

As Equipment Evolves, So Must Piping Practices ... Split Systems And Interconnecting Refrigerant Lines

from the editor ...

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The efficiency and reliability of an R-22, split air-conditioning system hinges largely on the piping that connects the refrigerant-condensing and air-handling sides of the system. Operational difficulties are inevitable if this interconnecting piping is improperly designed or installed, regardless of how carefully the equipment was selected and applied.

Interconnecting piping designs that successfully avoid these difficulties share several common traits:

- A simple, direct layout that reduces the amount of system refrigerant.
- A refrigerant tube size that consistently returns oil to the compressors.
- A refrigerant tube size that doesn't cause excessive pressure drops which reduce compressor efficiency and capacity.

Some of the piping techniques discussed in this newsletter wouldn't have been considered good practice in the past, but they work best and most reliably for modern commercial Trane equipment with scroll compressors.

This *Engineers Newsletter* previews the selection and refrigerant piping guidelines now recommended for Trane's current line of commercial split-system/scroll-compressor equipment.

“Double risers and riser traps are good examples of conventional piping practices no longer needed ...”

Equipment Selection

The success of any HVAC application begins with choosing the right system and properly sizing the equipment. If a split air-conditioning system best suits the project, then observe these guidelines:

- Base your selection on a minimum coil suction temperature of 40°F for constant-volume systems and 43°F for variable-air-volume (VAV) systems.

These limits promote stable performance over the system's entire operating range.

- Select the system using design conditions and check for proper operation at the expected operating extremes.
- Avoid using hot gas bypass in comfort cooling applications. It squanders energy and is seldom necessary for properly designed systems. If coil-frosting is a concern, consider adding an evaporator defrost control such as Froststat™ coil frost protection.

Interconnecting Piping

Keep these general guidelines in mind as you review the recommendations specific to suction, liquid, discharge and hot gas bypass lines:

- Limit overall line length, including the vertical suction and liquid risers. Enough subcooling may be lost as refrigerant travels up the liquid riser to cause flashing. Review any questionable applications with the manufacturer.
- Use Type L copper tubing for R-22. For copper-to-copper joints, use BCuP-6 without flux. For copper-to-steel or copper-to-brass joints, use BA9-28 with a non-acid flux.

- Rely on the equipment manufacturer to size the refrigerant lines. Only they know how the units interact with the system components.

- If the manufacturer has not sized the refrigerant lines, use pipe sizing software such as Trane™ Engineering Toolbox to quickly determine proper sizes for refrigerant lines based on current engineering data.

Suction Line. Pressure drop in the suction line adversely affects unit capacity and efficiency. A pressure drop of 6 psid in matched commercial Trane RAUC units reduces system capacity by 2.5 percent and efficiency by 1.5 percent over the standard 3 psid design.

With that in mind, consider these suction-line recommendations:

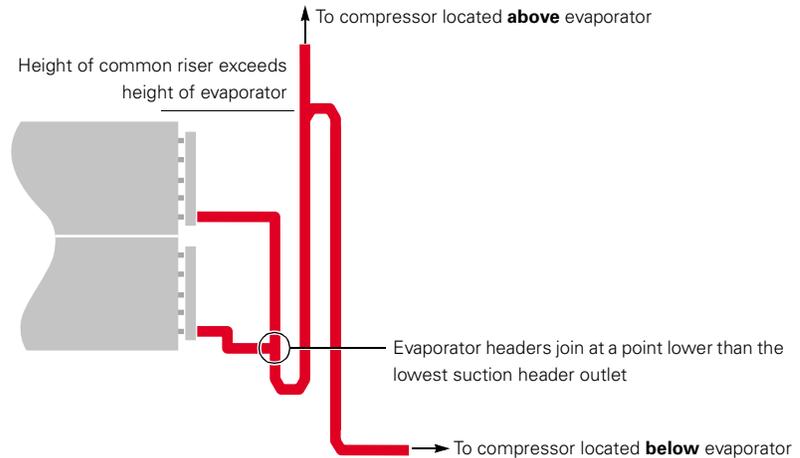
- Route the suction line from the evaporator to the compressor by the shortest path.

- Use different pipe sizes for horizontal and vertical lines to make it easier to match line pressure drop and refrigerant velocity to suction-line requirements.

- To assure proper oil entrainment and avoid sound transmission, size the suction line so that the refrigerant velocity equals or exceeds the required minimum velocity stated in Table 1 **and** remains below 4,000 fpm.

- Riser traps are unnecessary. If the riser is properly sized to maintain velocity, adding a trap only increases the suction-line pressure drop.

Figure 1.
Recommended Suction-Line Arrangements from Evaporator Headers



- Double risers are unnecessary. The steps of unloading for commercial Trane units with scroll compressors are such that a single, carefully selected riser can maintain oil circulation at any load condition.

- Even the most careful installation allows foreign matter into the system. That's why it's critical to install suction filters and properly maintain them. Once cleanup is complete, a fresh core should be installed in the shell to prevent oil trapping.

- Figure 1 illustrates one method of trapping the evaporator coil. The

suction lines from the evaporator headers should join at a point lower than the lowest suction header outlet. This arrangement drains the coils and prevents oil and refrigerant from "backfeeding" from one coil to the other(s).

The common connection should then rise above the height of the coil before proceeding to the compressor to prevent the refrigerant and oil in the evaporator from "free-draining" toward the compressor.

- Provide a 1-inch pitch **toward the evaporator** for every 10 feet of run to prevent any refrigerant that condenses in the suction line from flowing to the compressor when the unit is off.

- Specify suction-line insulation if moisture condensation and dripping pose a problem, or to prevent refrigerant from condensing inside the lines if long runs will be exposed to low temperatures.

- Don't install suction lines underground. The likelihood of corrosion, vibration, condensation of water outside—and refrigerant inside—the line, combined

Table 1.
Minimum Suction-Line Velocities for Oil Entrainment

Nominal Pipe Size, in.	Refrigerant Velocity, fpm	
	Riser	Horizontal
1-1/8	700	525
1-3/8	780	585
1-5/8	840	630
2-1/8	980	735
2-5/8	1080	810
3-1/8	1180	885

with inaccessibility and difficulty in maintaining cleanliness, make this practice unwise. If underground installation is unavoidable, make provisions to insulate, waterproof and encase the lines in a hard sleeve.

Liquid Line. Sufficient subcooling must be maintained at the expansion valve. To provide proper operation throughout the range of operating conditions, the liquid-line pressure drop should not exceed the unit's minimum subcooling value less 5°F. To achieve this objective, keep these liquid-line considerations in mind:

- Select the smallest, practical line size for the application. Limiting the refrigerant charge improves compressor reliability.
- When designing the liquid line for a typical air-conditioning application (i.e. one with an operating range of 40°F to 115°F), remember that every 10 feet of vertical rise will reduce subcooling by 2.8°F, while every 10 feet of vertical drop will add 1.1°F of subcooling.
- Specify one expansion valve per distributor. An expansion valve serving more than one distributor will distribute the refrigerant unevenly.
- Provide a 1-inch pitch toward the evaporator for every 10 feet of run. Since this pitch equals that of the suction line, the two may be run together.

If the system is designed with a liquid line rise, a column of liquid refrigerant remains atop the volume of refrigerant gas in the condenser whenever the unit

stops. The liquid refrigerant will eventually drain down the line and may fill the condenser ... perhaps even overflow to the compressor. Sloping the liquid line toward the evaporator creates a gas trap at the line's highest point, preventing liquid refrigerant from passing.

- Solenoid valves are required. They prevent liquid refrigerant from filling the evaporator when the compressor stops and slugging when the compressor restarts. Adding solenoid valves also prevents siphoning which could allow an elevated column of liquid to overcome the gas trap and flow back into the condenser and compressor.

“It’s prudent to avoid hot gas bypass in comfort cooling applications, especially those with variable-air-volume (VAV) systems.”

- If the liquid line must be routed through an area warmer than outdoor air temperature, insulate the line to prevent the refrigerant from flashing.
- Be sure to include a replaceable-core filter drier to permit proper system cleanup and moisture removal. The core should be changed whenever the system is opened for service.
- Consider adding a moisture-indicating sight glass to permit a visual check of the liquid column for bubbles. However, **never use the sight glass to**

determine whether the system is properly charged! Instead, either charge the system based on the required subcooling or calculate the amount of refrigerant needed and add it based on weight.

Discharge Line. Limit the pressure drop in the discharge line to 6 psid whenever possible to minimize the adverse effect on unit capacity and efficiency. While a pressure drop of as much as 10 psid is usually permissible, note that a 6-psid pressure drop reduces unit capacity by 0.9 percent and efficiency by 3 percent.

To design the discharge line properly, follow the guidelines recommended below:

- Choose the shortest route from the compressor to the condenser.
- Use different pipe sizes for horizontal and vertical lines to make it easier to match line pressure drop and refrigerant velocity to discharge-line requirements.
- To assure proper oil entrainment **and** avoid sound transmission, size the discharge line so that refrigerant velocity equals or exceeds the minimum velocity in Table 2 and remains below 3,500 fpm.
- Prevent oil and condensed refrigerant from flowing back into the compressor during “off” cycles by: (a) pitching the discharge line toward the condenser and (b) routing the discharge line so that it rises to the top of the condenser, then drops to the level of the condenser inlet, creating an inverted trap.

■ Double risers are unnecessary. The scroll compressors in current Trane commercial units unload to the extent that a single, properly sized riser can transport oil at any load condition.

■ Riser traps are also unnecessary. Avoid using riser traps. If the discharge riser is sized to maintain the proper refrigerant velocity, adding a trap will only increase the pressure drop.

Hot Gas Bypass Line. “Hot gas bypass” (HGBP) describes the refrigerant system design historically used to provide stable operation at low loads while avoiding coil freeze-up and compressor cycling problems. When the load falls below the compressor’s minimum stage of loading, the modulating HGBP valve attempts to maintain suction pressure by diverting hot gas from the compressor discharge to the evaporator inlet.

This strategy reduces the system’s cooling capacity since the diverted refrigerant bypasses the evaporator. It also increases compressor energy consumption significantly and can cause unstable operation if improperly applied.

It’s good design practice to **avoid hot gas bypass for comfort cooling applications**, particularly those with variable-air-volume (VAV) systems.

For other types of applications, observe these guidelines:

■ Size the HGBP line to carry only the desired amount of gas at a pressure drop equalling the sum (usually 20 to 40 psid) of the pressure drops for the discharge line *plus* the condenser and subcooler *plus* the liquid line. Oversizing the line can cause the HGBP and thermal expansion valves to “hunt.”

■ To assure proper oil entrainment, size the HGBP line so that refrigerant velocity equals or exceeds the minimum velocity recommended in Table 2.

■ Elevate the HGBP valve above the discharge line *and* the distributor inlet to promote free drainage away from the HGBP valve and toward the distributor or discharge line.

■ Insulate the HGBP line to prevent the refrigerant from condensing during low loads.

Table 2. Minimum Discharge-Line Velocities for Oil Entrainment

Nominal Pipe Size, in.	Refrigerant Velocity, fpm	
	Riser	Horizontal
7/8	375	285
1-1/8	430	325
1-3/8	480	360
1-5/8	520	390
2-1/8	600	450

Bottom Line ...

Reliability determines the success of a split air-conditioning system. Interconnecting refrigerant lines play an instrumental role in that success. It’s up to us to ensure that our system design practices evolve with equipment technologies.

This article revisited split-system application guidelines in light of current scroll compressor technology. They can be summarized as five fundamental “rules”:

- 1 Choose the right system, i.e. don’t specify split-system equipment when a chiller is best suited for the job.
- 2 Size the interconnecting lines to avoid the use of traps and double risers.
- 3 Slope the suction and liquid lines toward the evaporator.
- 4 Minimize the length of the interconnecting tubing.
- 5 Keep the system clean. ■

By Paul Solberg, applications engineer, and Brenda Bradley, information designer, Trane.

If you’d like to comment on this article, send a note to Trane, Engineers Newsletter Editor, 3600 Pammel Creek Road, La Crosse WI 54601, or e-mail us at comfort@trane.com.



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