Expansion valve

Selecting the right expansion valve design – which is the right one?

What are the differences between expansion valves with internal and with external pressure compensation?

Expansion valves with internal pressure compensation

The injection line connects the expansion valve to the evaporator input. The evaporation pressure at this point is ρ_O so that the pressure below the valve diaphragm is also ρ_O. In each of the components where the stream passes through, the pressure drops and the pressure ρ_O in the evaporator sinks in the direction of the flow. The pressure at the outlet is lower than at the inlet. In addition, the increase in superheat at the evaporator outlet (coil suction) corresponds exactly with the pressure loss in the evaporator. Because pressure is lost in every evaporator, however, the overheating for each expansion valve with internal pressure compensation would increase. The limit for a pressure drop in the evaporator in the acceptable range when the evaporating temperature is modified is approx. $\Delta_{t0} = 2K$. In this range, expansion valves with internal pressure compensation are often used and the related loss in capacity is accepted. But beyond this range valves with external pressure compensation are most often used.

Which evaporators are associated with a greater pressure drop?

- Evaporators with multiple injection
- High performance evaporators because these often operate with high refrigerant speed in order to achieve good heat transfer values
- Evaporators with long refrigerant paths

In these situations, expansion valves with external pressure compensation are used.

Expansion valves with external pressure compensation

As the previous example shows, the superheat is regulated at the evaporator outlet (coil suction). For this reason, the evaporator pressure must be recorded at the evaporator outlet. To do this, a pressure compensation line is laid from the evaporator outlet (coil suction) to the expansion valve. Usually the sensor is mounted first, then the pressure compensation line (in the direction of the flow). In this expansion valve is a partition; below this partition, the evaporator inlet pressure is higher; above it, the pressure is lower. This difference corresponds exactly with the pressure drop in the evaporator. In this way, the expansion valve regulates the normal superheat, preventing the loss of capacity associated with superheat that is too great. The pressure drop in the evaporator does not affect the superheat if the valve has external pressure compensation. The expansion valve with external pressure compensation cannot change the pressure drop, but it can prevent unnecessary increases in overheating and a drop in cooling performance.

Setting the expansion valve

The optimum capacity of an air cooler can only be achieved if the expansion valve is adapted for the respective air cooler system. For this reason, the expansion valve setting should be checked for every air cooler.

We want to make this possible without too much effort required for assembly, so all forced convection Air Coolers that operate with refrigerant are equipped with a Schrader valve soldered into the suction line.

As described previously, we determine the cooling capacity of our Air Coolers in accordance with EN 328. The superheat values, Δt_{oh}, specified there are 0.5 to 0.7 times temperature difference DT1. This should also be the goal in actual operation; e.g. at a DT1 of 8 K, about 4.0 to 5.5 K. The lower the superheat, the better the air cooler capacity. However, each thermostatic expansion valve, together with a specific air cooler allows only a specified lowest amount of superheat. Below this amount, i.e. if the valve is open too far, the valve regulates the amount based on sudden changes (Hunting), which leads to a lower capacity for the air cooler. The fluctuations should not exceed 0.5 K.

The right superheat ratio

The optimum superheat Δt_{0h} during operation is 0.65 times (overheating ratio) the temperature difference Δt_1 between the air inlet temperature t_{L1} and the evaporating temperature t_0 at the air cooler's suction line (Fig. 1, page 138).
If the valve facilitates the rating at superheat Δt_{0h} 4 K, a minimum temperature difference of Δt1 ~ 6 K can be achieved at the cooler:

$$\Delta t_1 = \Delta t_{0h} \;/\; 0.65 = 4\text{ K} \;/\; 0.65 = \sim 6\text{ K}$$

Expansion valve

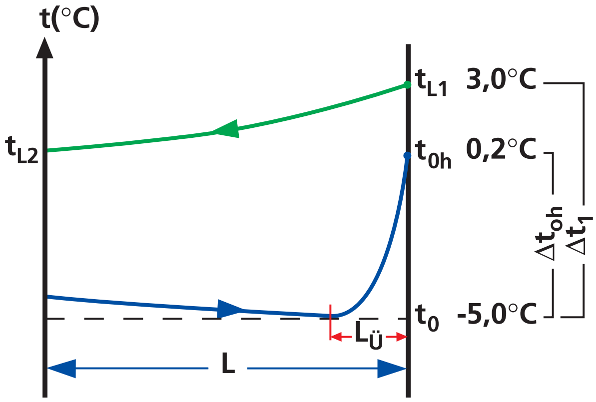

Fig. 1

t_{L1} = Air inlet temperature into the air cooler
t_{L2} = Air discharge temperature from the air cooler
t_{0h} = Overheating temperature at the outlet of the air cooler (suction)
t_0 = Evaporating temperature at the outlet of the air cooler (coil outlet)
L = Evaporating section length for the refrigerant
$L_Ü$ = Overheating section length ~10% of L

Overheating ratio =

$$\frac{\Delta t_{0h}}{\Delta t_1} = \frac{t_{0h} - t_0}{t_{L1} - t_0} = \frac{0{,}2 - (-5{,}0)}{3{,}0 - (-5{,}0)} = \frac{5{,}2}{8{,}0} = \underline{\underline{0{,}65}}$$

Influence of superheat on evaporator capacity

If the overheating ratio deviates from the specifications according to EN 328, not only the cooling capacity of the air cooler is modified (Fig. 2) but if the difference is great, serious malfunctions can be expected. This will be discussed later. Based on our experience, in actual operation a refrigeration system still functions acceptably at an overheating ratio between 0.5 and 0.7, i.e. the loss in capacity still does not appreciably affect the system's function.

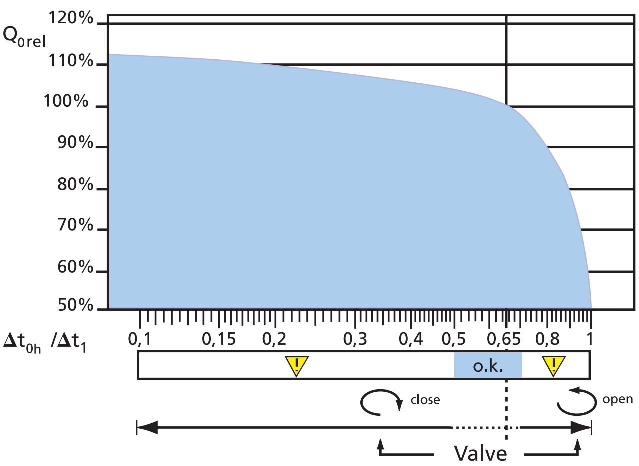

Fig. 2

Measurement of superheat

The air cooler must be completely ice and frost free and the designated ambient temperature achieved. On our forced convection Air Coolers pressure can be measured easily: a Schrader valve is soldered into the suction line in all standard models! Use a gauge in accordance with at least measuring class 1. The evaporating temper-
ature t can be read directly on the gauge. If only one pressure scale (excess pressure!) is available, the vapour pressure table (absolute pressure!) provides more assistance. The temperature measurement is performed near the sensor on the expansion valve. To prevent measuring errors, the measuring device sensor should be insulated to a length of 10 x the tube diameter. If temperature is recorded for at least 15 minutes, the measuring accuracy is higher. The difference between the measured temperature and the evaporating temperature is the superheat setting of the valve during operation (Fig. 3).

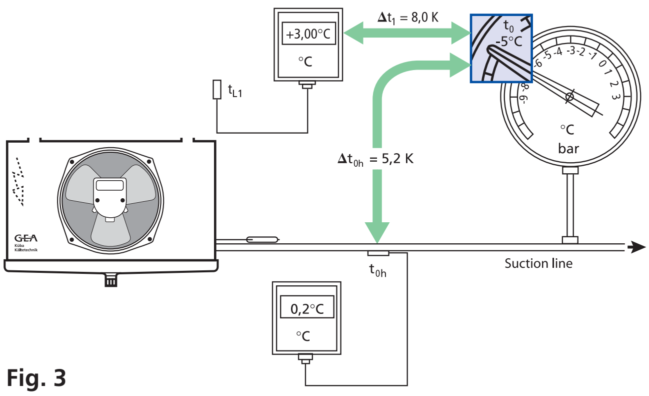

Fig. 3

Setting the expansion valve

If the superheat at the coil outlet deviates from the value Δt_1 x 0.65, the nominal capacity of the valve in not consistent with the air cooler at the operating point. To achieve better cooler performance, the valve must be adjusted. Observe the manufacturer's instructions. Always use small increments. After each adjustment of the valve, wait for stable function (often up to 30 minutes) and only then, if necessary, should it be turned further. If the refrigeration system is operated with a superheat ratio $<$0.65 at the coil outlet, i.e. with a valve that is opened too far, the regulation is based on sudden changes (Hunting). This also has a negative affect on the air cooler capacity. The fluctuations in superheat should not exceed $\pm$0,5 K.

Expansion valve

Check or readjust the expansion valve according to the following instructions:

1. Unscrew the cap on the Schrader valve and connect the P_0-suction pressure gauge. This gauge should have the highest metering accuracy possible. Read the temperature of the refrigerant or use the refrigerant gauge to determine the corresponding evaporating temperature.
2. About 5 to 10 cm away from the Schrader valve affix the t_{0h} sensor of a temperature recorder. Place the second temperature sensor of the recorder in the cooler air inlet. The distance between the air cooler and the t_{L1} sensor should be 15 to 20 cm. The air inlet temperature sensor may not move relative to the wall or other components.
3. To determine the superheat factor, only use measurements taken during stable cold storage operation, when the cooler is not subject to icing loads. It is imperative that the setting time, 15 minutes for each expansion valve, be observed. The cooling process should not be interrupted during this time period. If necessary, provide sufficient heat loading e.g. by opening the door, during the measuring period. When these prerequisites are met, the superheat factor can be determined by analyzing the results of the measurement.
4. From the evaporating temperature t_0 as determined and the actual air inlet temperature t_{L1} as read from the temperature recorder, the air inlet temperature difference Δt_1 (DT1) can be calculated in Kelvin [K].
5. From the evaporating temperature t_0 as determined and the actual superheat temperature t_{0h} as read from the temperature recorder and measured over a sufficient amount of time, Δt_{0h} (Dt_{0h}) can be calculated in [K]. Now use the gauge to locate the calculated Δt_1 (DT1) on the calculated Δt_{0h} (Dt_{0h}). If the black arrow points to the green area (marked **ok**), the expansion valve has been set correctly. Please take due note of the setting instructions provided by the expansion valve manufacturer.
6. After removing the P_0 suction pressure gauge, the cap on the Schrader valve must be screwed on again.
7. If soldering is carried out near the Schrader valve, protect it from heat or unscrew the gasket.

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