>
<td>Air Conditioning</td>
<td>+30°F to +60°F (0°C to +15°C)</td>
<td>VX100</td>
<td>JX60</td>
<td>SX110</td>
<td>KX200</td>
</tr>
<tr>
<td>Heat Pump</td>
<td>-15°F to +60°F (-30°C to +15°C)</td>
<td>VX100</td>
<td>—</td>
<td>—</td>
<td>KX200</td>
</tr>
</tbody>
</table>

|                     |                     | ZX180       | ZX200       | KX180        | ZX180  |

|                     |                     | ZX180       | ZX200       | KX180        | ZX180  |

|                     |                     | ZX180       | ZX200       | KX180        | ZX180  |

|                     |                     | ZX180       | ZX200       | KX180        | ZX180  |
Anti-Hunt Ballast Bulb

“X” Charge
The power element sensing bulb for an “X” charge contains an internal ballast material and the entire assembly is gas cross charged.

The combination of the cross charge and internal ballast results in a variable rate time constant dampening that reduces or entirely eliminates undesirable system hunt or instability caused by overfeeding or underfeeding the evaporator.

The top two graphs at the right illustrate the thermal ballast time delay characteristics. The top graph shows the bulb response to temperature change. The thermal bulb pressure will decrease rapidly when the temperature is decreased from point A to B causing the valve to modulate toward a lower flow position. As the temperature is increased back to point A, considerably more time is required to increase the thermal bulb pressure.

The second graph is an illustration characterizing the operating superheat variation of a typical refrigeration system. When the system load decreases, the suction line temperature and flow decrease and the operating superheat rises rapidly. As the suction line temperature increases, the bulb pressure will slowly increase and the operating superheat will decrease slowly to the predetermined level. This results in a sawtooth wave form which minimizes the system flood-back. After several cycles of continuous dampened amplitude, the system will operate at the predetermined superheat with minimum suction line fluctuations (anti-hunt).

The bottom graph illustrates the operation of a non-ballast bulb charge. Since it will respond quickly in an opening and closing manner, the valve may overfeed and underfeed causing undesirable system fluctuation referred to as hunt.
Internally and Externally Equalized Valves

Internally Equalized Valves
The outlet pressure of an internally equalized valve is transmitted to the underside of the diaphragm through an equalizer hole inside the valve body. Internally equalized valves should only be used with single circuit evaporators having a pressure drop no greater than the equivalent of a 2°F saturated temperature drop.

The equalizer passageway is the communication link from the evaporator to the underside of the diaphragm. Internally equalized valves incorporate an internal passage from the outlet valve cavity to the underside of the diaphragm. In applications where the pressure drop between the valve outlet and the evaporator outlet is negligible, internal equalizers are effective to communicate the actual evaporator pressure to the underside of the diaphragm. In the schematic to the right, the bulb pressure F-1 corresponding to refrigerant R-22 at 37°F is 64 psig. The evaporator pressure F-2 is 52 psig at 28°F and the superheat spring force F-3 is set for an equivalent pressure of 12 psig. The valve is now in balance with 64 psig above and below the diaphragm and the superheat setting is 9°F.

The following schematic shows the application of an internally equalized valve with a pressure drop of 10 psi across the evaporator. The evaporator saturated inlet pressure is 62 psig at 35°F. The superheat spring force (F-3) is set for an equivalent of 12 psig. The pressure under the diaphragm for an internally equalized valve would total 74 psig (12 plus 52 psig). The remote thermal bulb pressure F-1 is 74 psig, for balanced conditions. This bulb pressure corresponds to a saturation temperature of 44°F. The pressure at the outlet of the evaporator is only 52 psig, 10 psig below the inlet pressure. The saturation temperature at 52 psig is 28°F. Use of an internally equalized valve will result in a superheat of 16°F (44°F - 28°F) at the evaporator outlet. Accordingly, the internally equalized valve used with a high pressure drop evaporator will cause excessive superheat and corresponding capacity loss.

Externally Equalized Valves
Employment of an externally equalized valve is required to control the evaporator at the proper superheat when the pressure drop of the evaporator is high, i.e. greater than the equivalent of a 2°F saturated temperature drop. The externally equalized valve will sense the pressure at the outlet of the evaporator. In the schematic below, the pressure under the diaphragm now totals 64 psig (12 plus 52 psig). The thermal bulb pressure above the diaphragm force, F-1, also equals 64 psig while the corresponding saturation temperature is 37°F.

The superheat at the outlet of the evaporator is 9°F (37°F - 28°F). The use of a valve with an external equalizer has decreased the superheat from 16°F to 9°F and restored the superheat to the original value of 9°F with the same spring force of 12 psig.

Note: Never cap an external equalizer connection.

Refer to the evaporator manufacturer’s installation bulletin or look for a service port near the outlet of the evaporator for external equalizer installation.
General Information – TEV

Off Cycle Unloading (Bleed)
Internal bleed orifices are used to equalize the high and low side pressures during the off cycle so that low starting torque compressors can start. Systems such as air conditioners and heat pumps sometimes require a TEV with internal bleed due to the frequent cycling that occurs.

Consult the factory if a bypass bleed is required.

The required bleed size is a function of high and low side system volumes, refrigerant charge, and pressure difference across the valve prior to shutdown. These variables affect the equalization time required by a time delay device or thermostat reset. Bleed sizes are usually specified as a percentage of the nominal valve capacity and can range from 5% to 50%, although 15% to 30% is more commonly specified.

At the end of the valve model number, a letter “B” followed by digits indicates an internal bleed. These digits represent the bleed capacity as a percentage of the valve’s nominal capacity.

Example: HA 1-1/2 VX100 B20 – Bleed orifice 20% of 1-1/2 tons, or a 0.3 ton bypass bleed.

Because the internal bleed is an additional flow path in the valve, adding a bleed will increase the capacity of the valve. Thus, a 1.5 ton valve with a 20% bleed is actually capable of 1.8 tons.

Bulb Location and Installation
Since the control response of the bulb is critical for satisfactory operation, care should be taken in its mounting and positioning.

- Always make sure the suction line is cleaned before clamping the bulb in place.
- On lines that are 1/2” O.D. or smaller, the bulb may be installed on top of the line or side mounted (preferably at the 3 o’clock position).
- On lines that are 7/8” O.D. or larger, the remote bulb should be installed at approximately the 4 or 8 o’clock position.
- Never mount a bulb on the bottom of suction lines because a mixture of refrigerant and oil may be present at that point, especially on smaller lines.
- Avoid mounting the bulb on vertical lines or close to reversing valves.
- The bulb should be as close to the evaporator outlet as possible (generally 3 to 6 inches).
- On systems that have multiple evaporators, the bulb must be mounted on the suction line of the evaporator which it controls. Do not mount the bulb on the common suction line.
- Install traps on vertical risers. (See the illustration below.)
Balanced Port Valves

Parker balanced port thermostatic expansion valves can be applied to a broad range of air conditioning and refrigeration systems. They exhibit exceptional performance over a wide variation in load on a specific system, or the same valve can be applied to a large range of application capacities.

Features of the balanced port valve include:

- Compensates for wide variations in high to low side pressure.
- Compensates for wide variations in evaporator load.
- Compensates for changes in liquid line temperatures.
- Compensates for wide variations in pressure drop across the thermostatic expansion valve.

Operation

Conventional thermostatic expansion valves respond to four forces (see the illustration below):

- **Force 1** — Thermal bulb pressure times the diaphragm effective area. This force acts on the top of the diaphragm which tends to open the valve.
- **Force 2** — Evaporator pressure times the diaphragm effective area. This force acts on the underside of the diaphragm. It tends to close the valve. This force is transmitted to the diaphragm through the valve body with internally equalized valves and through the external connection on externally equalized valves.
- **Force 3** — Superheat spring force which assists in closing the valve.
- **Force 4** — High and low side pressure differential times the port area. This differential pressure force tends to open the valve.

Balanced port valves respond to forces F-1, F-2 and F-3 in a manner similar to conventional valves; however, they take a unique approach to the F-4 force created by high and low side pressure differentials across the valve orifice. (See figure below.) The area of the Parker Power Piston® is equal to the area of the port diameter. This force is cancelled out as the piston force and the force across the port are equal and opposite.

As inlet pressure changes, the F-4 force changes but always remain equal and opposite and is cancelled out, therefore, variations in valve system pressures do not have any effect on the static superheat setting of the valve.

The change in operation superheat is only affected by operating changes in load requirements. In contrast, unbalanced (conventional) valves will also change operating superheat due to the changes in inlet pressure F-4. This additional superheat change increases considerably as the port diameter and valve capacity increase.
Valve Selection Procedure

1. Determine application information.

It is important to obtain specific system information in order to choose the correct valve for a particular application. Listing this information will aid in making choices such as capacity, charge, and fitting configuration which will result in the best possible valve choice for the application.

- **System refrigerant.** Determine what refrigerant will be used in the system.
- **Evaporator load or system capacity.** Determine the design system capacity.
- **Evaporator operating temperature/pressure.** Determine the design evaporator temperature and pressure. Evaporator temperature is usually specified, or can be calculated by subtracting the “TD” temperature from the desired environment control temperature. Evaporator pressure can be determined by looking up the associated saturation pressure for the known evaporator temperature in a refrigerant table.
- **Evaporator pressure drop, distributor pressure drop.** Determine any pressure drop which will occur after the refrigerant exits the valve, such as distributor pressure drop and evaporator pressure drop.
- **Condenser operating pressure/liquid temperature.** Determine the condenser pressure and liquid temperature. When determining the liquid pressure, consider any factors which may affect the pressure entering the valve; such as friction losses, vertical lift, and pressure drop across system components such as driers, sight glasses, and other valves.

2. Determine the required nominal capacity and charge for the valve.

### Refrigerant Liquid Temperature Entering TEV

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>0°F</th>
<th>20°F</th>
<th>40°F</th>
<th>60°F</th>
<th>80°F</th>
<th>100°F</th>
<th>120°F</th>
<th>140°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-22</td>
<td>1.57</td>
<td>1.45</td>
<td>1.34</td>
<td>1.23</td>
<td>1.12</td>
<td>1.00</td>
<td>0.88</td>
<td>0.76</td>
</tr>
<tr>
<td>R-407C</td>
<td>1.58</td>
<td>1.45</td>
<td>1.32</td>
<td>1.18</td>
<td>1.04</td>
<td>0.89</td>
<td>0.74</td>
<td>0.57</td>
</tr>
</tbody>
</table>

### Pressure Drop (PSIG)

#### 20°F

<table>
<thead>
<tr>
<th>Valve Type</th>
<th>Orifice</th>
<th>Nominal Capacity (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(E), S(E), EC(E)</td>
<td>AA</td>
<td>0.5</td>
</tr>
<tr>
<td>C(E), S(E), EC(E)</td>
<td>A</td>
<td>1 to 1-1/2</td>
</tr>
<tr>
<td>C(E), S(e), E(C)</td>
<td>B</td>
<td>2 to 3</td>
</tr>
<tr>
<td>C(E), S(e), E(C)</td>
<td>C</td>
<td>3-1/2 to 5</td>
</tr>
</tbody>
</table>

### Connection configuration (fitting types, sizes, orientations)

Determine what style connections are best suited for the application, SAE flare or ODF copper.

2. Determine the required nominal capacity and charge for the valve.

#### Selection of nominal capacity

- **Find the correct capacity table.** Refer to capacity table section in Catalog E-1 and find the correct page for the system refrigerant in either tons or kilowatts.
- **Find the correct evaporator temperature for the application.**
- **Determine the pressure drop across the expansion valve.** Deduct the evaporator pressure from the condenser pressure, then deduct pressure losses due to distributors, vertical lift, other valves, driers in liquid line, and any significant friction losses in the evaporator and condenser refrigerant lines.
- **Find correct pressure drop column.**
- **Find a capacity selection in that column which most closely matches the desired system capacity.**
- **Determine the correct type and capacity valve from the left column.**
- **Correct table capacity for liquid line (subcooling) temperature.** Subcooling will normally increase both system and valve capacities. Subcooling will also increase the density of the liquid refrigerant, increase the enthalpy difference across the evaporator and prevent flash gas at the metering device. Flash gas severely reduces the refrigerant flow through the valve orifice, decreasing valve capacity and increasing operating superheat. Correct the system design capacity for liquid line temperature with the liquid temperature correction table located on that page.
Valve Selection Procedure

Nomenclature (Example)

<table>
<thead>
<tr>
<th>Valve Model</th>
<th>Adjustable</th>
<th>External Equalizer</th>
<th>Nominal Capacity in Tons</th>
<th>Refrigerant</th>
<th>Valve Charge</th>
<th>Maximum Operating Pressure (MOP)</th>
<th>Inlet Fitting Size and Type</th>
<th>Outlet Fitting Size and Type</th>
<th>External Equalizer Size and Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>A</td>
<td>E</td>
<td>3</td>
<td>V</td>
<td>X</td>
<td>100</td>
<td>3/8&quot; SAE</td>
<td>1/2&quot; SAE</td>
<td>1/4&quot; SAE/ODF</td>
</tr>
</tbody>
</table>

Selection of charge
- Refer to pages 4 and 5 for a full explanation of charge selection.
- Select a charge which is best suited for the application. Type “W” charges are good all-purpose charges, “Z” charges are meant for low temperature applications, and “X” charges are for applications requiring a pressure limit.

1. Choose the valve configuration which best suits the application.
   - Select a model which best suits the needs of the application based on fitting type, size, and orientation. Consider physical size.
   - Determine whether an external equalizer is necessary. Pressure drops in the evaporator which exceed the equivalent at a 2°F saturated temperature drop will require an externally equalized valve for proper operation. Any system with a distributor requires an externally equalized valve.
   - Determine the full model number by combining the information.

Example of Valve Selection Procedure

2. Determine application information
   - The following information was obtained from system design constraints. The example application is an R-22 freezer which operates continuously at a temperature of 15°F. The evaporator is rated at a 10°F TD, therefore the evaporator temperature is approximately 5°F.

   - System refrigerant
     R-22
   - System capacity
     18,000 BTU/hr (1.5 tons)

   - Evaporator temperature
     5°F Evaporator pressure 28 psig
   - Evaporator pressure losses
     Distributor pressure drop 35 psi estimated
     Evaporator pressure drop 6 psi estimated
   - Condenser pressure
     225 psig
     Liquid line pressure drop 4 psi estimated
     Liquid temperature 90°F
   - Connections required
     3/8" SAE liquid line connection
     1/2" SAE evaporator connection
   - Bypass bleed requirements
     None

2. Determine the required nominal capacity and charge for the valve.

   - Find the correct capacity table
     Refer to Catalog E-1
   - Find the correct evaporator
     Refer to 0°F evaporator section (closest to 5°F design temperature)
   - Determine available pressure drop
     Condenser pressure 225 psig
     Evaporator pressure - 28 psig
     Total pressure drop 197 psig
     Subtract losses
       Liquid line -4 psi
       Distributor -35 psi
       Evaporator -6 psi
     Net pressure drop 152 psi
   - Find correct pressure drop column
     Refer to 150 psi pressure drop column
   - Find a capacity selection
     A C(E)-A valve is rated at 1.87 tons
   - Correct table capacity for liquid temperature correction
     Refer to the liquid temperature table for R-22 and find a factor of 1.06.
     1.87 tons x 1.06 = 1.98 tons.

3. Choose the valve configuration that’s best for the application.
   - Select valve model
     Choose the C(E)-A for this example.
   - Determine if there is an external equalizer
     Pressure drop after the expansion valve is 41 psi (35 psi + 6 psi). It is necessary for the valve to be externally equalized, therefore the model number for the valve will include the “E”.

   - Determine the full model number; put the information together: CE-A-VW 3/8" X 1/2" SAE

<table>
<thead>
<tr>
<th>Rainbow Charge™ Refrigerant Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
</tr>
<tr>
<td>J</td>
</tr>
<tr>
<td>V</td>
</tr>
<tr>
<td>S</td>
</tr>
</tbody>
</table>
Superheat & Hunting

Tips for Understanding and Preventing Superheat Hunting in TEVs

A common problem facing refrigeration and air conditioning service technicians and contractors is that of superheat hunting by thermostatic expansion valves (TEVs). Here is a better understanding of a commonly overlooked cause of superheat hunting and how the problem might be corrected.

Defining Superheat “Hunting”
Superheat hunting is a cyclical fluctuation in suction superheat due to varying refrigerant flow rate in the system. Superheat hunting is the result of the expansion valve (see TEV illustration below) excessively opening and closing in an attempt to maintain a constant operating condition. Hunting can be observed as regular fluctuations in suction temperature, and in extremes, suction pressure. Excessive hunting can reduce the capacity and efficiency of the system resulting in uncomfortable conditions, loss of product, and wasted energy.

Common Reasons for TEV Hunting
- **Oversized valve** – The expansion valve may be oversized for the application or operating condition of the system. If the valve capacity significantly exceeds the requirements of the system, when the valve attempts to adjust to system load it overcompensates because it is oversized.
- **Incorrect charge selection** – The charge selected does not have the necessary control characteristics and/or dampening ability to stabilize operation.
- **Undercharged system** – Intermittent loss of subcooling is causing loss of expansion valve capacity and resulting intermittent high superheat.
- **Poor bulb contact** – Loss or delay of temperature signal to bulb causes erratic and unpredictable operation.
- **An imbalanced heat exchanger (multi-circuit coil)** – An imbalance in the heat load on each circuit creates a false temperature signal to the expansion valve bulb and results in erratic operation. Since this problem is commonly overlooked in the field, a closer examination and a possible solution are in order.

### Balanced or Unbalanced Circuits? TEVs on Multi-Circuit Heat Exchangers

TEVs respond, in part, to the temperature of the suction line. At the expansion valve outlet, flow is divided into 2 or more paths (circuits) at the inlet of the evaporator by the distributor. These paths recombine as they exit the evaporator into the suction header. (See the illustration below.)

Ideally, each circuit is equally loaded and absorbs an equivalent amount of heat. If one assumes the refrigerant flow rate and heat load through each circuit is equal, then the superheat condition exiting each circuit will be equal and when all of the flow streams recombine, the result is a “true” average condition of the evaporator suction gas. When one or more circuits has a lighter heat load, some refrigerant from that circuit remains unevaporated when it exits the coil. The suction temperature where the bulb is mounted will then be lower than the “true” average of the circuits if they were all properly superheated.

A conventional balanced port thermostatic expansion valve and the three forces it responds to:

- **Force F1** – Thermal bulb pressure times the diaphragm effective area. This force acts on the top of the diaphragm which tends to open the valve.
- **Force F2** – Evaporator pressure times the diaphragm effective area. This force acts on the underside of the diaphragm. It tends to close the valve. This force is transmitted to the diaphragm through the valve body with internal equalized valves and through the external connection in external equalized valves.
- **Force F3** – Superheat spring force which assists in closing the valve.

Expansion valve flow

[Diagram of expansion valve flow]
Superheat & Hunting

Sensing a low superheat condition will cause the valve to close down because it is sensing a condition which is not superheated enough; when the valve closes down, it restricts flow to all circuits and eventually dries out the circuits which are flooding. By this time, the remaining circuits have become highly superheated due to the reduced flow rate. At the point the “flooding” circuit(s) begin to be superheated, the suction temperature rises rapidly because there is no more liquid present to falsely reduce the suction temperature.

Sensing a now high superheat condition, the valve opens to decrease superheat and the lightly loaded circuit begins to flood into the suction manifold again. Suction temperature drops rapidly again, the valve closes down again, the sequence repeating in a cyclical fashion.

Again, the ideal situation is to assume each circuit is equally loaded and absorbs an equivalent amount of heat; in reality, this situation does not always occur. There are several reasons why circuits can become unevenly loaded:

- **Poor heat exchanger design** – In this case, each circuit is not of equal length and loading.
- **Poor refrigerant distribution** – This problem occurs due to the wrong choice of distributor or feeder tubes, partially blocked passageways of feeder tubes, unequal feeder tube lengths, and/or kinked feeder tubes.

**Uneven air flow** – Air flow across the evaporator is reduced in some areas while increased in other areas. Dirty coils or damaged coil fins can have a similar effect on air flow.

**Diagnosing a Hunting Problem: Is It the Heat Exchanger?**

Diagnosing a hunting problem due to an imbalanced heat exchanger requires measuring the exit temperature of each circuit upstream of the suction manifold. To perform this process, average the temperatures of all of the circuits upstream of the suction manifold and compare this average temperature to the actual temperature of the suction manifold close to where the bulb is mounted. If the average value of the circuit exit temperatures exceeds the actual suction temperature value by more than 2°F, then there is likely one or more circuit(s) which are not completely superheated (flooding). A closer examination of the individual circuit temperatures and the associated suction pressure should reveal which circuit(s) are causing the problem.

One simple rule to remember is that the valve’s response will favor the circuit that is flooding. Because of this favorable response, a heat exchanger can be operating at a reasonable exit superheat but still have a significant loss in capacity because the expansion valve is responding to one or more flooding circuits while the other circuits remain highly superheated, and thus highly inefficient.

**Correcting the Problem**

Correcting the problem can be a difficult task. First, the service tech must recognize the cause of the problem. If not, the problem can only be compensated for and this could mean a reduction in system performance. Here are some tips for correcting or compensating for an imbalanced heat exchanger:

- If possible, examine and correct any problems with air flow, coil circuitry, and distribution such that the circuits are more evenly fed and loaded. The goal is a more consistent circuit exit temperature on all circuits. One lightly loaded circuit may be tolerable if there are, for example, eight circuits. However, this is probably not the case if there are only three.
- Adjust the superheat of the valve to a slightly higher value. Attempting to control an evaporator near to or lower than 5°F operating superheat can exceed the sensing capability of most expansion valves and result in hunting and subsequent intermittent flooding.
- If practical, move the bulb farther downstream on the suction line. Better mixing of the refrigerant prior to the bulb can “smooth” out the valve response although capacity and efficiency may not improve significantly.
Technical Information – AEV

Understanding the Constant Pressure Valve

The constant pressure valve is a vital component of many refrigeration and A/C systems. It automatically meters refrigerant to the evaporator at a rate equal to compressor pumping capacity.

The constant pressure valve contains a diaphragm, control spring (FS1), seat and valve needle or ball. The control spring, above the diaphragm, moves the diaphragm down. This moves the valve open.

The opposing force is provided by low side evaporator pressure (FE) and a constant body spring force (FS2). This moves the valve closed. During the off cycle, evaporator pressure builds and overcomes spring pressure. This keeps the valve closed until the next ON cycle. At the start of the ON cycle, the compressor quickly reduces evaporator pressure. When this pressure equals the control spring pressure, the valve begins to open.

The valve opens when evaporator pressure is just below the control spring pressure setting. This is the valve’s opening point, or setting.

Bleeds

Bleed type valves permit pressures in the system to reach a balance point during the OFF cycle. At the next running cycle, the motor starts under practically no load. This allows the use of low starting torque compressor motors.

The bleed type (or slotted orifice) valve has a small slot in the valve seat. This prevents complete close off at the end of the machine’s ON cycle, permitting refrigerant flow at a reduced rate.

Proper selection should result in a bleed and orifice which will always have control over the refrigerant flow at all standard operating conditions. Application of a larger bleed will speed equalization time, but may cause the valve to lose control at high head pressure operating conditions. Loss of control means all the flow will be through the bleed and the valve will be closed because the bleed capacity matches the compressor capacity.

How to Select Constant Pressure Expansion Valves

1. Load on the system in Btu’s per hour or in tons (12,000 Btu per hour equals 1 ton)
2. System refrigerant
3. Evaporator temperature or pressure
4. Condensing temperature or pressure
5. Pressure drop across the valve
6. OFF-cycle unloading, if required

Elevation Change and Valve Setting

The control spring in a constant pressure valve works with atmospheric pressure to move the valve in an opening direction. Any substantial change in altitude after a valve has been adjusted will alter the low side flow rate maintained by the valve.

If a low side gauge is available, adjust the valve to increase the system pressure above the sea level reading by the amount shown in the gauge pressure correction column of the table below.
**Constant Pressure and EPR Valve Applications**

**Constant Evaporator Pressure**
Parker’s constant pressure expansion valves maintain a constant evaporator pressure for applications when close control of evaporator pressure and temperature is required.

**Freeze Protection**
Parker’s constant pressure expansion valves can be used to prevent evaporator freezing, which may occur at low loads on small air conditioning applications. The valve is installed in parallel with the system expansion device to maintain a minimum evaporator pressure when flow through the main expansion device is insufficient. An accumulator to protect the compressor from liquid is recommended.

**Crankcase Pressure Limiting**
Parker’s constant pressure expansion valves can be used to limit the maximum operating suction pressure to the compressor. The valve is adjusted to open at a predetermined outlet pressure while restricting flow at higher system inlet pressures in order to protect the compressor. Non-bleed type valves are recommended for this type application.
Constant Pressure and EPR Valve Applications

Hot Gas Bypass to Evaporator Inlet
Constant pressure expansion valves control hot gas bypass in systems where temperature is extremely critical and load conditions vary widely – particularly low loads. Installed between the discharge line and the evaporator, the valve controls pressure precisely. As the load drops, evaporator pressure decreases. It throttles open to maintain outlet pressure. This action maintains the temperature of the evaporator. This application may also be used as freeze protection.

EPR - Ice Cream Machine
Parker Model 139 EPRs are specifically designed for fractional horsepower evaporator applications where precise control of evaporator pressure is required when using a primary expansion device. A typical application is in a multiple evaporator system where different evaporator pressures and temperatures are desired. The 139 EPR may be used to control at a higher evaporator pressure than is present at the compressor suction.
# Pressure Temperature Chart

<table>
<thead>
<tr>
<th>Temperature</th>
<th>R-12</th>
<th>R-22</th>
<th>R-123</th>
<th>R-134a</th>
<th>R-502</th>
<th>AZ-50</th>
<th>R-507</th>
<th>R-717</th>
<th>MP 39</th>
<th>R-401A</th>
<th>HP 80</th>
<th>R-402A</th>
<th>HP 62</th>
<th>R-404A</th>
<th>FX 10</th>
<th>R-408A</th>
<th>FX 56</th>
<th>R-409A</th>
<th>AZ 20</th>
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<td>°F</td>
<td>°C</td>
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<td>150</td>
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**How to Determine Superheat**

1. Determine suction pressure at the evaporator outlet with gauge. On close coupled installations, suction pressure may be read at compressor suction connection.
2. Use pressure temperature chart to determine saturation temperature at observed suction pressure.
3. Measure suction gas temperature on the line at the expansion valve bulb’s remote location.
4. Subtract saturation temperature (from Step 2) from suction gas temperature (from Step 3). The difference is the superheat of the suction gas. (Example uses R-22.)

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*Figures in regular type = psig Figures in bold italics = inches Hg. Below 1 ATM*
## Quick Alternate Refrigerant Reference

<table>
<thead>
<tr>
<th>ASHRAE #</th>
<th>Replaces</th>
<th>Applications</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-134a</td>
<td>R-12</td>
<td>New equipment &amp; retrofits</td>
<td>Close match to CFC-12</td>
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<tr>
<td>R-401A</td>
<td>R-12</td>
<td>Retrofits</td>
<td>Close match to R-12</td>
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<td>R-402A</td>
<td>R-502/R-12</td>
<td>Retrofits</td>
<td>Higher discharge pressure than R-502</td>
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<tr>
<td>R-404A</td>
<td>R-502/R-22</td>
<td>New equipment &amp; retrofits</td>
<td>Close match to R-502 &amp; R-22</td>
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<td>R-407B</td>
<td>R-502</td>
<td>New equipment &amp; retrofits</td>
<td>Close match to R-502</td>
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<tr>
<td>R-407C</td>
<td>R-22</td>
<td>New equipment</td>
<td>Close match to R-22</td>
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<td>R-408A</td>
<td>R-502/R-22</td>
<td>Retrofits</td>
<td>Higher discharge pressure than R-502</td>
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<td>R-409A</td>
<td>R-12</td>
<td>Retrofits</td>
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<tr>
<td>R-410A</td>
<td>R-22</td>
<td>New equipment</td>
<td>Extremely higher discharge pressures</td>
</tr>
<tr>
<td>R-507</td>
<td>R-502/R-22</td>
<td>New equipment &amp; retrofits</td>
<td>Close match to R-502</td>
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## Conversion Reference

### Temperature

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<th>Unit Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>°F = [(°C x 9) / 5] + 32</td>
<td>°C = [(°F - 32) x 5] / 9</td>
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</table>

### Energy

<table>
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<th>Unit Conversion</th>
</tr>
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<tbody>
<tr>
<td>kW = tons x 3.51</td>
<td>kPa = PSI x 6.89</td>
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<tr>
<td>Btu/hr = Watts x 3.412</td>
<td>a. Btu/min = kW x 56.92</td>
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<tr>
<td>HP = kW x 1.34</td>
<td>b. kW = HP x 0.746</td>
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<tr>
<td>1 Ton (Refrigeration) = 12,000 Btu/hr</td>
<td>c. Btu = HP hr x 2544</td>
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<tr>
<td>Watts = HP x 745.7</td>
<td>d. 1 ft. (head) = 0.433 PSI</td>
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<tr>
<td>8.34 LB. @ 68°F</td>
<td>1.08 x TD x CFM</td>
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### Water Properties

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<thead>
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<th>Unit Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of One Gallon = 8.34 LB. @ 68°F</td>
<td>Specific Heat = 1 BTU/lb-°F</td>
</tr>
<tr>
<td>EER = Btu Out/Watts - hr In</td>
<td>Q = 500 x GPM x TD</td>
</tr>
<tr>
<td>Btu = HP hr x 2544</td>
<td>1 ft. (head) = 0.433 PSI</td>
</tr>
<tr>
<td>Btu/h = Watts x 3.412</td>
<td>a. Inches of Mercury = PSI x 2.036</td>
</tr>
<tr>
<td>HP = kW x 1.34</td>
<td>b. KPa = Inches Hg x 3.39</td>
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<tr>
<td>1 Ton (Refrigeration) = 12,000 Btu/hr</td>
<td>c. Q sensible = 1.08 x TD x CFM</td>
</tr>
<tr>
<td>Watts = HP x 745.7</td>
<td>d. Q total = 4.5 x ∆H x CFM</td>
</tr>
</tbody>
</table>
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