Subcooling

This guide explains what subcooling is, why it is important to the performance of a system and how to measure it.

What is subcooling

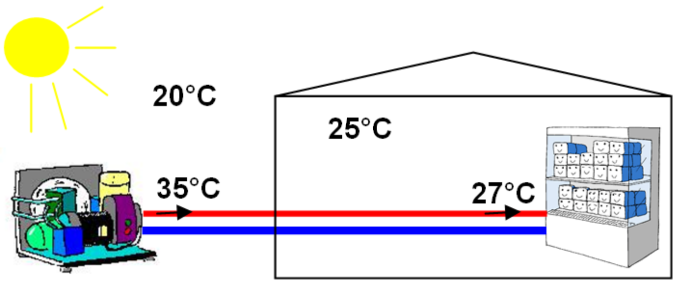
When a refrigerant is sub cooled it is a pure liquid at a lower temperature than the saturation (bubble) temperature. Sub cooling is the temperature difference between the liquid and its saturation temperature. On a refrigeration system this is:

Sub cooling = saturated condensing temperature – liquid temperature

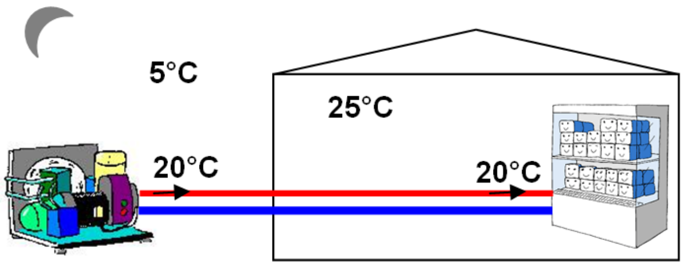
The liquid temperature is measured 100 mm from the inlet to the expansion valve

Sub cooled does not mean cold: a hot cup of coffee from a vending machine at 85^{O}C is a sub cooled liquid because it is 15^{O}C cooler than the saturation temperature of the water (100^{0}C).

In a refrigeration system, there should be subcooled liquid refrigerant in the liquid line between the receiver and the expansion valve. The liquid leaving the receiver will be at the condensing temperature – and therefore higher than ambient temperature (usually by between 10 and 20°C). It will cool down – subcool – as it travels along the liquid line. This will happen naturally, as shown in the example right, where the outside temperature is 20°C and the refrigerant condenses at 35°C. Although the inside (room) temperature is warmer than ambient, it is below the condensing temperature, so the refrigerant subcools. In the example the degree of subcooling is 8K.



However, in the next example the refrigerant has not subcooled because it is much colder outside, resulting in a condensing temperature lower than the inside (room) temperature. The refrigerant arriving at the expansion device will be a mixture of liquid and gas (flash gas), so it will have less capacity to absorb heat when it flows through the evaporator. It is not uncommon for this situation to occur, but it has an adverse impact on the performance of the system. Insulating the liquid line inside the building will reduce the amount of flash gas in the liquid arriving at the expansion device.



Why subcooling is important

The refrigerant that enters an expansion valve must be a subcooled liquid (i.e. pure liquid with no flash gas) to achieve the maximum cooling capacity. The low pressure liquid flowing through the evaporator absorbs heat as it evaporates, thus cooling the product. If the refrigerant at the valve entry is not a subcooled liquid – i.e. it is a mixture of flash gas and liquid as in the second diagram above – the system capacity and efficiency will drop. This is because gas is far less dense than liquid, so the amount of refrigerant which can flow through the expansion valve will be less, thus reducing its cooling capacity. The amount of flash gas entering the evaporator is also significantly increased, further reducing performance.

If the refrigerant into the expansion valve is not subcooled, the system will have to work harder and for longer to achieve the correct product temperature. This is the case if you see bubbles (flash gas) in the liquid line sight glass.

There are several reasons why refrigerant is not subcooled when it reaches the expansion valve:

- Shortage of refrigerant, either because of leakage or because the system has been undercharged;
- Blocked condenser surface or poor air flow;
- Liquid lines routed through areas where the surrounding temperature exceeds the condensing temperature. In this case the head pressure control setting should be increased and /or the liquid line should be insulated;
- Very long liquid lines and associated high pressure drops. A liquid pump can help to resolve this problem;
- Liquid receiver significantly lower than the expansion valve inlet (i.e. long risers).

The sight glass on the pack or condensing unit can only indicate the state of the refrigerant at the start of the liquid line. By the time the refrigerant has reached the expansion valve it may have lost subcooling, with the consequences described above. You need to measure the degree of subcooling to verify this.

Measuring subcooling

To measure subcooling you will need:

- A gauge manifold set with accurate gauges;
- An accurate electronic thermometer with a suitable touch/contact probe;
- A refrigerant comparator.

The most accurate method of measuring subcooling is as follows:

1. Measure the temperature on the liquid line about 10 cm before the inlet of the expansion device (T);
2. Measure the condensing pressure as close to the condenser as possible;
3. Work out condensing temp (CT) from a comparator;
4. Calculate the subcooling as follows: subcooling = CT – T.

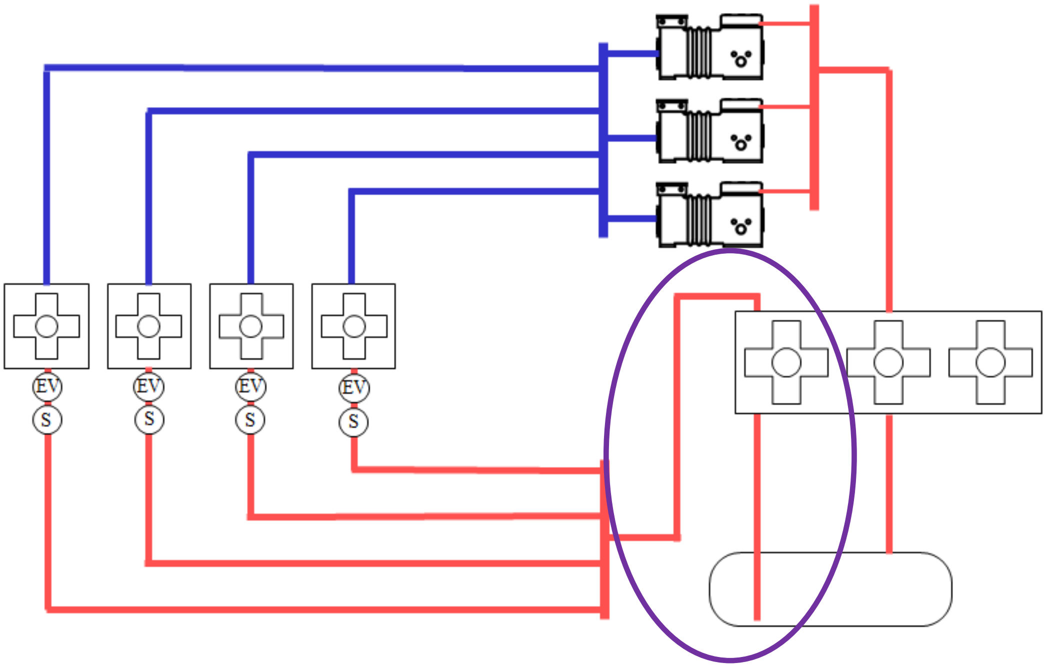
For a refrigerant blend use the saturated liquid (bubble) temperature as the condensing temperature.

Subcooling in the condenser

Subcooling will not usually occur in the condenser unless liquid backs up in the condenser. This can happen under some conditions:

- If the system is overcharged with refrigerant;
- When there is a condenser pressure regulator;
- If the refrigerant at the exit of the condenser cannot drain freely into the receiver, for example because the receiver is located above the condenser outlet or is warmer than the condenser.

Some condensers have a separate, additional pass which provides subcooling. It is connected after the receiver as shown, circled, in the diagram below for a central plant system.



Additional subcooling can also be achieved by using a mechanical subcooler (heat exchanger) in which some of the liquid is expanded and cools the main liquid line.

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