Refrigeration piping for DX: Part IV – suction line design

By WILLIAM J. COAD, PE

In last month's column, we stated that "the liquid line is perhaps the least critical of the piping segments insofar as potential damage to the compressor is concerned." The antithesis of that statement is that the suction line is perhaps the most critical. The suction line is the last leg of the journey of the refrigerant and oil after leaving the discharge valve to return to the compressor.

The two objectives in the design of the suction line are to hold the pressure loss to the minimum possible value and to return the oil (which separated from the liquid refrigerant as it changed to the gaseous phase in the evaporator) to the compressor.

On this page each month, the author shares his engineering philosophy by exploring a wide variety of topics, ranging from fundamentals to new frontiers, as they relate to building environmental systems. Mr. Coad is president of McClure Engineering Associates and affiliate professor of mechanical engineering at Washington University, St. Louis, Mo.

Considering first the pressure drop, refer to Fig. 1, a partial scale pressure-enthalpy diagram that illustrates the effect of suction line pressure drop on the compressor energy. As the gas leaves the evaporator with about 10 F of superheat at Point a, isentropic compression would follow the isentropic Curve s to Point b. However, the actual compressor curve would lean out to the right along the polytropic line represented by the curved Line a-c. However, a pressure drop in the suction line would be represented by the vertical downward Line a-a′ so that the refrigerant enters the compressor at the lower Point a′. Since compression lines flatten out moving upward, this is seen to have a somewhat magnifying impact upon the energy consumed!

The system designer should understand the impact of the pressure drop upon the power or energy requirement in each particular system, but as a guideline, common practice has been to limit the pressure loss in the entire suction system to a pressure differential equivalent to 2 F saturation temperature (approximately 4 psi for R-22, 2 psi for R-12).

The second objective, the return of oil to the compressor, requires practices similar to those discussed for the discharge line. In the suction line, however, the problem is more critical since the oil is more viscous and therefore harder to move at the lower temperatures.

Starting at the outlet of the evaporator, the suction line should always drop vertically downward or run horizontally at a downward slope to a point where it then drops vertically downward. The objective is to clear the evaporator of any oil, thus preventing it from being trapped in the evaporator. Once the oil has been cleared from the evaporator, the only remaining problem is to keep it moving. The velocity in horizontal lines is generally adequate to move the oil along with the refrigerant effectively. However, if the situation allows, it is recommended to provide a slight pitch in the direction of flow (say, ⅛ in. per ft) to assure that there will be no accidental low spots in the lines. Also, if there are any branch connection inlets into the horizontal line, such as a branch inlet from another evaporator, they should always enter the top of the line.

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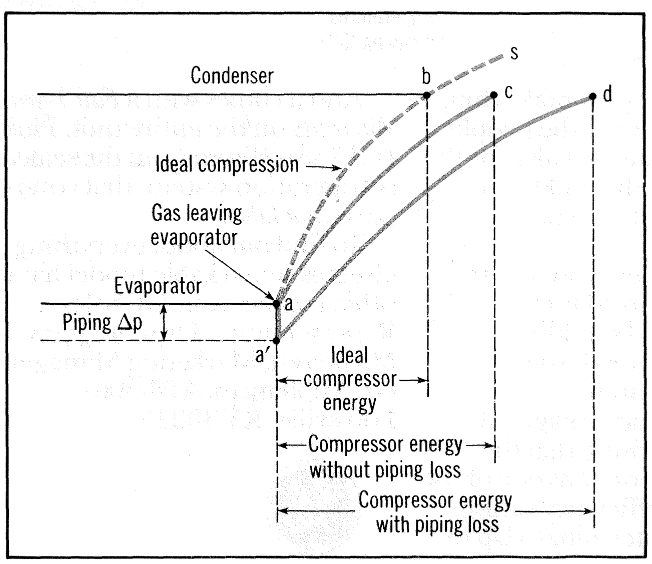
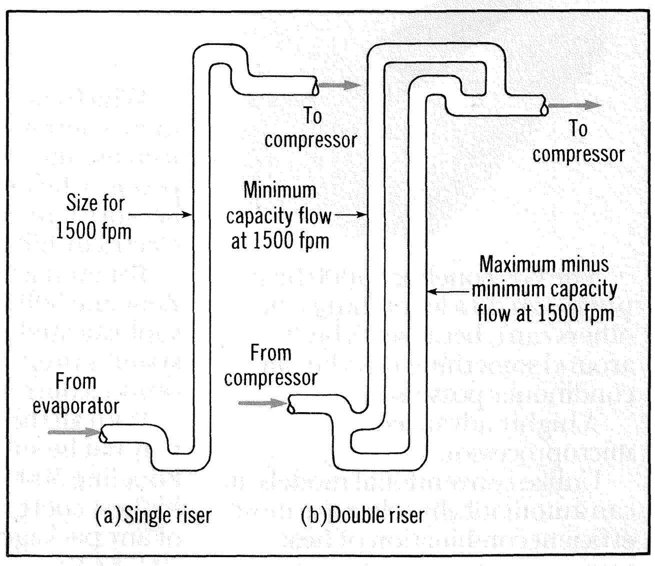


1 Pressure-enthalpy diagram demonstrates effects of suction line pressure drop.



2 Oil entrainment techniques for suction line.

Fundamentals to frontiers

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Where the line must rise in the direction of flow, a trapping technique similar to that for the discharge line is used, as shown in Fig. 2. In a system with a single compressor and no cylinder unloading (or other type of variable flow), a single trap is used, as illustrated in Fig. 2a. For the suction line, the vertical line should be sized for a minimum of 1500 fpm and a maximum of 2500 fpm.* As with the discharge line, if the system is designed for variable refrigerant flow, such that at the lowest load or flow condition the velocity in the riser would drop below the minimum requirement, then the double riser technique of Fig. 2b is used, with the minimum capacity riser sized for nominally 1500 fpm at the minimum flow capacity and the other riser sized for the maximum less the minimum capacity.

Needless to say, the successful design of a refrigeration system requires extensive knowledge of all of the aspects of the systems, such as component capacity matching, controls, and specialty devices, in addition to the piping systems themselves. But an understanding of proper piping practices is essential if the designs are to be successful, and the addition of controls or specialty devices to offset poor piping practices, although all too common, is a technique that will lead to disaster. Thus, the designer should always keep the piping system simple and follow the basic objectives discussed in this series. Ω

**The velocity ranges given in this series have been demonstrated to provide effective oil return without excessive pressure drops. However, much more extensive data are available relating to this matter in the* ASHRAE Handbook *chapter "System Practices for Halocarbon Refrigerants" (currently Chapter 3 of the* 1986 Refrigeration Handbook.