Internal equalizer. When the refrigerant pressure drop through a single circuit evaporator is equivalent to a 2 F deg drop in evaporator temperature, or less, a thermostatic expansion valve having an internal equalizer may be used. Internal equalization simply means that valve outlet pressure is transmitted through an internal passage to the underside of the diaphragm. See Fig. 4.

The friction loss in many evaporators is greater than the 2 F deg equivalent. Where the pressure drop type refrigerant distributor is used, the pressure drop across the distributor may be as high as 25 to 35 psi, and the pressure at the outlet of the expansion valve will be considerably higher than the pressure at the evaporator outlet. As a result, an internally equalized valve will control at an abnormally high superheat, since P_2 is a false pressure and does not reflect the true pressure in the evaporator. Under these conditions, the evaporator will not perform efficiently because it is starved for refrigerant. Furthermore, the false pressure is not constant, but varies with evaporator load and consequently cannot be compensated for by adjusting the superheat setting of the valve.

External equalizer. In order to avoid the ill effects on system performance that evaporator or refrigerant distributor pressure drop, or both, will produce with an internal equalizer valve, a valve having an external equalizer is used. Instead of the internal communicating passage shown in Fig. 4, an external connection to the underside of the diaphragm is provided. The external equalizer line is connected either to the suction line, as shown in Fig. 9, or into the evaporator at a point downstream from the major pressure drop, thereby freeing the operating pressures at the diaphragm from any effect of pressure drop or of fluctuations in pressure drop, between the expansion valve outlet and the evaporator outlet.

Pilot-operated thermostatic expansion valves are used on large systems where the capacity required per valve is beyond the range of the direct-operated type valves. The pilot-operated valve consists of a piston type pilot-operated regulator, which is used as the main expansion valve, and a low-capacity thermostatic expansion valve, which serves as an external pilot valve. The small pilot thermostatic expansion valve supplies pressure to, or bleeds pressure from, the piston chamber (depending on the regulator design) in response to a change in the operating superheat. Pilot operation permits the use of a characterized port in the main expansion valve for the purpose of providing good modulation over a wide range of loading. Therefore, the pilot-operated valve performs well on refrigerating systems having some form of compressor capacity reduction, such as cylinder unloading. Fig. 10 illustrates such a control valve applied to a large capacity, direct expansion chiller.

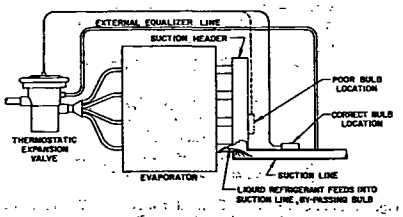


Fig. 9 .... Bulb Location for Thermostatic Expansion Valve

The auxiliary pilot controls need only be sized to handle the pilot circuit flow; this permits the use of smaller controls than if full system capacity were to be handled. For example, in Fig. 10 a small solenoid valve in the pilot circuit, installed ahead of the thermostatic expansion valve, converts the pilot-operated valve into a stop valve when the solenoid valve is closed.

Application

Hunting of the thermostatic expansion valve is characterized by alternate overfeeding and starving of the refrigerant feed to the evaporator, thereby producing sustained cyclic changes in the pressure and temperature of the refrigerant gas leaving the evaporator. Extreme hunting reduces the refrigeration system capacity because the mean evaporator pressure and temperature are lowered and compressor capacity is thereby reduced. If the overfeeding of the expansion valve results in intermittent flooding of liquid into the suction line, the compressor may be damaged eventually.

Although hunting is commonly attributed to the action of the thermostatic expansion valve, the valve alone is seldom responsible. One reason for the existence of hunting is that all evaporators have an inherent time lag. When the bulb signals for a change in refrigerant flow, the refrigerant must traverse the entire evaporator before a new signal reaches the bulb. This lag or time lapse may result in continuous overshooting of the valve operation both in the opening and closing directions. In addition, the thermostatic element has a time lag due to its mass, which may be in phase with the evaporator lag and amplify the original over-shooting.

It is often possible to alter the response rate of the thermostatic element by using thermal ballast or by changing the mass or heat capacity of the bulb, thereby introducing a damping action which will effectively minimize or even eliminate the original hunt. A change in valve gradient may accomplish the same result.

Extremely high refrigerant velocity in the evaporator can also cause hunting of the valve. Liquid refrigerant movement under these conditions is in the form of waves, or *slugs*, which completely fill a portion of the evaporator tube and are ejected into the suction line. These unevaporated slugs chill the bulb and temporarily reduce the feed of the valve, resulting in intermittent starving of the evaporator.

On multiple circuit evaporators, a lightly loaded or overfed circuit will also flood out into the suction line, chill the bulb, and throttle the valve. Again, the effect is intermittent; when the valve feed is reduced the flooding ceases and the valve reopens.

Hunting can be minimized or avoided by:

1. Selection of the proper valve size. Oversized valves generally tend to aggravate hunting.

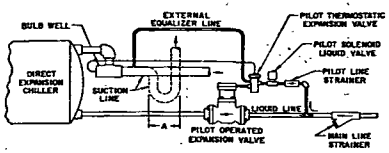


Fig. 10 .... Pilot-Operated Thermostatic Expansion Valve Controlling Liquid Refrigerant Flow to a Direct Expansion Chiller

2. Changing the valve adjustment. Lower superheat settings usually (but not always) tend to increase hunting.
3. Selection of the correct thermostatic element charge. Cross-charged elements have inherent anti-hunt characteristics.
4. Designing the evaporator for a short refrigerant path, consistent with good heat transfer.
5. Correct sizing and arrangement of suction piping.
6. Correct location and application of the bulb.
7. Selection of the best location for the external equalizer line connection.

Bulb location. Clamping the bulb on a horizontal suction line meets the requirements of most installations. Good thermal contact between the bulb and the suction line must be provided. Ideally, the bulb should be located reasonably close to the evaporator outlet, upstream of suction line traps, and on the evaporator side of any liquid-to-suction heat exchanger.

Certain installations require increased sensitivity of the bulb as a protective measure against floodback. The bulb, if it is located in a well in the suction line, has a rapid response feature because of its intimate contact with the refrigerant stream. The bulb sensitivity can be further increased by the use of a smaller bulb than is normally supplied. However, the use of the smaller bulb is limited to gas-charged valves. Although the details of refrigerant piping are not the subject of this chapter, good piping practice has a direct bearing on expansion valve performance.

Fig. 11 illustrates the proper piping arrangement when the suction line run is located above the evaporator. An oil trap, as short as possible, is located *downstream* from the bulb. The vertical riser or risers must be sized to produce a refrigerant velocity which will assure continuous return of oil to the compressor. The terminal end of the riser or risers enters the horizontal run at the top of the suction line; this avoids interference from the overfeeding of any other liquid expansion valve, and drain-back during the off-cycle.

A heavy concentration of oil circulated with oil-miscible refrigerants has the effect of elevating their boiling temperatures. The response of the thermostatic charge of the expansion valve, on the other hand, is related to the saturation pressure and temperature of pure refrigerant. In an operating system, the false pressure-temperature signals of oil-rich refrigerants will invariably cause floodback or operating superheats which are considerably lower than indicated, and quite often will cause erratic valve operations. Either the oil pumping rate must be reduced or an effective oil separator used, to keep the oil concentration at an acceptable level.

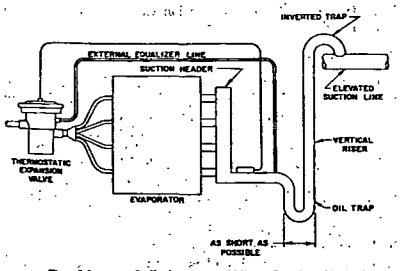


Fig. 11 .... Bulb Location When Suction Main Is Above Evaporator

The external equalizer line is ordinarily connected at the evaporator outlet, as shown in Fig. 9. It may also be connected at the evaporator inlet or at any other point in the evaporator downstream of the major pressure drop. On evaporators with long refrigerant circuits having inherent lag, *hunting* may thus be minimized by changing the point of connection of the external equalizer line. Where suction line controls such as evaporator pressure regulators are required, one of the alternate locations of the equalizer may assist in stabilizing the modulation of both valves and prevent one valve from opposing or bucking the other. However, a compensating superheat adjustment may be required for the different locations of the external equalizer line connection.

The ambient temperature at the valve does not assure a corresponding temperature of the diaphragm chamber, because a certain amount of heat is conducted to the cooler valve body. It is not unusual for the diaphragm chamber temperature to fall below that of the bulb. When this occurs with a gas-charged valve, the entire thermostatic charge can condense in the diaphragm chamber, and the refrigerant feed can then be controlled from that point. Extreme starving of the evaporator, to the point of complete cessation of feed, is characteristic of this condition. For this reason, refrigerant distributors of the pressure drop type are normally used with gas charged valves. The pressure drop through the distributor elevates the valve body temperature above that of the evaporator and assists in maintaining control at the valve bulb. Refrigerant distributors are described in Chapter 34. Liquid and liquid cross-charged thermostatic expansion valves will operate regardless of the temperature of the space in which they are located because of the *cross-ambient* characteristics of the charge.

Direct expansion chillers are among the few applications in which gas-charged valves are successfully used without refrigerant distributors. This is possible because of operation at considerably lower superheats and narrower ranges of operating temperatures than the other types of direct expansion evaporators. At these low superheats, usually 4 to 6 F deg, condensing of the charge in the diaphragm housing can be avoided if proper valve application and installation practices are followed.

Flooded System

The application of thermostatic expansion valves to flooded evaporators is rather uncommon. Superheat is necessary for proper valve control, and only a few degrees of suction vapor superheat in a flooded evaporator will incur a substantial loss in capacity. If the bulb is installed downstream from a liquid-to-suction heat exchanger, a thermostatic expansion valve can be made to operate on a higher superheat available at this point. Valve control is apt to be rather poor because of the variable rate of heat exchange as flow rates change.

However, valves with modified thermostatic elements are available, in which electrical heat is supplied to the bulb. The bulb is inserted into the system in direct contact with refrigerant liquid in the evaporator. Contact of cold refrigerant liquid with the bulb overrides the artificial heat source and throttles the expansion valve. As the liquid falls away from the bulb, the valve feed again increases. Although similar in construction to a thermostatic expansion valve, this is essentially a liquid level control, modulating type valve.