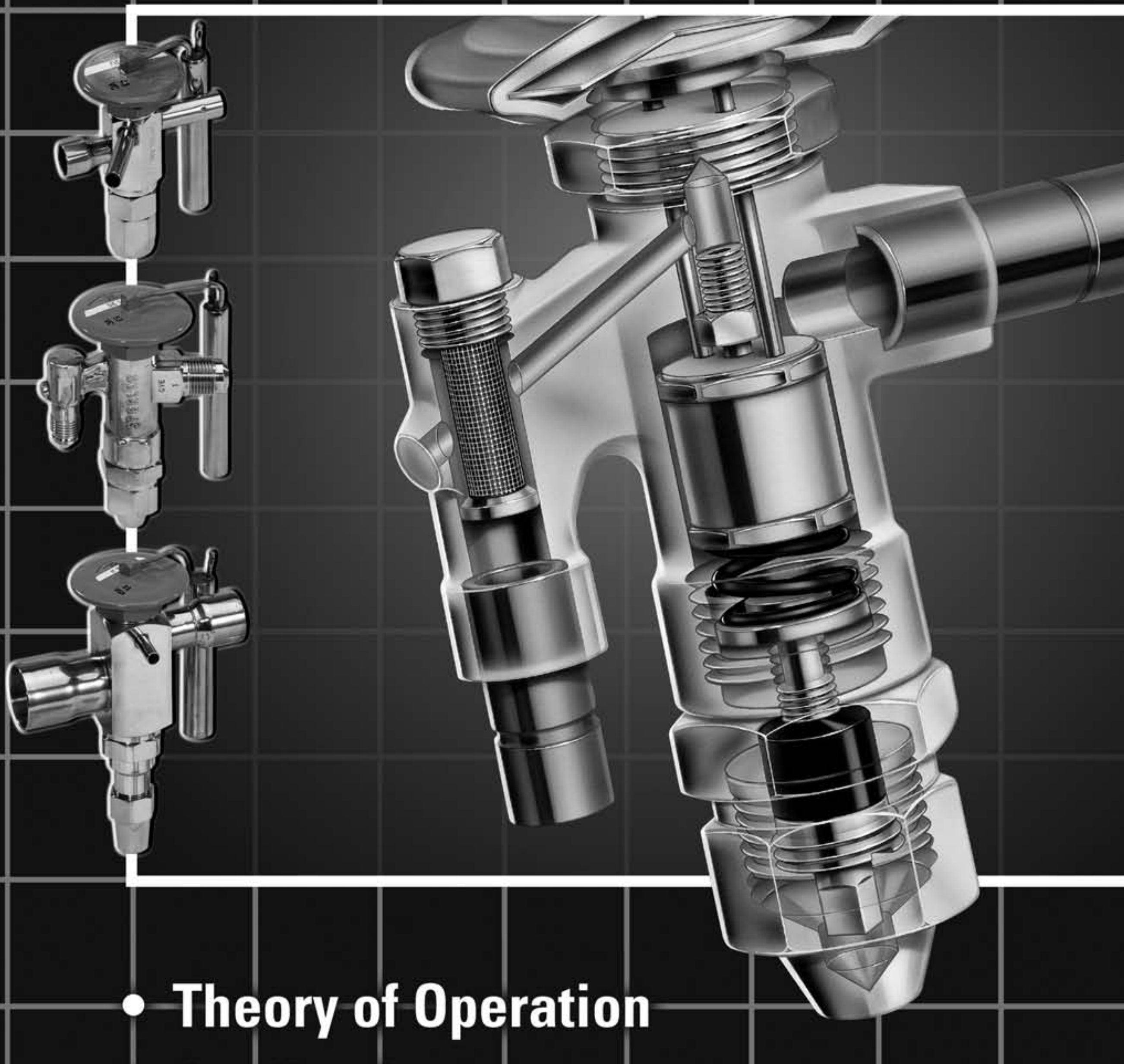
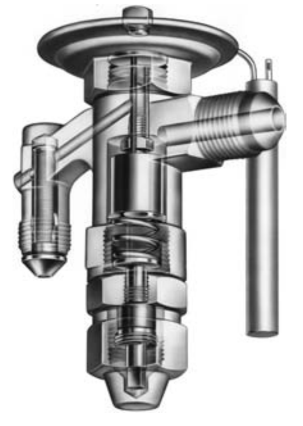
August 2005 / **BULLETIN 10-9**

THERMOSTATIC EXPANSION VALVES



- Theory of Operation
- Application
- Selection

THERMOSTATIC EXPANSION VALVES



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Outstanding Features & Benefits of Sporlan Thermostatic Expansion Valves

- **SELECTIVE THERMOSTATIC CHARGES**
  Designed to provide optimum performance for all applications—air conditioning and heat pump, medium and low temperature refrigeration.
- **THERMOSTATIC ELEMENT DESIGN**
  Long lasting and field proven stainless steel diaphragm and welded element construction.
- **DIAPHRAGM DESIGN**
  Large flat diaphragm permits precise valve control.
- **REPLACEABLE THERMOSTATIC ELEMENTS**
  Field replaceable elements on all standard valves.
- **BALANCED PORT DESIGN [TYPES (E)BF, EBS & O]**
  Provides perfect pin and port alignment, and prevents changes in pressure drop across the valve from influencing valve operation. Provides excellent control on applications having widely varying operating conditions.
- **PIN CARRIER DESIGN (CONVENTIONAL VALVES)**
  Provides precise pin and port alignment, and better seating.
- **ACCESSIBLE INTERNAL PARTS**
  Durable, leakproof body joint construction allows the valve to be disassembled, and the internal parts cleaned and inspected.
- **MATERIALS OF CONSTRUCTION**
  Pin and port materials offer maximum protection against corrosion and erosion.
- **SILVER SOLDERED CONNECTIONS**
  For leakproof, high strength connection-to-body joints.
- **ADJUSTABLE SUPERHEAT DESIGN**
  All standard valves are externally adjustable except the Type NI, which is internally adjustable through its outlet connection.

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Refer to Bulletin 10-10 for complete specifications of Thermostatic Expansion Valves, with Selective Thermostatic Charges.

Refer to Bulletin 10-11 for a complete discussion on Installing and Servicing Thermostatic Expansion Valves.

FOR USE ON REFRIGERATION and/or AIR CONDITIONING SYSTEMS ONLY

Bulletin 10-9, August 2005 supersedes Bulletin 10-9 dated June 2001 and all prior publications.

SPORLAN THERMOSTATIC EXPANSION VALVES

The thermostatic expansion valve (TEV) controls the flow of liquid refrigerant entering the direct expansion (DX) evaporator by maintaining a constant **superheat** of the refrigerant vapor at the outlet of the evaporator. **Superheat is the difference between the refrigerant vapor temperature and its saturation temperature**. To measure the superheat the TEV controls, the difference between the actual temperature at the sensing bulb and the saturation temperature corresponding to the suction pressure at the sensing bulb location is determined. By controlling superheat, the TEV keeps nearly the entire evaporator surface active while not permitting liquid refrigerant to return to the compressor. The ability of the TEV to match refrigerant flow to the rate at which refrigerant can be vaporized in the evaporator makes the TEV the ideal expansion device for most air conditioning and refrigeration applications.

THE REFRIGERATION SYSTEM

To understand the function of the thermostatic expansion valve, a short discussion of the refrigeration system is necessary. The refrigeration system can be defined as a closed system in which the process of absorbing and rejecting heat is performed by flowing a refrigerant in a vapor compression cycle. In its simplest form, the refrigeration system consists of five components: the compressor, condenser, evaporator, expansion device, and interconnecting piping.

The heart of the system is the compressor since it causes the refrigerant flow. Its function is simply to receive low pressure (and temperature) refrigerant vapor from the evaporator and compress it into high pressure (and temperature) refrigerant vapor. The high pressure vapor is then converted to a liquid phase in the condenser. The condenser performs this function by removing heat from the vapor and rejecting the heat to the air, or to water in the case of a water cooled condenser. The liquid, which remains at a high pressure, passes through the expansion device and becomes a low pressure two phase (liquid and vapor) mixture. This refrigerant mixture returns to its vapor phase in the evaporator by absorbing heat from the medium being cooled.

The selection of the expansion device is of particular importance to the operation of the refrigeration system because it regulates refrigerant flow into the evaporator. An expansion device which is misapplied or incorrectly sized will ordinarily result in operational difficulties and poor system performance. For example, an undersized expansion device will prevent sufficient refrigerant from flowing into the evaporator causing a reduction in the design cooling capability of the system. An oversized expansion device may allow too much refrigerant into the evaporator causing liquid refrigerant to flow back to the compressor. The latter condition is referred to as **floodback**. Both conditions will invariably result in compressor damage if not quickly remedied. Therefore, the expansion device requires attention to its selection and application.

TYPES OF EXPANSION DEVICES

Expansion devices can be divided into four general categories: the fixed area restrictor, the automatic (constant pressure) expansion valve, the thermostatic expansion valve, and the electric expansion valve. The fixed area restrictor expansion device is simply a precisely formed restriction through which liquid refrigerant flows. Two common examples of this type of device are the capillary tube, or *cap tube*, and the short tube restrictor, or plug orifice. These devices are typically used on certain small air conditioning and refrigeration systems where operating conditions permit moderately constant evaporator loading and constant condenser pressures. The drawback associated with these devices is their limited ability to efficiently regulate refrigerant flow in response to changes in system operating conditions, since they are sized based on one set of conditions.

Like the fixed area restrictor, the automatic expansion valve (AEV) is best suited for applications having moderately constant evaporator loading. The AEV regulates refrigerant flow by simply maintaining a constant evaporator or valve outlet pressure. As the heat load on the evaporator rises, the AEV decreases refrigerant flow to maintain evaporator pressure at the valve's setting. Conversely, the AEV increases refrigerant flow when the evaporator heat load decreases to maintain evaporator pressure at the valve's setting. As a result, the AEV starves the evaporator at high load conditions, and overfeeds it at low load conditions.

The thermostatic expansion valve provides an excellent solution to regulating refrigerant flow into a direct expansion type evaporator. The TEV regulates refrigerant flow by maintaining a nearly constant superheat at the evaporator outlet. As superheat at the evaporator outlet rises due to increased heat load on the evaporator, the TEV increases refrigerant flow until superheat returns to the valve's setting. Conversely, the TEV will decrease refrigerant flow when superheat lowers as a result of a decreased heat load on the evaporator. The effect of this type of regulation is it allows the evaporator to remain as nearly fully active as possible under all load conditions. The concept of superheat, and the proper method of measuring it is further explained on Page 14, *TEV Operation and Performance*.

The thermostatic expansion valve provides an additional benefit when charging the system with refrigerant. When a TEV is used, the system refrigerant charge is usually not as critical as with the other expansion devices. The proper operation of a fixed restriction and, to a lesser extent, an automatic expansion valve depends on having an exact amount of refrigerant in the system.

The electric expansion valve (EEV) provides a means by which applications can be designed with sophisticated system control functions. This type of valve is controlled by an electronic circuit which is often designed to allow the valve to control some aspect of system operation in addition to superheat at the outlet of the evaporator. For example, evaporator discharge air temperature or water temperature from a chiller could be monitored by the EEV's controller. See Bulletin 100-9 for details on electric valves for refrigerant control or contact Sporlan for additional information.

HOW THE THERMOSTATIC EXPANSION VALVE WORKS

Basic Operation

In order to understand the principles of thermostatic expansion valve operation, a review of its major components is necessary. A **sensing bulb** is connected to the TEV by a length of capillary tubing which transmits bulb pressure to the top of the valve's **diaphragm**. The sensing bulb, capillary tubing, and diaphragm assembly is referred to as the **thermostatic element**. The thermostatic element on all standard Sporlan TEVs is replaceable.

The diaphragm is the actuating member of the valve. Its motion is transmitted to the **pin** and **pin carrier** assembly by means of one or two **pushrods**, allowing the pin to move in and out of the valve **port**. The **superheat spring** is located under the pin carrier, and a **spring guide** sets it in place. On externally adjustable valves, an external **valve adjustment** permits the spring pressure to be altered.

There are three fundamental pressures acting on the valve's diaphragm which affect its operation: sensing bulb pressure **P1**, equalizer pressure **P2**, and equivalent spring pressure **P3** (see Figure 1). The sensing bulb pressure is a function of the temperature of the **thermostatic charge**, i.e., the substance within the bulb. This pressure acts on the top of the valve diaphragm causing the valve to move to a more open position. The equalizer and spring pressures act together underneath the diaphragm causing the valve to move to a more closed position. During normal valve operation, the sensing bulb pressure must equal the equalizer pressure plus the spring pressure, i.e.:

$$P1 = P2 + P3$$

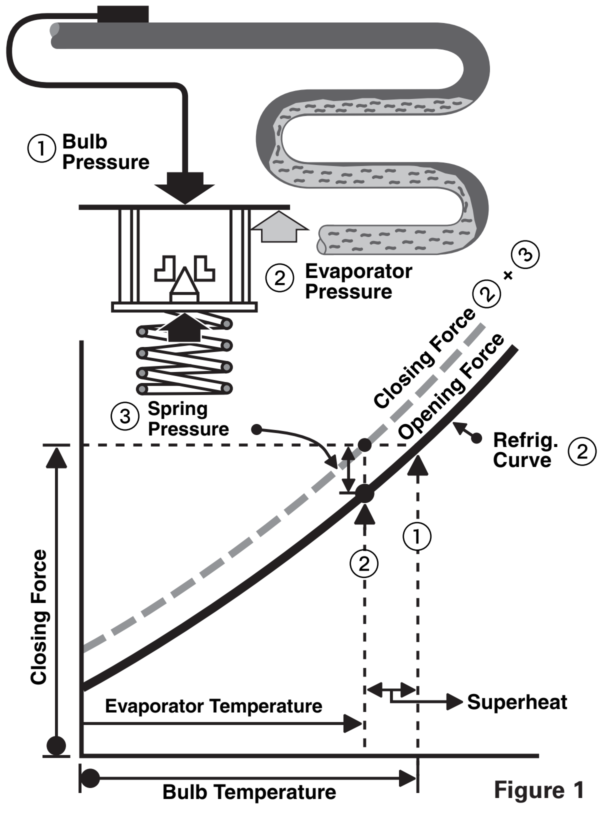


Figure 1

Equivalent spring pressure is defined as the spring force divided by the effective area of the diaphragm. The effective area of the diaphragm is simply the portion of the total diaphragm area which is effectively used by the bulb and equalizer pressures to provide their respective opening and closing forces. Equivalent spring pressure is essentially constant once the valve has been adjusted to the desired superheat. As a result, the TEV functions by controlling the difference between bulb and equalizer pressures by the amount of the spring pressure.

The function of the sensing bulb is to sense the temperature of the refrigerant vapor as it leaves the evaporator. Ideally, the bulb temperature will exactly match the refrigerant vapor temperature. As the bulb temperature increases, bulb pressure also increases causing the valve pin to move away from the valve port, allowing more refrigerant to flow into the evaporator. The valve continues in this opening direction until the equalizer pressure increases sufficiently that the sum of the equalizer and spring pressures balance with the bulb pressure. Conversely, as the bulb temperature decreases, the bulb pressure decreases causing the valve pin to move toward the valve port, allowing less refrigerant to flow into the evaporator. The valve continues to close until the equalizer pressure decreases sufficiently that the sum of the equalizer and spring pressures balance with the bulb pressure.

A change in refrigerant vapor temperature at the outlet of the evaporator is caused by one of two events: (1) the spring pressure is altered by means of the valve adjustment, and (2) the heat load on the evaporator changes. When spring pressure is increased by turning the valve adjustment clockwise, refrigerant flow into the evaporator is decreased. Vapor temperature at the evaporator outlet increases since the point where the refrigerant completely vaporizes moves further back within the evaporator, leaving more evaporator surface area to heat the refrigerant in its vapor form. The actual refrigerant vapor and bulb temperature will be controlled at the point where bulb pressure balances with the sum of the equalizer and spring pressures. Conversely, decreasing spring pressure by turning the valve adjustment counterclockwise increases refrigerant flow into the evaporator and decreases refrigerant vapor and bulb temperature. Spring pressure determines the superheat at which the valve controls. Increasing spring pressure increases superheat, decreasing spring pressure decreases superheat.

An increase in the heat load on the evaporator causes refrigerant to evaporate at a faster rate. As a result, the point of complete vaporization of the refrigerant flow is moved further back within the evaporator. Refrigerant vapor and bulb temperature increase, causing bulb pressure to rise and the valve to move in the opening direction until the three pressures are in balance. Conversely, a reduction in the heat load on the evaporator will cause the vapor and bulb temperature to fall and the valve to move in a closed direction until the three pressures are in balance. Unlike a change in the spring pressure due to valve adjustment, a change in the heat load on the evaporator does not appreciably affect the superheat at which the thermostatic expansion valve controls. This is due to the fact that the TEV is designed to maintain an essentially constant difference between bulb and equalizer pressures, thus controlling superheat regardless of the heat load.

Effect of Pressure Drop Across the Valve Port

An additional pressure affecting valve operation, which is not considered fundamental, arises from the actual pressure drop across the valve port. This pressure **P4** can be related to the three fundamental pressures as the product of pressure drop across the valve port and the ratio of the port area to the effective area of the diaphragm, i.e.:

P4 = Pressure Drop x (Port Area / Effective Diaphragm Area)

With Sporlan's conventional TEV design, this pressure is an opening influence since refrigerant flow tends to move the valve in an opening direction. As a result, our original equation is modified as follows:

$$P1 + P4 = P2 + P3$$

P4 becomes more significant to TEV operation the greater the port area to effective diaphragm area ratio, and the greater the pressure drop varies across the valve port.

Balanced Port TEVs

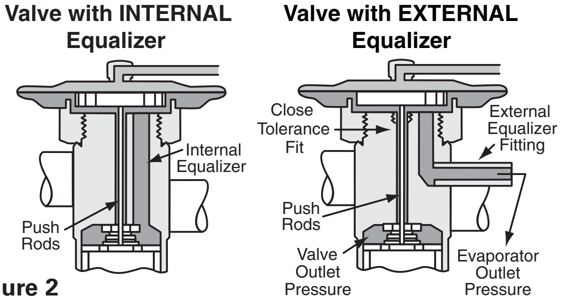
Sporlan introduced the concept of the **balanced port** thermostatic expansion valve in 1946 on large tonnage Types T and W valves. This concept provided the means to either largely reduce or eliminate the effect of pressure drop across the valve port. This design utilized a double seating piston operated by a single pushrod. The two port construction divided the refrigerant flow in opposite directions, thereby providing a semi-balanced pressure differential across the piston.

Improved balanced port designs resulted in a fully balanced Type O valve, and then the Types (E)BF, SBF, and EBS valves for smaller capacity applications. For additional information on the types and applications of balanced port TEVs, refer to Page 9, *Thermostatic Expansion Valve Applications*.

Equalization Method

As previously discussed on Pages 3 and 4, the operation of the thermostatic expansion valve is determined by the relationship between three fundamental pressures: bulb pressure, equalizer pressure, and equivalent spring pressure. These pressures are illustrated in Figure 1. The equalizer pressure is the evaporator pressure the valve senses. The means used to transmit this pressure from the refrigeration system to the underside of the valve diaphragm is referred to as the equalization method.

Evaporator pressure is transmitted to the underside of the valve diaphragm by one of two methods. If the valve is **internally equalized**, the evaporator pressure at the valve outlet is transmitted to the diaphragm via a passageway within the valve body or through a clearance around the pushrods. If the valve is **externally equalized**, the underside of the valve diaphragm is isolated from the valve outlet pressure by the use of packing material around the pushrods or with pushrods which are closely fitted. Evaporator pressure is transmitted to the diaphragm by a tube connecting the suction line near the evaporator outlet to an external fitting on the valve. The external fitting is connected to a passageway which leads to the underside of the valve diaphragm. See Figure 2.


Valve with INTERNAL Equalizer

Valve with EXTERNAL Equalizer

Figure 2

Internally equalized TEVs should be limited to single circuit evaporator coils having a pressure drop no greater than the equivalent of a 2°F saturated temperature change. Refer to Table 1 for recommended maximum allowable pressure drop values for internally equalized valves.

Externally equalized TEVs, however, are not affected by pressure drop across the evaporator, including pressure drop from refrigerant distributors employed by multi-circuited evaporator coils. An externally equalized TEV may be used for all refrigeration applications. It provides no operational disadvantages with respect to an internally equalized valve other than requiring an external equalizer line be connected. Figures 3, 4, and 5 illustrate the effects of evaporator pressure drop on an internally and externally equalized TEV.

Table 1

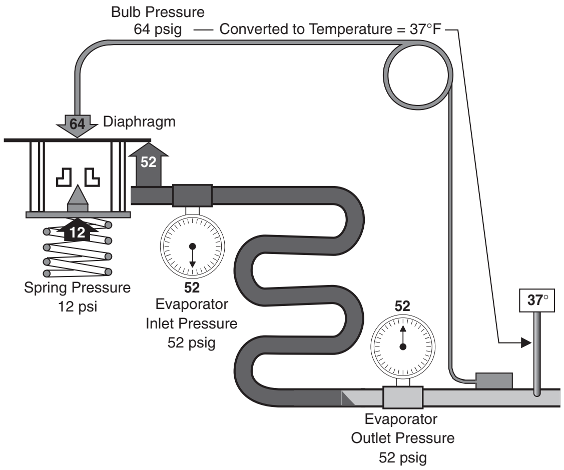
Refrigerant	Evaporating Temperature °F				
	40	20	0	–20	–40
	Pressure Drop —psi				
12, 134a	2.00	1.50	1.00	0.75	—
22	3.00	2.00	1.50	1.00	0.75
404A, 502, 507	3.00	2.50	1.75	1.25	1.00
717 (Ammonia)	3.00	2.00	1.50	1.00	—

IMPORTANT: The External Equalizer must be used on evaporators which employ a refrigerant distributor.

When an externally equalized TEV is used, the equalizer connection on the TEV must be connected to the suction line near the outlet of the evaporator, and not capped!

Figure 3 shows an internally equalized valve feeding a single circuit evaporator which has no pressure drop. The system refrigerant is R-22 and, for the purpose of illustration, R-22 is also used as the thermostatic charge. The evaporator pressure at the valve outlet and at the sensing bulb location is 52 psig. The sum of this pressure and the 12 psi spring pressure produces a 64 psig pressure in the closing direction. For the valve to properly operate, a 64 psig opening bulb pressure is required to balance pressure. Since the sensing bulb consists of liquid R-22, its pressure-temperature characteristic is identical to the saturation curve of R-22, and a 37°F bulb temperature is required. The superheat at which the valve is controlling is calculated by subtracting the saturation temperature of the evaporator pressure at the sensing bulb location by the bulb temperature. In this case, the superheat is 9°F.

Figure 3



Closing Pressure..= 52 + 12 = 64 psig
(Evaporator Inlet Pressure Plus Spring Pressure)

Bulb Pressure Necessary to Open Valve...64 psig

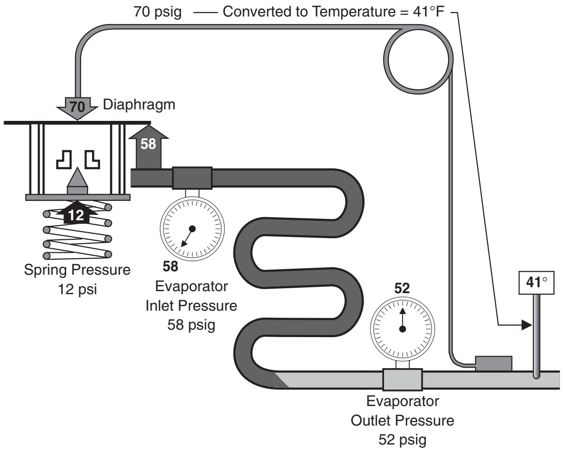
Bulb Pressure Equivalent to 64 psig...37°F

Saturated Temperature Equivalent to Evaporator Outlet Pressure.........................28°F

SUPERHEAT...9°F
Bulb Temperature Minus Saturated Evaporator Temperature

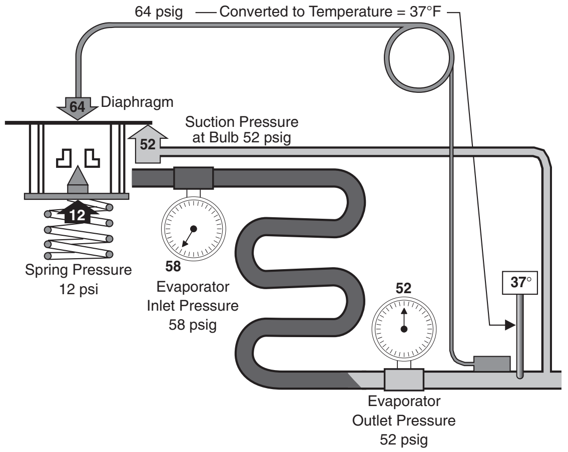
Figure 4 shows the same internally equalized valve on a system having the same evaporator pressure at the sensing bulb location. The evaporator coil, however, now has a pressure drop of 6 psi. Since an internally equalized valve senses evaporator pressure at the valve outlet, the total pressure in the closing direction becomes 58 psig plus the 12 psi spring pressure, or 70 psig. A bulb pressure of 70 psig is now required for proper valve regulation, which translates to a 41°F bulb temperature. The superheat becomes 13°F, or 4°F higher than the superheat calculated in Figure 3. This rise in superheat is due to the pressure drop in the evaporator. Consequently, pressure drop between the valve outlet and the sensing bulb location causes an internally equalized TEV to operate at a higher than desired superheat.

Figure 4



Closing Pressure (Evaporator Inlet Pressure Plus Spring Pressure)	= 58 + 12 = 70 psig
Bulb Pressure Necessary to Open Valve	70 psig
Bulb Temperature Equivalent to 70 psig	41°F
Saturated Temperature Equivalent to Evaporator Outlet Pressure	28°F
SUPERHEAT **Bulb Temperature Minus Saturated Evaporator Temperature**	**13°F**

Figure 5



Closing Pressure (Suction Pressure at Bulb Plus Spring Pressure)	= 52 + 12 = 64 psig
Bulb Pressure Necessary to Open Valve	64 psig
Bulb Temperature Equivalent to 64 psig	37°F
Saturated Temperature Equivalent to Evaporator Outlet Pressure	28°F
SUPERHEAT **Bulb Temperature Minus Saturated Evaporator Temperature**	**9°F**

Figure 5 shows the same system as in Figure 4, but with an externally equalized TEV installed. Since an externally equalized TEV senses evaporator pressure at the evaporator outlet, it is not influenced by pressure drop through the evaporator. As a result, the TEV senses the correct pressure, and controls at the desired superheat.

These diagrams can be used to show the influence evaporator pressure drop has on internally equalized TEVs as evaporating temperatures fall. Table 1 provides general recommendations for maximum pressure drops that can be safely tolerated by internally equalized valves. These recommendations are suitable for most field installed systems. Use externally equalized TEVs when pressure drops exceed values shown in Table 1, or when pressure drops cannot be determined. **An externally equalized TEV should be used whenever a refrigerant distributor is used with the evaporator.**

Refer to Bulletin 10-11, TEV Installation, Field Service and Assembly, regarding recommendations for the location of the sensing bulb and external equalizer connection to the suction line.

Thermostatic Charges

As previously mentioned, the TEV's sensing bulb transmits pressure to the top of the diaphragm by a length of capillary tubing. The **thermostatic charge** is the substance in the TEV's sensing bulb which responds to suction line temperature to create the bulb pressure, and it is designed to allow the TEV to operate at a satisfactory level of superheat over a specific range of evaporating temperatures. The subject of thermostatic charges is best approached by describing the categories into which charges are classified. These categories are the following:

1. Liquid Charge
2. Gas Charge
3. Liquid-Cross Charge
4. Gas-Cross Charge
5. Adsorption Charge

The conventional liquid charge consists of the same refrigerant in the thermostatic element that is used in the refrigeration system, while the liquid-cross charge consists of a refrigerant mixture. The term **cross charge** arises from the fact that the pressure-temperature characteristic of the refrigerant mixture used within the sensing bulb will cross the saturation curve of the system refrigerant at some point.

Both the liquid and liquid-cross charges contain sufficient liquid such that the bulb, capillary tubing, and diaphragm chamber will contain some liquid under all temperature conditions. This characteristic prevents **charge migration** of the thermostatic charge away from the sensing bulb if the sensing bulb temperature becomes warmer than other parts of the thermostatic element. Charge migration will result in loss of valve control. An additional characteristic of these charges is their **lack of a maximum operating pressure (MOP)** feature. A thermostatic charge with an MOP feature causes the TEV to modulate in the closed direction above a predetermined evaporator pressure, thereby restricting flow to the evaporator and limiting the maximum evaporator pressure at which the system can operate.

Similarly, the gas charge consists of the same refrigerant in the thermostatic element that is used in the refrigeration system, while the gas-cross charge consists of a refrigerant mixture. Unlike the liquid type charges, both gas charges are distinguished by having a vapor charge in the thermostatic element which condenses to a minute quantity of liquid when the TEV is in its normal operating range. This characteristic provides an MOP for the valve at the bulb temperature at which the liquid component of the charge becomes vapor. Above this bulb temperature, a temperature increase does not significantly increase thermostatic charge pressure, limiting the maximum evaporator pressure at which the system can operate. A disadvantage of this type of thermostatic charge is the possibility of charge migration.

The adsorption charge consists of a noncondensable gas and an adsorbent material located in the sensing bulb. As the temperature of the bulb increases, gas is expelled (desorbed) from the adsorbent material increasing bulb pressure. Conversely, as the temperature of the bulb decreases, gas is adsorbed thus decreasing bulb pressure. Like the liquid and liquid-cross charges, the adsorption charge does not provide an MOP, and it will not migrate.

SPORLAN THERMOSTATIC EXPANSION VALVES

Sporlan manufactures thermostatic expansion valves for all air conditioning and refrigeration applications. For applications using refrigerants R-12, R-22, R-134a, R-404A, R-502, and R-507, Sporlan's standard line of TEVs are available with SAE flare, ODF solder, ODF solder flange, and FPT flange connections. Specifications for the TEVs are provided in Bulletin 10-10. Materials and details of construction are also provided in Bulletin 10-10.

For refrigerant R-717 (ammonia) applications, Sporlan TEVs are available with FPT and socket weld flange connections. These valves are manufactured and marketed through the Refrigeration Specialties Division of Parker Hannifin.

Valve capacity ratings for refrigerants R-12, R-22, R-134a, R-401A, R-402A, R-404A, R-407A, R-407C, R-408A, R-409A, R-502, R-507, and R-717 are listed in Bulletin 10-10. The capacity tables on these pages specify valve ratings at selected evaporator temperatures. Contact Sporlan for applications not specifically listed in Bulletin 10-10.

In addition to the standard line of TEVs listed in this bulletin, Sporlan also manufactures special valve types to fill specific requirements for OEM customers. These OEM valve types include the Type BI, I, FB, and X TEVs. Special features such as bleed ports, nonadjustable construction, and extra length capillary tubing are available for many standard and OEM valves. Automatic expansion valves are also available on special order. If you have a special refrigerant flow control application, contact Sporlan for assistance.

Alternative Refrigerants

Sporlan has an ongoing program to evaluate alternative refrigerants and, when applicable, their associated refrigerant lubricants to assess compatibility with our materials of construction. For additional information on this subject, contact Sporlan. Table 2 lists some of the major HFC and HCFC replacement refrigerants for R-11, R-12, R-114, and R-502.

Table 2

CFC	Intermediate Alternatives (HCFC)	Long Term Alternatives (HFC)
R-11	R-123	–
R-12	R-401A (MP39) R-401B (MP66) R-409A (FX-56)	R-134a
R-114	R-124	–
R-502	R-402A (HP80) R-408A (FX-10)	R-404A (HP62) R-407A (KLEA*60) R-507 (AZ-50)

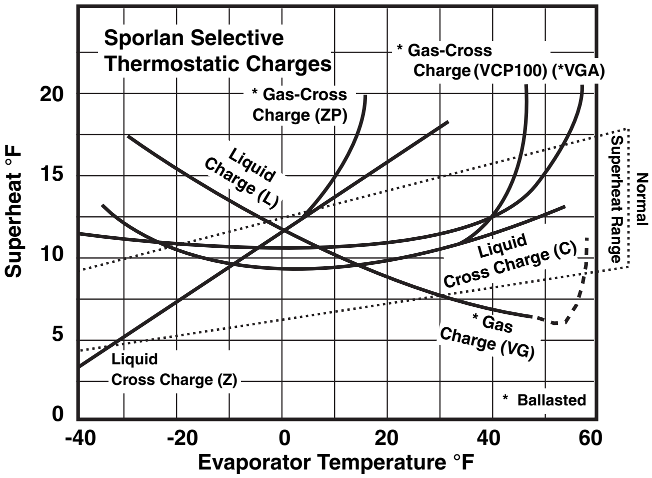
*KLEA is a trade name of ICI FLUOROCHEMICALS.

Sporlan Selective Charges

Sporlan introduced **Selective Charges** for TEVs over 50 years ago, recognizing that a single thermostatic charge cannot work effectively over the useful range of evaporating temperatures of many standard refrigerants. The present universal acceptance of Selective Charges is evidence of their many operational advantages. An explanation of their applications, design features, and advantages of each Selective Charge follows. Recommended Sporlan thermostatic charges for various applications are listed on Page 18.

The thermostatic expansion valve's **static superheat** versus evaporator temperature is referred to as the **superheat characteristic curve**. This curve is helpful in understanding TEV operation since its shape describes the valve's operation at a given setting over a range of evaporating temperatures. Figure 6 illustrates the superheat characteristic curves of standard Sporlan thermostatic charges. The concept of static superheat is described on Page 14, *Factors Affecting TEV Operation and Performance.*

Figure 6



Air Conditioning and Heat Pump Applications

These applications usually require a pressure limiting (MOP type) thermostatic charge to limit compressor loading during system pulldown. The pressure limiting charge causes the TEV to open only slightly until the system evaporator pressure is reduced below the MOP of the charge, permitting rapid pulldown.

The Sporlan thermostatic charges listed on Page 18 under the air conditioning and heat pump section are gas-cross charges.

Figure 6 illustrates the superheat characteristic curves of the Sporlan VCP100 and VG charges, a gas-cross charge and a gas charge respectively for R-22 applications. The VCP100 charge has a flatter operating range which allows the TEV to maintain a more constant superheat with changes in evaporating temperature. This characteristic is generally desired since many air conditioning and heat pump systems operate over a significant range of evaporating temperatures. The VG charge has limited application except for our WVE-180 valve. The vertical portion of the curves is the MOP region of both charges.

Sporlan pressure limiting charges also help reduce the problem of the TEV alternately overfeeding and underfeeding the evaporator, which is usually termed **hunting** or **cycling**. The amount of hunting in a system is influenced by the design of the evaporator coil, suction line piping at the valve's sensing bulb location, and the variability of the heat load on the evaporator. Hunting may cause a reduction in total system capacity, and a noticeable variation of evaporator pressure on systems having one evaporator. If hunting is severe, occasional floodback may result.

To help reduce or eliminate valve hunting, many Sporlan pressure limiting thermostatic charges feature the **FLOWMASTER** design introduced by Sporlan in 1948. This design incorporates a **thermal ballast** with the charge to help stabilize valve control.

Originally, it was felt that a highly temperature sensitive TEV would best be able to reduce hunting. This concept has proved to be incorrect for the majority of air conditioning and heat pump applications and, in fact, it was found to often aggravate hunting problems. A less temperature sensitive TEV using specifically designed pressure limiting thermostatic charges has proven to be the best solution for these applications.

Type VGA Thermostatic Charge — The VGA charge is a specially designed pressure limiting charge for R-22 air conditioning and heat pump applications. The constituents and thermal ballast used with this thermostatic charge provide exceptional anti-hunt characteristics, which makes it the recommended charge for the majority of these applications. Due to its design, the MOP of the VGA charge is not as defined as the VCP100 charge, our alternate standard thermostatic charge for R-22 air conditioning and heat pump applications. **Therefore, if a defined MOP is not required, the VGA charge may be used in place of the VCP100 charge.**

Table 3

Refrigerant	Thermostatic Charge	MOP - psig	
		Factory Air Test	Nominal System
12	FCP60	60	50
	FCP	40	30
	FZP	20	12
22	VCP100	100	90
	VGA	*	*
	VCP	65	55
	VZP40	40	30
134a	JCP60	60	50
	JCP	40	30
404A	SCP115	115	105
	SCP	75	65
	SZP	45	35
502	RCP115	115	105
	RCP	75	65
	RZP	45	35
507	PZP	45	35

*Above normal operating conditions.

Maximum operating pressures for standard Sporlan pressure limiting charges are listed in Table 3. The factory air test pressure represents the valve MOP determined by a Sporlan air test fixture. The nominal system pressure is the actual system MOP. If an application requires a pressure limiting charge with an MOP not shown, contact Sporlan for assistance.

Due to the design of pressure limiting charges, the valve diaphragm and capillary tubing must be kept at a temperature warmer than the bulb during system operation. Otherwise, migration of the charge away from the bulb will occur, and cause loss of valve control.

A properly selected and applied pressure drop type distributor is effective in preventing charge migration. Figure 7 illustrates how the pressure drop across this type of distributor keeps the TEV outlet pressure and temperature higher than the suction gas temperature.

Pressure drop at the refrigerant distributor does not affect system capacity. The refrigerant distributor simply lowers the pressure drop across the TEV by a small amount. If the TEV is properly sized, it will maintain desired superheat (and system capacity) with the remaining pressure drop available to the valve.

When applying a TEV and distributor, the two components perform together to provide stable system operation. Application of these components is much more critical on systems that operate at part-load conditions much of their operating time, e.g., variable air volume (VAV) systems and refrigeration systems with compressor unloading. See Bulletin 20-10 for complete information on refrigerant distributors.

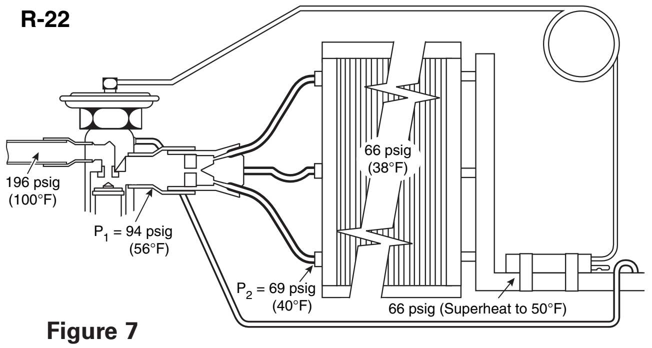


Figure 7

Refrigeration Applications

Ordinary refrigeration applications may be divided into the following three categories: commercial refrigeration, low temperature refrigeration, and extremely low temperature refrigeration. For each of these categories, Sporlan has developed a Selective Charge to provide optimum valve performance. These charges are described below.

Type C Charges — The charges listed under the commercial refrigeration section in the Recommended Thermostatic Charges table on Page 18 are collectively known as C Charges. These charges are liquid-cross charges and have an operating range from an evaporating temperature of 50°F to –10°F. Figure 6 illustrates a typical superheat characteristic curve of the C Charge. For comparison purposes, the superheat characteristic curve of a straight liquid charge is also shown. The flatter curve of the C Charge allows the valve to respond in a more stable manner to changes in evaporator pressure. Depending on the static superheat requirements, the Type C Charge has been applied by some manufacturers to display cases operating at both medium and low temperature.

Types Z and ZP Charges — The charges listed under the low temperature refrigeration section are the Types Z and ZP Charges. The Z Charges (FZ, VZ, SZ, RZ, and PZ) are liquid-cross charges having an operating range from an evaporating temperature of 0°F to –40°F. A typical superheat characteristic curve of the Z Charge is illustrated in Figure 6. Since the curve slopes upward to the right, the valve will control at lower superheat values as evaporator temperature decreases, providing operational advantages for low temperature refrigeration. This characteristic prevents floodback during compressor startup, reduces the load on the compressor after startup, and permits rapid pulldown. Since the majority of low temperature systems operate at or near a specific evaporating temperature, the TEV can be set for optimum superheat at the design temperature permitting the system to operate as efficiently as possible.

The Types ZP Charges (FZP, VZP, SZP, RZP, and PZP) are gas-cross charges having the same operating range as the Type Z Charges. A typical superheat characteristic curve of the ZP Charge is illustrated in Figure 6. The Z and ZP Charges are essentially the same with the exception of the ZP Charge providing an MOP. **Type ZP Charges are not intended as replacements for Z Charges. Each should be selected for its unique purpose. A ZP Charge should only be used for low temperature refrigeration systems where it is necessary to limit evaporator pressure during pulldown**.

During and after a hot gas defrost cycle or after a shutdown period, evaporator pressure may rise to a level the compressor motor cannot handle. In such cases, a pressure limiting charge is often effective in limiting suction pressure at the compressor. For systems employing long suction lines, a crankcase pressure regulating (Sporlan CRO type) valve may be required to limit suction pressure at the compressor quickly. While a pressure limiting charge can be used with a CRO valve, pulldown time may be adversely affected if the charge MOP and the CRO valve setting are close to one another. Therefore, Sporlan does not recommend a CRO valve and a pressure limiting TEV be used on the same system.

Type X Charge — The charges listed under the extremely low temperature refrigeration are known as the X Charges. The X Charges are liquid-cross charges having an operating range from an evaporating temperature of –40°F to –100°F. This curve is similar to the Z Charge curve since the performance characteristics of the Z Charges previously discussed apply very well to extremely low temperature refrigeration. Contact Sporlan for assistance in selecting TEVs for applications requiring the X Charge.

Special Selective Thermostatic Charges and Elements

Sporlan manufactures a number of special thermostatic charges and elements designed for specific applications. A few of these are described below:

Type N Charge — This charge is an adsorption type charge which has a superheat characteristic curve similar to the C Charge but tends to be less responsive. The N Charge is a noncondensable charge, and it has no MOP feature. The N Charge is used on special medium and high temperature applications such as chillers which are located outdoors and must operate while exposed to cold temperatures.

Hydraulic Elements — These thermostatic elements are specially designed double diaphragm elements which provide a pressure limiting feature without the problems associated with charge migration from the bulb when the element becomes cooler than the bulb. The hydraulic element is often used on chillers which require a TEV with an MOP type charge, but experience problems with charge migration caused by cold ambient temperatures. For additional information on the hydraulic element, contact Sporlan.

Mechanical Pressure Limit Elements — These thermostatic elements may use either liquid or liquid-cross charges, and they employ a mechanical means to limit suction pressure (PL-type). A collapsible member is used to limit evaporator pressure when it exceeds a specified value. This method of limiting evaporator pressure is considered obsolete, and replacement valves and thermostatic elements are no longer available. A cross reference is available from the obsolete PL element to the thermostatic element with the MOP charge, please refer to Bulletin 210-10-17.

Special Refrigerants — Thermostatic charges for use with special refrigerants are available. These refrigerants include: R-13, R-23, R-13B1, R-124, and R-503. Contact Sporlan for assistance in valve selection for special refrigerant applications.

Desuperheating Charges — Special thermostatic charges have been developed for applications requiring suction gas desuperheating. The subject of hot gas bypass and desuperheating TEVs is discussed on Page 12.

THERMOSTATIC EXPANSION VALVE APPLICATIONS

Due to its superior operating characteristics, the TEV is currently used on a wide variety of applications. These applications include both large and small capacity air conditioning and heat pump systems; commercial refrigeration systems including refrigerated display cases, ice cubers, and soft drink dispensers; and low temperature refrigeration systems.

Most air conditioning and refrigeration systems use some method of capacity reduction to match the capacity of the system to a reduced heat load condition, commonly referred to as partload operation. The simplest method of capacity reduction is cycling the compressor, usually in response to a thermostat. Other methods of capacity reduction include using compressors equipped with cylinder unloaders, bypassing hot gas, or some combination of the above. A discussion on these capacity reduction methods and their effect on TEV operation is presented later in this section.

The thermostatic expansion valve is a modulating type flow control device with the capability to adjust to low load conditions and maintain reasonable refrigerant flow control. The range of effective TEV control, however, has limits and may not be capable of operating properly on a system requiring a high degree of capacity reduction. As a result, systems using capacity reduction methods require the use of proper design and installation practices.

System Design Factors

Predicting TEV performance at reduced system capacities is difficult due to the many influencing design factors present in any system. These factors include: TEV sizing, refrigerant distribution, TEV setting, evaporator coil design, suction line piping, and bulb location. General recommendations which address these factors are provided below. By observing these recommendations, a conventional TEV can be expected to operate satisfactorily down to approximately 35 percent of its rated capacity. The Types (E)BF, SBF, EBS, and O valves, featuring the balanced port design, can be expected to operate satisfactorily down to approximately 25 percent of its rated capacity.

Valve Size — The TEV should be sized as close as possible to the system's maximum designed heat load condition. A valve with a capacity rating up to 10 percent below the full load conditions may be selected if the system is to operate at reduced loads for long periods of time, and if slightly higher than normal superheats can be tolerated at full load conditions.

Distributor Sizing — The proper sizing of the distributor is extremely important for systems using methods of capacity reduction. The function of the refrigerant distributor is to evenly distribute refrigerant to a multi-circuited evaporator. If the distributor cannot perform its function at all load conditions erratic TEV operation can be expected. For the pressure drop type distributor, the distributor nozzle and tubes must be checked for proper sizing at both minimum and maximum load conditions. See Bulletin 20-10 for further information.

Superheat Adjustment — The superheat setting of the TEV should be set at the highest possible superheat that can be tolerated at full load conditions. A high superheat setting will reduce problems associated with mild TEV hunting at low load conditions. High superheats are more acceptable on air conditioning systems where the wide temperature difference between the refrigerant and the air allows the TEV to operate at higher superheats without a significant loss in coil capacity.

Evaporator Coil Design — When the evaporator is circuited to provide counterflow of the refrigerant relative to the direction of the air flow, superheat will normally have the least effect on evaporator capacity and suction pressure fluctuations will be minimized.

Refrigerant velocity inside the evaporator should be high enough to prevent excessive trapping of liquid refrigerant and oil, which may cause TEV hunting. Multi-circuited coils should be designed in such a manner that each circuit is exposed to the same heat load. Air flow across the coil must be evenly distributed.

Large capacity air conditioning evaporator coils are often split into multiple sections so that one or more of these sections can be shut off for capacity control during part-load operation. Therefore, a TEV is required to feed each of these sections. The methods used to split these coils are referred to as: **row split, face split,** and **interlaced**. Generally, TEVs will operate best on interlaced coils.

Suction Line Piping — Approved methods of suction line piping including recommended bulb locations and use of traps are covered in Bulletin 10-11. Where system designers and manufacturers have tested and approved other methods of piping, these methods should be used when installing or servicing their systems.

Sensing Bulb Location — The TEV's sensing bulb should be located on a horizontal section of suction line near the evaporator outlet and, in the case of an externally equalized valve, upstream of the equalizer connection on the suction line. Refer to Bulletin 10-11 for additional information on bulb location and installation.

Vapor Free Liquid Refrigerant — Another important aspect in assuring proper TEV operation is providing vapor free liquid refrigerant to the inlet of the TEV. Vapor in the liquid line may severely reduce the capacity of the TEV hindering proper refrigerant flow to the evaporator. An adequately sized liquid-to-suction heat exchanger will help assure vapor free liquid by providing some amount of subcooling to the liquid. In addition, the heat exchanger provides an added advantage to the system by vaporizing small quantities of liquid refrigerant in the suction line before the liquid reaches the compressor. A Sporlan See•All® Moisture-Liquid Indicator installed near the TEV inlet offers a visual check for vapor free refrigerant.

Balanced Port TEVs

One of the factors limiting a TEV's ability to operate at part-load conditions is a variation in pressure drop across the TEV during normal system operation due to changes in head pressure. As previously discussed on Page 3, *How The Thermostatic Expansion Valve Works*, pressure drop across the TEV influences valve operation, particularly with the larger capacity valves which possess larger port areas. To counteract the effects of this force Sporlan has incorporated balanced port design features into selected valve types.

Sporlan introduced this feature in 1946 using a double port construction on two large capacity valves: the Types T and W. The Type T valve later became our Type V valve when the valve design was modified. This double port construction features a piston which seats against two ports, and significantly reduces the effects of pressure drop across the valve.

The refrigerant flow entering these valve types is divided between the two ports, the force of the refrigerant flow being transmitted to the midsection of the piston. The force of the flow heading to the lower port is largely canceled out by the force of the flow heading to the upper port due to the design of the piston. A **semi-balanced** valve is achieved, allowing the valve to operate at a lower percentage of its rated capacity than a conventionally designed valve.

Sporlan introduced a patented discharge bypass valve with a **fully balanced** design in 1965, the Type ADRHE-6. This design was later used with the Type O TEV, which was introduced in 1971.

The Type O valve is designed to eliminate the effects of pressure drop across the valve. The Type O valve features a piston which seats against the valve's single port. See Figure 8. A passageway drilled through the piston allows liquid line pressure to be transmitted to the bottom side of the piston. A synthetic cup seal encircling the piston traps this pressure underneath the piston, which causes the force due to the liquid line pressure on top of the piston to be canceled. Satisfactory operation down to 25% or lower of rated capacity can be expected with the Type O valve provided that the aforementioned design recommendations are followed.

Recent efforts by system manufacturers to reduce operating costs of refrigeration systems by allowing condenser pressures to fall or float with lower ambient temperatures has created a need for a small capacity TEV with a balanced port design and superior modulating characteristics. This effort is particularly apparent with supermarket applications. Sporlan introduced the Types (E)BF and EBS valves in 1984 to meet this need.

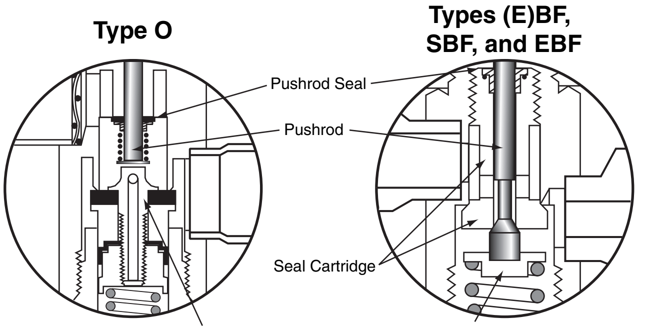


Figure 8

The Types (E)BF and EBS valves feature a single pushrod which extends through the port of the valve. See Figure 8. The port and pushrod cross sectional areas are identical so that the opening force created by pressure drop across the port is canceled by the pressure drop across the pushrod. Furthermore, excellent pin and port alignment is provided by this design. Refer to the section, *Effect of Pressure Drop Across the Valve Port*, on Page 4 for additional information.

The Type (E)BF valve with the 'AA' port was developed by Sporlan in 1988. Its original design used a patented two pushrod construction (U.S. patent 4,750,334) similar to the conventional Type F valve, and the balanced design was achieved by the use of a third *floating rod* located above the valve port. As with the single rod balanced port construction, the *floating rod* causes the pressure drop across it to offset the opening force created by the pressure drop across the port.

The 'AA' port Type (E)BF valve was later redesigned in 1993 to a single pushrod construction like the other Type (E)BF valve sizes. All 'AA' port valves carrying a '3393' date code or later will have the single pushrod construction.

System Design For Part-Load Conditions

On systems where the compressor can unload to 50 percent of its rated capacity, care must be exercised when selecting expansion valves and refrigerant distributors. If the compressor can unload below 33 percent of its rated capacity, special design considerations may be necessary to assure proper TEV operation. Figures 9, 10, and 11 are piping schematics illustrating three possible methods of balancing the capacity of the TEV and distributor with the compressor during low load operation. Recognized piping references such as the equipment manufacturer's literature and the ASHRAE Handbooks should be consulted for further information on this subject. **Sporlan cannot be responsible for damages arising from improper piping practices or the improper use of its products.**

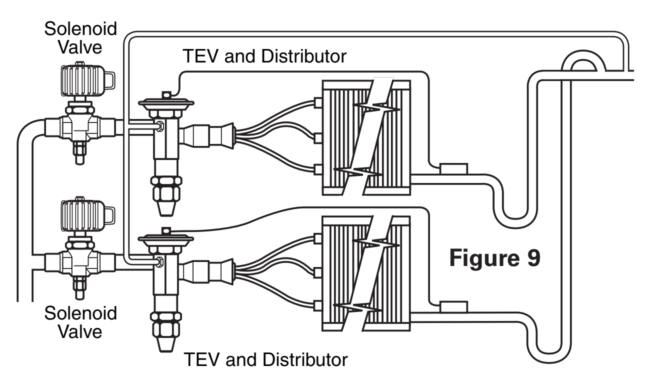


Figure 9

Capacity Reduction – 2 or more evaporator sections handling same load.

Two or More Evaporator Sections Handling the Same Load

Figure 9 illustrates two parallel evaporators each controlled by a separate TEV and refrigerant distributor. Each evaporator shares half of the total common load. The liquid line solenoid valve ahead of each TEV is electrically connected to the compressor capacity modulating system. When the compressor capacity is reduced to 50%, one of the two solenoid valves closes stopping refrigerant flow to one TEV. The TEV remaining in operation will then have a rated capacity approximately equal to the compressor capacity operating 50% unloaded.

This technique may be carried further by using additional evaporator sections, each controlled by a separate TEV and refrigerant distributor. Using multiple evaporator sections will let highly reduced loads to be properly controlled.

Single Evaporator Controlled by Two TEVs

For evaporator coils which are not split by design, i.e., row split, face split, or interlaced, the following techniques may be employed to improve part-load operation.

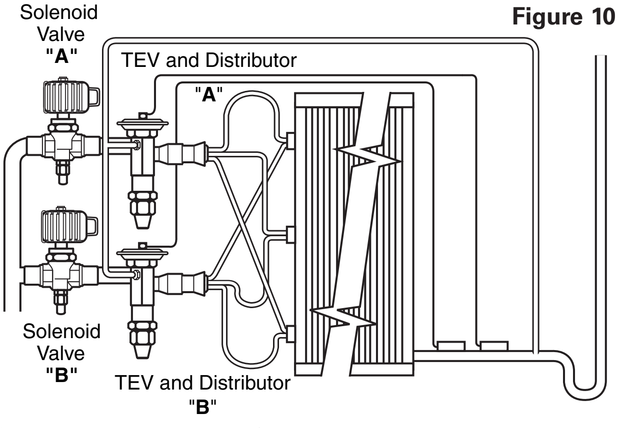
Figure 10 illustrates the use of two TEVs and two distributors feeding a single evaporator. Each evaporator circuit is fed by two distributor circuits, one from each distributor. The solenoid valves are connected to the compressor capacity modulating system as mentioned before. Using this configuration, TEV and distributor capacities can be reduced in three stages. As an example, assume that TEV and distributor combination **A** are sized to handle 67% of the load and combination **B** 33% of the load. The three stages of valve and distributor capacity reduction result from opening or closing the solenoid valves according to the following table:

Table 4

Compressor Capacity Percent of Full Capacity	Position of Solenoid Valve "A"	Position of Solenoid Valve "B"	Total Valve and Distributing Loading Percent of Rated Capacity
100%	Open	Open	100%
83%			83%
67%		Closed	100%
50%			75%
33%	Closed	Open	100%
16%			50%

Another variation of this technique is to have each evaporator circuit fed by a single distributor circuit and size the TEVs and distributors on the expected load of the total number of circuits fed by each TEV. Reducing evaporator capacity is accomplished by closing a solenoid valve which deactivates the circuits being fed by the TEV and distributor downstream of the solenoid valve. This method of capacity control, however, requires a degree of care since the heat load on the evaporator circuits will be affected in the manner in which circuits are deactivated.

Figure 10



Capacity Reduction – Single evaporator controlled with 2 TEVs and 2 Solenoid Valves.

Hot Gas Bypass and Desuperheating TEVs

Systems which are required to operate at load conditions below the unloading capabilities of their compressors present an additional design problem. To balance the system under these conditions, bypassing a controlled amount of hot gas to the suction side of the system provides a practical solution. Bypassing hot gas is accomplished with a modulating control valve known as a **discharge bypass valve**. Sporlan manufactures a complete line of these valves. For details, refer to Bulletin 90-40.

For close coupled systems, the preferred method of hot gas bypass is bypassing to the inlet of the evaporator. This method has three advantages: (1) the TEV will respond to the increased superheat of the vapor leaving the evaporator and will provide the liquid required for desuperheating; (2) the evaporator serves as an excellent mixing chamber for the bypassed hot gas and the liquid vapor mixture from the TEV; and (3) oil return from the evaporator is improved since the refrigerant velocity in the evaporator is kept high by the hot gas.

For multi-evaporator or remote systems, bypassing hot gas directly into the suction line in the manner illustrated in Figure 11 may be necessary. In addition to the discharge bypass valve, an auxiliary TEV known as a **desuperheating TEV** is required to supply the necessary liquid refrigerant to cool the discharge gas entering the suction line. Compressor manufacturers generally rate their air conditioning compressors for a 65°F return gas temperature, and this temperature is usually appropriate for selecting desuperheating TEVs. Many refrigeration and low temperature compressors, however, require lower suction gas temperatures to prevent discharge gas temperatures from rising too high and damaging compressor parts and carbonizing oil. Consult the compressor manufacturer if the maximum permissible suction gas temperature for a compressor is not known.

Sporlan has developed special desuperheating thermostatic charges. See Table 5 below. Each charge will allow the desuperheating TEV to control the listed suction gas superheat. For suction gas temperatures that require superheats other than those listed, contact Sporlan or the compressor manufacturer for assistance.

*THERMOSTATIC CHARGES

Table 5

For Desuperheating Thermostatic Expansion Valves

Refrigerant	Suction Gas Superheat* °F	Minimum Allowable Evaporating Temperature at Reduced Load Condition °F	
		40° thru –15°	–16° thru –40°
12, 134a	25	L2	L1
	35		L2
	45	L3	
22	25	L1	L1
	35		
	45	L2	L2
404A, 502, 507	35	L1	L1
	45		

* For suction gas temperatures that require superheats other than those listed above, contact Sporlan or the compressor manufacturer for assistance.

Sizing a desuperheating valve involves determining the amount of refrigerant liquid necessary to reduce the suction gas temperature to the proper level. For hot gas bypass applications, a desuperheating valve can be properly sized from the selection procedure provided in Bulletin 90-40.

An externally equalized TEV is recommended for most desuperheating applications. If the piping of the desuperheating TEV is close coupled, an internally equalized valve may be used. Figure 11 illustrates the use of an externally equalized desuperheating TEV. Refer to the section, *Equalization Method* on Page 5 for further information on this subject.

When piping the discharge bypass valve and the desuperheating TEV, remember that good mixing of the discharge gas and liquid must be obtained before the mixture reaches the sensing bulb of the desuperheating TEV. Improper mixing may produce unstable system operation causing the desuperheating TEV to hunt. Proper mixing can be accomplished in two ways: (1) install a suction line accumulator downstream of both valve outlet connections with the desuperheating TEV bulb downstream of the accumulator; or (2) mix the liquid vapor mixture from the desuperheating TEV and the hot gas from the bypass valve together before connecting a common line to the suction line. The latter method is illustrated in Figure 11.

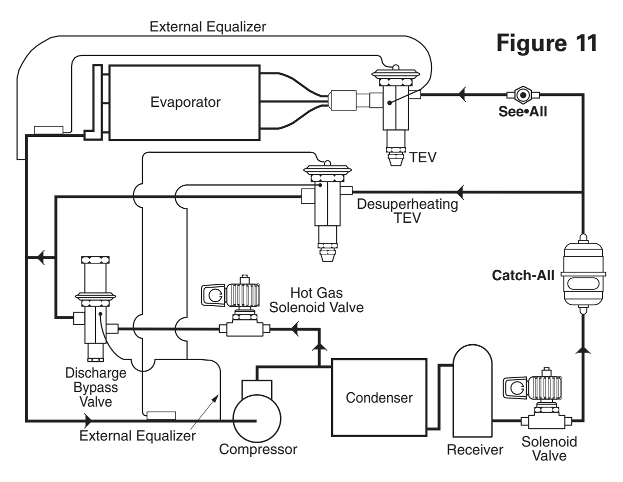


Figure 11

Off-Cycle Pressure Equalization

Certain applications utilizing low starting torque single phase compressor motors (e.g., a permanent split capacitor motor) require some means of pressure equalization during system offcycle. Pressure equalization is necessary since low starting torque compressors are not capable of restarting against a large pressure differential. Typical applications requiring pressure equalization are small air conditioning and heat pump systems which frequently cycle on and off in response to a thermostat.

Permanent Bleed Port — Any Sporlan thermostatic expansion valve may be ordered with a **bleed port**. Standard bleed port sizes are: 5%, 10%, 15%, 20%, 30%, and 40%. Bleed ports are designated by the percentage they increase nominal valve capacity at 40°F evaporator temperature. For example, a 2 ton TEV with a 30% bleed will have the capacity of: 2 x 1.3 = 2.6 tons. Refer to Page 17 for *Ordering instructions*. Please contact Sporlan for assistance in selecting appropriate bleed port sizes.

The subject of pressure equalization during system off-cycle should not be confused with the external equalizer of the TEV. System pressure equalization is accomplished by allowing a certain amount of refrigerant to leak through a machined notch or hole in the valve seat during system off-cycle. The external equalizer of the TEV, however, simply allows the valve to sense evaporator pressure. The external equalizer does not provide pressure equalization during system off-cycle.

The Rapid Pressure Balancer (RPB) Feature — The thermostatic expansion valve with the Rapid Pressure Balancer (RPB) feature was developed by Sporlan in response to an industry demand for a TEV which would equalize system pressures during off-cycle more rapidly than a TEV with a permanent bleed port. In some cases, the bleed port has proved somewhat slow at equalizing system pressures creating restart problems for low starting torque compressor motors. The RPB feature, however, has been proven to reduce equalization times, normally to within two minutes after system off-cycle.

The RPB feature is actuated following system off-cycle. Immediately after compressor shutdown, the evaporator pressure rises forcing the valve's pin carrier to a more closed position. When the RPB feature is used, the pin carrier continues its motion and opens a secondary spring loaded bleed port allowing rapid pressure equalization to occur. Upon compressor restart, evaporator pressure falls closing the spring loaded bleed port. The bleed position and the normal operating position of the RPB are illustrated in Figure 12.

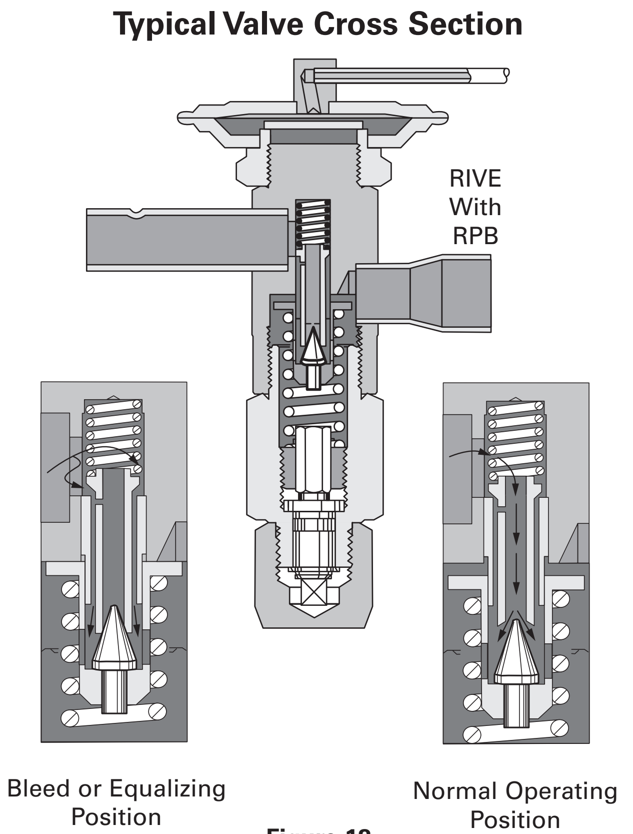

Typical Valve Cross Section

Figure 12

The RPB feature has a specific application. The feature should only be used on small air conditioning and heat pump systems which use a low starting torque single phase compressor motor. On heat pump applications, the RPB feature should only be used on the **indoor coil**. Since the outdoor coil may be exposed to cold ambient temperatures, there exists a possibility the evaporator pressure may fall too slowly upon compressor restart to reset the RPB feature. In addition, the RPB feature is not recommended nor is it required for any system employing electrical **hard start** components.

The RPB feature is available with the Type RI TEV, and it can be specified on a special order basis for Types C and S TEVs up to and including 4 tons R-22 nominal capacity. Refer to the valve specification sheets for further information. For OEM type TEVs, contact Sporlan regarding the availability of the RPB feature. A **Catch-All® Filter-Drier** should be installed near the inlet of a TEV having the RPB feature to assure proper valve operation.

The normal capacity of the valve is increased by 15% when the rapid pressure balancer is used. A cross drilling is part of the internal construction of the RPB feature and this drilling provides the additional refrigerant flow.

R-717 (Ammonia) Applications

Thermostatic expansion valves for ammonia applications require special design considerations due to the erosive effects of ammonia vapor. For this type of application, Sporlan has developed the Types D and A thermostatic expansion valves. Like other components of any ammonia system, the Types D and A valves are made from steel and steel alloys. The materials used in the manufacture of these valves are listed in Bulletin 10-10.

With ammonia systems, the formation of flash vapor at the expansion valve port causes valve seat erosion or wire drawing to occur. This effect is further aggravated by high velocity ammonia mixed with dirt or scale passing through the port of the expansion valve. Fortunately, seat erosion can be minimized and valve life extended if the following steps are taken:

1. Maintain vapor-free liquid at the TEV inlet at all times.
2. Maintain clean ammonia through effective filtration.
3. Reduce the velocity of the ammonia through the TEV port by reducing the pressure drop across the port.

Step 1 can be accomplished through proper system design. Liquid line vapor is prevented by adequately sizing liquid lines and providing sufficient subcooling. Step 2 can be assured with the use of a Sporlan **Catch-All® Filter-Drier**. This filter-drier is an effective scale trap when used on ammonia systems. For further information on the use of the **Catch-All Filter-Drier** with ammonia systems, refer to Bulletin 40-10.

Step 3 is accomplished through the use of a removable **discharge** tube located in the outlet of all Type D valves and the nominal 20, 30, and 50 ton Type A valves. This discharge tube represents the principal difference between Sporlan ammonia TEVs compared to TEVs used with other refrigerants. The discharge tube functions by removing a portion of the total pressure drop across the valve resulting in a lower pressure drop across the valve port. Liquid velocities and the formation of flash vapor at the valve port are reduced, extending the life of the valve. Discharge tube sizes are listed in the Types D and A valve specifications located in Bulletin 10-10.

The discharge tube should be removed and discarded when a Sporlan refrigerant distributor is used with the ammonia TEV since the function of the discharge tube is accomplished by the distributor nozzle. If the discharge tube is not removed from the valve, the combination of the discharge tube and distributor nozzle may create an excessive pressure drop resulting in a substantial loss of TEV capacity. Refer to Bulletin 20-10 for further information on ammonia distributors.

The nominal 75 and 100 ton Type A valves do not employ a discharge tube since their valve outlets are designed to serve as a secondary orifice to reduce pressure drop across the valve port.

Table 6

Thermostatic Charge	Evaporator Temperature °F
C	40° to 0°
Z	0° to –30°

For applications at evaporator temperatures below minus 30°F, consult Sporlan.

Thermostatic Charges for Ammonia Valves

Thermostatic charges C, Z, and L are available for the Type D thermostatic expansion valve. The Type L thermostatic charge is the only charge available for the Type A valve.

The Types C and Z thermostatic charges provide operating advantages for systems that cycle in response to a suction pressure switch or thermostat. These charges are also recommended for systems using a small capacity compressor. The table above lists the recommended temperature range for each charge.

Cold storage plants will often have large centralized ammonia systems. These systems will consist of many evaporators connected to one or more large compressors. With many thermostatic expansion valves operating at a common evaporator pressure, a change in flow rate made by one valve will not have a significant effect on the evaporator pressure. This operating characteristic makes it more desirable for the thermostatic expansion valve to be more responsive to changes in bulb temperature. This is the feature of the Sporlan Type L charge. Therefore, for large ammonia systems consisting of multiple evaporators, the Type L charge is recommended.

FACTORS AFFECTING TEV OPERATION AND PERFORMANCE

Many factors exist which influence TEV operation and performance. The following discussion lists the major factors:

Superheat

Superheat is defined as the difference between the refrigerant vapor temperature and its saturation temperature. To properly measure the superheat the TEV is controlling, the **pressure-temperature method** is used. This method consists of measuring the suction pressure at the sensing bulb location, converting this pressure to its saturation temperature by using a pressure temperature (P-T) chart, and subtracting the saturation temperature from the vapor temperature measured at the sensing bulb location. For example, the superheat of R-22 vapor at 50°F and 68.5 psig at the sensing bulb location is calculated as follows:

saturation temperature of R-22 vapor at 68.5 psig = 40°F
superheat = 50°F - 40°F = 10°F

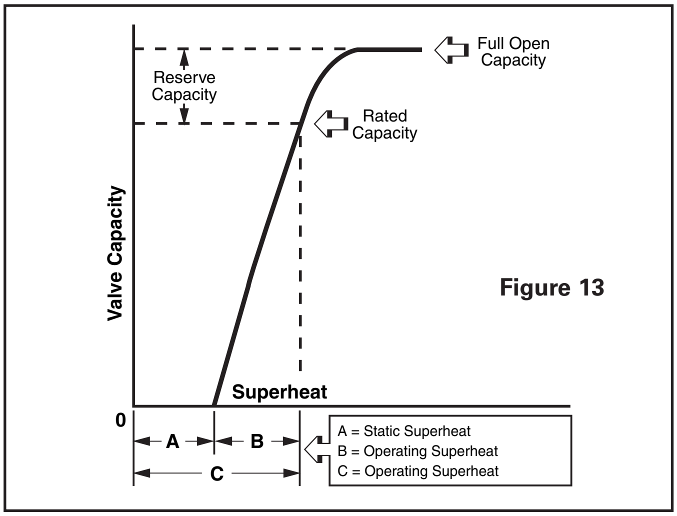


Figure 13

Another method of measuring superheat the TEV is controlling is the **two temperature method**. With this method, saturation temperature is measured directly by placing a temperature probe on the evaporator surface, normally at a location one-half to two-thirds the distance through the evaporator coil. Since this method can only approximate true saturation temperature, it is not as reliable as the pressure-temperature method, and it should be avoided whenever possible.

The TEV is designed to control superheat at a constant value at the location of its sensing bulb. The level of superheat determines to what extent the valve is open. A TEV controlling at a high superheat will be further open than a TEV controlling at a low superheat. Refer to the section, *How the Thermostatic Expansion Valve Works*, on Page 3 for additional information. Figure 13 shows a plot of valve capacity versus superheat for a typical TEV, illustrating the effect superheat has on valve capacity. For the purpose of understanding the relationship between superheat and valve capacity, superheat may be described as follows:

Static Superheat — static superheat is the amount of superheat necessary to overcome the spring and equalizer pressures so that any additional superheat will cause the valve to open.

Opening Superheat — opening superheat is the amount of superheat required to move the valve pin away from the seat after the spring and equalizer pressures have been overcome to permit refrigerant flow.

Operating Superheat — operating superheat is the superheat at which the TEV operates on a refrigeration system. Operating superheat is the sum of static and opening superheats. The valve capacity versus operating superheat curve is referred to as the **valve gradient.**

The most desirable operating superheat for a particular system largely depends on the **temperature difference (TD)** between the refrigerant and the medium being cooled. The basic definition of TD is the difference between evaporator temperature and the entering temperature of the medium being cooled, i.e., air or water. Systems with a high TD, such as air conditioning and heat pump systems, can tolerate higher superheats without appreciable loss in system capacity. Refrigeration and low temperature systems require low superheats due to their lower TDs. The table below provides general recommendations for superheat settings for different evaporator temperature ranges. **These settings are only estimates for typical system designs and should only be used if setting guidelines are unavailable from the system manufacturer:**

General Guidelines for Superheat Settings **Table 7**

Application ➧	Air Conditioning & Heat Pump	Commercial Refrigeration	Low Temperature Refrigeration
Evaporator Temperature °F	50° to 40°	40° to 0°	0° to –40°
Suggested Superheat Setting °F	8° to 12°	6° to 8°	4° to 6°

When a Sporlan TEV is properly selected and applied, the factory superheat setting will usually provide an operating superheat in the range of 8 to 12°F. A precise determination of the valve's operating superheat from a factory setting is not possible since factory settings are determined on the basis of static superheat, and opening superheat of the valve is influenced by several design factors within the system. Once the TEV has been placed on the system and set to the desired operating superheat, however, the valve's static superheat can be measured on a test fixture permitting the desired setting to be duplicated for production runs.

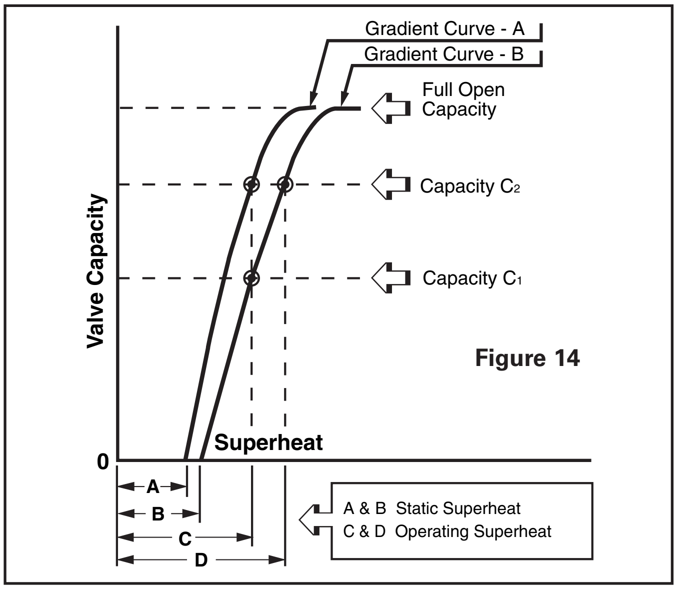


Figure 14

All Sporlan TEVs have reserve capacity in addition to the capacity shown in the rating tables in Bulletin 10-10. This reserve capacity should not be considered when selecting a valve and, in most cases, will not be utilized if the valve is properly selected and applied. Reserve capacity, however, is an important and necessary characteristic of any well designed TEV. Reserve capacity enables the valve to adjust for a temporary increase in load, periods of low condensing pressure, and moderate amounts of flash gas in the liquid line.

Valve Setting

All Sporlan TEVs will produce rated capacity at the standard factory setting. If the valve adjusting stem is turned clockwise, the additional spring pressure created will increase static superheat and decrease the valve's capacity to a limited degree. Turning the adjusting stem counterclockwise will decrease static superheat and increase the valve's capacity to a limited degree. Figure 14 illustrates the effect setting has on valve capacity.

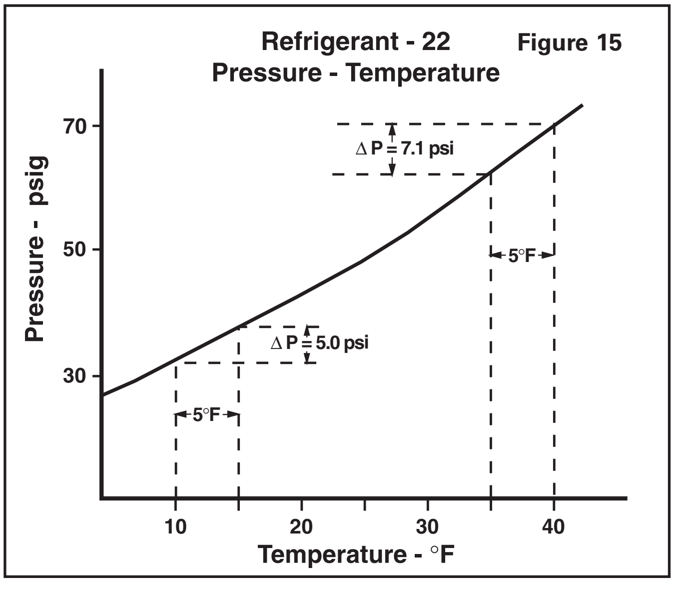


Figure 15

Referring to Gradient Curve **A** in Figure 14, Capacity **C2** is achieved with a static superheat setting of **A** and an operating superheat of **C**. Turning the adjusting stem clockwise will increase the static superheat and shift the curve to the right. This new curve, identified as Gradient Curve **B**, shows that valve capacity will decrease to capacity **C1** at the same operating superheat **C**. Capacity **C2** can only be achieved at the expense of a higher operating superheat designated as **D**.

On an operating system where a given valve capacity is required, any valve adjustment will merely change the superheat at which the valve is operating.

Evaporator Temperature

The pressure-temperature curves for all refrigerants have a flatter slope at lower temperatures. Figure 15 illustrates a P-T curve using R-22 as an example. The P-T curve for a thermostatic charge will also be flatter at lower temperatures. As a result, a given bulb temperature change causes a smaller bulb pressure change at lower evaporator temperatures. A given change in superheat will result in less pressure difference across the valve diaphragm at lower evaporating temperature causing a reduction in valve opening and valve capacity.

Subcooling

Subcooling is defined as the difference between the refrigerant liquid temperature and its saturation temperature. For example, the amount of subcooling of R-22 liquid at 85°F and 196 psig is calculated as follows:

saturation temperature of R-22 liquid at 196 psig =
100°F subcooling = 100°F - 85°F = 15°F

Adequate subcooling of the refrigerant liquid is necessary to prevent the formation of liquid line vapor due to pressure losses in the liquid line. Vapor in the liquid line, even in small quantities, will measurably reduce valve capacity. Several methods by which liquid line vapor can be prevented in spite of relatively high liquid line pressure losses are explained in Bulletin 10-11.

Table 8

Refrigerant	Vertical Lift – Feet				
	20	40	60	80	100
	Static Pressure Loss – psi				
12	11	22	33	44	55
22, 404A	10	20	30	39	49
134a, 502	10	20	30	40	50
410A	9	17	26	34	43
507	8	17	25	34	42
717 (Ammonia)	5	10	15	20	25

Table 9

Refrigerant	*Average Pressure Drop Across Distributor
12, 134a	25 psi
22, 404A, 502, 507	35 psi
410A	45 psi
717 (Ammonia)	40 psi

*See Sporlan Bulletin 20-10 for pressure drop data as related to percent loading.

Pressure losses in the liquid line result from friction and static pressure losses. Minimizing these pressure losses as much as possible is necessary for proper system design. Friction losses may be minimized by properly sizing the liquid line and liquid line accessories such as a solenoid valve and filter-drier. Static pressure losses, however, are solely the result of the weight of the vertical height of refrigerant liquid. As a result, static pressure losses can only be minimized by reducing the upward vertical height refrigerant liquid must travel. Table 8 may be used to determine the static pressure loss of a liquid line. When the sum of the static pressure and friction losses are known, the amount of subcooling necessary to prevent vapor from forming in the liquid line can be determined. For example, if the sum of the static and friction losses is 14 psi for an R-22 system, and the condensing temperature is 100°F, the subcooling necessary is as follows:

saturation pressure of R-22 at 100°F condensing = 196 psig pressure at TEV inlet = 196 -14 = 182 psig
saturation temperature of R-22 liquid at 182 psig = 95°F
subcooling required = 100 - 95 = 5°F

Refrigerant Liquid Temperature and Pressure Drop Across TEV

The refrigerant liquid temperature entering the TEV and the pressure drop available across the TEV influence valve capacity. The valve capacity ratings displayed in Bulletin 10-10, are based on 100°F vapor free liquid entering the valve for R-12, R-22, R-134a, R-401A, R-402A, R-404A, R-407A, R-407C, R-408A, R-409A, R-502, and R-507. R-717 (ammonia) valve capacity ratings are based on 86°F vapor free liquid entering the valve. Liquid correction factors for other liquid temperatures are included in Bulletin 10-10 along with the ratings tables for each of the refrigerants listed above. The tables also provide valve capacities for typical pressure drops across the TEV.

Thermostatic Charge

The pressure-temperature curves of the various Sporlan Selective Charges have different characteristics. The same amount of superheat will not produce equal valve openings for each type of charge. The valve capacity ratings shown in this bulletin specify the thermostatic charges which they are based on.

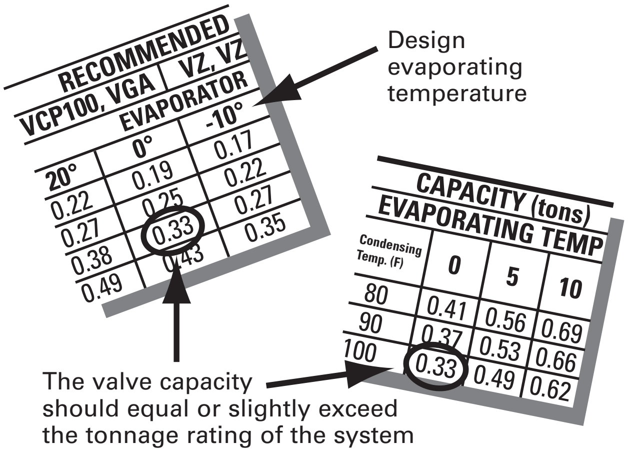
SELECTION PROCEDURE

The following procedure should be used when selecting a Sporlan TEV:

1. Determine pressure drop across valve — Subtract the evaporating pressure from the condensing pressure. The condensing pressure used in this calculation should be the minimum operating condensing pressure of the system. From this value, subtract all other pressure losses to obtain the net pressure drop across the valve. Be sure to consider all of the following possible sources of pressure drop: (1) friction losses through refrigeration lines including the evaporator and condenser; (2) pressure drop across liquid line accessories such as a solenoid valve and filter drier; (3) static pressure loss (gain) due to the vertical lift (drop) of the liquid line; and (4) pressure drop across a refrigerant distributor if used. Table 9 specifies typical pressure drops across Sporlan type refrigerant distributors at design load conditions. Refer to Bulletin 20-10 for further information on refrigerant distributors.

2. Determine the liquid temperature of the refrigerant entering the valve — The TEV capacity tables in Bulletin 10-10, are based on a liquid temperature of 100°F for R-12, R-22, R-134a, R-401A, R-402A, R-404A, R-407A, R-407C, R-408A, R-409A, R-502 and R-507. R-717 (ammonia) capacities are based on 86°F. For other liquid temperatures, apply the correction factor given in the tables for each refrigerant.

3. Select valve from the capacity tables — Select a valve based on the design evaporating temperature and the available pressure drop across the valve. If possible, the valve capacity should equal or slightly exceed the design rating of the system. Be sure to apply the appropriate liquid temperature and pressure drop correction factors to the valve ratings shown in the tables. Once the desired valve capacity has been located, determine the nominal capacity of the valve from the second column of the tables. On multiple evaporator systems, select each valve on the basis of individual evaporator capacity.



CAPACITY (tons)

Condensing Temp. (F)	EVAPORATING TEMP 0	5	10
80	0.41	0.56	0.69
90	0.37	0.53	0.66
100	0.33	0.49	0.62

4. Determine if an external equalizer is required — The amount of pressure drop between the valve outlet and bulb location will determine if an external equalizer is required. Refer to the section, *Equalization Method*, on Page 5 for further information on this subject.

5. Select body type — Select the body type from Table 10 according to the style connections desired. For complete specifications on each TEV type including nominal ratings, refer to Bulletin 10-10 for valve's specifications.

6. Select the Sporlan Selective Thermostatic Charge — Select the charge according to the design evaporating temperature from the Table on Page 18. Refer to Pages 7 thru 9 for a complete discussion of the Sporlan Selective Thermostatic Charges available.

Selection Example
Refrigerant 22
Application: air conditioning

Design evaporator temperature	40°F
Design condenser temperature	105°F
Refrigerant liquid temperature	90°F
Design system capacity	2 tons

Available pressure drop across TEV:

Condensing pressure (psig)	211
Evaporating pressure (psig)	69
	142
Liquid line and accessories loss (psi)	7
Distributor and tubes loss (psi) ①	35
	100

Refrigerant liquid correction factor	1.06

The SVE-2 has valve capacity of: 2.00 x 1.06 = 2.12 tons at 40°F evaporating temperature, 100 psi pressure drop, and 90°F liquid temperature.

Thermostatic charge (from Table on Page 18): VGA ②

Selection:

SVE-2-GA 1/2” x 5/8” ODF— 5’, 1/4” ODF equalizer

① An externally equalized valve must be used on evaporators employing a refrigerant distributor due to the pressure drop created by the distributor.

② Refer to the section, Sporlan Selective Charges, on Page 7 for information regarding the differences between the VGA and VCP100 charges. Please note that the refrigerant charge designation in the thermostatic charge ("V" in this case) is dropped when it is incorporated into the valve model designation.

Refrigerant Color Code Used on Decals

R-12	Yellow	R-402A	Sand/Beige
R-13	Blue	R-404A	Orange
R-13B1	Blue	R-407C	Light Brown
R-22	Green	R-410A	Pink
R-23	Blue	R-500	Orange
R-114	Blue	R-502	Purple
R-124	Blue	R-503	Blue
R-134a	Blue	R-507	Teal
R-401A	Pink	R-717	White

For the complete valve specification, **also include all connection sizes and capillary tube length.**

Table 10

Body Type	Internal or External Equalizer	Connections	For Complete Specifications	Refrigerant
NI	Internal	SAE Flare	Bulletin 10-10	12, 22, 134a, 401A, 402A, 404A, 407A, 407C, 408A, 409A, 502, 507
RC	External	SAE Flare or ODF Solder	Bulletin 10-10-5	22
		ODF Solder		410A
RI (RPB only)		SAE Flare or ODF Solder	Bulletin 10-10	22
F	Either	SAE Flare		12, 22, 134a, 401A, 402A, 404A, 407A, 407C, 408A, 409A, 502, 507
EF		ODF Solder		
Q		SAE Flare		
EQ		ODF Solder		
SQ				
G		SAE Flare		
EG		ODF Solder		
C		SAE Flare		
BF				
EBF		ODF Solder		
SBF				
BQ		SAE Flare	Bulletin 10-10-6	
EBQ		ODF Solder		
SBQ				
S			Bulletin 10-10	
EBS	External			
O				
H	Either	ODF Solder-Flange		
M	External			
V				
W				12, 22, 134a, 401A, 407A, 407C, 409A
D	Either	FPT Pipe-Flange or Socket Weld-Flange		717 Only
A				

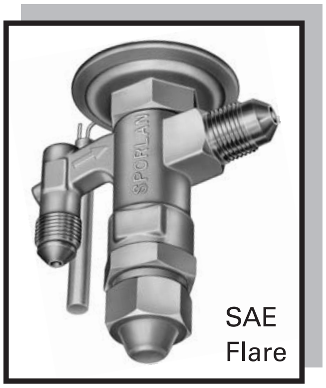
EXAMPLE

7. Ordering instructions — Combine the letters and numbers in the following manner to obtain the complete valve designation. Also include all connection sizes and the capillary tube length.

S	V	E	-	5	-	GA	3/8" SAE Flare	X	1/2" SAE Flare	X	1/4" SAE Flare Equalizer	X	5'
Body Type	Refrigerant Designation	"E" specifies external equalizer. Omission of letter "E" indicates valve with internal equalizer eg. GR-1-Z		Nominal Capacity in Tons		Thermostatic Charge	Inlet Connection Size and Style		Outlet Connection Size and Style		External Equalizer Connection Size and Style		Capillary Tubing Length

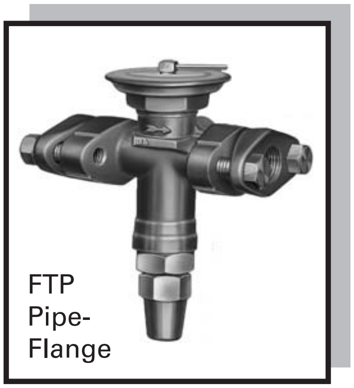
Refrigerant Designation

F	12	**S**	404A
E	13	**N**	407C
T	13B1	**R**	408A
V	22	**Z**	410A
G	23	**D**	500
B	114	**R**	502
Q	124	**W**	503
J	134a	**P**	507
X	401A	**A**	717
L	402A		



SAE Flare

ODF Solder



FTP Pipe-Flange

ODF Solder-Flange

SPORLAN SELECTIVE CHARGES ENGINEERED for PEAK PERFORMANCE for EACH SPECIFIC APPLICATION

Recommended Thermostatic Charges*

Refrigerant	Air Conditioning or Heat Pump	Commercial Refrigerant 50 F to° –1 °F 0	Low Temperature Refrigerant 0°F to –40°F	Extreme Low Temperature Refrigerant –40°F to –100°F
12	FCP60	FC	FZ & FZP	—
22	VCP100 and VGA	VC	VZ & VZP40	VX
134a	JCP60	JC	—	—
404A	SCP115	SC	SZ &SZP	SX
410A	ZN	—	—	—
502	RCP115	RC	RZ & RZP	RX
507	—	PC	PZ & PZP	PX
717	**Refer to the section on ammonia refrigeration on page 13.**			

***Application Factors:**

1. The Type ZP charges have essentially the same characteristics as the Type Z charge with one exception: They produce a pressure limit (MOP). ZP charges are not intended as replacements for Z charges. Each should be selected for its own unique purpose. See Page 8 for additional application discussion.

2. All air conditioning and heat pump charges are intended for use with externally equalized valves. See Page 5 for complete discussion on when to use an external equalizer.

3. Type L Liquid charges are also available for most commonly used refrigerants in most element sizes.

4. If in doubt as to which charge to use, review discussion on Pages 7 and 8 or contact Sporlan with complete system data.

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