

THE REFRIGERATION SYSTEM

AN INTRODUCTION TO REFRIGERATION

APPLICATION NOTE

BASIC REFRIGERATION PRINCIPLES

If you were to place a hot cup of coffee on a table and leave it for a while, the heat in the coffee would be transferred to the materials in contact with the coffee, i.e. the cup, the table and the surrounding air. As the heat is transferred, the coffee in time cools. Using the same principle, refrigeration works by removing heat from a product and transferring that heat to the outside air.

REFRIGERATION SYSTEM COMPONENTS

There are five basic components of a refrigeration system, these are:

- Evaporator
- Compressor
- Condenser
- Expansion Valve
- Refrigerant; to conduct the heat from the product

In order for the refrigeration cycle to operate successfully each component must be present within the refrigeration system.

The Evaporator

The purpose of the evaporator is to remove unwanted heat from the product, via the liquid refrigerant. The liquid refrigerant contained within the evaporator is boiling at a low-pressure. The level of this pressure is determined by two factors:

- The rate at which the heat is absorbed from the product to the liquid refrigerant in the evaporator
- The rate at which the low-pressure vapour is removed from the evaporator by the compressor

To enable the transfer of heat, the temperature of the liquid refrigerant must be lower than the temperature of the product being cooled. Once transferred, the liquid refrigerant is drawn from the evaporator by the compressor via the suction line. When leaving the evaporator coil the liquid refrigerant is in vapour form.

The Compressor

The purpose of the compressor is to draw the low-temperature, low-pressure vapour from the evaporator via the suction line. Once drawn, the vapour is compressed. When vapour is compressed it rises in temperature. Therefore, the compressor transforms the vapour from a low-temperature vapour to a high-temperature vapour, in turn increasing the pressure. The vapour is then released from the compressor in to the discharge line.

The Condenser

The purpose of the condenser is to extract heat from the refrigerant to the outside air. The condenser is usually installed on the reinforced roof of the building, which enables the transfer of heat. Fans mounted above the condenser unit are used to draw air through the condenser coils.

The temperature of the high-pressure vapour determines the temperature at which the condensation begins. As heat has to flow from the condenser to the air, the condensation temperature must be higher than that of the air; usually between -12°C and -1°C. The high-pressure vapour within the condenser is then cooled to the point where it becomes a liquid refrigerant once more, whilst retaining some heat. The liquid refrigerant then flows from the condenser in to the liquid line.

The Expansion Valve

Within the refrigeration system, the expansion valve is located at the end of the liquid line, before the evaporator. The high-pressure liquid reaches the expansion valve, having come from the condenser. The valve then reduces the pressure of the refrigerant as it passes through the orifice, which is located inside the valve. On reducing the pressure, the temperature of the refrigerant also decreases to a level below the surrounding air. This low-pressure, low-temperature liquid is then pumped in to the evaporator.

The Refrigerant

The type of refrigerant used will depend on the pressure capabilities of the system and the temperatures that have to be achieved during refrigeration. The following brief table shows the relationship between temperature and pressure, given in bara, for two common refrigerants.

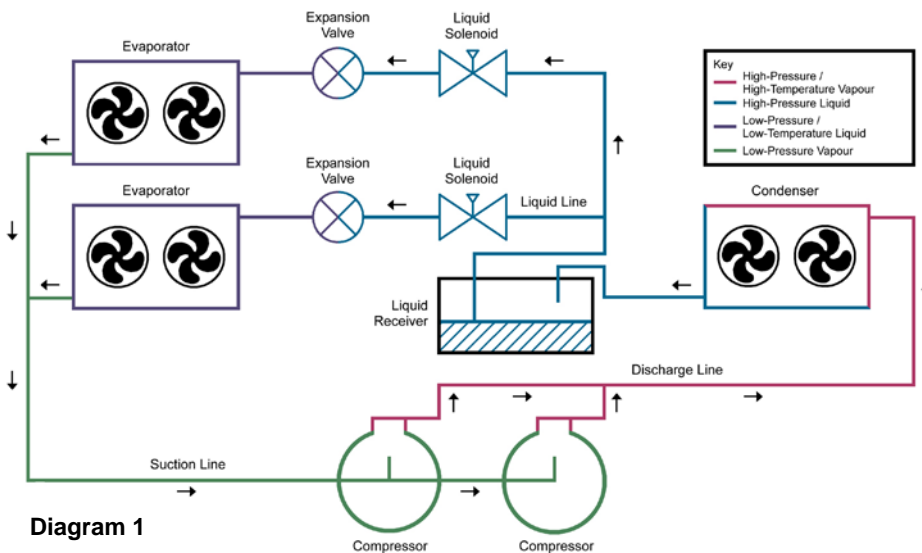
Temperature (°C)	Pressure (bar absolute)			Temperature (°F)
	R-134a	R-404A	R-410A	
-40	0.51	1.35	1.76	-40
-30	0.84	2.08	2.71	-22
-20	1.33	3.06	4.01	-4
0	2.93	6.09	7.99	0
20	5.72	10.96	14.43	68
30	7.70	14.27	18.83	86
40	10.17	18.26	24.17	104

THE REFRIGERATION CYCLE

The refrigeration cycle (shown in Diagram 1 below) begins with the refrigerant in the evaporator. At this stage the refrigerant in the evaporator is in liquid form and is used to absorb heat from the product. When leaving the evaporator, the refrigerant has absorbed a quantity of heat from the product and is a low-pressure, low-temperature vapour.

This low-pressure, low-temperature vapour is then drawn from the evaporator by the compressor. When vapour is compressed it rises in temperature. Therefore, the compressor transforms the vapour from a low-temperature vapour to a high-temperature vapour, in turn increasing the pressure. This high-temperature, high-pressure vapour is pumped from the compressor to the condenser; where it is cooled by the surrounding air, or in some cases by fan assistance. The vapour within the condenser is cooled only to the point where it becomes a liquid once more. The heat, which has been absorbed, is then conducted to the outside air.

At this stage the liquid refrigerant is passed through the expansion valve. The expansion valve reduces the pressure of the liquid refrigerant and therefore reduces the temperature. The cycle is complete when the refrigerant flows into the evaporator, from the expansion valve, as a low-pressure, low-temperature liquid.



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