This article was published in ASHRAE Journal, June 2013. Copyright 2013 ASHRAE. Posted at www.ashrae.org. This article may not be copied and/or distributed electronically or in paper form without permission of ASHRAE. For more information about ASHRAE Journal, visit www.ashrae.org.

Who's in Charge?

By Andy Pearson, Ph.D., C.Eng., Member ASHRAE

This article is the sixteenth in a series exploring refrigeration and heat pump concepts without using jargon.

Having addressed the question of direct versus flooded last month, it's now time to delve into the consequences of those decisions. The cooling capacity delivered by a refrigeration system is determined by the amount of gas that the compressor can pump from the low pressure side to the high pressure side, but the flow rate of refrigerant back from the condenser to the evaporator is controlled by the "expansion valve."

These come in all shapes and sizes and with a variety of control strategies to match. Problems with refrigeration systems are usually physical or mental. Physical problems are most often associated with the compressor, which is by far and away the most complex mechanical item in the system. Mental problems (or control system issues if you want to sound fancy) usually relate to the control of the expansion process and its relationship to the compressor capacity.

It is helpful to divide expansion control strategies into two classes that I like to call "high side" and "low side" control. This is most evident when a float is used—either as a switch or level measurer that sends a signal to a control valve, or as a one piece float control (like the ball-cock in a water tank, which both measures the level and controls the flow in a single device). Some floats measure the level in a tank on the low pressure side of the system and open up the expansion valve to let more liquid through when the level gets too low. A more subtle version looks for a level on the high pressure side of the system and opens up the expansion valve when the level gets too high. The "HP float valve" is this type, so in this sense it's the opposite of a water ball-cock.

A thermostatic expansion valve, as used in nearly all direct expansion (DX) systems, is a kind of low side control because it modulates the refrigerant liquid flow based on measurement of the pressure and temperature at the evaporator outlet (which of course is on the low side of the system).

Bilko was a master of low side control, but needed a receiver.

So why would you choose high side or low side control? The main consequence of the choice is what happens to the "spare" refrigerant in the system. You might not think that you have any spare; it sounds a bit wasteful to admit it. However, if the capacity is variable (that is, if the compressor volume flow is variable) then there will sometimes be a need to stash some of the refrigerant charge in a holding tank because it is not needed under all the different load conditions.

When the load on the evaporator is high, it mainly contains gas (by volume) and as the load falls the tubes tend to fill up with liquid. To cope with this there needs to be a reservoir somewhere to hold the surplus that will be required when the load falls. For a high side control system the reservoir has to be on the low side, and vice versa. Unfortunately, with most direct systems it's not possible to store on the low side, so they need to be low side control with a high pressure receiver. This is a simple design, but the main disadvantage of this approach is that the refrigerant content is increased, making it more difficult to design a low charge system.

Household fridges are an interesting example. The expansion happens in a carefully designed restriction called a capillary tube. The compressor either runs on full capacity or is idle. The compressor mass flow is on or off. The capillary mass flow is a function of the pressure difference, and since the low side pressure is relatively stable (fixed by the temperature of the fridge, which is what switches the compressor on and off) the only variable is the high side pressure. This is a form of high side control.

If the capillary mass flow is not enough to match the compressor then liquid will build up in the condenser outlet, reducing the available heat transfer surface and raising the condensing pressure. This balances the system, but at the expense of efficiency. The capillary performance is made more stable by brazing it alongside the compressor suction, so superheating the suction gas and providing some subcooling of the condenser outlet at the same time. This also reduces the amount of gas created in the expansion process within the tube. That's a lot of thermodynamics to pack down the back of your fridge!

Andy Pearson, Ph.D., C.Eng., is group engineering director at Star Refrigeration in Glasgow, U.K. ■