

In general, direct-expansion and liquid overfeed system evaporators have fewer oil return problems than do flooded system evaporators because refrigerant flows continuously at velocities high enough to sweep oil from the evaporator. Low-temperature systems using hot-gas defrost can also be designed to sweep oil out of the circuit each time the system defrosts. This reduces the possibility of oil coating the evaporator surface and hindering heat transfer.

Flooded evaporators can promote oil contamination of the evaporator charge because they may only return dry refrigerant vapor back to the system. Skimming systems must sample the oil-rich layer floating in the drum, a heat source must distill the refrigerant, and the oil must be returned to the compressor. Because flooded halocarbon systems can be elaborate, some designers avoid them.

System Capacity Reduction. Using automatic capacity control on compressors requires careful analysis and design. The compressor can load and unload as it modulates with system load requirements through a considerable range of capacity. A single compressor can unload down to 25% of full-load capacity, and multiple compressors connected in parallel can unload to a system capacity of 12.5% or lower. System piping must be designed to return oil at the lowest loading, yet not impose excessive pressure drops in the piping and equipment at full load.

Oil Return up Suction Risers. Many refrigeration piping systems contain a suction riser because the evaporator is at a lower level than the compressor. Oil circulating in the system can return up gas risers only by being transported by returning gas or by auxiliary means such as a trap and pump. The minimum conditions for oil transport correlate with buoyancy forces (i.e., density difference between liquid and vapor, and momentum flux of vapor) (Jacobs et al. 1976).

The principal criteria determining the transport of oil are gas velocity, gas density, and pipe inside diameter. Density of the oil/refrigerant mixture plays a somewhat lesser role because it is almost constant over a wide range. In addition, at temperatures somewhat lower than -40°C , oil viscosity may be significant. Greater gas velocities are required as temperature drops and the gas becomes less dense. Higher velocities are also necessary if the pipe diameter increases. Table 19 translates these criteria to minimum refrigeration capacity requirements for oil transport. Suction risers must be sized for minimum system capacity. Oil must be returned to the compressor at the operating condition corresponding to the minimum displacement and minimum suction temperature at which the compressor will operate. When suction or evaporator pressure regulators are used, suction risers must be sized for actual gas conditions in the riser.

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

Riser Sizing. The following example demonstrates the use of Table 19 in establishing maximum riser sizes for satisfactory oil transport down to minimum partial loading.

Example 3. Determine the maximum size suction riser that will transport oil at minimum loading, using R-22 with a 120 kW compressor with capacity in steps of 25, 50, 75, and 100%. Assume the minimum system loading is 30 kW at 5°C suction and 40.6°C condensing temperatures with 10 K superheat.

Solution: From Table 19, a 54 mm OD pipe at 5°C suction and 30°C liquid temperature has a minimum capacity of 23.1 kW. From the chart at the bottom of Table 19, the correction multiplier for 40°C suction temperature is about 1. Therefore, 54 mm OD pipe is suitable.

Based on Table 19, the next smaller line size should be used for marginal suction risers. When vertical riser sizes are reduced to provide satisfactory minimum gas velocities, pressure drop at full load increases considerably; horizontal lines should be sized to keep total

pressure drop within practical limits. As long as horizontal lines are level or pitched in the direction of the compressor, oil can be transported with normal design velocities.

Because most compressors have multiple capacity-reduction features, gas velocities required to return oil up through vertical suction risers under all load conditions are difficult to maintain. When the suction riser is sized to allow oil return at the minimum operating capacity of the system, pressure drop in this portion of the line may be too great when operating at full load. If a correctly sized suction riser imposes too great a pressure drop at full load, a double suction riser should be used.

Oil Return up Suction Risers: Multistage Systems. Oil movement in the suction lines of multistage systems requires the same design approach as that for single-stage systems. For oil to flow up along a pipe wall, a certain minimum drag of gas flow is required. Drag can be represented by the friction gradient. The following sizing data may be used for ensuring oil return up vertical suction lines for refrigerants other than those listed in Tables 19 and 20. The line size selected should provide a pressure drop equal to or greater than that shown in the chart.

Saturation Temperature, $^{\circ}\text{C}$	Line Size	
	50 mm or less	Above 50 mm
-18	80 Pa/m	45 Pa/m
-46	100 Pa/m	57 Pa/m

Double Suction Risers. Figure 3 shows two methods of double suction riser construction. Oil return in this arrangement is accomplished at minimum loads, but it does not cause excessive pressure drops at full load. Sizing and operation of a double suction riser are as follows:

1. Riser A is sized to return oil at minimum load possible.
2. Riser B is sized for satisfactory pressure drop through both risers at full load. The usual method is to size riser B so that the combined cross-sectional area of A and B is equal to or slightly greater than the cross-sectional area of a single pipe sized for acceptable pressure drop at full load without regard for oil return at minimum load. The combined cross-sectional area, however, should not be greater than the cross-sectional area of a single pipe that would return oil in an upflow riser under maximum load.
3. A trap is introduced between the two risers, as shown in both methods. During part-load operation, gas velocity is not sufficient to return oil through both risers, and the trap gradually fills up with oil until riser B is sealed off. The gas then travels up riser A only with enough velocity to carry oil along with it back into the horizontal suction main.

The trap's oil-holding capacity is limited by close-coupling the fittings at the bottom of the risers. If this is not done, the trap can accumulate enough oil during part-load operation to lower the compressor crankcase oil level. Note in Figure 3 that riser lines A and B

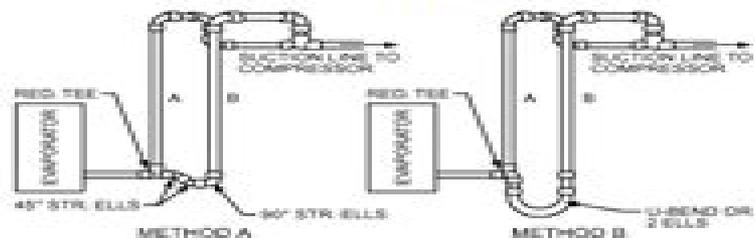


Fig. 3 Double-Suction Riser Construction

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