Expansion Devices

Two purposes

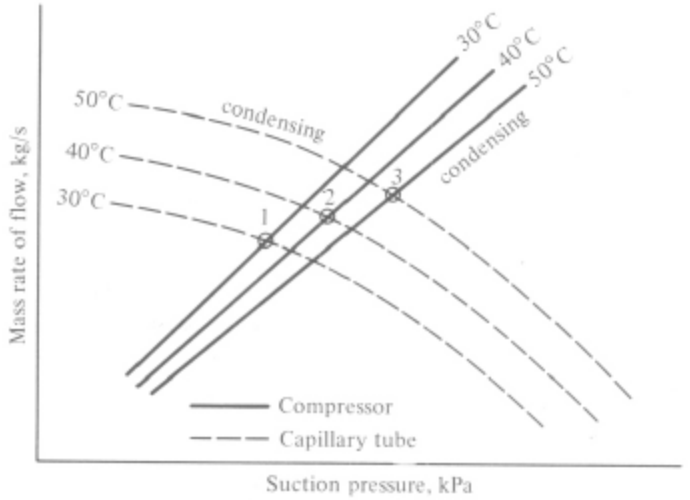
- Reduce pressure of refrigerant at approx. constant enthalpy, resulting in a large temperature drop
- Regulate refrigerant flow to the evaporator

- Main types
  - Capillary tubes – used up for refrigerating capacities of approx. 10 kW or less; common in domestic refrigerators
  - Constant-pressure expansion valve – for systems with refrigerating capacity of 30 kW or less
  - Float valves – used in large industrial applications
  - Thermostatic expansion valve - the most popular type of valve, capable of providing a wide range of evaporator temperatures

Capillary Tubes

- 1 to 6 m long, 0.5 to 2 mm inside diameter
- Pressure drops through the tube due to friction and fluid acceleration
- Cap tubes and cheap and reliable, but they can't adjust to changes in parameters such as added load, suction pressure, etc. You'd need to install a new tube to get different system performance. They also can be clogged.
- Mass flow rate is determined by a balance point between cap tube and compressor performance.
- If there is too much or too little heat transfer in the evaporator for the given balance point, the evaporator will be starved or overfed.

Capillary Tubes, cont.



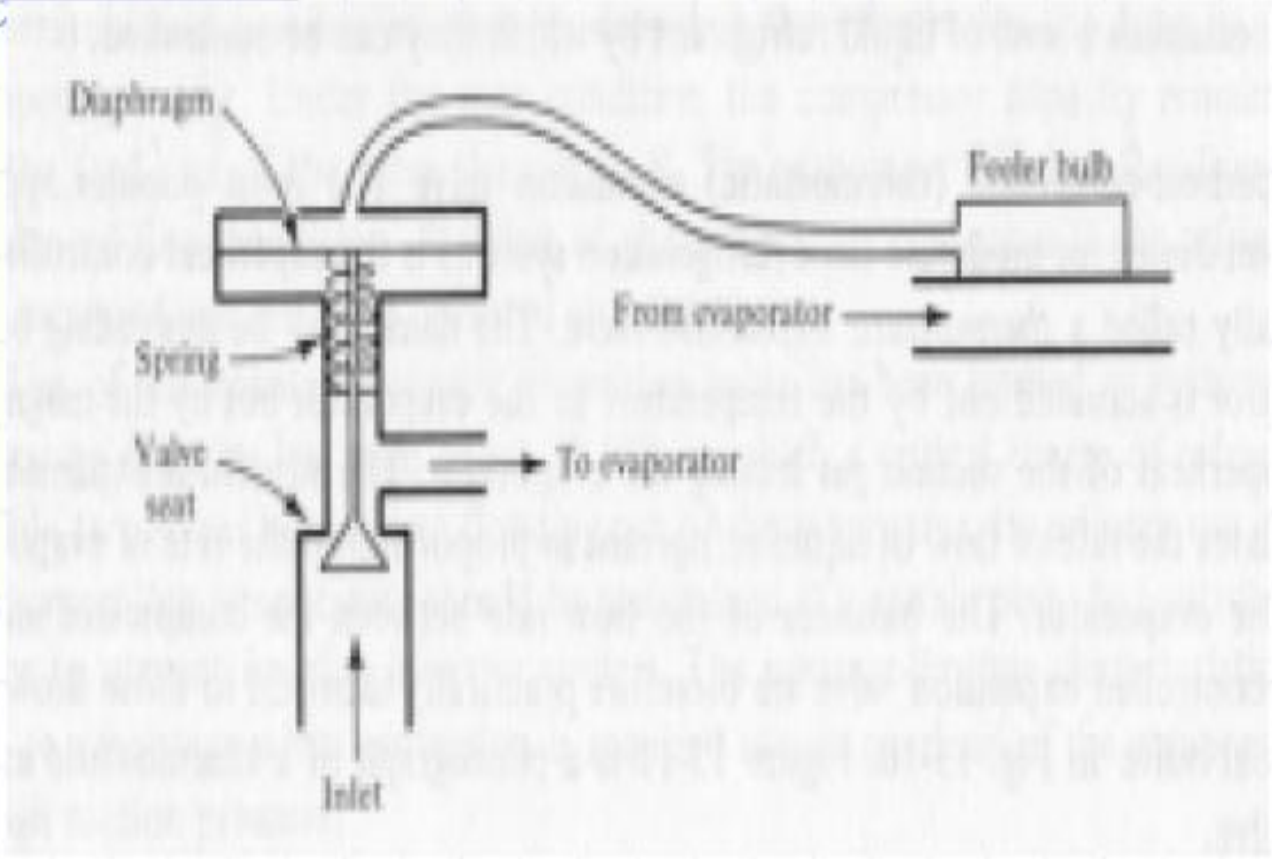
- Starved evaporator– not enough refrigerant to provide enough cooling capacity
- Overfed evaporator – too much refrigerant for the amount of cooling needed, resulting in slugging of the compressor (liquid drops enter the compressor)

- As a result, refrigerant charge must be within close limits. Therefore, cap tubes are usually used only with hermetically sealed compressors since they don't leak.
- Usually only liquid enters the tube. As the pressure and temperature drop, more and more of the liquid flashes to vapor.
- Vapor has a larger specific volume than liquid, so the fluid must speed up.
- If the pressure drops low enough, choked flow will result. Further decreases in pressure will have no effect on the flow rate through the nozzle. In this case, sonic velocity occurs at the end of the tube!

Constant-Pressure Expansion and Float Valves

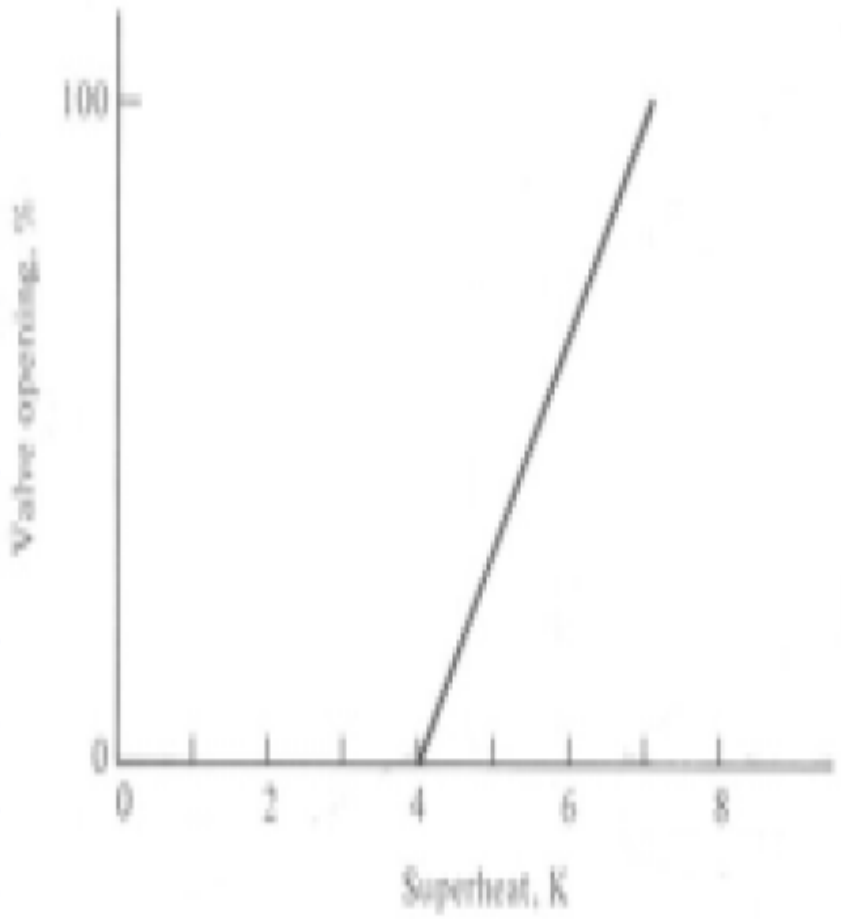
- Constant-pressure expansion valves maintain constant pressure in the evaporator by opening or closing
  - Used a lot when a very precise evaporator temperature is needed, such as in water coolers (to prevent freezing) or rooms where humidity control is very important (such as banana-curing rooms)
- Float valves maintain the liquid level in the evaporator at a constant level by opening or closing
  - Can react easily to changes in load
  - Used in large installations
  - In smaller installations where continuous-tube evaporators are used, they can't be used since it's nearly impossible to establish a liquid level.

Thermostatic (Superheat-Controlled) Expansion Valve



- Feeler bulb is filled with same refrigerant as in system and is clamped to the outlet of the evaporator. If too little refrigerant is in the evaporator, it will be very superheated at the exit. This will make the refrigerant in the feeler bulb evaporate, increasing the pressure on the diaphragm. This will open the valve further, letting more refrigerant in, decreasing the temperature at the evaporator exit.

Thermostatic (Superheat-Controlled) Expansion Valve, c



- This is the type of valve in the ac system downstairs
- Velocity of fully opened valve

$$Velocity = C\sqrt{2(pressure\ difference\ in\ kPa)}\ \ m/s$$

Where C is experimentally determined by the manufacturer

Electric Expansion Valve

- Like a thermostatic expansion valve, except a thermister is used to sense the evaporator exit temperature.
- Used for a lot for systems that can be run as either heat pumps or ac units since it's OK to run fluid through them backwards