

in its pressure will cause some of the refrigerant to flash into gas.

The presence of flash gas in the liquid line has several detrimental effects: (a) it increases the pressure drop due to friction, and this, in turn causes further flashing; (b) it reduces the capacity of the liquid metering device, and starves the evaporator unless the device is purposely over-sized to handle the expected amount of flash gas; (c) it causes erosion of the valve pin and seat, and creates a noticeable noise as it passes through the metering device; (d) it causes erratic control of the liquid refrigerant entering the evaporator.

In consideration of these potential difficulties, it is apparent that the liquid line should be designed so that the liquid entering the liquid metering device is slightly subcooled, and troublesome flash gas is eliminated.

The liquid refrigerant as it leaves the condenser or receiver is normally at a temperature equal to or higher than the ambient temperature. Thus flashing of liquid into gas is usually not the result of temperature increase but rather of pressure decrease caused by line friction and static head.

Liquid leaving the condenser is also usually subcooled 5 to 10 deg, depending on type of condenser and operating conditions. This amount of liquid subcooling will take care of a moderate amount of line friction and a small lift without excessive flash gas.

With a noticeable friction drop or a static head due to elevation of the liquid metering device above the condenser, or both, it may be necessary to resort to some means of liquid subcooling to prevent flashing in the liquid line.

Liquid Subcooling Requirements

Where liquid subcooling is required this is usually accomplished in one or both of the following ways: by use of a liquid-suction heat exchanger and/or by liquid subcooling coils in evaporative condensers.

The determination of how much liquid subcooling is required to offset friction and static head losses is quite simple. At normal liquid temperatures, the static pressure loss due to elevation at the top of a liquid lift is equal to one psi for every 1.8 ft of Refrigerant 12 and 2.0 ft of Refrigerant 22.

For example, assume a Refrigerant 12 system having a condensing temperature of 100 F, a liquid lift of 35 ft, a piping friction loss of 3 psi, plus losses through valves and accessories totaling 7.4 psi.

Following are the calculations for the amount of liquid subcooling required under these conditions:

Pressure loss due to pipe friction	= 3.0 psi
Pressure loss due to valve, etc.	= 7.4 psi
Pressure loss due to 35 ft liquid lift 35/1.8	= 19.5 psi
Total pressure loss in liquid line	= 29.9 psi
Condensing pressure (at 100 F)	= 116.9 psig
Net pressure at liquid feed valve inlet	= 116.9 - 29.9
	= 87.0 psig
Saturation Temperature at 87.0 psig	= 82.0 F

The subcooling required is equal to the condensing temperature minus the saturation temperature at 87 psig, or 100 - 82 = 18 F deg.

Therefore, the liquid subcooling required to prevent liquid flashing is 18 F.

Piping Arrangements

The preferred method of running a liquid line to multiple expansion valves on a coil bank is to drop down vertically at

the coil to get as even distribution as possible of subcooled liquid to each valve.

Where long vertical lifts occur between evaporators on a common liquid riser it becomes difficult to completely eliminate liquid flashing, as a result of the pressure reduction due to elevation. This condition will, of course, result in poor performance and loss of capacity at the expansion devices. To make it worse it also causes unequal distribution of liquid refrigerant because the uppermost evaporators get most of the flash gas.

The liquid riser arrangement (Fig. 1) helps to correct this situation. Flash gas formed in each section of the riser will tend to go to the nearest evaporator. This will help prevent the uppermost evaporator from getting all of the flash gas in the riser.

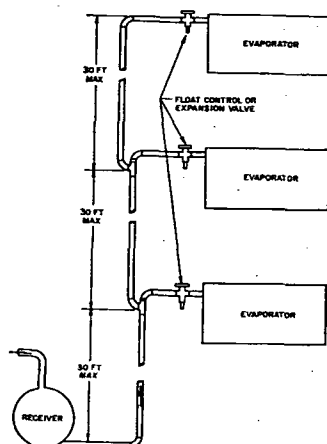
Since expansion valve capacities are reduced due to flash gas and reduced inlet pressure, they should be oversized as directed by manufacturer's ratings, when these conditions are present.

SUCTION LINES

Design Considerations

Suction lines are the most critical from a design and construction standpoint. Refrigerant suction lines should be designed:

1. To provide the correct size for a practicable pressure drop at full load. (See Chapter 69.)
2. To return oil from the evaporator to the compressor under minimum load conditions.
3. To prevent liquid from draining into the compressor during shutdown.



* When sufficient liquid subcooling is not available.

Fig. 1 . . . Liquid Riser Piping for Evaporators at Different Levels Above Receiver.*

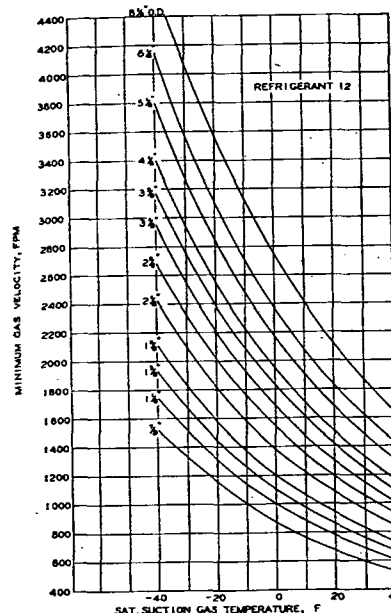


Fig. 2 . . . Minimum Gas Velocity for Oil Entrainment in Copper Tube Suction Risers (Refrigerant 12)*

4. To prevent draining of oil from an active evaporator into an idle evaporator.

Oil Circulation in Halocarbon Type Systems

Lubricating oil is lost from reciprocating machines during normal operation because these machines are designed so that the pistons and piston rings ride on a film of oil while traversing the cylinder. A small quantity of this oil is continuously pushed on through the cylinders and out with the discharge gas.

Since it is inevitable that oil will leave the compressor with the refrigerant, means must be provided in systems using Refrigerants 12, 22 and 500 to return this oil at the same rate at which it leaves.

Oil which leaves the compressor reaches the condenser and there becomes dissolved with the liquid refrigerant. In this condition it readily passes through the liquid supply lines to the evaporators. In the evaporator, however, a distillation process occurs and there is almost complete separation of the oil and refrigerant. Very little oil can remain in the relatively cold and less dense refrigerant vapor at the temperature and pressure corresponding to its evaporating condition. Therefore, the oil which is separated in the evaporator can only be

returned to the compressor by gravity or by entrainment with the returning gas.

Oil Return Up Suction Risers

Most refrigeration piping systems contain a suction riser either because the evaporator is at a lower level than the compressor, or to minimize the possibility of liquid draining from the evaporator into the compressor during compressor off cycles.

Oil circulating in the system can be returned up gas risers only by entrainment with the returning gas.

Minimum Gas Velocities for Oil Return Up Suction Risers

The principal criteria determining whether or not oil can be entrained and thereby carried up a suction riser are gas velocity, gas density and pipe inside diameter.

Since mass velocity is more the determining factor than actual gas velocity only, in achieving oil entrainment, the gas density plays an important part. At lower suction temperatures refrigerant gas becomes less dense and the required minimum gas velocity necessary to entrain oil up risers is greater than at higher suction temperatures.

The mass velocity concept however, is not sufficient by itself. The variances in the relationship between pipe cross-section area and wetted perimeter for the different pipe sizes must be taken into account. The oil returning up a suction riser usually creeps up the inner surface of the pipe. It is therefore dependent on the mass velocity of the gas at the wall surface. The larger the pipe diameter, the greater will be the required velocity at the center of the pipe to maintain a given velocity at the wall surface.

Other factors effecting oil entrainment are oil viscosity, oil to refrigerant ratio in the system and oil density. However, these factors are relatively constant for the average refrigerant system and need not be treated as variables.

The curves in Figs. 2 and 3 are based on the concepts outlined above and indicate the minimum suction gas velocities for successful oil entrainment with Refrigerants 12 and 22 up Type L copper tube suction risers for various suction temperatures and pipe sizes. The suction gas temperature shown indicates the saturated temperature corresponding to the compressor suction pressure. It does not represent the actual suction gas temperature which will usually be superheated to some extent.

It would be good practice to size suction line risers for about 25 percent greater gas velocity than shown in Figs. 2 and 3, at lowest partial loading.

Suction risers must be sized for minimum system capacity. It is extremely important that oil be returned to the compressor at the operating condition corresponding to the minimum displacement and minimum suction temperature at which the compressor will operate.

For compressors with capacity control, the minimum capacity is the lowest capacity at which the compressor can operate. For multiple compressors with capacity control the minimum capacity is the lowest at which the last operating compressor can run.

Riser Sizing

Example 1 illustrates the use of Figs. 2 and 3 in establishing maximum riser sizes for satisfactory oil entrainment down to minimum partial loading.

Example 1: Determine the maximum size suction riser