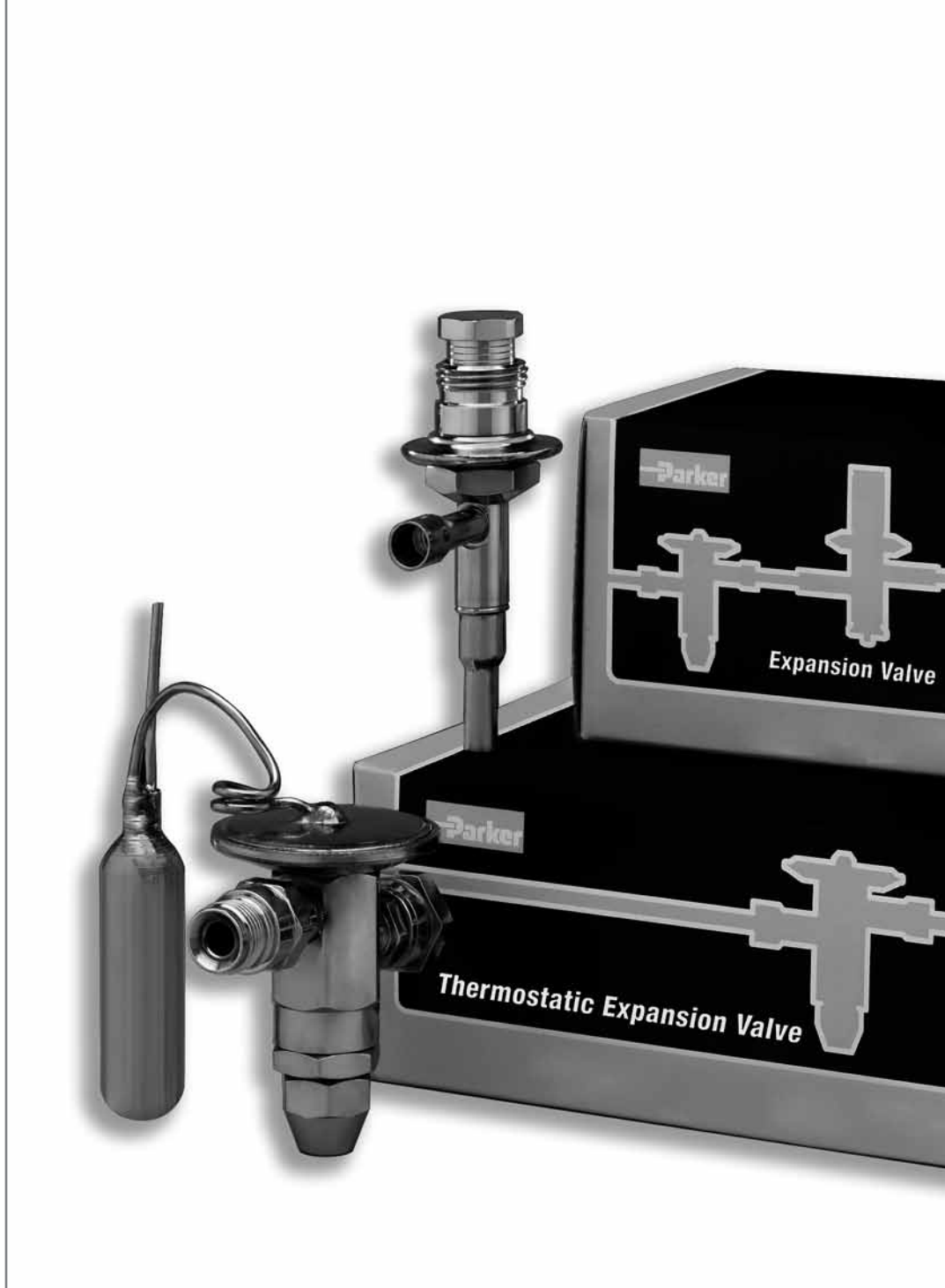


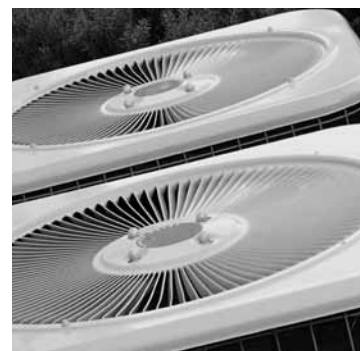


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TEV & AEV Theory and Application

Catalog E-1a, January 2012



ENGINEERING YOUR SUCCESS.

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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.

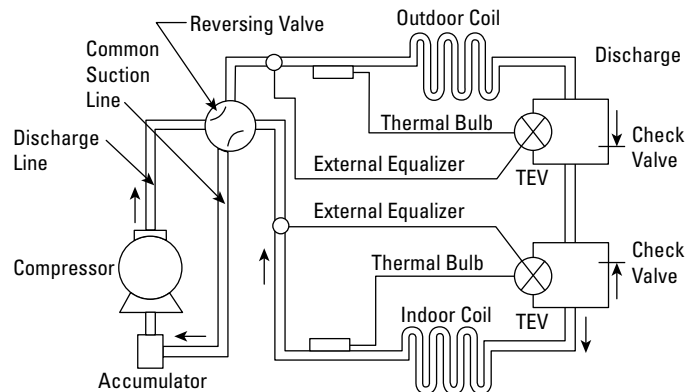
Note: The schematics at the right show the air conditioning systems in the cooling mode. By switching the 4-way valve, flow from the compressor will be directed from the outdoor coil to the indoor coil changing the systems from cooling to heating.

General Information

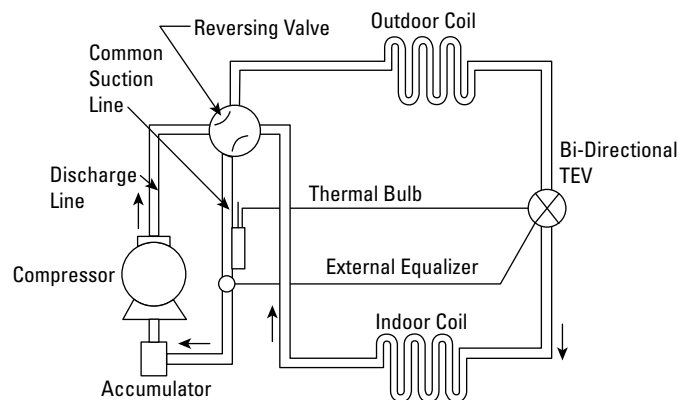
Operation

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

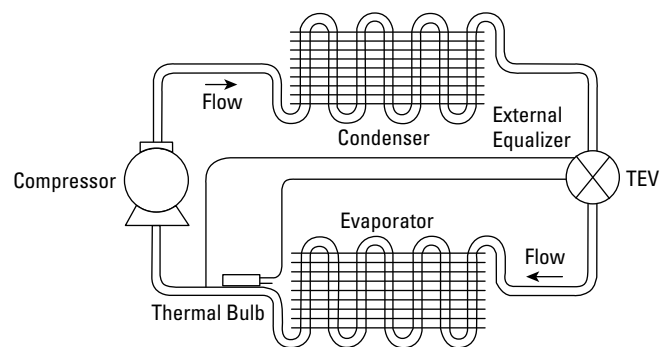
Conventional TEV



Bi-directional TEV



Thermostatic Expansion Valve



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.

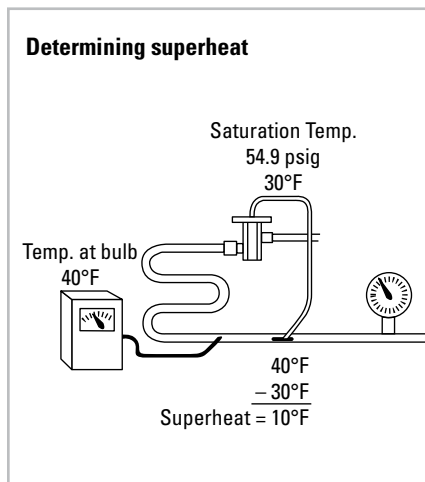
General Information

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 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

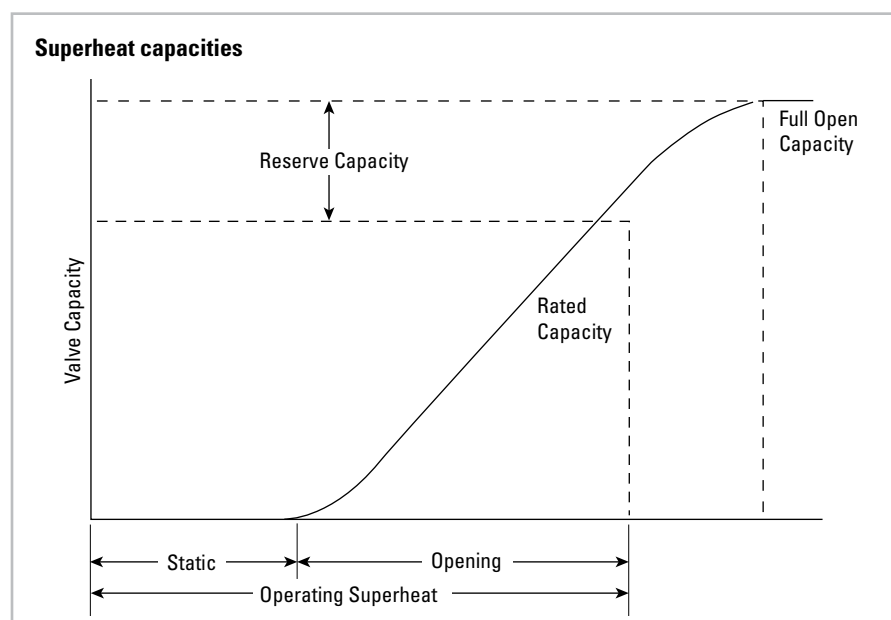
Parker “sets” the thermostatic expansion valve superheat at the static condition described above. Turning the adjusting screw clockwise will increase the

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

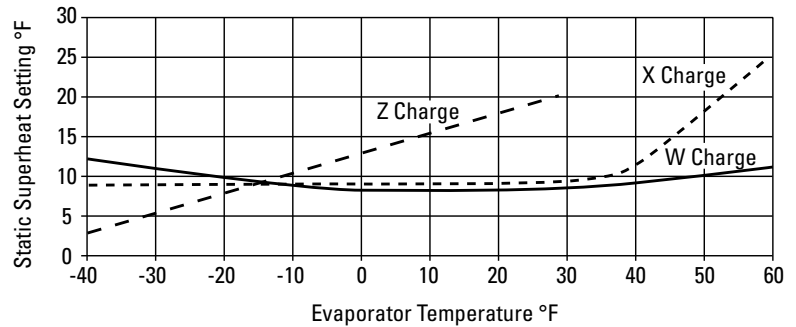
“Z” Charge

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

Parker Thermostatic Charges



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

Application	Applicable Evaporator Temperature Range °F (°C)	R-22/R-407C	R-12/R-134a	R-502/R-404A	R-410A
Low Temp Refrigeration	-40°F to 0°F (-40°C to -20°C)	VZ	—	SZ	—
Commercial Refrigeration	-40°F to +60°F (-40°C to +15°C)	VW	JW	SW	—
Low Temp Pressure Limiting	-40°F to 0°F (-40°C to -20°C)	VX35	—	SX35	—
Commercial Pressure Limiting	-10°F to +60°F (-20°C to +15°C)	VX100	JX60	SX110	KX200
Air Conditioning	+30°F to +60°F (0°C to +15°C)	VX100	JX60	SX110	KX200 ZX180 ZX200
Heat Pump	-15°F to +60°F (-30°C to +15°C)	VX100	—	—	KX200 ZX180 ZX200

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

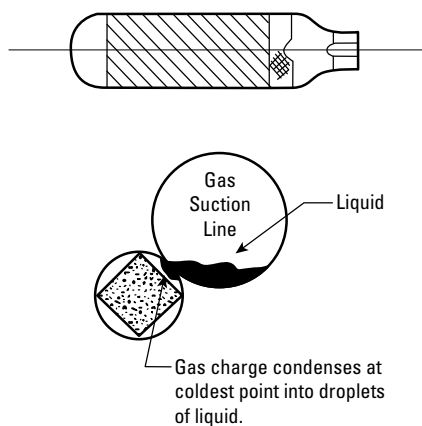
thermal bulb pressure will decrease rapidly when the temperature is decreased from point A to B causing the valve to modulate toward a lower flow position. As the temperature is increased back to point A, considerably more time is required to increase the thermal bulb pressure.

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

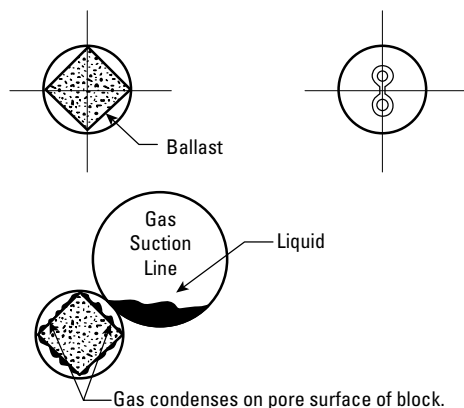
increase and the operating superheat will decrease slowly to the predetermined level. This results in a sawtooth wave form which minimizes the system flood-back. After several cycles of continuous dampened amplitude, the system will operate at the predetermined superheat with minimum suction line fluctuations (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.

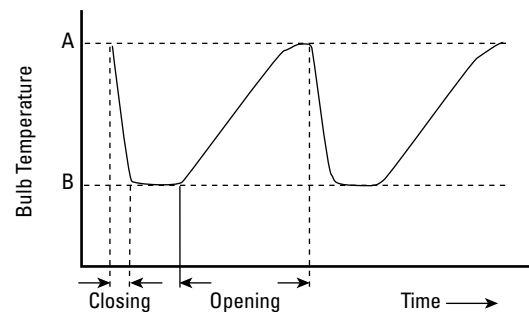
Bulb colder than ballast block



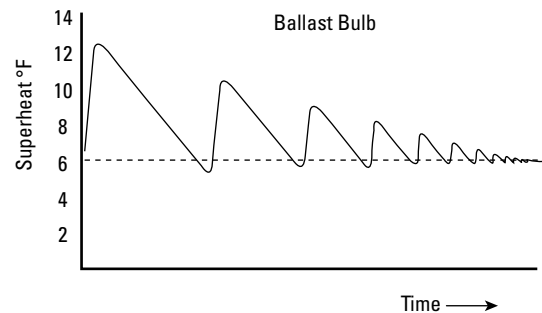
Ballast block colder than bulb



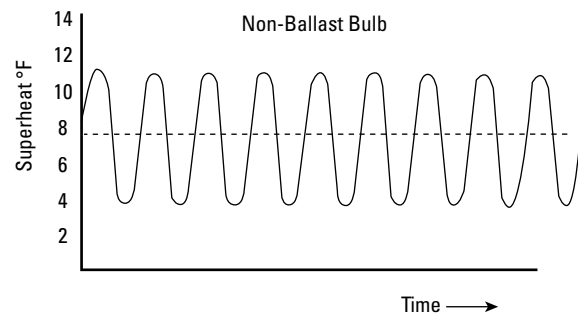
Bulb response to temperature change



Operating superheat variation of a typical refrigeration system



Operation of a non-ballast bulb charge



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 + 62 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 psi 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

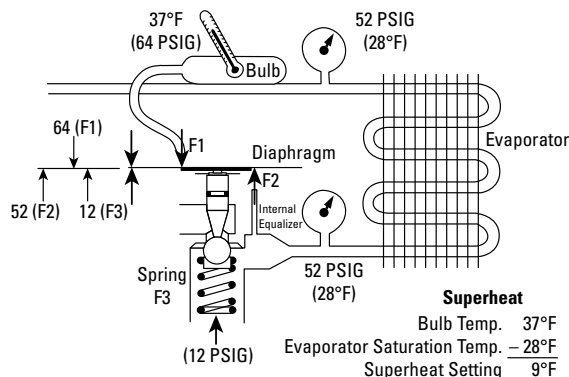
evaporator is 9°F (37°F - 28°F). The use of a valve with an external equalizer has decreased the superheat from 16°F to 9°F and restored the superheat to the original value of 9°F with the same spring force of 12 psig.

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.

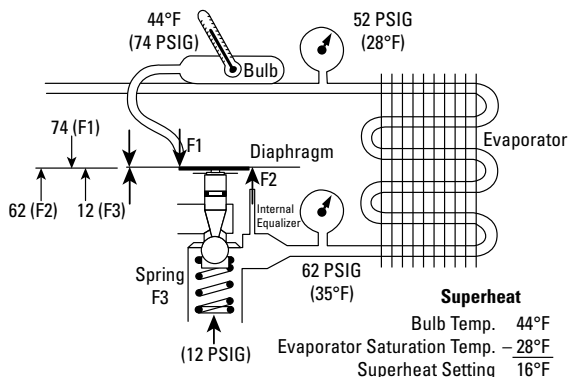
Internally equalized valve with 0 psi drop in evaporator

R-22



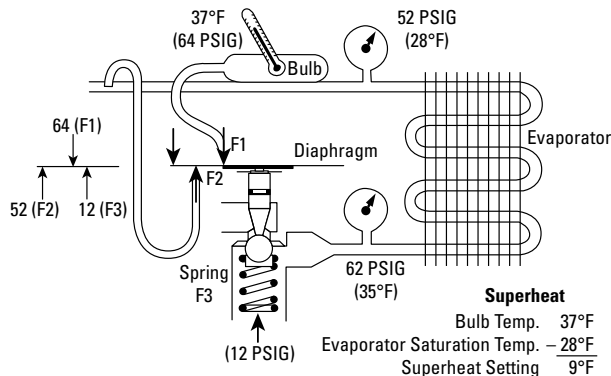
Internally equalized valve with 10 psi drop in evaporator

R-22



Externally equalized valve with 10 psi drop in evaporator

R-22



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.

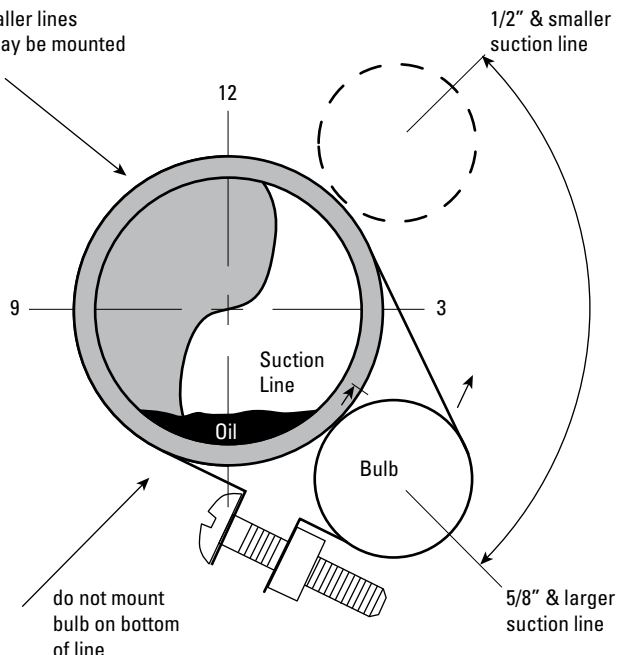
- Always make sure the suction line is cleaned before clamping the bulb in place.
- On lines that are 1/2" O.D. or smaller, the bulb may be installed on top of the line or side mounted (preferably at the 3 o'clock position).
- On lines that are 7/8" O.D. or larger, the

remote bulb should be installed at approximately the 4 or 8 o'clock position.

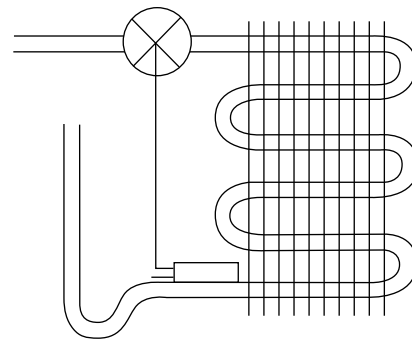
- Never mount a bulb on the bottom of suction lines because a mixture of refrigerant and oil may be present at that point, especially on smaller lines.
- Avoid mounting the bulb on vertical lines or close to reversing valves.
- The bulb should be as close to the evaporator outlet as possible (generally 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.)

Bulb location

on smaller lines
bulb may be mounted
on top



Installation of traps



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.

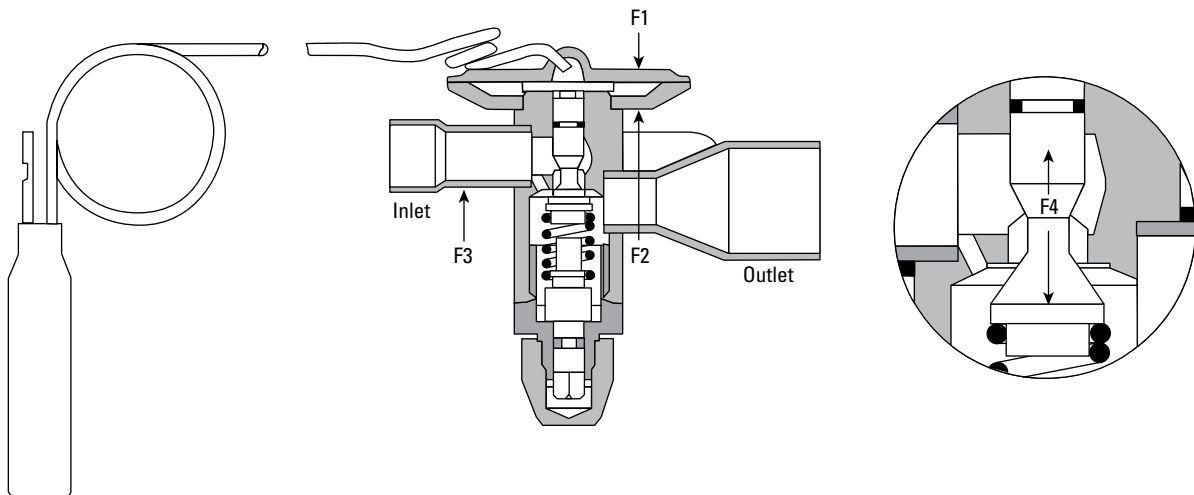
Balanced port valves respond to forces F-1, F-2 and F-3 in a manner similar to conventional valves; however, they take a unique approach to the F-4 force created by high and low side pressure differentials across the valve orifice. (See figure below.) The area of the Parker Power Piston® is equal to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

Forces that change conventional thermostatic expansion valves responses



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.

Refrigerant	Vertical Lift Pressure Drop					
	psi			bar		
	20 ft.	40 ft.	60 ft.	5 m	10 m	15 m
R-22	10	20	30	0.56	1.1	1.7
R-134a	10	20	30	0.57	1.1	1.7
R-404A	8	16	24	0.46	0.91	1.4
R-407C	9	17	26	0.49	0.98	1.5
R-507	8	17	25	0.48	0.96	1.4

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

Refrigerant	Liquid Temperature Entering TEV							
	0°F	20°F	40°F	60°F	80°F	100°F	120°F	140°F
	Correction Factor							
R-22	1.57	1.45	1.34	1.23	1.12	1.00	0.88	0.76
R-407C	1.58	1.45	1.32	1.18	1.04	0.89	0.74	0.57

Valve Type	Orifice	Nominal Capacity (Tons)	Evaporator Temperature°F							
			Pressure Drop (PSIG)							
			75	100	125	150	175	200	225	250
C(E), S(E), EC(E)	AA	1/2	0.5	0.6	0.7	0.8	0.8	0.9	0.9	1.0
C(E), S(E), EC(E)	A	1 to 1-1/2	1.5	1.8	2.0	2.1	2.3	2.5	2.4	2.8
C(E), S(E), EC(E)	B	2 to 3	2.8	3.2	3.6	3.9	4.2	4.5	4.8	5.1
C(E), S(E), EC(E)	C	3-1/2 to 5	4.3	5.0	5.6	6.1	6.6	7.1	7.5	7.9
C(E), S(E), EC(E)	D	6	5.2	6.0	6.7	7.4	7.9	8.5	9.0	9.5

- A. Evaporator Temperature
B. Pressure Drop
C. Design System Tonnage
D. Valve Type

- **Connection configuration** (fitting types, sizes, orientations) Determine what style connections are best suited for the application, SAE flare or ODF copper.
- **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.

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.

Valve Selection Procedure

Nomenclature (Example)

H	A	E	3	V	X	100	3/8"r SAE	x	1/2" SAE	x	1/4" SAE/ODF
Valve Model	Adjustable	External Equalizer Omit for Internal Equalizer	Nominal Capacity in Tons	Refrigerant	Valve Charge See pages 4 and 5. W Z X	Maximum Operating Pressure (MOP)	Inlet Fitting Size and Type		Outlet Fitting Size and Type		External Equalizer Size and Type

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.

Selection of nominal capacity

- 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.

This valve will be operating at 76% capacity

Selection of charge

- Select appropriate charge
From evaporator temperature range on page 5, choose "VW" charge

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**

Rainbow Charge™ Refrigerant Designation	
Z	R-410A
J	R-134a, R-401A (MP39), R-401B (MP66)
V	R-407C (AC9000), R-22
S	R-125, R-404A (HP62), R-402A (HP80), R-402B (HP81), R-507 (AZ50)

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

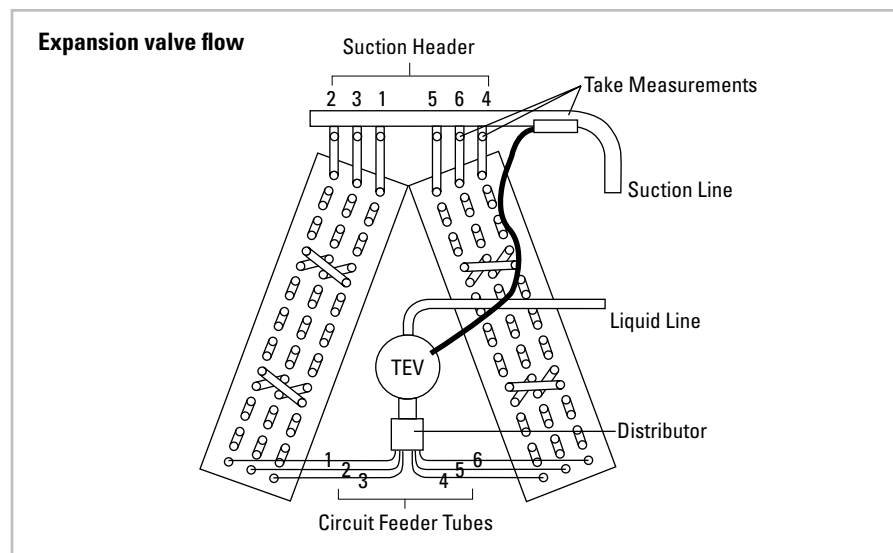
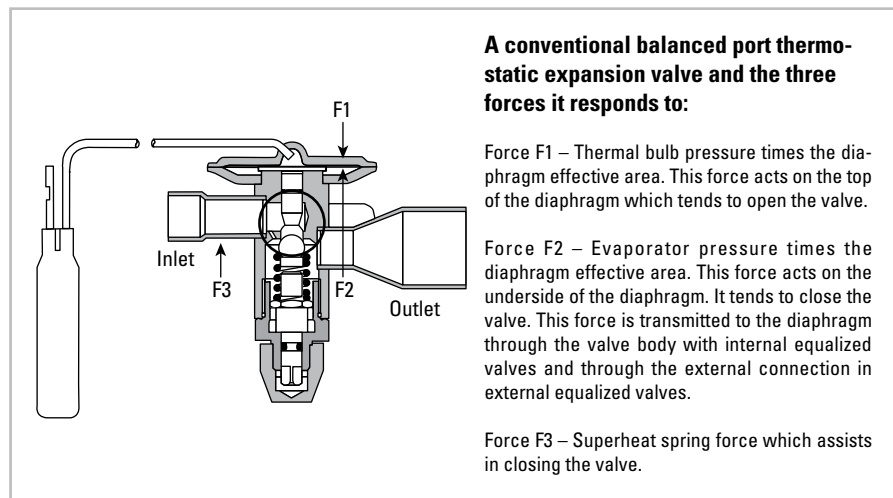
- **Oversized valve** – The expansion valve may be oversized for the application or operating condition of the system. If the valve capacity significantly exceeds the requirements of the system, when the valve attempts to adjust to system load it overcompensates because it is oversized.
- **Incorrect 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.



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.

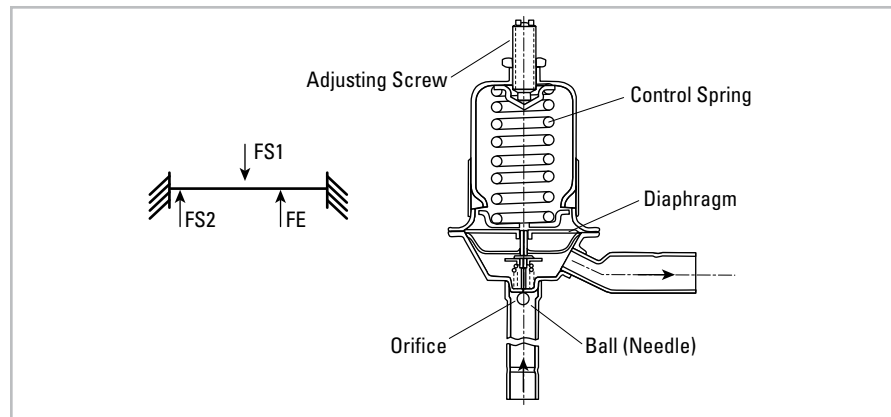
How to Select Constant Pressure Expansion Valves

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.



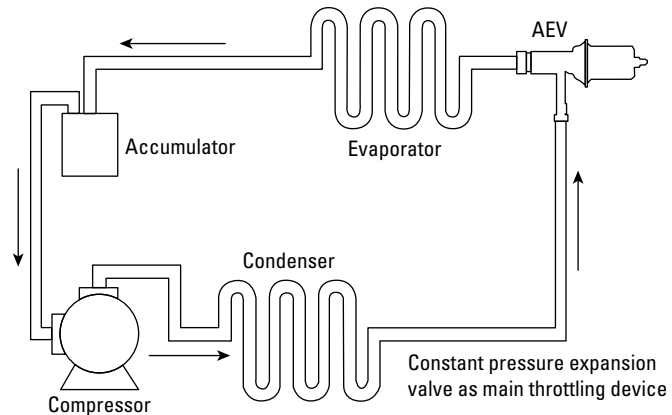
Altitude Feet	Barometric Pressure		Gage Pressure correction (psia)
	Inches Hg.	psia	
0	29.92	14.70	—
500	29.38	14.70	-0.30
1000	28.86	14.19	-0.51
1500	28.33	13.91	-0.79
2000	27.82	13.58	-1.12
2500	27.32	13.41	-1.29
3000	26.82	13.20	-1.50
3500	26.33	12.92	-1.78
4000	25.84	12.70	-2.00
4500	25.37	12.44	-2.26
5000	24.90	12.23	-2.57
5500	24.43	12.01	-2.69
6000	23.98	11.78	-2.92
6500	23.53	11.55	-3.15
7000	23.09	11.33	-3.37
7500	22.65	11.10	-3.60
8000	22.22	10.92	-3.78
8500	21.80	10.70	-4.00
9000	21.39	10.50	-4.20
9500	20.98	10.30	-4.40
10,000	20.58	10.10	-4.60

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.

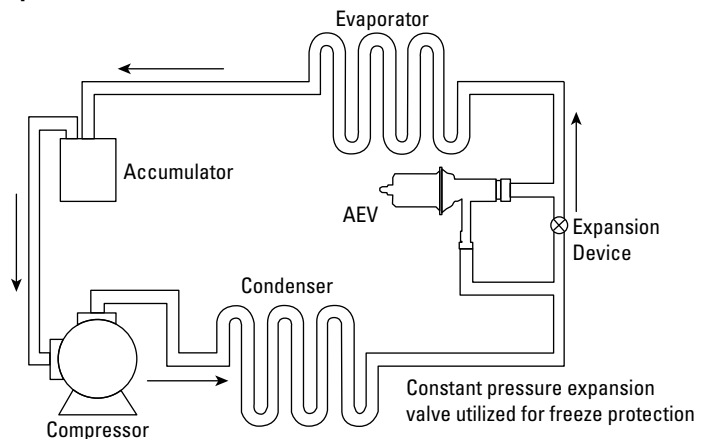
Main throttle



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.

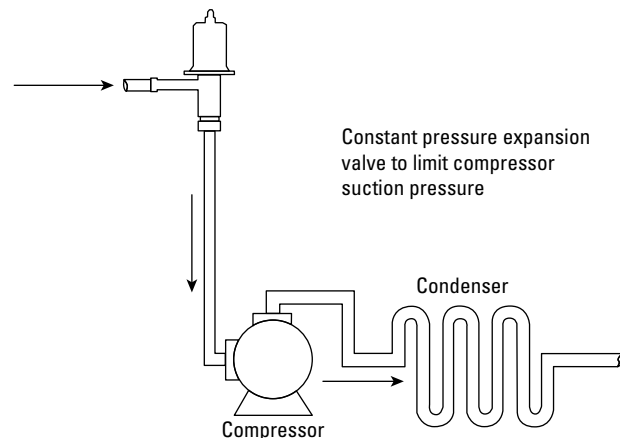
Freeze protection



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.

Crankcase pressure limiting

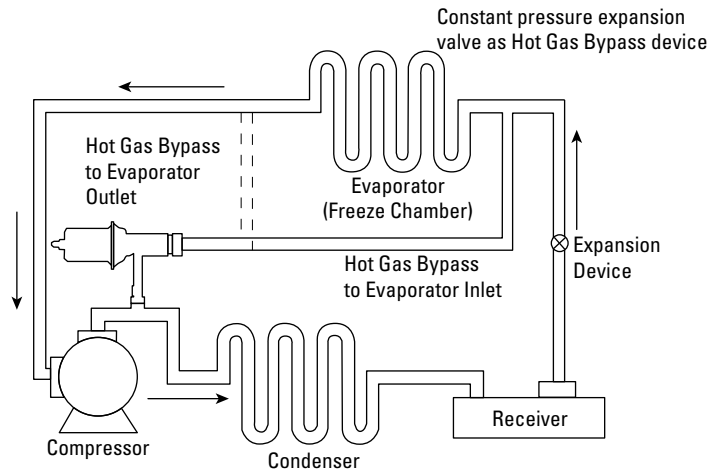


Constant Pressure and EPR Valve Applications

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.

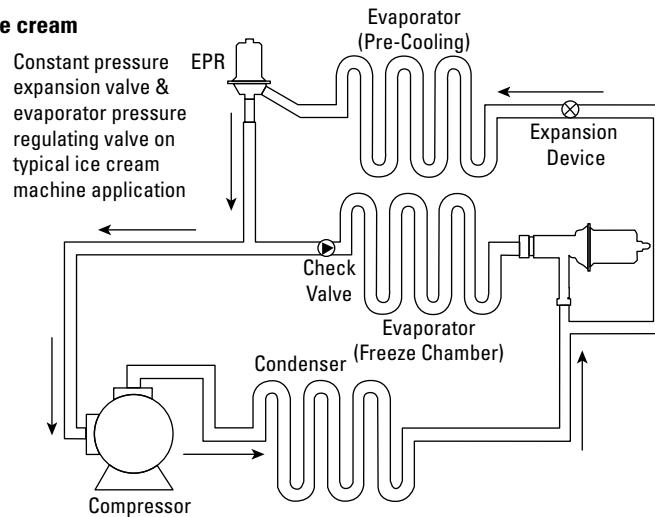
Hot gas bypass to evaporator inlet



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.

EPR – Ice cream



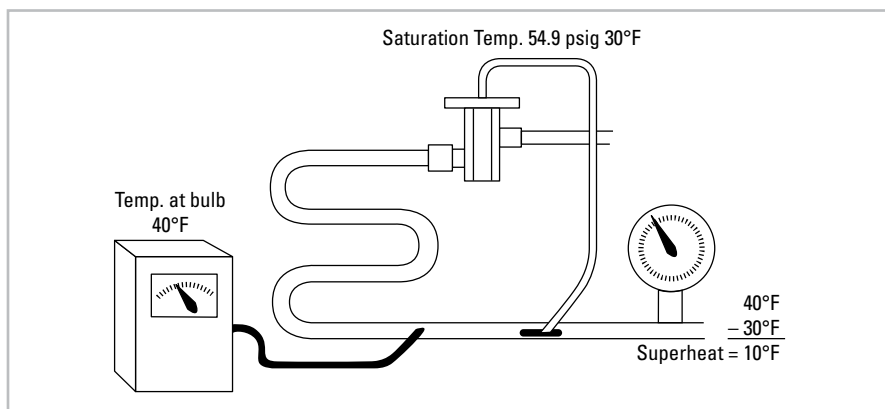
Pressure Temperature Chart

Temperature		R-12	R-22	R-123	R-134a	R-502	AZ-50 R-507	R-717	MP 39 R-401A		HP 80 R-402A		HP 62 R-404A	FX 10 R-408A	FX 56 R-409A		AZ 20 R-410A
°F	°C								Liquid	Vapor	Liquid	Vapor	Liquid	Liquid	Liquid	Vapor	
-50	-45.6	15.4	6.2	29.2	18.4	0.2	1.0	14.4	—	—	—	—	0.6	1.6	12.4	17.2	5.0
-45	-42.8	13.3	2.7	29.0	16.6	1.9	3.0	11.8	—	—	—	—	2.7	1.1	9.7	15.2	7.0
-40	-40.0	11.0	0.5	28.9	14.7	4.1	5.5	8.8	8.1	13.2	6.8	6.3	5.0	3.3	6.8	13.1	11.6
-35	-37.2	8.4	2.6	28.7	12.3	6.5	8.2	5.5	5.1	10.7	9.6	9.1	7.6	5.6	3.5	10.7	14.9
-30	-34.4	5.5	4.9	28.4	9.7	9.2	11.1	1.7	1.7	7.9	12.6	12.1	10.4	8.2	0.0	8.1	18.5
-25	-31.7	2.3	7.4	28.1	6.8	12.1	14.3	1.2	1.0	4.8	16.0	15.4	13.4	11.0	2.0	5.1	22.5
-20	-28.9	0.6	10.1	27.8	3.6	15.3	17.8	3.5	3.0	1.4	19.6	18.9	16.8	14.1	4.1	1.9	26.9
-15	-26.1	2.4	13.2	27.4	0.1	18.8	21.7	6.2	5.2	1.2	23.6	22.9	20.5	17.5	6.5	0.8	31.6
-10	-23.3	4.5	16.4	27.0	2.0	22.6	25.8	9.0	7.7	3.3	27.9	27.1	24.5	21.2	9.0	2.8	36.8
-5	-20.6	6.7	20.0	26.5	4.1	26.6	30.3	12.3	10.3	5.5	32.6	31.7	28.8	25.2	11.8	4.9	42.5
0	-17.8	9.1	24.0	25.9	6.5	31.1	35.2	15.6	13.2	8.0	37.6	36.7	33.5	29.5	14.8	7.2	48.6
5	-15.0	11.8	28.2	25.3	9.1	35.9	40.5	19.5	16.3	10.7	43.1	42.1	38.6	34.2	18.1	9.7	55.2
10	-12.2	14.6	32.7	24.6	11.9	41.0	46.1	23.7	19.7	13.7	49.0	48.0	44.0	39.3	21.7	12.5	62.3
15	-9.4	17.7	37.7	23.7	15.1	46.5	52.2	28.3	23.4	16.9	55.3	54.2	49.9	44.8	25.5	15.4	70.0
20	-6.7	21.0	43.0	22.8	18.4	52.5	58.8	33.4	27.4	20.4	62.1	60.9	56.2	50.7	29.6	18.7	78.3
25	-3.9	24.6	48.7	21.8	22.1	58.8	65.8	38.8	31.7	24.2	69.3	68.1	63.0	57.0	34.0	22.2	87.2
30	-1.1	28.4	54.9	20.7	26.1	65.6	73.3	44.9	36.4	28.3	77.1	75.8	70.3	63.7	38.7	26.0	96.8
35	1.7	32.5	61.4	19.5	30.4	72.8	81.3	51.4	41.3	32.8	85.4	84.0	78.1	71.0	43.8	30.1	107.0
40	4.4	36.9	68.5	18.1	35.1	80.5	89.8	58.4	46.6	37.6	94.2	92.8	86.4	78.7	49.2	34.5	118.0
45	7.2	41.6	76.0	16.6	40.0	88.7	98.9	66.1	52.4	42.7	104.0	102.0	95.2	87.0	54.9	39.2	130.0
50	10.0	46.7	84.0	15.0	45.4	97.4	109.0	74.3	58.5	48.2	114.0	112.0	104.7	95.8	61.0	44.3	142.0
55	12.8	52.0	92.5	13.1	51.2	107.0	119.0	83.2	65.0	54.1	124.0	123.0	114.7	105.1	67.6	49.8	156.0
60	15.6	57.7	101.6	11.2	57.4	116.4	130.0	92.6	71.9	60.4	136.0	134.0	125.3	115.1	74.5	55.6	170.0
65	18.3	63.7	111.0	9.0	64.0	127.0	141.0	102.8	79.3	67.2	147.0	146.0	136.6	125.6	81.8	61.9	185.0
70	21.1	70.1	121.4	6.6	71.1	138.0	154.0	113.8	87.1	74.4	160.0	158.0	148.6	136.8	89.5	68.6	201.0
75	23.9	76.9	132.0	4.0	78.6	149.0	167.0	125.5	95.4	82.1	173.0	171.0	161.2	148.7	97.7	75.8	217.0
80	26.7	84.1	144.0	1.2	86.7	161.0	180.0	138.0	104.0	90.2	187.0	185.0	174.6	161.2	106.4	83.4	235.0
85	29.4	91.7	156.0	0.9	95.1	174.0	195.0	151.4	114.0	98.9	202.0	200.0	188.8	174.4	115.5	91.5	254.0
90	32.2	99.7	168.4	2.5	104.2	187.4	210.0	165.5	123.0	108.0	218.0	215.0	203.7	188.4	125.2	100.2	274.0
95	35.0	108.0	182.0	4.2	113.8	201.0	226.0	180.6	134.0	118.0	233.0	232.0	219.4	203.1	135.3	109.4	295.0
100	37.8	117.0	196.0	6.1	124.1	216.2	244.0	196.7	145.0	128.0	251.0	249.0	235.9	218.7	146.0	119.2	317.0
105	40.6	127.0	211.0	8.1	134.9	232.0	252.0	213.9	156.0	139.0	269.0	267.0	253.4	235.0	157.2	129.6	341.0
110	43.3	136.0	226.4	10.3	146.3	247.9	281.0	231.8	169.0	151.0	288.0	286.0	271.7	252.1	169.0	140.6	365.0
115	46.1	147.0	243.0	12.6	158.4	265.0	301.0	251.0	181.0	163.0	308.0	305.0	290.9	270.2	181.4	152.3	391.0
120	48.9	158.0	260.0	15.1	171.1	282.7	322.0	271.1	195.0	176.0	328.0	326.0	311.1	289.1	194.4	164.7	418.0
125	51.7	169.0	278.4	17.7	184.5	301.0	344.0	292.5	209.0	189.0	350.0	347.0	332.3	308.9	208.0	177.8	446.0
130	54.4	181.0	296.8	20.6	198.7	320.8	368.0	314.9	224.0	203.0	372.0	370.0	354.5	329.7	222.3	191.6	476.0
135	57.2	193.0	317.0	23.6	213.6	341.0	393.0	338.8	239.0	218.0	396.0	393.0	377.8	351.5	237.2	206.3	507.0
140	60.0	207.0	337.3	26.8	229.3	362.6	419.0	363.5	255.0	234.0	420.0	418.0	402.2	374.3	252.9	221.8	539.0
145	62.8	220.0	359.0	30.2	245.7	385.0	446.0	390.2	272.0	250.0	446.0	443.0	427.7	398.1	269.3	238.2	573.0
150	65.6	235.0	381.0	33.8	263.0	408.4	475.0	417.4	299.0	267.0	472.0	470.0	454.4	423.0	293.0	286.4	608.0

Figures in regular type = psig **Figures in bold italics = inches Hg. Below 1 ATM**

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).



Quick Alternate Refrigerant Reference			
ASHRAE #	Replaces	Applications	Notes
R-134a	R-12	New equipment & retrofits	Close match to CFC-12
R-401A	R-12	Retrofits	Close match to R-12
R-402A	R-502/R-12	Retrofits	Higher discharge pressure than R-502
R-404A	R-502/R-22	New equipment & retrofits	Close match to R-502 & R-22
R-407B	R-502	New equipment & retrofits	Close match to R-502
R-407C	R-22	New equipment	Close match to R-22
R-408A	R-502/R-22	Retrofits	Higher discharge pressure than R-502
R-409A	R-12	Retrofits	Higher discharge pressure than R-12
R-410A	R-22	New equipment	Extremely higher discharge pressures
R-507	R-502/R-22	New equipment & retrofits	Close match to R-502

Conversion Reference		
Temperature °F = [(°C x 9) / 5] + 32 Temperature °C = [(°F - 32) x 5] / 9 kW = tons x 3.51 COP = kW Out/kW In EER = Btu Out/Watts - hr In Btu/min = kW x 56.92 Btu = HP hr x 2544 Btu/h = Watts x 3.412 HP = kW x 1.34 1 Ton (Refrigeration) = 12,000 Btu/hr Watts = HP x 745.7	Meters = inches x 0.0254 Kilograms = lbs. x 0.4536 Cubic Feet = Gallons x 0.1337 Cubic Feet/Hr = GPM x 8.021 kPa = Inches Hg x 3.39 kPa = PSI x 6.89 Atmospheres = PSI x .06805 Inches of Mercury = PSI x 2.036 PSIA = PSIG + 14.7	Water Properties Weight of One Gallon = 8.34 LB. @ 68°F Specific Heat = 1 BTU/lb-°F Qt = 500 x GPM x TD 1 ft. (head) = 0.433 PSI Psychrometrics Q sensible = 1.08 x TD x CFM Q total = 4.5 x ΔH x CFM

OFFER OF SALE

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3. **Delivery Dates; Title and Risk; Shipment.** All delivery dates are approximate and Seller shall not be responsible for any damages resulting from any delay. Regardless of the manner of shipment, title to any products and risk of loss or damage shall pass to Buyer upon tender to the carrier at Seller's facility (i.e., when it's on the truck, it's yours). Unless otherwise stated, Seller may exercise its judgment in choosing the carrier and means of delivery. No deferment of shipment at Buyers' request beyond the respective dates indicated will be made except on terms that will indemnify, defend and hold Seller harmless against all loss and additional expense. Buyer shall be responsible for any additional shipping charges incurred by Seller due to Buyer's changes in shipping, product specifications or in accordance with Section 13, herein.
4. **Warranty.** Seller warrants that the Products sold hereunder shall be free from defects in material or workmanship for a period of twelve months from the date of delivery to Buyer or 2,000 hours of normal use, whichever occurs first. This warranty is made only to Buyer and does not extend to anyone to whom Products are sold after purchased from Seller. The prices charged for Seller's products are based upon the exclusive limited warranty stated above, and upon the following disclaimer: **DISCLAIMER OF WARRANTY: THIS WARRANTY COMPRISES THE SOLE AND ENTIRE WARRANTY PERTAINING TO PRODUCTS PROVIDED HEREUNDER. SELLER DISCLAIMS ALL OTHER WARRANTIES, EXPRESS AND IMPLIED, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**
5. **Claims; Commencement of Actions.** Buyer shall promptly inspect all Products upon delivery. No claims for shortages will be allowed unless reported to the Seller within 10 days of delivery. No other claims against Seller will be allowed unless asserted in writing within 60 days after delivery or, in the case of an alleged breach of warranty, within 30 days after the date within the warranty period on which the defect is or should have been discovered by Buyer. Any action based upon breach of this agreement or upon any other claim arising out of this sale (other than an action by Seller for any amount due to Seller from Buyer) must be commenced within thirteen months from the date of tender of delivery by Seller or, for a cause of action based upon an alleged breach of warranty, within thirteen months from the date within the warranty period on which the defect is or should have been discovered by Buyer.
6. **LIMITATION OF LIABILITY.** UPON NOTIFICATION, SELLER WILL, AT ITS OPTION, REPAIR OR REPLACE A DEFECTIVE PRODUCT, OR REFUND THE PURCHASE PRICE. **IN NO EVENT SHALL SELLER BE LIABLE TO BUYER FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF, OR AS THE RESULT OF, THE SALE, DELIVERY, NON-DELIVERY, SERVICING, USE OR LOSS OF USE OF THE PRODUCTS OR ANY PART THEREOF, OR FOR ANY CHARGES OR EXPENSES OF ANY NATURE INCURRED WITHOUT SELLER'S WRITTEN CONSENT, EVEN**

IF SELLER HAS BEEN NEGLIGENT, WHETHER IN CONTRACT, TORT OR OTHER LEGAL THEORY. IN NO EVENT SHALL SELLER'S LIABILITY UNDER ANY CLAIM MADE BY BUYER EXCEED THE PURCHASE PRICE OF THE PRODUCTS.

7. **Contingencies.** Seller shall not be liable for any default or delay in performance if caused by circumstances beyond the reasonable control of Seller.
8. **User Responsibility.** The user, through its own analysis and testing, is solely responsible for making the final selection of the system and Product and assuring that all performance, endurance, maintenance, safety and warning requirements of the application are met. The user must analyze all aspects of the application and follow applicable industry standards and Product information. If Seller provides Product or system options, the user is responsible for determining that such data and specifications are suitable and sufficient for all applications and reasonably foreseeable uses of the Products or systems.
9. **Loss to Buyer's Property.** Any designs, tools, patterns, materials, drawings, confidential information or equipment furnished by Buyer or any other items which become Buyer's property, may be considered obsolete and may be destroyed by Seller after two consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property. Seller shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.
10. **Special Tooling.** A tooling charge may be imposed for any special tooling, including without limitation, dies, fixtures, molds and patterns, acquired to manufacture Products. Such special tooling shall be and remain Seller's property notwithstanding payment of any charges by Buyer. In no event will Buyer acquire any interest in apparatus belonging to Seller which is utilized in the manufacture of the Products, even if such apparatus has been specially converted or adapted for such manufacture and notwithstanding any charges paid by Buyer. Unless otherwise agreed, Seller shall have the right to alter, discard or otherwise dispose of any special tooling or other property in its sole discretion at any time.
11. **Buyer's Obligation; Rights of Seller.** To secure payment of all sums due or otherwise, Seller shall retain a security interest in the goods delivered and this agreement shall be deemed a Security Agreement under the Uniform Commercial Code. Buyer authorizes Seller as its attorney to execute and file on Buyer's behalf all documents Seller deems necessary to perfect its security interest. Seller shall have a security interest in, and lien upon, any property of Buyer in Seller's possession as security for the payment of any amounts owed to Seller by Buyer.
12. **Improper use and indemnity.** Buyer shall indemnify, defend, and hold Seller harmless from any claim, liability, damages, lawsuits, and costs (including attorney fees), whether for personal injury, property damage, patent, trademark or copyright infringement or any other claim, brought by or incurred by Buyer, Buyer's employees, or any other person, arising out of: (a) improper selection, improper application or other misuse of Products purchased by Buyer from Seller; (b) any act or omission, negligent or otherwise, of Buyer; (c) Seller's use of patterns, plans, drawings, or specifications furnished by Buyer to manufacture Product; or (d) Buyer's failure to comply with these terms and conditions. Seller shall not indemnify Buyer under any circumstance except as otherwise provided.
13. **Cancellations and Changes.** Orders shall not be subject to cancellation or change by Buyer for any reason, except with Seller's written consent and upon terms that will indemnify, defend and hold Seller harmless against all direct, incidental and consequential loss or damage. Seller may change product features, specifications, designs and availability with notice to Buyer.
14. **Limitation on Assignment.** Buyer may not assign its rights or obligations under this agreement without the prior written consent of Seller.
15. **Entire Agreement.** This agreement contains the entire agreement between the Buyer and Seller and constitutes the final, complete and exclusive expression of the terms of the agreement. All prior

or contemporaneous written or oral agreements or negotiations with respect to the subject matter are herein merged.

16. **Waiver and Severability.** Failure to enforce any provision of this agreement will not waive that provision nor will any such failure prejudice Seller's right to enforce that provision in the future. Invalidity of any provision of this agreement by legislation or other rule of law shall not invalidate any other provision herein. The remaining provisions of this agreement will remain in full force and effect.
17. **Termination.** This agreement may be terminated by Seller for any reason and at any time by giving Buyer thirty (30) days written notice of termination. In addition, Seller may by written notice immediately terminate this agreement for the following: (a) Buyer commits a breach of any provision of this agreement (b) the appointment of a trustee, receiver or custodian for all or any part of Buyer's property (c) the filing of a petition for relief in bankruptcy of the other Party on its own behalf, or by a third party (d) an assignment for the benefit of creditors, or (e) the dissolution or liquidation of the Buyer.
18. **Governing Law.** This agreement and the sale and delivery of all Products hereunder shall be deemed to have taken place in and shall be governed and construed in accordance with the laws of the State of Ohio, as applicable to contracts executed and wholly performed therein and without regard to conflicts of laws principles. Buyer irrevocably agrees and consents to the exclusive jurisdiction and venue of the courts of Cuyahoga County, Ohio with respect to any dispute, controversy or claim arising out of or relating to this agreement. Disputes between the parties shall not be settled by arbitration unless, after a dispute has arisen, both parties expressly agree in writing to arbitrate the dispute.
19. **Indemnity for Infringement of Intellectual Property Rights.** Seller shall have no liability for infringement of any patents, trademarks, copyrights, trade dress, trade secrets or similar rights except as provided in this Section. Seller will defend and indemnify Buyer against allegations of infringement of U.S. patents, U.S. trademarks, copyrights, trade dress and trade secrets ("Intellectual Property Rights"). Seller will defend at its expense and will pay the cost of any settlement or damages awarded in an action brought against Buyer based on an allegation that a Product sold pursuant to this Agreement infringes the Intellectual Property Rights of a third party. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of such allegations of infringement, and Seller having sole control over the defense of any allegations or actions including all negotiations for settlement or compromise. If a Product is subject to a claim that it infringes the Intellectual Property Rights of a third party, Seller may, at its sole expense and option, procure for Buyer the right to continue using the Product, replace or modify the Product so as to make it noninfringing, or offer to accept return of the Product and return the purchase price less a reasonable allowance for depreciation. Notwithstanding the foregoing, Seller shall have no liability for claims of infringement based on information provided by Buyer, or directed to Products delivered hereunder for which the designs are specified in whole or part by Buyer, or infringements resulting from the modification, combination or use in a system of any Product sold hereunder. The foregoing provisions of this Section shall constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for infringement of Intellectual Property Rights.
20. **Taxes.** Unless otherwise indicated, all prices and charges are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority upon the manufacture, sale or delivery of Products.
21. **Equal Opportunity Clause.** For the performance of government contracts and where dollar value of the Products exceed \$10,000, the equal employment opportunity clauses in Executive Order 11246, VEVRAA, and 41 C.F.R. §§ 60-1.4(a), 60-741.5(a), and 60-250.4, are hereby incorporated.



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Climate and Industrial Controls Group
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