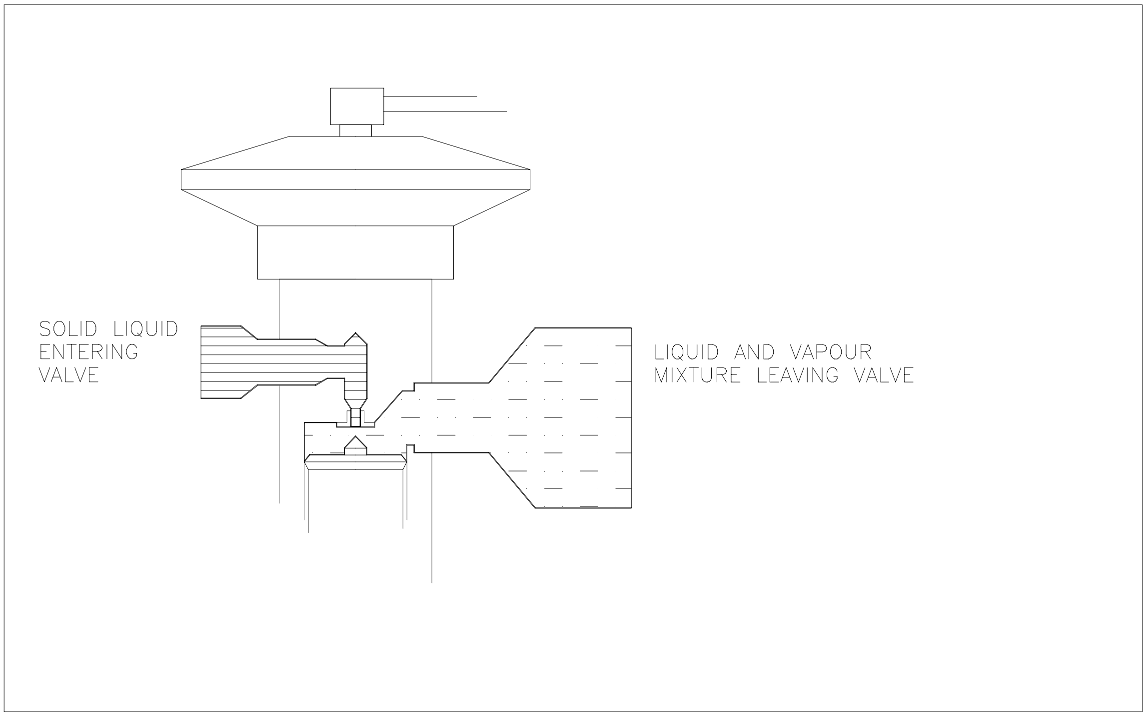
Fundamentals of Refrigeration **Part 6 Distribution**

To date we have only considered systems in which the evaporator has a single refrigerant circuit. When there is more than one path for the refrigerant to flow we must consider distribution of the refrigerant.

The distribution problem.

As liquid passes through the expansion valve a proportion flashes off to give two phase flow (liquid mixed with vapour) , as shown in the diagram below.



This mixture is mainly liquid by weight, but the vapour occupies most of the space.

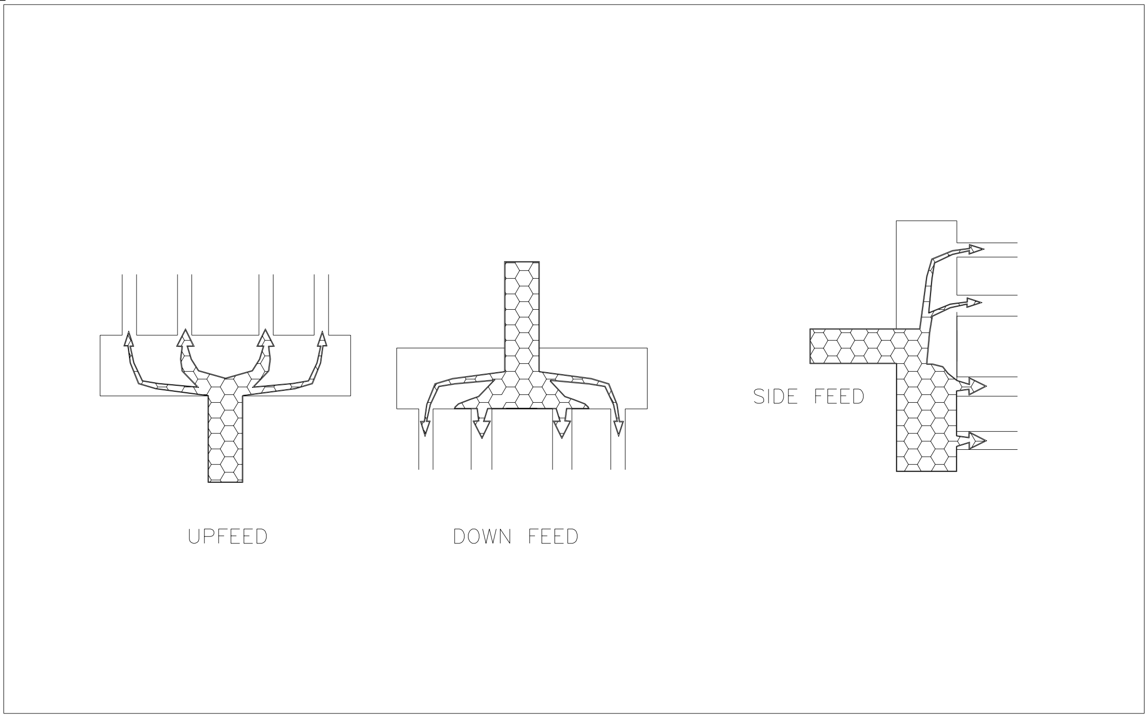
A typical R22 application would give proportions as shown below.

REFRIGERANT	% WEIGHT	% VOLUME
LIQUID	77	7
VAPOUR	23	93

The tabulated values are based on 43°C liquid entering the TEV and 7.2°C evaporating temperature. In this example liquid makes up 77% of the mass flow whilst occupying only 7% of the volume.

A second problem arises from the fact that the liquid and vapour streams move at different velocities as a result of the effect of gravity on the liquid portion of the flow.

If a simple header is used to divide the flow into each of the evaporator circuits, the circuits will not receive equal amounts of refrigerant. The circuits which have the easiest path will receive the most.



This diagram shows the effect of using a simple header in three different configurations.

To achieve proper distribution, the liquid portion of the two phase flow must be divided equally between the circuits.The solution to this problem is twofold. Firstly the liquid and vapour portions need to be mixed together and secondly to remain as a homogeneous two phase mixture until the flow has been divided.

How a liquid distributor achieves these aims.

The two phase refrigerant flow leaving the TEV enters the distributor nozzle. The nozzle increases the velocity of the two phase flow, mixing its liquid and vapour components. The outlet of the nozzle is focused on to a dispersion cone which divides the flow equally into passage ways arranged equally around the cone. The refrigerant is then conveyed, by the distributor tube into the evaporator.

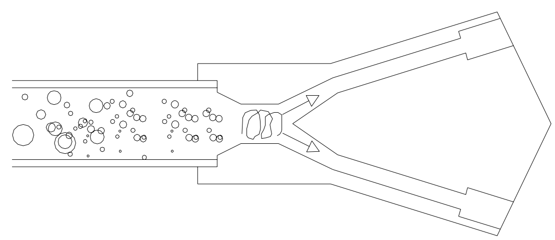
Pressure drop across the distributor creates the high velocity necessary to distribute the refrigerant flow effectively. High velocity is the key to the distributor’s success. Pressure drop across the nozzle focuses the flow, and provides the necessary mixing. Pressure drop across the distributor tubes assists in balancing the flow as it enters the distributor’s passageways. Distributor tube and nozzle sizing is, therefore, critical to proper distributor operation.

It should be remembered that the dispersion cone is designed to distribute flow to regularly positioned holes around the cone. Plugging holes is bad practice and should be avoided.

Distributor pressure drop does not reduce system capacity. As the liquid reaches the expansion valve it is necessary for the pressure to reduce, before entering the evaporator. If we consider the expansion valve and liquid distributor as a single component it is easier to understand. The liquid entering the expansion valve will be at the condensing pressure. The liquid leaving the distributor tubes will be at suction pressure. The pressure drop across our TEV/distributor will be condensing pressure- evaporating pressure. If the pressure drop across the distributor is 50% of this value it follows that the pressure drop across the expansion valve will be 50%. If the pressure drop across the distributor is 25% then the pressure drop across the expansion valve will be 75%. The overall effect will not be any different from the point of view of the system.

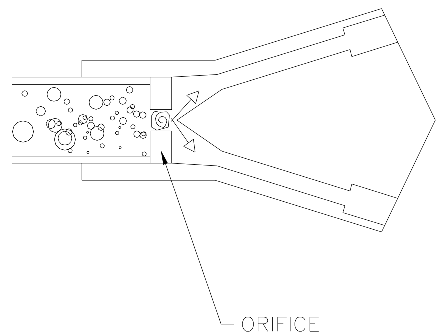
For each circuit to offer equal resistance, distributor tube lengths must be the same. Furthermore distributor tubes should be carefully bent to avoid kinks or sharp bends which would reduce the cross sectional area of the tube and increase the resistance to flow.

There are two types of nozzle which are used on liquid distributors. These are venturi and orifice.



VENTURI TYPE DISTRIBUTOR

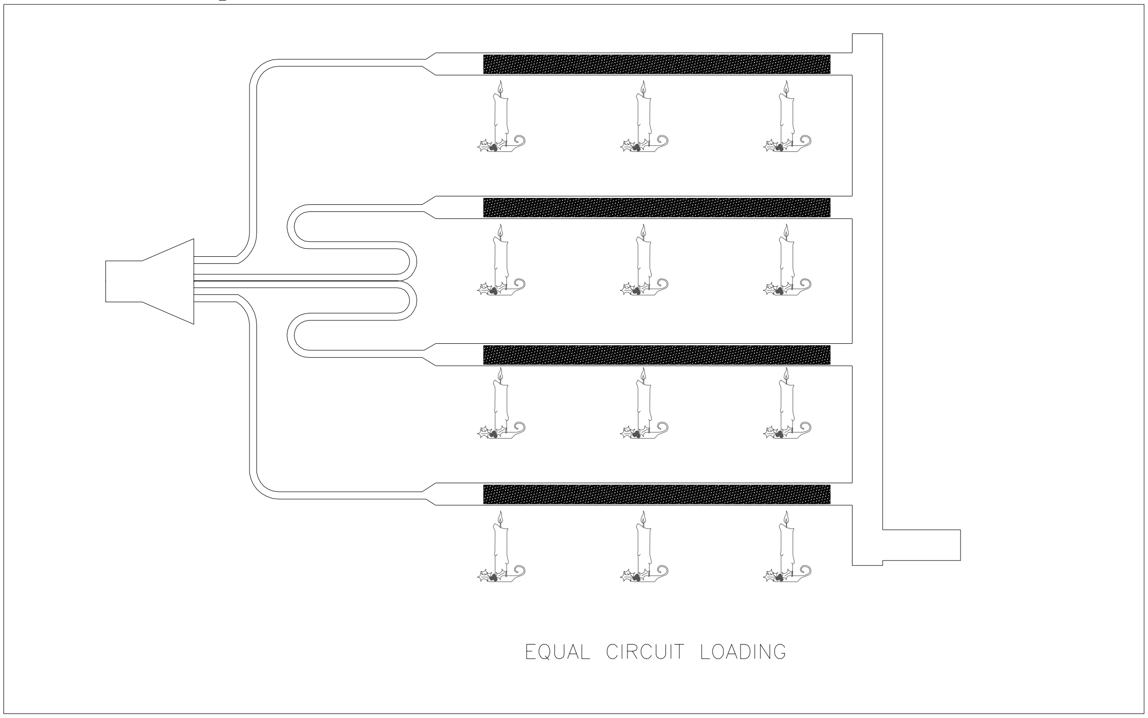
Venturi type distributors have a fixed tapered converging/diverging nozzle and are generally used on smaller equipment.



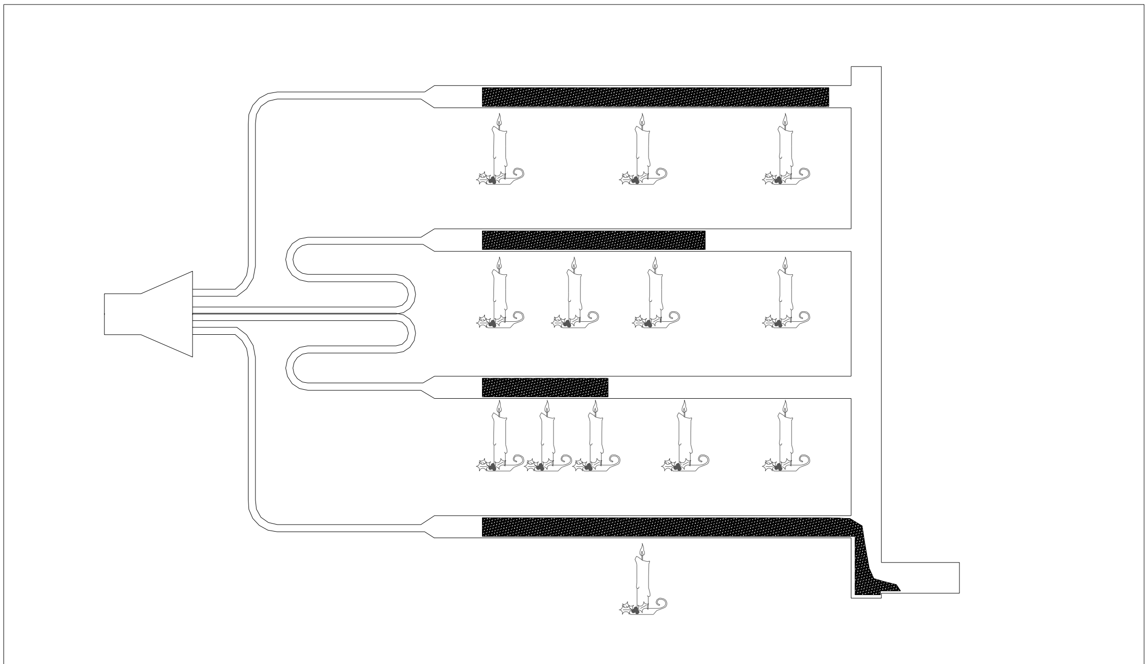
ORIFICE TYPE DISTRIBUTOR

Orifice type distributors have a disc with a circular hole (or orifice) which determines the flow capacity. All the larger coils use this type of distributor.

Since the distributor is designed to disperse equal amounts of refrigerant to each circuit, it is essential that the heat load on all circuits of the evaporator coil be the same. This means that all the circuits should have the same number of tubes, ideally all the circuits would be identical. If the coil is circuited with vastly differing circuits the effect will be the same as with poor distribution.



This diagram shows a properly circuited coil. Each of the circuits has the same amount of heat applied and the liquid finishes boiling off at the same position.



This diagram shows a coil which has been poorly circuited. It should be noted that the circuits with the highest circuit load are being starved of refrigerant whilst the lowest circuit is allowing unexpanded liquid to enter the header. Let us now reconsider the thermostatic expansion valve on such a system. Thermostatic expansion valves work on the temperature of the vapour leaving the evaporator. If one of the circuits permits unexpanded liquid to enter the suction line ,the bulb temperature will fall. If the bulb temperature falls the valve will close.

We are then wasting a large part of our coil superheating refrigerant which has already expanded whilst controlling on the poorest circuit.

Under such circumstances the coil will fail to perform to design conditions.

Selecting the correct Distributor.

1. Select the correct distributor tube size. The charts that we use are rated in TR (tons of refrigeration) To convert duty to tons divide kW by 3.516. Take **circuit load** in kW and divide by 3.516. Take 2/3 of the finned height as the distributor tube length. Divide by 25.4 to give length in inches. Look in the length correction factor table and obtain the correction factor. **Divide** the circuit load in Tons by the correction factor.

If no liquid temperature has been specified use correction factor for 90°F (1.17). **Divide** the corrected duty by the liquid temperature correction factor. We now have a corrected circuit load. Use the corrected circuit load in the selection tables and use the tube diameter nearest to the required duty.

Example1.

Coil on 134a with a circuit load of 3 kW and finned height of 1828mm evaporating at 40°F.

Convert circuit load to Tons =3/3.516=0.85324 TR

Take 2/3 of finned height =1219mm

Divide by 25.4 =48”

Correction factor for 48” =0.86

Divide circuit load by correction factor =0.85324/0.86 =0.99214 TR

Correction factor for 90°F =1.17

Divide 0.99214 by 1.17 = 0.848 TR

Look in 134a chart under 40°F evaporating ¼” line capacity is 0.85 TR .

This is almost exactly what we require so ¼” lines are correct.

Sizing the distributor orifice

To size the distributor orifice take **total section load** and convert to Tons Refrigeration.

Adjust for liquid temperature.

Select orifice from chart for required refrigerant.

Example 2.

Total duty for the 134a coil described above is 36 kW in two refrigeration sections(Two distributors) .It has 6 circuits on each section.

Duty per section is 18kW = 5.12 TR

Adjust for 90°F liquid =5.12/1.17 = 4.38 corrected Tons.

Look in chart under 134a for nozzle with this rating.

Nearest nozzle size is number 6 with an orifice diameter of 6.2mm.

This is rated at 4.26 TR

Pressure drop will be approx. 6% above ideal and is therefore acceptable.

Capacity controlled compressors.

Orifices should always be selected between 50% and 200% of the rated values to operate correctly. Where we have capacity controlled compressors it is important that the distributor be sized for operation at minimum load from the compressor. If the Minimum level of duty is below 50% of the maximum, it will be necessary to undersize the orifice at full load in order to compensate for the operation at minimum load.