Fundamentals of Refrigeration **Part 3 Refrigeration 2.**

Categories of Compressors
There are three main categories of compressor.
1.Open drive.
Open drive compressors are driven by a motor which is external to the compressor and does not come into contact with the refrigerant.The compressor drive shaft passes through the casing via a shaft seal. Shaft seals are there to prevent the leakage of any refrigerant to the outside of the compressor,however ,it is not always possible to prevent all leakage and this type of compressor has a greater tendancy to produce leaks than the other categories.
The heat of rejection for open drive compressors is less than for either of the remaining categories as the motor losses are not transferred to the refrigerant.This means that the operating range of open drive compressors is greater than is possible with hermetic or semi-hermetic compressors.
2. Semi-hermetic or accessible hermetic.
These compressors are designed in such a way as the drive motor is encased within the body of the compressor. This has the advantage that there are no shaft seals to leak and the motor cooling is accomplished by transferring the motor heat to the refrigerant for rejection at the condenser. Semi -hermetic compressors are built with bolt on cylinder heads and sump, which enables component parts to be replaced.
Most large commercial refrigeration will use this type of compressor.
3. Hermetic.
Hermetic compressors are similar to semi-hermetic compressors in that the motors are fitted within the casing of the compressor. They differ in the method of construction and appearance of the compressor.
The body of a hermetic compressor is usually a two part steel shell which is welded together after the compressor has been put into the interior. Connections are usually copper pipes brought through the steel case although larger models may be fitted with service valves. The majority of compressors used are from this category and your freezer or fridge at home will be fitted with a hermetic compressor.
Types of compressor
There are a number of different types of compressor which fall into the above categories. The way they are defined relates to the method used to compress the refrigerant. The most common type of compressor which we will encounter will be reciprocating .

Reciprocating Compressors.

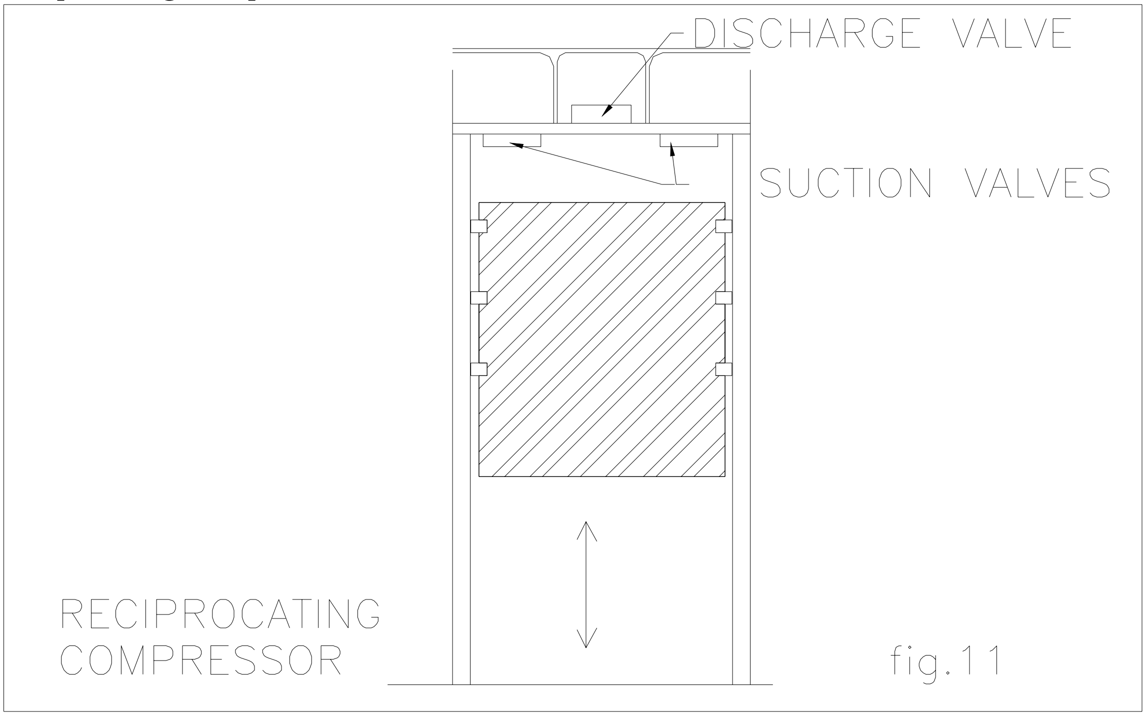


fig.11

In reciprocating compressors the refrigerant is compressed by one or more pistons drawing refrigerant into a cylinder and then pushing it out again into a much smaller volume. The compression given by this type of compressor is in the form of pulses of high pressure refrigerant. The number of pulses is determined by the number of cylinders which operate for a single revolution of the crankshaft and the speed at which the crankshaft turns.

Reciprocating compressors are available in all of the categories that we have identified. The direction of rotation is not critical.

Types of compressor

Screw Compressors.
Two types of screw compressor are available.These are designated as monoscrew or twinscrew.

Monoscrew.

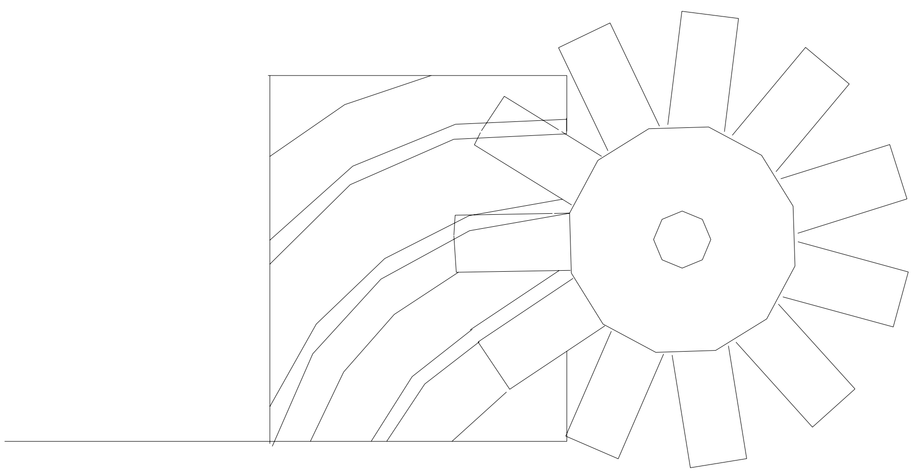
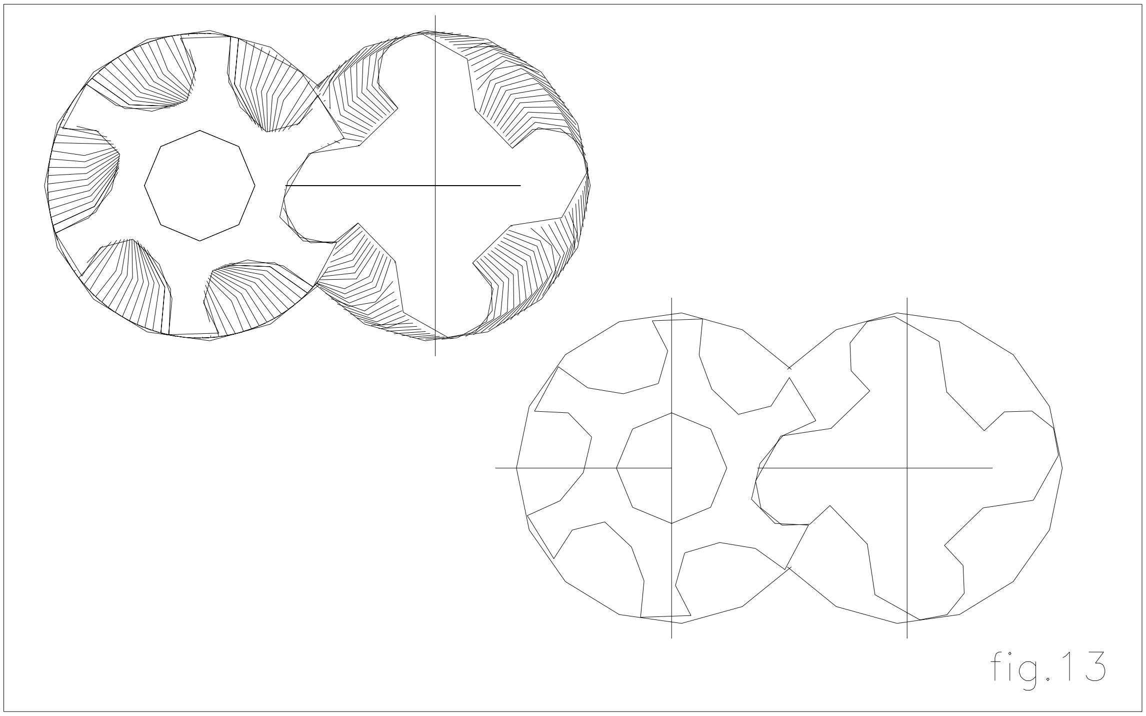


fig.12

The monoscrew compressor is constructed with a single screw which meshes with 2 gate rotors.As the main rotor turns, the gas is pushed along the grooves in the screw by the blades on the gate rotors and is compressed until the end of the screw passes the outlet from the compressor allowing the compressed gas to be discharged into the system.As the rotors are placed to follow each other, the compression from this type of compressor is continuous .fig.12 shows this.

Twinscrew



The twinscrew compressor has two main rotors. One rotor is fitted with six paths whilst the other is fitted with 4 lobes. This is shown on fig.13.As the compressor rotates the refrigerant gas is pushed forward by the two rotors in a similar way that toothpaste is squeezed out of a tube when the bottom is pressed. Again these compressors are designed so that the following compression has already started before the first one has finished ,giving a continuous,non pulsating output.

Rotary compressors.

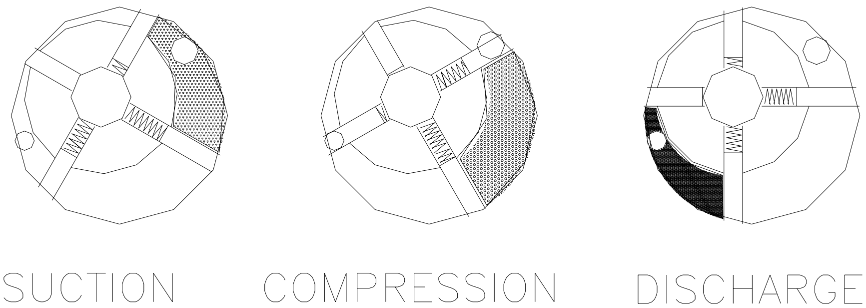
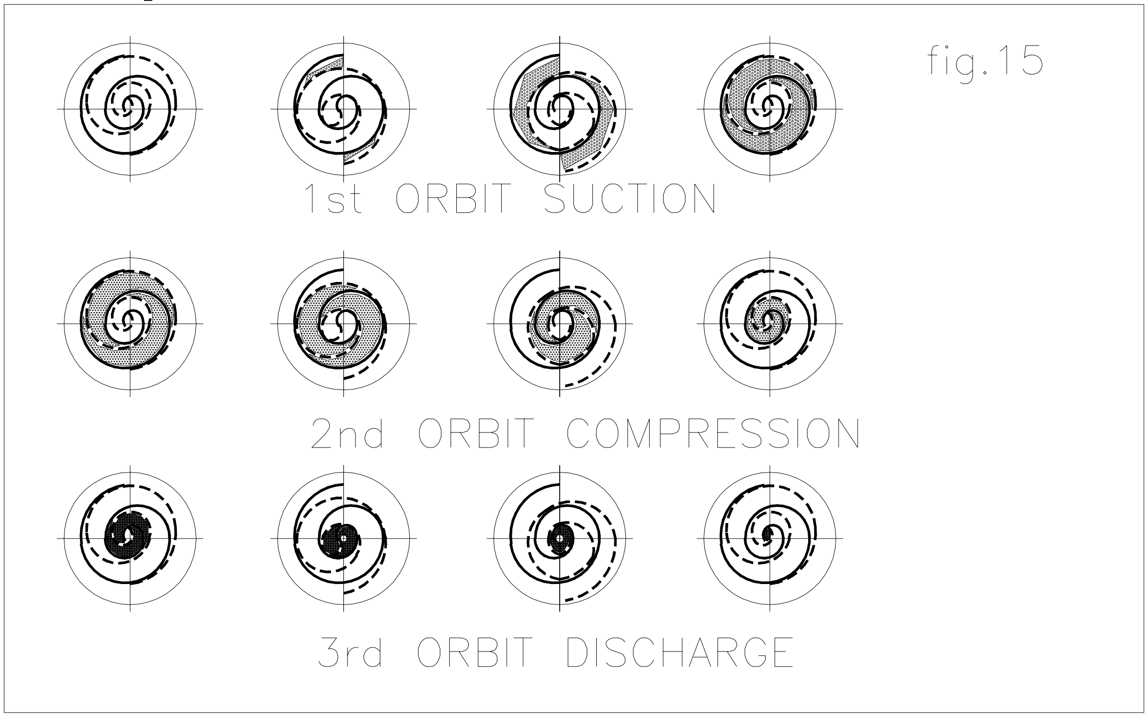


fig.14

Rotary compressors are used on very small equipment ,usually in air conditioning.
The compressor consists of a rotor with a number of sprung loaded vanes. This rotor runs eccentrically in a ring which causes the refrigerant to be compressed.Fig.14 shows a typical arrangement. The advantage of these compressors is the lack of moving parts which can wear out. These compressors are generally supplied as hermetic type only.

Scroll compressors



The scroll compressor is quite a new design of compressor. The compressor has two scrolls ,one rotating and one fixed. The scrolls move relative to each other to create pockets into which refrigerant is drawn and compressed Fig. 15 shows the way that the scroll compressor operates.

All of the screw, rotary and scroll compressors can only operate in one direction of rotation .

Oil transfer

Compressors are all composed of components, which move continuously. In order that wear is minimised , and the compressor does not overheat ,lubricating oil is pumped around the compressor. This oil , in most cases, mixes with the refrigerant and is circulated around the system. Ideally we would like the oil to remain in the compressor so we must devise a strategy to return the oil to the compressor in a manner that does not cause damage.

It has been discovered that the velocity of vapour has an important bearing on the ability of a system to return oil to the compressor. As a general rule vapour velocities should not be less than 500 feet/minute in horizontal tubes and 1000 feet / minute in vertical tubes for successful oil entrainment.

It is sometimes not practical to maintain velocities at these levels and it may be necessary to introduce a further component into the compressor discharge line to separate the oil from the refrigerant and return it to the compresssor crankcase. This item is simply called an oil separator. The draw back of this device is that it cannot tell the difference between oil and liquid refrigerant and so certain precautions must be used with these devices. It is normal practice to heat the oil separator to prevent refrigerant from remaining in a liquid state. It is also essential that the oil return line is closed off when the compressor is not running. A solenoid valve is usually employed for this purpose.

How does a refrigeration system work?

Consider this typical refrigeration system.

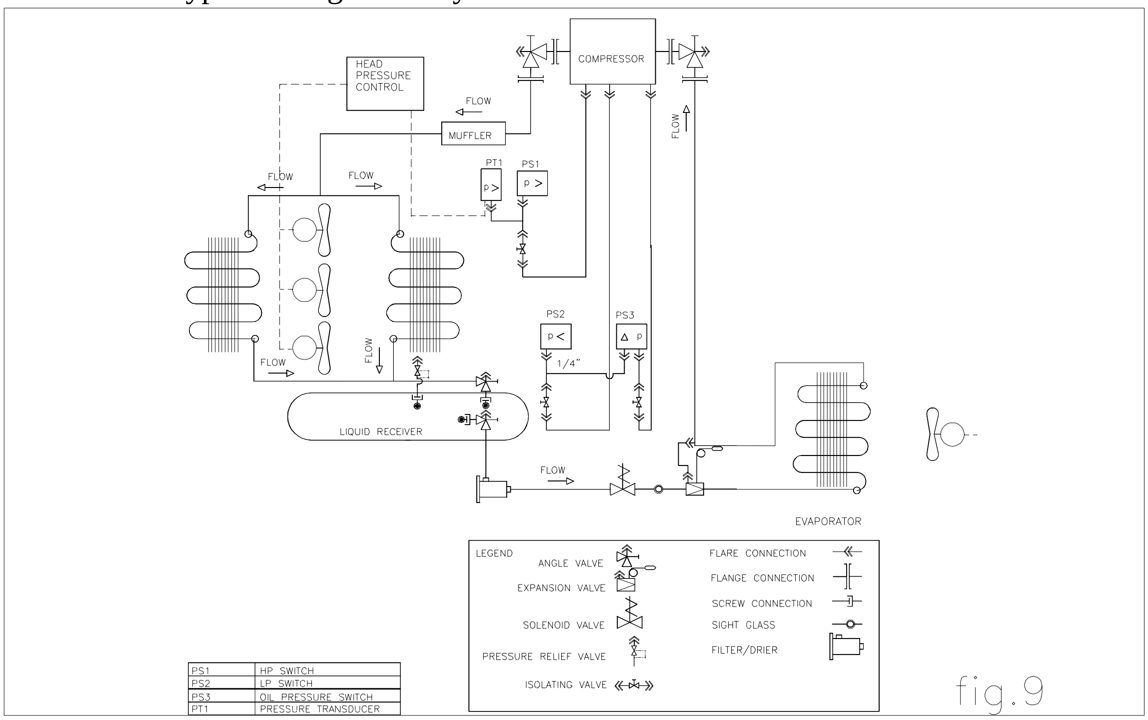
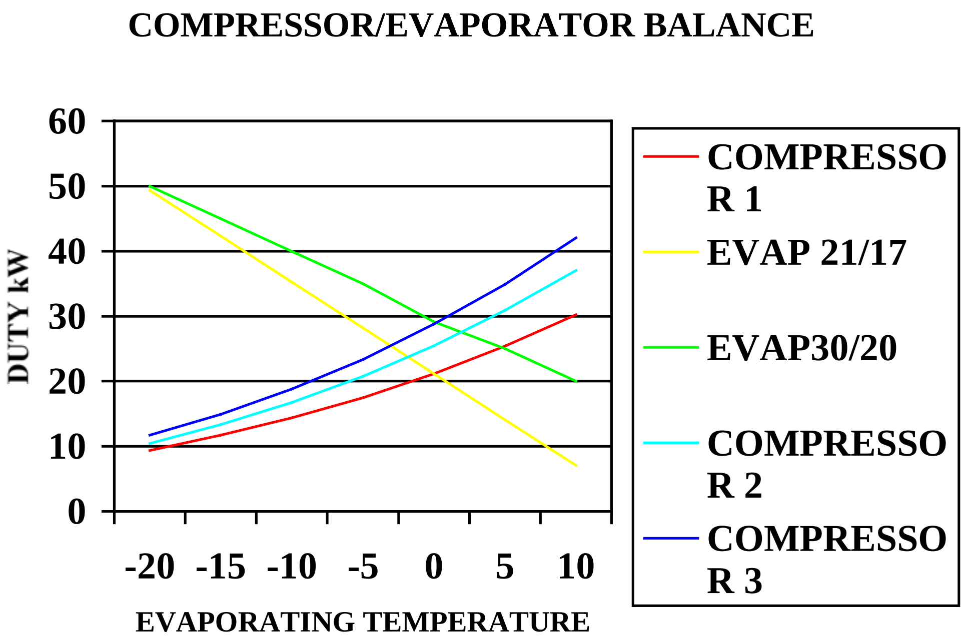


fig.9

The compressor sucks vapourised refrigerant from the evaporator and increases its pressure and temperature. This vapour then flows to the condenser where colder air is blown across the coils causing heat to be removed from the refrigerant contained in the tubes.

When sufficient heat has been removed from the refrigerant it changes its state and becomes a liquid. The liquid is then circulated to the expansion valve which meters the liquid into the coil in quantities that will be totally vapourised by the relatively warm air that is blowing across the evaporator. The cycle then repeats. The latent heat ,which we discussed in part 1, is added to the total refrigerant energy level in the evaporation process and it is rejected in the condensation process. It requires no change in temperature but the addition or reduction in energy levels is very significant.

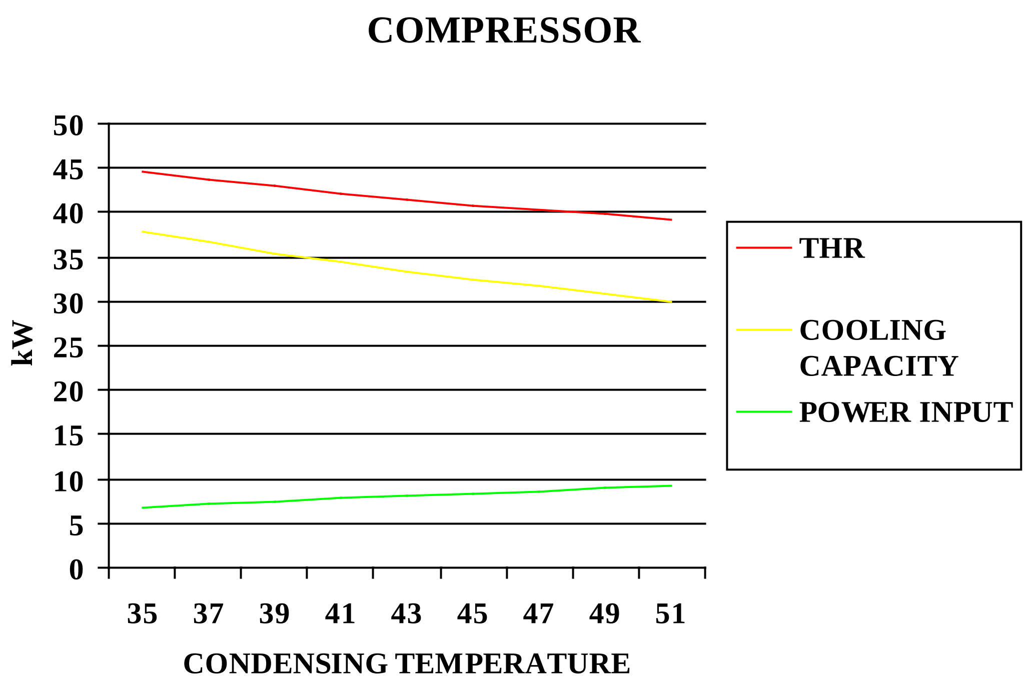
Compressor /evaporator balance



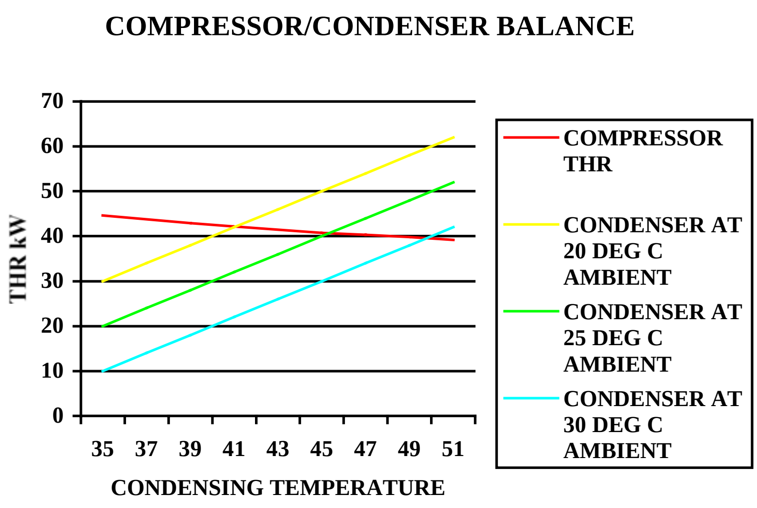
As previously discussed an evaporator is continuously boiling off liquid refrigerant which is entering the coil through the expansion valve. The quantity of refrigerant that it is capable of evaporating is determined by the energy levels of the air entering the coil and the ability of the compressor to remove the evaporated refrigerant.
Let us take a fresh air cooling coil as an example. The design for the coil is 30°C dry bulb 20°C wet bulb entering and 15°C dry bulb 13°C wet bulb leaving. The coil is designed to evaporate at 5°C. The air flow is 1.0 m3/s.The duty is 25kW.
In order that the coil performs to the above conditions it is necessary that a compressor with a cooling duty of 25kW at 5°C is fitted to the system.
Now let us suppose that something changes. This is a fresh air coil so it will only be supplied with air at ambient conditions. So let us consider what happens when the air on temperature falls to 21°C dry bulb and 17°C wet bulb. Our compressor is still capable of removing 25kW at 5°C and 21kW at 0°C . The system will rebalance until the compressor duty is exactly equal to the coil duty. In this case the air would leave the coil at 10.18°C dry bulb and 9.9°C wet bulb and evaporate at 1.5°C. Let us now consider what happens if the air flow is operating at less than design conditions. If we assume that the air volume is 10% lower than design because the filters on the unit are becoming dirty the air side conditions have changed again and this will cause the coil to evaporate at 0.5°C and the duty will reduce to 21.5 kW.

Compressor/condenser balance

We must now consider the other side of the system where we are to reject the heat that we have removed from the evaporator. The compressor delivers the mass of gas removed from the evaporator at a much higher pressure and passes it to the condenser. The work needed to compress the gas is added to the gas as heat. The total amount of heat to be rejected is the cooling duty added to the heat of compression and is known as the total heat of rejection THR.



As with cooling coils the condenser will have different capacities dependant on the difference in temperature between the ambient and the saturation temperature of the refrigerant. If the ambient temperature is high the ability of the condenser to form liquid is reduced. This means that more of the condenser is filled with gas. For a given mass flow the gas will occupy considerably more space than liquid and the pressure will therefore rise. When the pressure in a refrigerant rises its saturation point also rises. When it reaches a level such that the full mass flow is being liquified at a constant pressure this will be the balance point for the compressor /condenser combination.



The balance point will only change if one of the following occurs.

1. ambient temperature falls or increases
2. cooling duty in the evaporator falls or increases
3. compressor capacity falls or increases