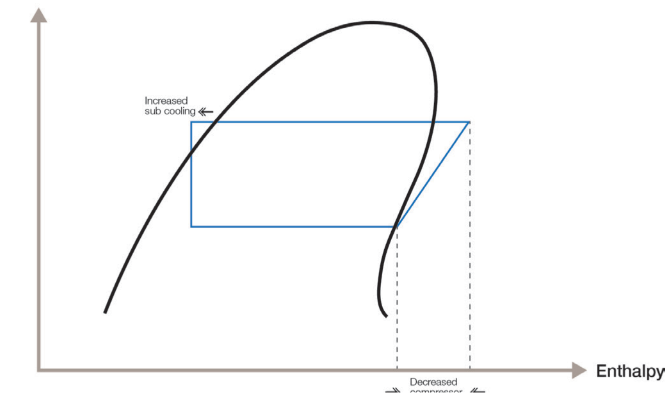
Combined condenser & subcooler in a plate-and-frame heat exchanger

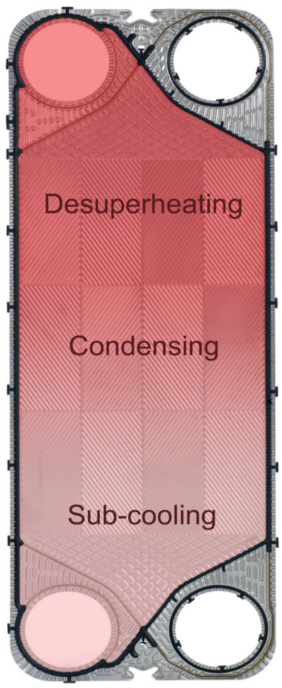
As the refrigeration system often is one of the main electrical energy consumers in the utilities part of the plant, energy efficient design can give substantial economical savings. By integrating subcooling into the plate heat exchanger condenser it's possible to improve energy efficiency without excessive pipe work and introduction of additional heat exchanger components.

The traditional way of saving energy, through use of heat exchangers in a chiller or heat pump, is by increasing the evaporation temperature and/or decreasing the condensation temperature. By doing so the overall energy consumption can be reduced. However, the requirements from the secondary system might set both physical and economical limits for this, as at one point it's no longer economically valid to increase the condensation and evaporation temperature.

A third way of increasing the efficiency and COP (Coefficient Of Performance) of a refrigeration system is to subcool the liquid condensate. As the amount of subcooling increases, less mass flow is needed for the same capacity, which will result in less flow to the compressor and less energy consumption. This way of taking care of "free-energy" will benefit both a traditional chiller and heat pumps. The savings in compressor power consumption can be substantial as shown in the diagram below.

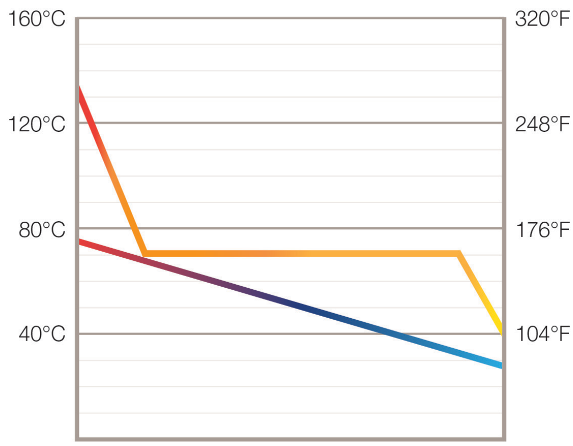


The traditional way to use subcooling in an industrial refrigeration system is to introduce an additional heat exchanger dedicated to cooling of the condensate. This might result in such a high initial investment cost for both the vessel and the associated piping system that the gains of the subcooling are lost.



By using a plate heat exchanger it's possible to use one heat exchanger as a combined de-superheater (cooling the superheated discharge gas from the compressor), condenser and sub-cooler.

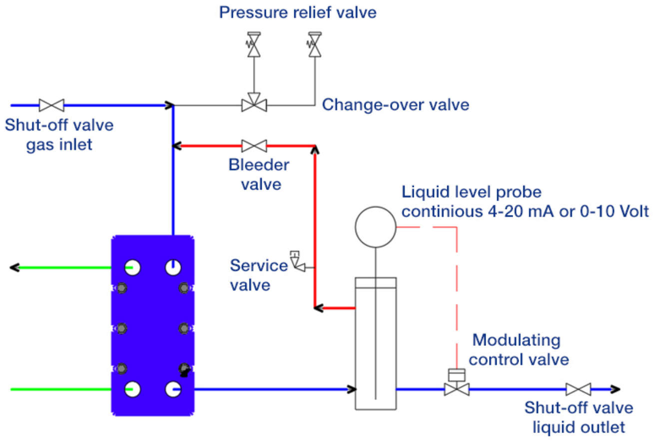
The amount of possible subcooling will to a high extent be defined by the temperature of the secondary media. A large temperature difference on the secondary media will allow for more subcooling compared to a low temperature difference. It should be noted that a too high subcooling might result in an increased condensation temperature as the temperature program will set the physical limitation for the process.

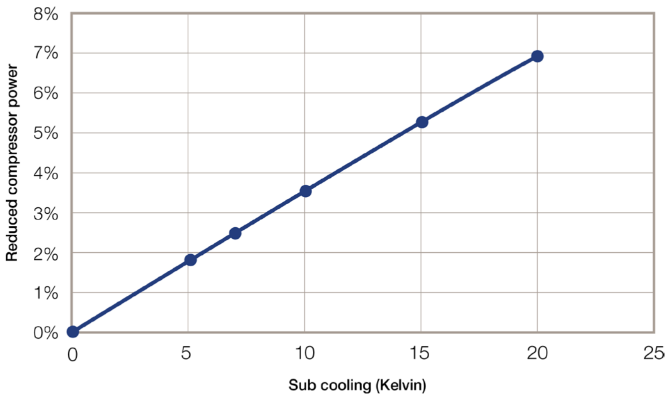


How to control the sub cooling

If subcooling is desired, the hold up time in a condenser can be increased by creating a liquid level at the bottom of the condenser unit. One way to do this is by elevating the HP float valve relative to the condenser outlet or by adjusting the pipe routing. Elevation creates a liquid level inside the condenser, thus subcooling the liquid prior to expansion. Unfortunately, the valves today often have an inbuilt by-pass which takes away this option. The subcooling requires additional condenser heat transfer area but improves plant efficiency and increase the energy efficiency (COP) in a heat pump.

To be able to get and control a liquid level for subcooling, an arrangement like the below can be used (constant level, the probe will tell the expansion valve via the PLC to open or close).





Savings at Tcond = 65°C and Tevap = 10°C

There are several brands on the market with standard devices. Normally the shortest probe is 300 mm, and that is enough for the function in Alfa Laval semi-welded plate heat echangers. Alfa Laval will inform about the level needed at 100% capacity. If other variations of load will occur, contact Alfa Laval and discuss the unique system depending on e.g. temperature program, type of compressor technology used, efficiency demand in part load etc.