MISCELLANEOUS
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DESIGN AND FABRICATION GUIDELINES

I–INTRODUCTION

Lennox split system condensing units and heat pumps (four tons and under) match with line sets of varying lengths of up to 50 feet (linear). These applications offer quick and simple installations that are trouble free if the line sets are properly installed. On split commercial applications and residential installations beyond 50 feet, special design considerations must be followed to assure satisfactory system performance. An improperly designed system could result in a serious loss of capacity or even compressor failure.

This manual does not include piping information for Zonemaster systems. Refer to the Zonemaster installation instructions for further information about the Zonemaster system.

The intent of this manual is to represent generally accepted safe engineering practices. Specifications and limits outlined in this manual are subject to change. System design should conform to all codes, laws and regulations applying at the site at the time of installation. In addition, the procedures and limits outlined in this manual do not supersede local, state or national codes under any circumstances. If you have questions or comments about any of this information, contact Lennox Application (Technical Support) in Dallas, Texas.

II–GENERAL INFORMATION

Four prime considerations in designing refrigeration lines are:
1) cost of tubing, refrigerant and installation;
2) pressure drop in lines;
3) oil return; and
4) amount of refrigerant in the system.

Cost is an obvious consideration which dictates that the smallest tubing possible be used that will result in a system with acceptable pressure drop.

Pressure drop is important from a performance standpoint. The following general statements point out the effects of pressure drop in the various components of the refrigeration piping system:

1) *Pressure drop in the suction line* reduces capacity and increases power consumption. For air conditioning systems, a one pound drop in the suction line reduces capacity approximately one percent. A suction line pressure drop of up to 3psi (3% capacity loss) is generally acceptable. A higher pressure drop may be necessary in some applications to achieve adequate velocity for oil return even though this will result in higher capacity loss.

2) *Pressure drop in the liquid line* produces no significant capacity loss as long as 100% liquid is delivered to the expansion valve and the pressure available is adequate to produce the required flow. Pressure drop due to lift must be added to the friction losses to determine total pressure drop. At normal liquid temperatures, R22 pressure drops 1/2 pound per foot of vertical liquid lift.

Oil return is a major consideration since some oil is continually being circulated with the liquid refrigerant and separates in the evaporator. Oil must be returned to the compressor by entrainment with the refrigerant vapor. *Minimum* velocity must be 800 fpm (approximately) in horizontal runs, 1500 fpm (approximately) in vertical suction risers.

Subcooling should be at least 10°F leaving the outdoor unit. All Lennox equipment is designed so that the charge may be adjusted to provide at least 10°F subcooling. This will allow a 30 to 35 pound drop in the liquid line (including pressure drop due to friction loss and vertical lift).

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One contributor to pressure loss in refrigerant lines is elbows and fittings. Figure 1 shows how lines can be run to avoid pressure losses.

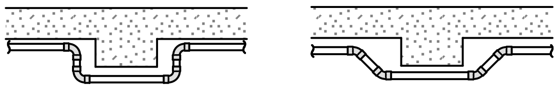


FIGURE 1

In systems with lines over 50 feet and with suction line 7/8 inch O.D. or smaller, add 3 ounces of oil for each 10 feet of line over 50 feet. For systems with 1-1/8 inch O.D. and larger suction lines, add 4 ounces of oil for each 10 feet of line above 50 feet. When adding oil, use non-foaming refrigeration oil with a viscosity above 200 (e.g. 3G or 4G).

A major cause of compressor failure is liquid slugging. Due to the additional refrigerant required to fill the lines, the likelihood of slugging is greatly increased with lines over 50 feet in length. It is desirable to use the smallest liquid line that will not result in refrigerant flashing due to pressure drop. Table 1 (in Appendix) shows that each incremental increase in liquid line size results in a 40 to 50 percent increase in liquid to fill the line.

The liquid line must not directly contact the vapor line. If the refrigerant line plan results in a pressure drop of 20psi or more, the liquid line should be insulated in all places where it passes through an environment (such as an attic) which experiences temperatures higher than the subcooled refrigerant (approximately 105°F to 115°F liquid at 95°F ambient).

Refrigeration lines must not be buried in the ground unless they are insulated and waterproofed. Uninsulated copper lines buried in wet soil or under concrete can cause serious capacity loss and erratic operation as well as early failure due to corrosion. See Appendix for more information.

Systems with buried refrigerant lines can experience significant or total capacity loss if allowed to transmit heat to the surroundings. In addition, buried lines are susceptible to corrosion which can shorten the life of the system. For this reason, buried lines must rest inside a sealed, watertight, thermally insulated conduit. The lines must not contact the soil for any reason and the conduit must be designed so it cannot collect and retain water.

Expansion valves are required on all commercial installations and all residential (and multifamily) installations with lines over 50 feet linear.

In all installations with lines over 50 feet, use only hard copper refrigeration tubing (clean and dry). Soft copper is prone to sagging in long horizontal runs. Elbows, Tees, Couplings and other joints should be made of wrought copper and elbows should be long radius. For leak free joints, properly clean tubing and fittings and use a brazing material with at least 3 to 5 percent silver content ("sil-phos"). To prevent copper oxides from forming inside copper tubing it is necessary to bleed dry nitrogen through the tubing during the soldering process.

⚠ WARNING

Fire Hazard. Never bleed oxygen through lines when soldering joints. Oxygen burning in the presence of oil can cause damage, personal injury or death.

⚠ WARNING

Explosion Hazard. Never use oxygen in refrigerant lines. Oxygen in contact with oil creates an explosive mixture which can cause damage, personal injury or death.

⚠ WARNING

Explosion Hazard. Always use a regulator on nitrogen bottle. Never connect bottle directly to gauges or hoses without first regulating output. Hoses, gauges and or refrigerant lines could burst under pressure causing damage, personal injury or death.

III–LIMITATIONS FOR A/C SYSTEMS

Lennox line sets may be used up to 50 feet linear length (not including equivalent length of fittings). Lines over 50 feet up to 150 feet linear should be sized in accordance with section V.

Applications with less than 50 linear feet of refrigerant line may use RFC metering devices on approved matchups as listed in Lennox' Engineering Handbook. Plans with less than 50 linear feet of line may also use Lennox pre-fabricated line sets if available as listed in Lennox' Engineering Handbook.

Maximum suction lift must not exceed 150 linear feet and maximum liquid lift must not exceed 50 linear feet.

When line lengths exceed 50 feet, a liquid line solenoid should be installed at the evaporator coil. If the compressor is not equipped with a crankcase heater, one must be added. In addition, only expansion valves may be used (RFC and cap-tube expansion devices are not acceptable). In applications where the lines exceed 75 feet, the solenoid valve should be installed with a non-recycling pump-down control. See appendix for more information and typical wiring.

Line lengths over 150 feet linear are not recommended. Contact Lennox Application Department for engineering assistance.

In applications where cooling operation below 50°F is anticipated and an economizer is not being used, low ambient (head pressure) controls must be installed. See Low ambient section in Appendix.

IV–LIMITATIONS FOR HEAT PUMP SYSTEMS

Lennox line sets may be used up to 50 feet linear length (does not include equivalent length of fittings). Lines over 50 feet and up to 100 feet linear should be sized in accordance with section V.

In applications up to 50 feet linear, either expansion valve or RFC metering may be used on approved system matchups as listed in Lennox' Engineering Handbook. But, when the lines exceed 50 feet, an expansion valve (in the indoor unit) and an accumulator (in the outdoor unit) are both required. Expansion valve (in the indoor unit) and accumulator should be used in all commercial installations regardless of line length. Most Lennox equipment is equipped with a factory installed accumulator. Never add a second accumulator. If an accumulator is not supplied and one must be added, the accumulator must be properly sized and must be located in the suction line between the reversing valve and the compressor. In addition, when lines exceed 50 feet, a compressor crankcase heater must be added to the compressor if not factory supplied.

If heat pump refrigerant lines must exceed 100 feet, contact Lennox Application Department for further assistance. This application is not recommended and should be avoided.

Never install a liquid line filter drier in addition to factory installed driers due to risk of excess pressure drop and risk of improper installation. Some Lennox heat pump units are factory equipped with a liquid line filter drier with internal check valve. If a liquid line filter drier must be installed in a heat pump system make sure that refrigerant can only flow one way through the device.

Special consideration must be given to heat pump systems when there is a difference in elevation between the outdoor and indoor units. Due to the reversal of refrigerant flow from heating to cooling cycle, there is always a liquid and suction lift to consider when sizing the refrigerant lines.

Maximum liquid lift should not exceed 50 linear feet (due to the static pressure drop of 25psi). Additional pressure drop due to friction will result in total pressure drop approaching the 30psi maximum that could produce flashing.

Likewise, maximum suction lift must not exceed 50 feet due to limitations placed on the liquid line. (When refrigerant flow is reversed, a liquid drop will become a liquid lift). The vapor line must be sized as a suction riser with adequate velocity for oil return if there is any difference in elevation between the indoor and outdoor units.

In applications where *cooling* operation below 50°F is anticipated and an economizer is not being used, low ambient (head pressure) controls must be installed.

Solenoid valves are uni-directional devices. Since solenoid valves are uni-directional, they are seldom used on heat pump systems. If used, they require a check valve to bypass refrigerant around the solenoid during the heating cycle. Never install a pump-down cycle on a heat pump system.

V–PIPE SIZING, LINE LAYOUT AND DESIGN (A/C and Heat Pump Systems)

The first step in the design of a piping system is to layout the entire system (i.e. relative location of the condensing unit and the evaporator, length of each segment of the piping system, length of suction risers and liquid risers etc...) Start by making a sketch of the system including lengths of pipe, number of elbows, tees, valves, and any other irregular piping and fittings needed. This information will be used to determine total “equivalent” length for calculating pressure drop due to friction.

The same methods apply to both A/C and heat pump systems. A suction line sized to produce adequate velocity for oil entrainment and pressure drop with minimum capacity reduction will function properly as a hot gas discharge line during a heating cycle. Also, if there is a vertical difference in height between the outdoor and indoor units, there is always a vapor and liquid lift to consider in sizing due to the reversal of refrigerant flow.

A–Liquid Line Design

Considerations

The purpose of the liquid line is to convey a full column of 100% liquid from the condenser to the metering device at the evaporator without flashing. The amount of liquid line pressure drop which can be tolerated is dependent on the number of degrees of liquid subcooling leaving the condenser and the saturated condensing temperature. If the condensing temperature and subcooling are known, the maximum allowable pressure drop can be calculated.

Lennox equipment is designed to hold a charge allowing 10°F subcooling at 95°F ambient. High efficiency equipment five tons capacity and under typically operates at a saturated condensing temperature of 115°F, (245psi) (see footnote 1). Equipment above five tons capacity typically operates at a saturated condensing temperature of 125°F, (280psi) (footnote 1).

Maximum Allowable Pressure Drop, Example 1

A high efficiency unit operating at 10°F subcooling and 115°F (245psi) condensing temperature, find the maximum allowable pressure drop in the liquid line. Refer to the pressure/temperature chart (figure 16) in the appendix. 115°F condensing temperature minus 10°F subcooling equals 105°F subcooled liquid temperature (212psi - see footnote 2). 245psi condensing pressure minus 212psi subcooled pressure equals 33psi. The maximum allowable pressure drop is 33psi.

Maximum Allowable Pressure Drop, Example 1

A mid efficiency unit operating at 10°F subcooling and 125°F (280psi) condensing temperature, find the maximum allowable pressure drop in the liquid line. Refer to the pressure/temperature chart (figure 16) in the appendix. 125°F condensing temperature minus 10°F subcooling equals 115°F subcooled liquid temperature (245psi - see footnote 2). 280psi condensing pressure minus 245psi subcooled pressure equals 35psi. The maximum allowable pressure drop is 35psi.

Two factors must be considered when sizing liquid lines:

Pressure Drop in Lines

First, the pressure drop through the liquid line is not especially critical provided that 100% liquid is available entering the expansion device. For the most part, the generation of flash gas will be determined by the amount of pressure drop in the liquid line. To calculate total pressure drop in liquid lines, the following must be determined then added together:

1) Pressure drop due to friction in pipe (figure 2), fittings and field installed accessories such as a drier, solenoid valve or other devices (table 1). The pressure drop due to friction is usually smaller than pressure drop due to lift but must be considered. The pressure drop ratings of field installed devices is usually supplied by the manufacturer of the device and should be used if available.

2) Pressure drop due to vertical liquid lift (1/2 pound per foot) is usually large and may be a limiting factor in the ultimate design of the system.

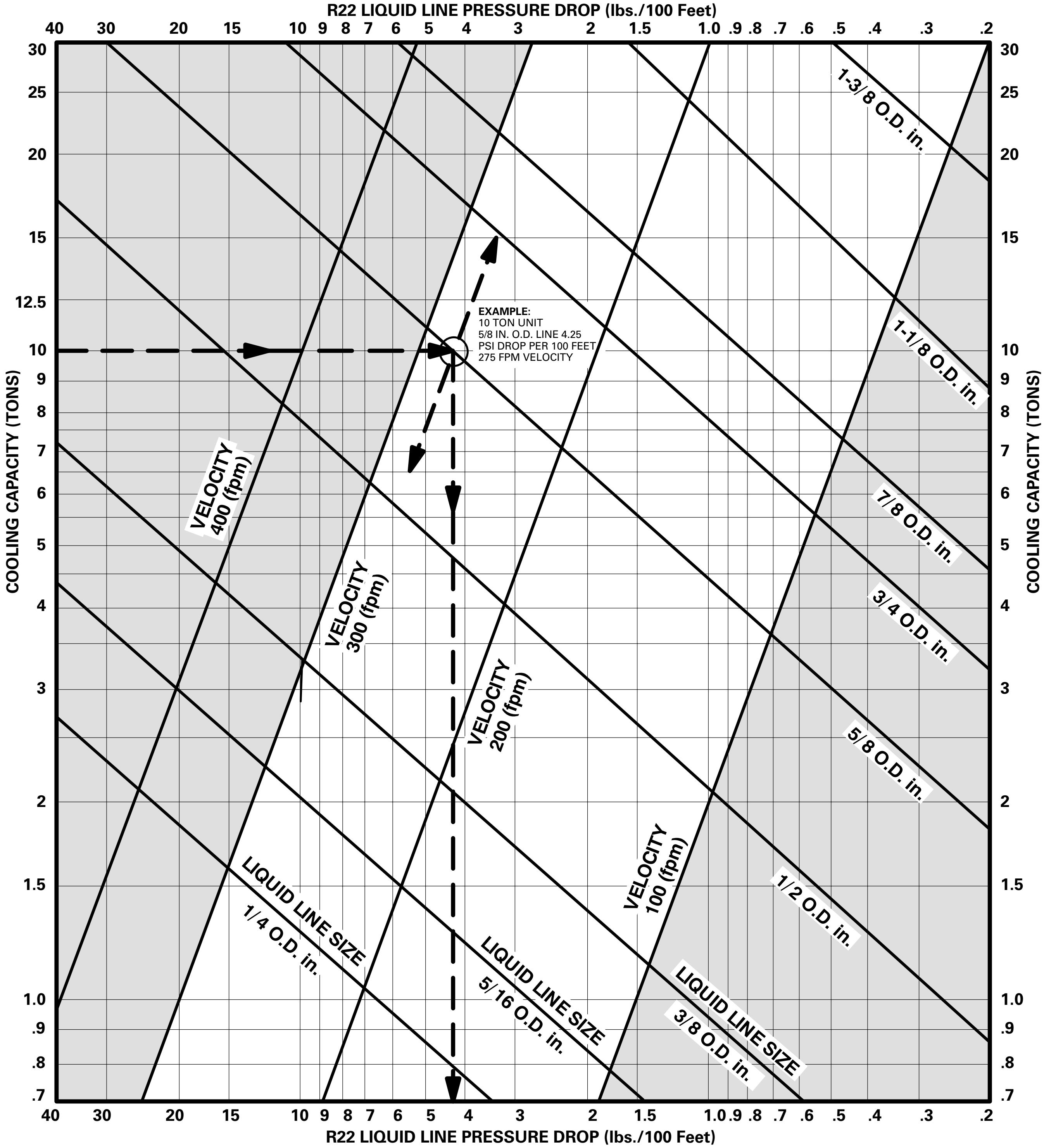
Pressure Across Expansion Device and Distributor

Next, the pressure entering the expansion device must be sufficient to produce the required flow through the expansion device. A pressure drop of 100 psi across the expansion valve and distributor is necessary to produce full refrigerant flow at rated capacity. Therefore, it is necessary for liquid refrigerant (free of flash gas) to be delivered to the expansion valve at a minimum of 175 psi.

Footnote 1 – The temperature listed here is an arbitrary number chosen to represent summer operating conditions. The condensing temperature at summer operating conditions is used to calculate maximum allowable pressure drop. This number may vary with regional climate.

Footnote 2 – This is the pressure below which subcooled liquid will begin to form flash gas.

REFRIGERANT-22 LIQUID LINE PRESSURE DROP/VELOCITY
At 45°F Evaporating Temperature and 125°F Condensing Temperature



To use this chart, first find capacity (tons) on left side of chart. To find pipe size, proceed right to smallest pipe size. Pressure drop (vertical line) and velocity (diagonal lines) can then be determined for the pipe size selected. For example, for 10 ton unit, select 5/8 in. O.D. line.

NOTE—Shaded area denotes unacceptable velocity range.

FIGURE 2

Sizing Procedure – First Example Simple System

Given: 10 ton (single speed) condensing unit on ground level with a 10 ton evaporator on the third level above ground and a total of 96 feet (linear) of piping. Unit is charged with 10°F subcooling at 125°F condensing temperature (280 psi R22 liquid). See figure 3.

Find: Select tube size from figure 2.

Figure 2 illustrates the relationship between liquid line sizing, pressure drop per 100 feet, velocity range and tonnage. When using liquid line solenoid valves, velocities should not exceed 300 fpm to avoid liquid hammer when closing. Enter figure 2 from left and extend to the right to the smallest tube size that will not exceed 300 fpm velocity.

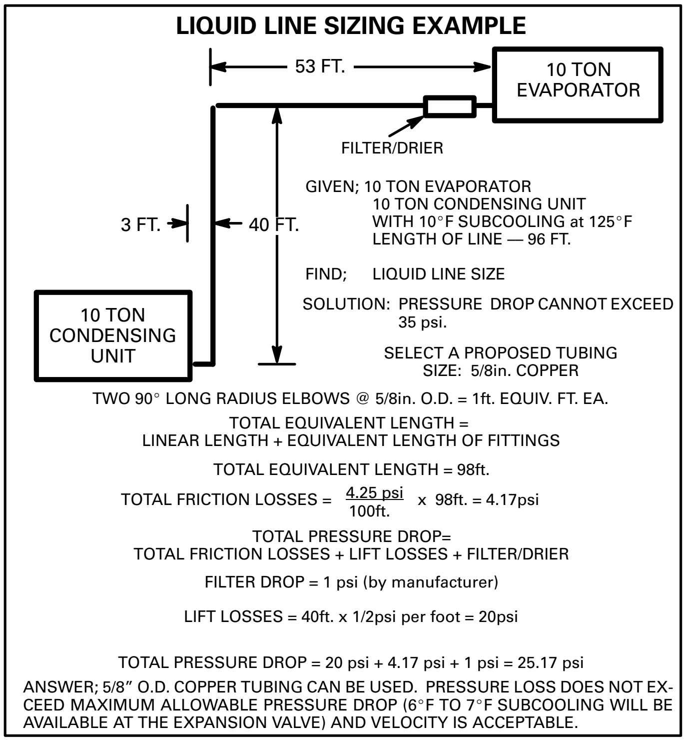


FIGURE 3

Solution: For a 10 ton system, 5/8 inch O.D. line with 4.25 psi per 100 feet drop is selected. Now, calculate pressure drop due to friction and liquid lift to determine if this is a good selection.

The pressure lost to two elbows must be added to the equation. The total friction drop for 96 feet of 5/8 inch O.D. pipe plus (from table 2) 1 equivalent foot per elbow = 98 equivalent feet.

Figure 2 shows that, in a 10 ton system, we can expect 4.25 psi drop per 100 feet of 5/8 inch O.D. copper. When we multiply 4.25/100 by 98 equivalent feet, we see that the total friction loss is 4.17 psi.

Now, we must add the pressure drop for vertical lift. R22 pressure drop is 1/2 psi per foot of vertical lift. When multiplied by 40 feet vertical lift we find that pressure drop due to lift = 20 psi.

Finally, we have added a filter drier to the liquid line which has 1psi drop (this number provided by manufacturer).

Add the three components of pressure drop together to find that the total pressure drop in this 5/8 inch line = 25.17 psi.

Now, by comparing 25.17 psi to our maximum allowable pressure drop we find that this setup falls well within the acceptable range. The 5/8 inch line, therefore, is a good selection because it is well below the maximum allowable pressure drop, is in a satisfactory velocity range, uses minimum refrigerant and provides sufficient pressure at the expansion valve.

First Example
Alternative Pipe Size

Suppose 3/4 inch O.D. line with 1.6 psi drop per 100 feet had been selected. The total equivalent length is computed by adding the linear length (96 ft.) plus the equivalent length of the fittings (from table 2, two 90° ells at 1.25 ft. each). The total equivalent length is 98.5 feet. The total friction drop would have been 1.6/100 multiplied by 98.5 = 1.57 psi. When the pressure drop due to lift (20 psi) and the filter drier (1 psi) are added we find that the total pressure drop for 3/4 inch line = 22.57 psi.

Yet, 3/4 inch line is a less desirable choice. Why?

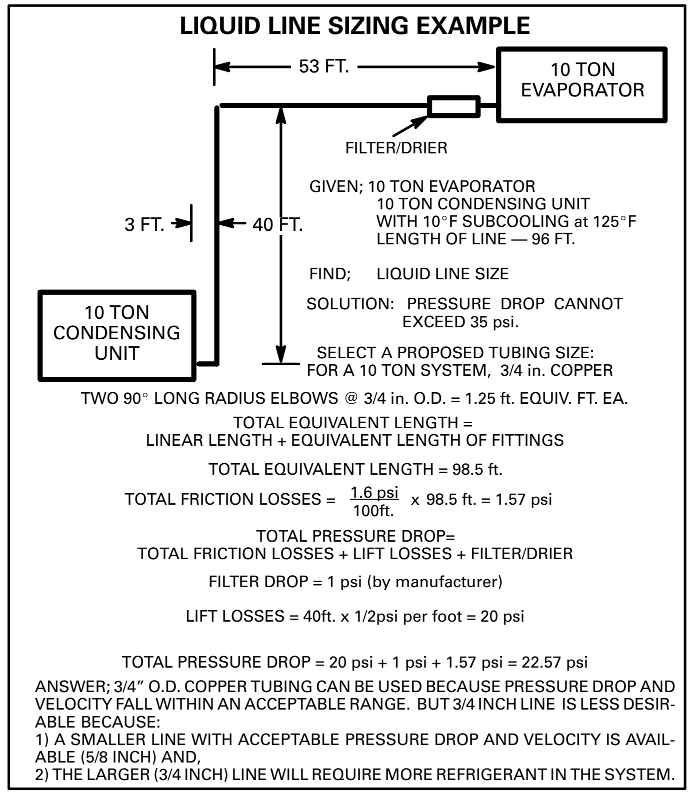


FIGURE 4

The difference in pressure drop between 5/8 inch line and 3/4 inch line is only 2.35 psi. But, the larger line adds 5.5lbs. more refrigerant into the system (see table 1). The risk of refrigerant slugging is increased and the smaller line will be less costly. The smaller line should be used.

B–Suction Line Design

Principles

The purpose of the suction line is the return of refrigerant vapor and oil from the evaporator to the compressor. The sizing of vertical risers is extremely important. Movement of oil droplets up the inner surface of the tubing is dependant on the mass velocity of the gas at the wall surface.

The larger the pipe the greater the velocity required at the center of the pipe to maintain a given velocity at the wall surface.

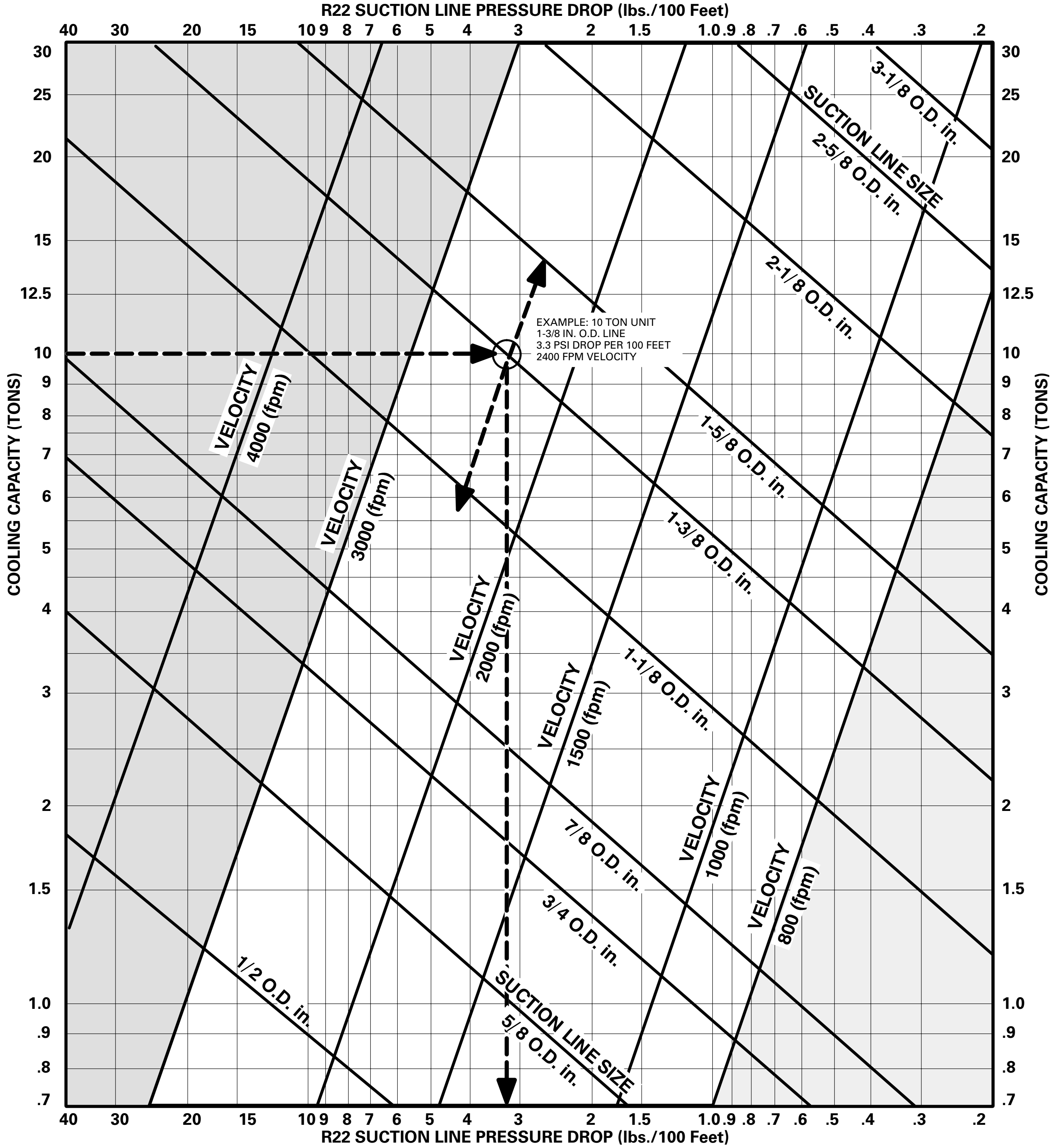
Suction line design is critical. The design must minimize pressure loss to achieve maximum unit efficiency and yet provide adequate oil return to the compressor under all conditions.

Because oil separates from the refrigerant in the evaporator, the suction velocity must be adequate to sweep the oil along. Horizontal suction lines require a minimum of 800 fpm velocity for oil entrainment. Suction risers require 1200 fpm minimum and preferably1500 fpm regardless of the length of the riser.

Figure 5 illustrates the relationship between suction line sizing, pressure drop per 100 feet, velocity and cooling tonnage. This chart is used to determine suction line pressure drop which can then be used to determine suction line capacity loss. This chart can also be used to determine suction line velocity to assure oil return to the compressor.

Vertical lift does not significantly affect pressure drop. However, systems will lose approximately 1% capacity for every pound of pressure drop due to friction in the suction line. This "1%" factor is used to estimate the capacity loss of refrigerant lines. To use the "1%" factor, first you must use figure 5 to estimate the pressure drop in the "total equivalent length" of the lines you choose.

REFRIGERANT-22 SUCTION LINE PRESSURE DROP/VELOCITY PER 100ft. OF LINE
At 45°F Evaporating Temperature and 125°F Condensing Temperature



To use this chart, first find capacity (tons) on left side of chart. To find pipe size, proceed right to smallest pipe size. Pressure drop (vertical line) and velocity (diagonal lines) can then be determined for the pipe size selected. For example, for 10 ton unit, select 1-3/8 in. O.D. line. NOTE—Shaded area denotes unacceptable velocity range.

FIGURE 5

The (Engineering Handbook) capacity ratings of Lennox split system equipment show the capacity when matched with a particular indoor coil and 25 ft. of refrigerant line. These capacity ratings have the loss for a 25ft. refrigerant line already deducted. When you use this manual to estimate the capacity loss due to friction, you must calculate the pressure drop of the entire refrigerant line then subtract the pressure drop of a 25ft. line. See figure 6. Remember, the objective is to hold refrigerant line capacity loss to a minimum.

Considerations

When an evaporator is located above or on the same level as the condensing unit, the suction line must rise to the top of the evaporator. See figure 7. This helps prevent liquid from migrating to the compressor during the off cycle. Traps should also be installed at the bottom of all vertical risers.

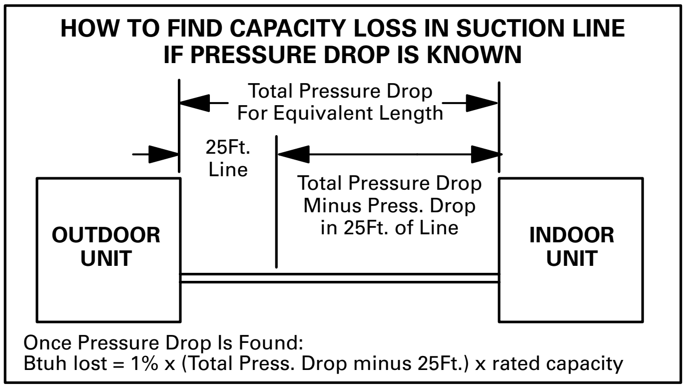


FIGURE 6

In air conditioning systems, horizontal suction lines should be level or slightly sloped toward the condensing unit. In air conditioning and heat pump systems, pipe must avoid dips or low spots that can collect oil. For this reason, hard copper should be used, especially on long horizontal runs.

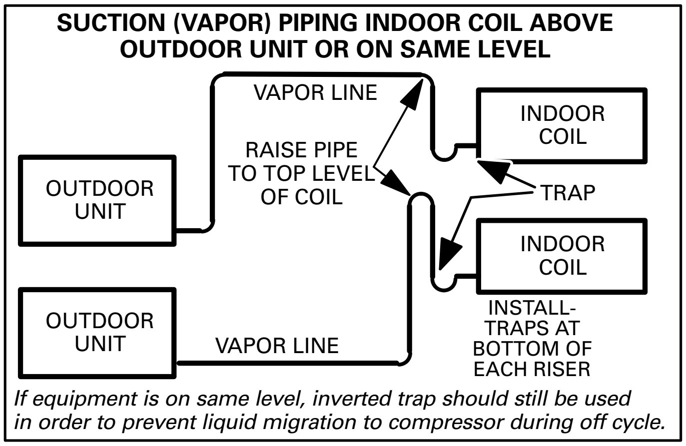


FIGURE 7

To aid in the return of oil, a trap should be installed at the bottom of any suction riser (remember, a heat pump vapor line can act as a suction riser when refrigerant flow is reversed).

When selecting suction/vapor line sizes, the following points must be remembered:

1) Velocity must be maintained in order to provide adequate oil return to the compressor.

2) Capacity loss must be held within the job requirements.

Field installed components, such as suction line driers, mufflers etc. contribute to both pressure drop and capacity loss. The resultant pressure drop must be considered (see manufacturer's data for pressure drop information).

Sizing Procedure

Before selecting pipe size, make a sketch of the layout complete with fittings, driers, valves etc. Measure the linear length of each line and determine the number of ells, tees, valves, driers etc. Add equivalent length of fittings (table 2) to linear length of pipe to get total equivalent length used in determining friction loss.

Suction Line Sizing Procedure – First Example

Given: Five ton (60,000Btuh) condensing unit on same level with condenser, with 65 feet of piping and 8 ells (as in figure 7).

Find: Select tube size from figure 5.

Figure 5 illustrates the relationship between suction line sizing, pressure drop per 100 feet, velocity range and tonnage.

Solution: Enter figure 5 from left (tons capacity) and extend to the right to the smallest tube size with velocity less than 3000 fpm.

Suction line velocity should not exceed 3000 fpm in order to avoid possible noise complaints. This rule may be slightly exceeded when added velocity is required to entrain oil vertically.

1-1/8 inch O.D. line with 2.8 psi per 100 feet pressure drop and 1950 fpm velocity is selected. Now calculate pressure drop due to friction loss to determine if this is a good selection.

65 feet of pipe, plus 8 ells (1.8 equivalent feet each, from table 2) = 79.4 feet equivalent length.

When we multiply 2.8/100 by 79.4 equivalent feet, we see that the total friction loss is 2.22 psi.

1-1/8 inch line appears to meet the requirements in figure 5. Find the capacity loss in 1-1/8 in. line to determine net capacity.

Air Conditioning and Heat Pump system capacities are based on matched systems with 25 equivalent feet of refrigerant line operating at ARI conditions. As figure 6 shows, the pressure drop in 25 feet of line must be subtracted from the total equivalent length.

The pressure drop in 25 feet of 1-1/8 inch line is:
2.8/100 multiplied by 25 = 0.7psi
The total pressure drop for the line is:
2.22psi minus 0.7psi = 1.52 psi

The capacity loss (figure 6) is:
0.01 x 1.52 x 60,000 = 912 Btuh or approximately 1.5%.

First Example
Alternative Pipe Size

Suppose 7/8 inch O.D. line with a pressure drop of 12 psi per 100 feet had been selected. 65 feet of pipe, plus 8 ells (1.5 equivalent feet each, from table 2) = 77 feet equivalent length. The total friction drop would be 12/100 multiplied by 77 = 9.24 psi.

The pressure drop in 25 feet of 7/8 inch line is:
12/100 multiplied by 25 = 3psi
The total pressure drop for the line is:
9.24psi minus 3psi = 6.24 psi

The capacity loss (figure 6) is:
0.01 x 6.24 x 60,000 = 3744 Btuh or approximately 6.24%.
This is a poor selection for two reasons:
1) The high velocity may cause excess suction line noise.
2) The capacity loss may not be acceptable if the system is designed with close tolerance.

Suction Line Sizing Procedure – Second Example

Given: 7-1/2 ton condensing unit with evaporator lower than condenser, with 112 feet of piping and 4 ells. The piping includes 20 feet of vertical lift and 92 feet of horizontal run.

Find: Select tube size from figure 5.

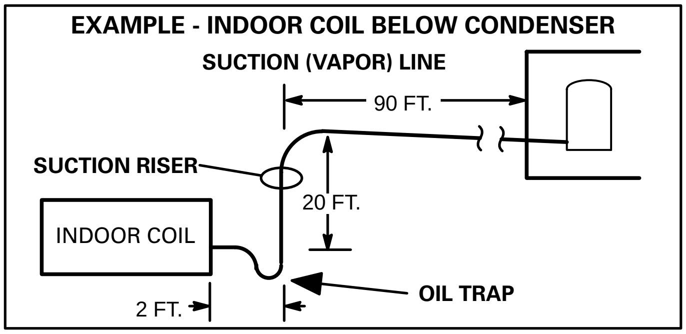


FIGURE 8

Solution: 1-1/8 inch O.D. line with 6 psi per 100 feet pressure drop and 2900 fpm velocity is selected. Now, calculate pressure drop due to friction to determine if this is a good selection.

From table 2, four ells at 1.8 equivalent feet each = 7.2 equivalent feet. When added to the 112 feet of pipe, the total equivalent feet becomes 119.2 feet (round up to 120 feet).

When we multiply 6/100 by 120 equivalent feet, we see that the total friction loss is 7.2 psi.

Use figure 5 to calculate the pressure drop in 25 feet of 1-1/8 inch line. When we multiply 6/100 by 25 feet, we see that the friction loss is 1.5 psi.

The capacity lost in the "total equivalent length" of the refrigerant line (using figures 5 and 6) = 1% x (7.2 – 1.5) x 90,000.
Btuh lost= 0.01 x (5.7) x 90,000
Btuh lost = 5130
Capacity loss for the line selected is approximately 5.7%.

The preceding calculation shows that this is a workable system but will result in a loss of capacity and efficiency.

Second Example
Alternative Pipe Size

Using the same (7-1/2 ton) example, this time select 1-3/8 inch O.D. line. 1-3/8 inch O.D. line with 2 psi per 100 feet pressure drop has 1760 fpm velocity. Now calculate pressure drop due to friction loss to determine if this is a better selection.

From figure 5, four ells at 2.4 equivalent feet each = 9.6 equivalent feet. When added to the 112 feet of pipe, the total equivalent feet becomes 121.6 feet (round up to 122 feet).

When we multiply 2/100 by 122 equivalent feet, we see that the total friction loss is 2.4 psi.

Use table 5 to calculate the pressure drop in 25 feet of 1-3/8 inch line. When we multiply 2/100 by 25 feet, we see that the friction loss is 0.5 psi.

The capacity lost in the "total equivalent length" of the refrigerant line (using figures 5 and 6) = 1% x (2.4 – 0.5) x 90,000.
Btuh lost= 0.01 x (1.9) x 90,000
Btuh lost = 1710
Capacity loss for the line selected is approximately 1.9%.

The conditions in this example will allow either 1-1/8 inch or 1-3/8 inch suction line to be used since capacity loss is minimized and velocity is sufficient to return oil to the compressor.

Third Example - Suction Sizing with Variable Capacity Two Speed Condensing Unit

Some variable capacity installations may use a single suction riser for minimum load conditions without serious penalty at design load. Lennox units with two speed compressors have approximately 60% capacity at low speed and normally do not require double suction risers (Zonemaster not included).

Given: 15 ton two-speed condensing unit with a single 15 ton (dual circuit) evaporator.
High Speed Capacity = 15 tons and,
Low Speed Capacity = 9 tons.

The system is plumbed with the evaporator 60 feet below the condensing unit and 40 feet horizontally away from the condensing unit. A trap is plumbed at the bottom of the riser. The trap is composed of 90° ells.

Find: Determine if single suction riser is suitable or if double suction riser must be used.

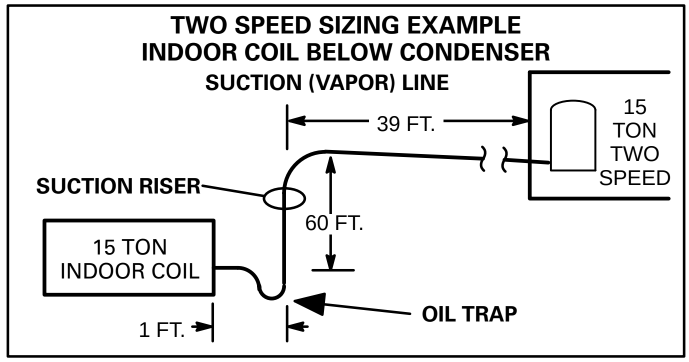


FIGURE 9

Solution: Select the line size based on full unit capacity (15 tons). 1-5/8 inch O.D. line with 3 psi per 100 feet pressure drop and 2600 fpm velocity (at full capacity) is selected. Then determine the equivalent length of the segment to calculate the pressure drop.

60 feet of pipe (vertical), plus 40 feet of pipe (horizontal), plus four 90° elbows (2.8 equivalent feet each) = 111.2 equivalent feet length (round to 111).

From figure 5, 1-5/8 inch O.D. suction line with 15 tons capacity has 3 psi drop per 100 feet. When we multiply 3/100 by 111 equivalent feet, we see that the total friction loss is 3.3 psi.

Use table 5 to calculate the pressure drop in 25 feet of 1-5/8 inch line. When we multiply 3/100 by 25 feet, we see that the friction loss is 0.75 psi.

The capacity lost in the "total equivalent length" of the refrigerant line (using figures 5 and 6) = 1% x (3.3 – 0.75) x 180,000.
Btuh lost= 0.01 x (2.55) x 180,000
Btuh lost = 4590
Capacity loss for the line selected is approximately 2.55%.

Low Speed Capacity

1-5/8 inch line appears to be appropriate for this system operating at full (15 ton) capacity. Now we must check the low speed (9 ton) capacity to determine if 1-5/8 inch line is appropriate.

Lennox two speed units operate at approximately 60% capacity when operating on low speed:
15 tons x 0.6 = 9 tons (if an engineering data sheet is available use the actual capacities rather than this approximation).

9 tons capacity when used with 1-5/8 inch pipe (figure 5) indicates a velocity of 1500 fpm. This is sufficient to return oil to the compressor and meets the requirement of maintaining at least 1500 fpm in vertical risers.

When comparing high speed to low speed performance in this case we find that a single 1-5/8 inch suction riser may be used and double suction risers are not required.

Systems on the Fringe

Many two speed applications will require a reduction in suction riser size to maintain adequate velocity for oil return at low speed. For example, a 5 ton two speed system will normally use a 1-1/8 inch suction line (figure 5). A suction riser in this system may be reduced to 7/8 inch pipe size while the horizontal runs may use 1-1/8 inch pipe size.

Figure 5 shows the tradeoffs that will result from downsizing the riser. The disadvantage is that the riser will exceed 3000 fpm when operating at full capacity (potential for sound transmission). In addition, the pressure drop in the smaller line will result in significantly greater pressure drop (capacity loss). The advantage is that the smaller line will guarantee sufficient velocity for oil return when operating at reduced capacity.

If, by reducing the riser pipe size, the pressure drop (capacity loss) becomes unacceptable, the system must be designed with double suction risers.

Fourth Example
Suction Sizing Variable Capacity - Hot Gas Bypass

There are two basic types of hot gas bypass kits. The most desirable is the type that feeds the hot gas from the compressor discharge line to a side tap on the distributor in the evaporator coil. When installed in this manner, full flow of suction gas is maintained in the suction line and suction piping should follow standard procedures as outlined in the previous sections.

The second type of hot gas bypass is installed and connected within the condensing unit. This is known as a "run-around" hot gas bypass in that hot compressor discharge gas and liquid from the liquid line are circuited to the hot gas bypass valve and directly into the suction line.

This method reduces flow through the evaporator and suction line. Special handling of suction risers is required.

When to Use Double Suction Risers

If a condensing unit can unload more than 50% either by a hot gas bypass (run-around cycle) or other mechanical means, double suction risers may be required.

If the condensing unit unloads less than 50%, suction lines can be generally sized in accordance with the previous sections. If the suction velocity is high enough to entrain oil when the unit is operating at reduced capacity, double suction risers are generally not required.

In general, double suction risers are required any time the minimum load on the compressor does not create sufficient velocity in vertical suction risers to return oil to the compressor. Double suction risers are also generally required any time the pressure drop or velocity in a single suction riser is excessive.

How Double Suctions Risers Work

Figure 10 shows a typical double suction riser installation. A trap is installed between the two risers as shown. During partial load operation (figure 11) when gas velocity is not sufficient to return oil through both risers, the trap gradually fills with oil until the second riser is sealed off. When this occurs, the vapor travels up the first riser only. With only the first riser being used, there is enough velocity to carry the oil. ***This trap must be close coupled to limit the oil holding capacity to a minimum.*** Otherwise, the trap could accumulate enough oil on a partial load to seriously lower the compressor crankcase oil level.

The second suction riser must enter the main suction line from the top to avoid oil draining down the second riser during a partial load. See Figure 11.

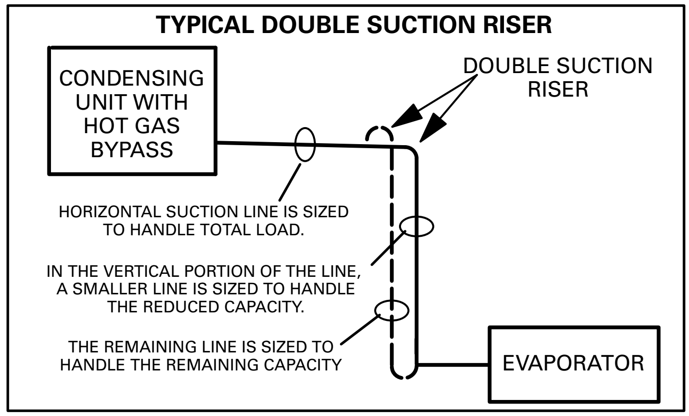


FIGURE 10

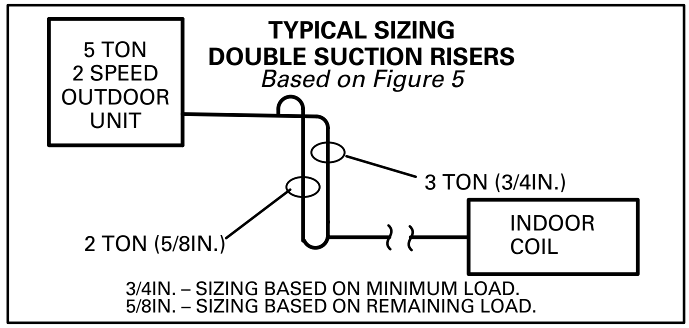


FIGURE 11

Sample Calculation

Given: 10 ton condensing unit with hot gas bypass (run-around type) or mechanical unloaders capable of 65% unloading. Matched evaporator is located below condensing unit. Piping will require 57 (linear) feet of pipe (figure 12). Construction without double suction risers will only require 2 ells.

Find: 1) Select tube sizes for horizontal runs and risers (figure 5).
2) Determine if double suction risers are needed.
3) Size double suction riser for proper system performance.

Solution: Size each segment based on the tons of refrigerant that will flow in the segment.

Full load capacity = 10 tons. Minimum load capacity is 35% of 10 tons = 3.5 tons. The difference between full capacity and part load capacity is 6.5 tons.

From figure 5, select a pipe size for full load capacity. 1-3/8 inch O.D. pipe with 3.3 psi drop per 100 feet and 2400 fpm velocity is selected. Now, by using figure 5, find the velocity for the selected pipe size at part load capacity. The part load velocity is approximately 850 fpm. 850 fpm is sufficient to return oil in horizontal runs but not in vertical risers.

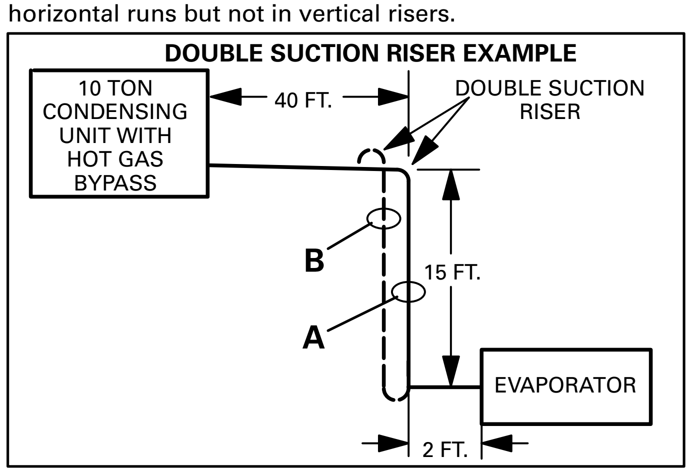


FIGURE 12

If we tried to size this system by simply reducing the riser size to 1-1/8 inch, we would find the velocity in the riser to be excessive (3800 fpm) when the system is operating at full capacity. As a result of these obstacles, this system will require construction of double suction risers. Construction of double suction riser will require five ells and two tees total for a system.

Size small riser (Riser carrying smallest part of load)

The unit produces 3.5 tons capacity at minimum load. Select from figure 5 a 7/8 inch O.D. line (smallest line with acceptable velocity). When operating at 3.5 tons capacity, this line will operate at 2500 fpm and will produce 6 psi drop per 100 ft.

Size large riser (Riser carrying largest part of load)

The larger line carries 6.5 tons capacity at full load. Select from figure 5 a 1-1/8 inch O.D. line (smallest line with acceptable velocity). When operating at 6.5 tons capacity, this line will operate at 2500 fpm and will produce 4.5 psi drop per 100 ft.

Putting the Segments Together

Next, we must determine if the line sizes we selected will result in satisfactory pressure drop between the condensing unit and the evaporator.

Start by finding the total equivalent feet of the large (B) riser. 15 feet of pipe, plus two tees (branch side of tee at 4.5 equivalent feet each), plus four ells (1.8 equivalent feet each) = 31.2 equivalent feet length.

Now, find the total equivalent feet of the small (A) riser. 15 feet of pipe, plus one ell (1.5 equivalent feet), plus one tee (branch side of tee at 3.5 equivalent feet), plus one tee (line side of tee at 1.0 equivalent feet) = 21.0 equivalent feet length.

Use the total equivalent length of each riser to compute the pressure drop of each riser. For the large (B) riser, 1-1/8 inch O.D. suction line with 6.5 tons capacity has 4.5 psi drop per 100 feet. When we multiply 4.5/100 by 31.2 equivalent feet, we see that the total friction loss is 1.4 psi.

For the small (A) riser, 7/8 inch O.D. suction line with 3.5 tons capacity has 6 psi drop per 100 feet. When we multiply 6/100 by 21 equivalent feet, we see that the total friction loss is 1.26 psi.

The total pressure drop for the riser is equal to the average of the pressure drop in both risers:
1.4 (B riser pressure drop) + 1.26 (A riser pressure drop) = 2.66
2.66 ÷ 2 = 1.33 (average pressure drop through A and B risers).

Find the pressure drop for the horizontal run of pipe. 1-3/8 inch pipe at 10 tons capacity has 3.3 psi drop per 100 feet. When we multiply 3.3/100 by 61 equivalent feet, we see that the total friction loss is 2.01 psi.

The pressure drop through the risers is added to the pressure drop through the horizontal run to find the total pressure drop for the system:
2.01 psi (horiz. run) + 1.33 psi (avg. riser) = 3.34 psi.

Use table 5 to calculate the pressure drop in 25 feet of 1-3/8 inch line. When we multiply 3.3/100 by 25 feet, we see that the friction loss is 0.825 psi.

The capacity lost in the "total equivalent length" of the refrigerant line (using figures 5 and 6) = 1% x (3.34 – 0.825) x 120,000.
Btuh lost= 0.01 x (2.515) x 120,000
Btuh lost = 3018
Capacity loss for the line selected is approximately 2.5%.

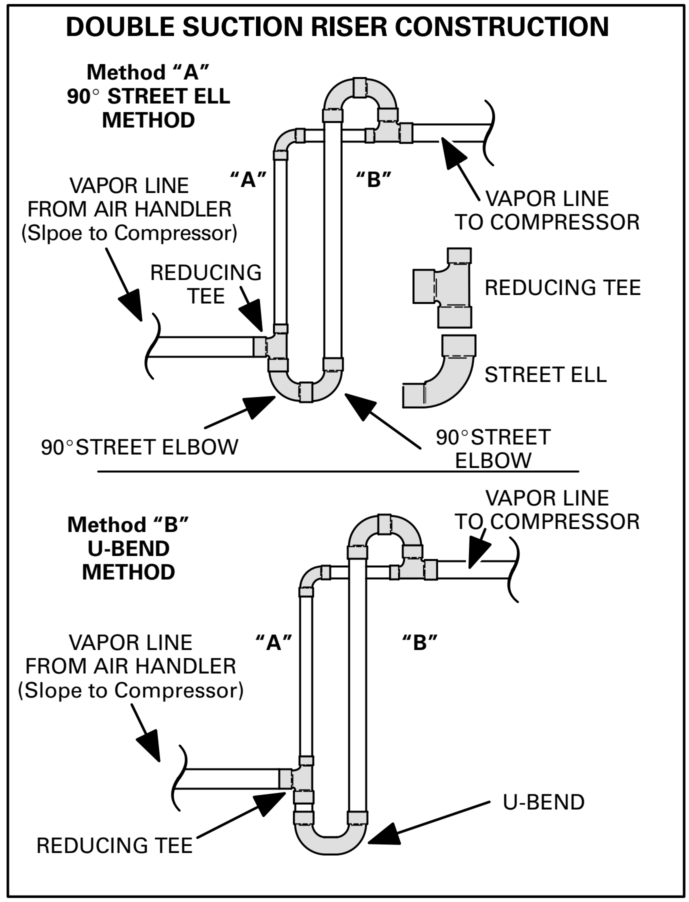


FIGURE 13

VI–Appendix

A– Refrigerant Capacity in Lines

TABLE 1

Refrigerant Charge (lbs.) in Various Lengths of Type L Copper Tubing for R-22 Air Conditioning Systems @ 45°F Suction and 125°F Liquid

Length of Lines (ft.)	Line Size (O.D. in.)											
	3/8	1/2	5/8		3/4		7/8		1-1/8	1-3/8	1-5/8	2-1/8
	Liquid	Liquid	Liquid	Suction	Liquid	Suction	Liquid	Suction	Suction	Suction	Suction	Suction
10	0.378	0.702	1.128	0.0293	1.683	0.0437	2.34	0.0608	0.1037	0.1579	0.223	0.388
20	0.756	1.404	2.256	0.0586	3.366	0.0874	4.68	0.1216	0.2074	0.3158	0.446	0.776
30	1.134	2.106	3.384	0.0879	5.049	0.1311	7.02	0.1824	0.3111	0.4737	0.669	1.164
40	1.512	2.808	4.512	0.1172	6.732	0.1748	9.36	0.2432	0.4148	0.6316	0.892	1.552
50	1.890	3.510	5.640	0.1465	8.415	0.2185	11.70	0.3040	0.5185	0.7895	1.115	1.940
60	2.268	4.212	6.768	0.1758	10.098	0.2622	14.04	0.3648	0.6222	0.9474	1.338	2.328
70	2.646	4.914	7.896	0.2051	11.781	0.3059	16.38	0.4256	0.7259	1.1053	1.561	2.716
80	3.024	5.616	9.024	0.2344	13.464	0.3496	18.72	0.4864	0.8296	1.2632	1.784	3.104
90	3.402	6.318	10.152	0.2637	15.147	0.3933	21.06	0.5472	0.9333	1.4211	2.007	3.492
100	3.780	7.020	11.280	0.2930	16.830	0.4370	23.40	0.6080	1.0370	1.579	2.230	3.880

B– Equivalent Length

Table 2

Equivalent Length in Feet of Straight Pipe for Valves and Fittings

Line Size O.D. in.	Solenoid/ Globe Valve	Angle Valve	90° Long* Radius Elbow	45° Long* Radius Elbow	Tee Line	Tee Branch
3/8	7	4	0.8	0.3	0.5	1.5
1/2	9	5	0.9	0.4	0.6	2.0
5/8	12	6	1.0	0.5	0.8	2.5
3/4	14	7	1.3	0.6	0.9	3.0
7/8	15	8	1.5	0.7	1.0	3.5
1-1/8	22	12	1.8	0.9	1.5	4.5
1-3/8	28	15	2.4	1.2	1.8	6.0
1-5/8	35	17	2.8	1.4	2.0	7.0
2-1/8	45	22	3.9	1.8	3.0	10
2-5/8	51	26	4.6	2.2	3.5	12

Long radius elbow. Multiply factor by 1.5 for short radius elbow equivalent length.

C–Charge for Subcooling

To operate at rated capacity and efficiency, all air conditioning and heat pump systems must be properly charged. Most equipment manufactured in recent years depends on subcooling to attain rated capacity and efficiency. See definition of subcooling in glossary of terms. A unit can operate at what appears to be normal pressure and temperature, and if the refrigerant charge does not provide the proper subcooling for the application, as much as 8 to 10% of its capacity can be lost without any reduction in power consumption.

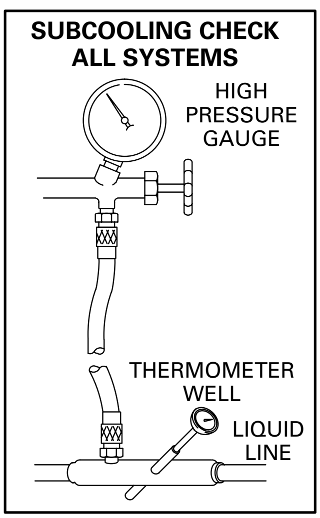


FIGURE 14

Some Lennox equipment is designed to operate at peak efficiency with less than 10°F subcooling. Yet, if the refrigerant incurs much restriction, such as that experienced in vertical lift, less subcooling may not be adequate and a loss of capacity will be experienced.

Lennox equipment is designed so the refrigerant charge may be adjusted in order to obtain 10°F subcooling.

Many charging methods are available (charts, superheat, approach, sight glass) but none of these methods will assure you of a solid column of liquid at the expansion valve. A favorite of the service tech has been the sight glass. It will show that a solid column of liquid is present, but it will not provide information regarding subcooling. A common problem with a sight glass in a long line system is that flash gas can form after the sight glass and before the expansion valve.

How to charge a unit using subcooling

1– Indoor temperature must be between 70°F and 80°F.

2– Fill thermometer well with oil (to assure accurate reading) and insert thermometer in well.

3– Hook up gauges to liquid and suction lines.

4– Turn on unit (cooling mode if heat pump – high speed if two speed compressor) and operate long enough for pressure to stabilize (at least five minutes).

5– Read condensing temperature from gauge and read liquid line temperature from thermometer.

6– To achieve 10°F subcooling, liquid line should be 10°F cooler than condensing temperature. The amount of subcooling will vary with outdoor temperature.
Add refrigerant to make liquid line cooler.
NOTE– If system is grossly overcharged, liquid line will get cooler as refrigerant is added.
NOTE–After checking charge, if suction pressure is excessively low, do not add charge. Check filters, air volume and check for restrictions is system (i.e. strainers, driers, expansion valve etc)
Recover refrigerant to make liquid line warmer.

Low Ambient Charging (Below 70° F Outdoor Temp.)

Air flow will need to be restricted in order to boost liquid line pressure above 240 psig.

In order to obtain proper results, it is important that you block equal sections of the coil with cardboard, plastic sheet or similar material. On formed (wrap around) coils, the blockage should be applied totally covering the coil from top to bottom and then extending from side to side.

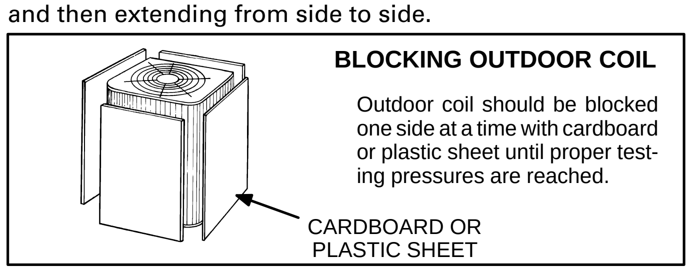
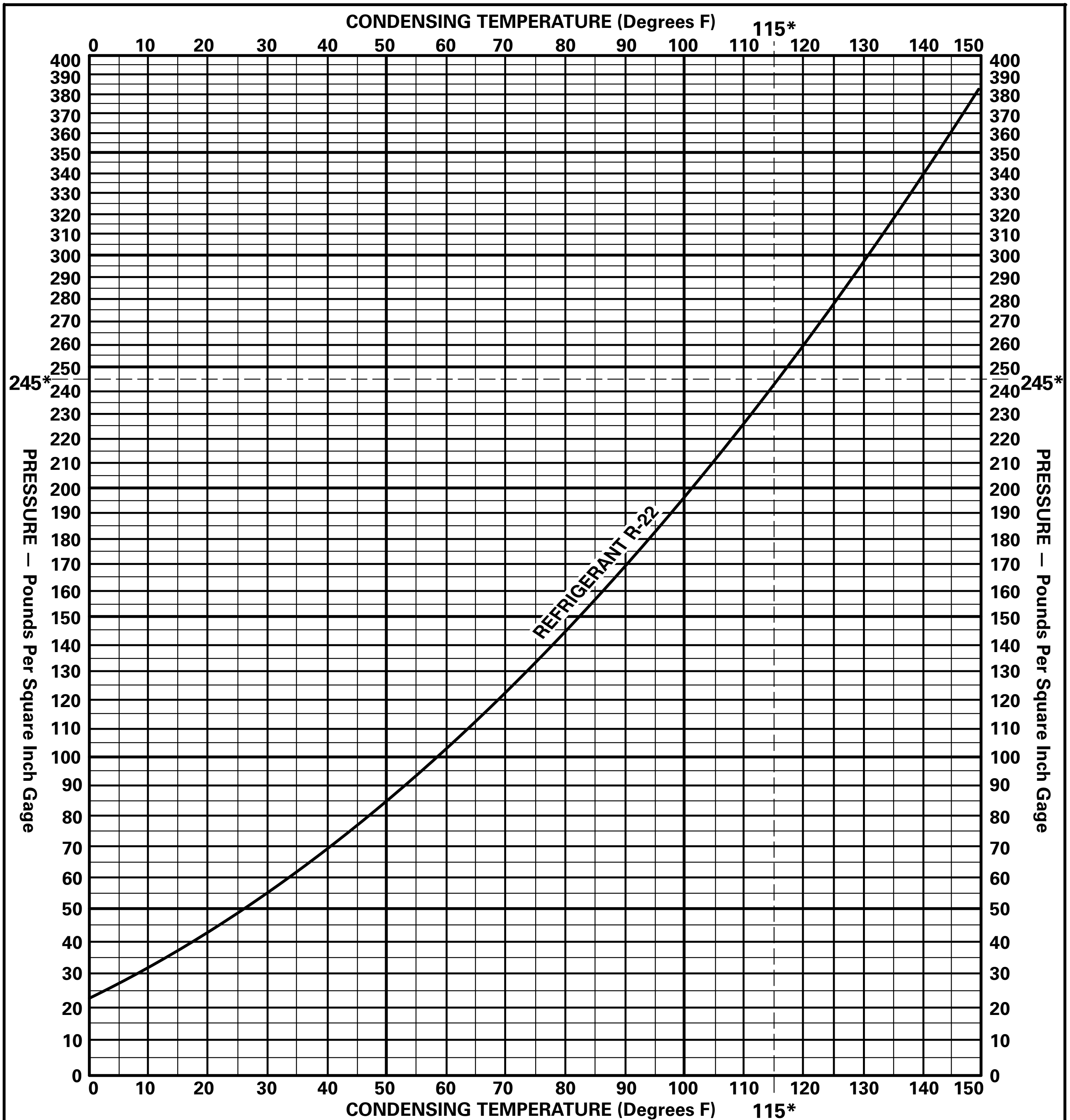


FIGURE 15

D– R22 Pressure Temperature Chart

R22 SATURATION TEMPERATURE



R22 Pressure Temperature Table (Psig)

Degrees F	R22	Degrees F	R22	Degrees F	R22	Degrees F	R22	Degrees F	R22
–40	0.6	18	41.1	36	63.3	75	133.4	120	262.5
–30	409	20	43.3	38	66.1	80	145.0	125	280.7
–20	10.2	22	45.5	40	69.0	85	157.2	130	299.7
–10	16.6	24	47.9	45	76.6	90	170.0	135	319.6
0	24.1	26	50.3	50	84.7	95	183.6	140	340.3
10	32.9	28	52.7	55	93.3	100	197.9	145	362.0
12	34.9	30	55.2	60	102.4	105	212.9	150	384.6
14	36.9	32	57.8	65	112.2	110	228.6	155	406.3
16	39.0	34	60.5	70	122.5	*115	*245.2	160	433.3

** Denotes summer operating conditions.*

FIGURE 16

E– Pump Down Cycle Control

NON-RECYCLING PUMP DOWN CONTROL FIELD WIRING DIAGRAM

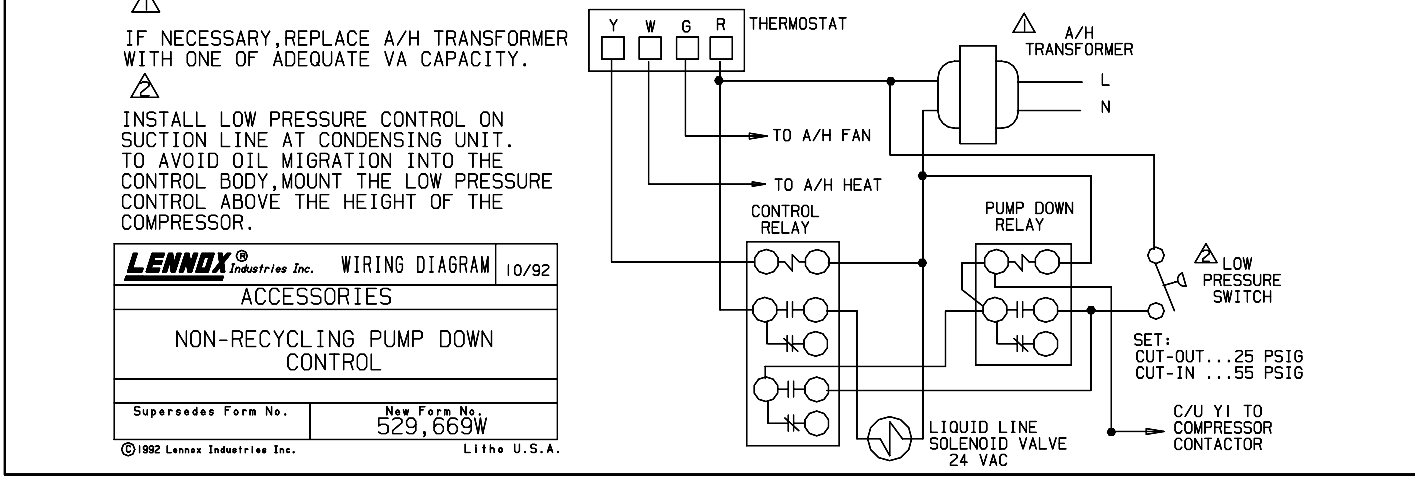


FIGURE 17

Operating Sequence

The following sequence refers to figure 17: On a call for cooling, the thermostat energizes the “Y” circuit which in turn energizes the control relay.

The control relay energizes the liquid line solenoid valve and prepares a circuit to energize the pumpdown relay when the low pressure switch closes.

Opening the liquid line solenoid valve causes refrigerant to flow from the higher pressure condenser and liquid line into the evaporator and suction line. Pressure in the suction line quickly rises to the 55psig cut-in pressure closing the low pressure switch.

The low pressure switch energizes the pump down relay and the compressor contactor starting the condenser. The pump down relay seals itself around the control relay.

When cooling is satisfied, the thermostat “Y” circuit is de-energized dropping out the control relay and the liquid line solenoid valve. The compressor continues to operate pumping refrigerant from the evaporator and suction line into the condenser and liquid line which is sealed by the closed liquid line solenoid.

When the suction line pressure drops to 25psig the low pressure switch opens de-energizing the pump down relay and the compressor contactor. The compressor cannot operate until there is another call for cooling.

Lower cut-in and cut-out pressures may be required for low ambient cooling operation.

F– Low Ambient Cooling

All Lennox equipment is designed for low ambient cooling operation down to 50°F. Low ambient cooling operation below 50°F requires the addition of Lennox low ambient control kits. Cooling operation below 30°F requires Lennox low ambient control kit plus a variable speed controller on the outdoor fan(s).

Lennox low ambient kits are available for all Lennox (expansion valve equipped) units. These kits may need to be installed and may need to be supplemented with field installed equipment when applied to systems with long refrigerant lines. Field installed equipment may include any or all of the following; solenoid valve installed in the liquid line at the evaporator, pump-down controls, accumulator, additional crankcase heaters or capacity unloading.

If your application requires low ambient cooling operation and also requires long refrigerant lines, you should contact Lennox Application Engineering for technical assistance before designing your refrigerant line system.

Factory supplied low ambient kits may include low ambient thermostat, low pressure switch, relays or any combination of the above. The variable speed controller and freezestat are available through Lennox Dealer Service Centers.

The operation of each kit is different for each model number. Refer to the low ambient kit for specific information.

Generally, the low ambient kits are wired to accomplish the following: Low pressure switches are installed to sense head pressure and cycle the condenser fan. The fan is cycled in order to keep head pressure high during low ambient operation. Low ambient thermostats are used in capacity reduction (two speed and multi-compressor units) to lock-out full capacity operation when ambient temperature drops. Relays are added to the low ambient kits to help accomplish the necessary switching. Variable speed controllers may require ball bearing fan motors for proper operation at low speed.

Table 3

Lennox Low Ambient Cooling Recommendations for Split Systems with Long Refrigerant Lines

Product Family			Low Ambient Operation Without Low Ambient Kit Installed	Low Ambient Operation With Lennox Low Ambient Kit Added And Field Installed Freezestat	Low Ambient Operation With Lennox Low Ambient Kit Added and With Field Supplied Outdoor Fan Speed Control* And Freezesatat Added
Split Systems Residential and Commercial	RFC Metering	A/C or Heat Pump	Down to 60°F	Kit Not Available Operation Below 60°F Not Recommended	- - - -
	Expansion Valve	A/C	Down to 50°F	Down to 30°F	Down to 0°F
		Heat Pump	Down to 50°F	Down to 30°F	Cooling Operation Below 30°F Not Recommended

**Requires ball bearing motor construction. Outdoor fan motor may have to be changed in some instances.*

If low ambient operation is required and the outdoor unit is exposed to high prevailing winds, a permanent wind barrier should be constructed to protect the outdoor coil. In cooling operation, high prevailing winds can significantly reduce head pressure. In heat pumps, high prevailing winds can reduce the effectiveness of the defrost cycle. Use the minimum installation clearances (provided in Engineering Handbook) as a guide when constructing a wind barrier. Wind barriers should extend vertically to the height of the coil.

G–Complex Liquid Line Sizing

Example - Liquid Sizing with Multiple Evaporators

Occasionally, more than one evaporator may be connected to one condensing unit. The line sizing method shown here is for a system with multiple evaporators operating simultaneously. This method does not apply to Lennox Zonemaster system which utilizes the RTM1 tank module allowing each evaporator to operate independently. The surest and safest method way to pipe a Zonemaster system is to run a liquid and suction line from each evaporator back to a liquid and suction manifold located at the RTM1 tank module.

In this example, all the evaporators are located above the condensing unit. All evaporators experience the effects of liquid lift. The system is equipped with a 2 ton, 5 ton and 3 ton evaporator in order from top to bottom.

Given: 10 ton commercial (single speed) condensing unit on ground with three evaporators above condenser. See figure 18.

Find: Select tube size from figure 2.

Solution: Size each segment based on the tons of refrigerant that will flow in the segment.

Segment A to B

First solve segment A to B (10 tons). Figure 2 indicates that, for a 10 ton system, 5/8 inch O.D. liquid line should be selected (smallest liquid line with acceptable velocity). Figure 2 also indicates that 5/8 inch line carrying 10 tons of capacity has 4.3 psi drop per 100 feet. Then determine the equivalent length of the segment to calculate the pressure drop.

21 feet of pipe, plus three 90° elbows (one equivalent foot each, from table 2), plus one tee (line side of tee at 0.8 equivalent feet each, from table 2) = 24.8 equivalent feet length (round up to 25 equivalent feet).

When we multiply 4.3/100 by 25 equivalent feet, we see that the total friction loss is 1.1 psi.

Now, we must add the pressure drop for vertical lift. R22 pressure drop is 1/2 psi per foot of vertical lift. When multiplied by 10 feet vertical lift we find that pressure drop due to lift = 5 psi.

When the two components of pressure drop are added together we find that the total pressure drop in this 5/8 inch line = 6.1 psi.

Segment B to C

B to C has a capacity of three tons. Figure 2 indicates a three ton system should use 3/8 inch O.D. line (smallest line with acceptable velocity). Now, determine the equivalent length of the segment to calculate the pressure drop.

Two feet of pipe, plus one tee (branch side of tee at 1.5 equivalent feet each) = 3.5 equivalent feet length (round up to 4 equivalent feet).

From figure 2, 3/8 inch O.D. liquid line with 3 tons capacity has 8.3 psi drop per 100 feet. When we multiply 8.3/100 by 4 equivalent feet, we see that the total friction loss is 0.33 psi.

Vertical lift = 0.

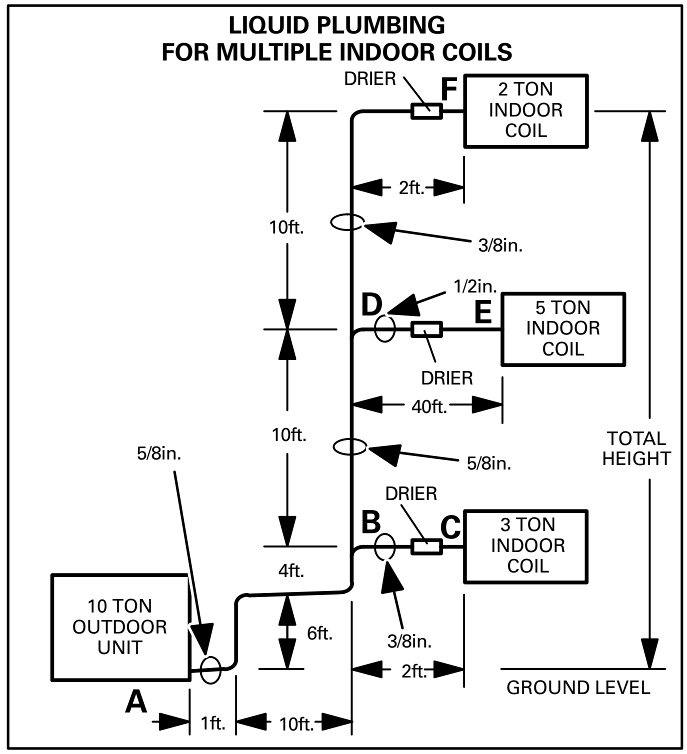


FIGURE 18

In this segment, the only component of pressure drop is the equivalent length; 0.33 psi.

Segment B to D

B to D has a capacity of seven tons. Select from figure 2 a 5/8 inch O.D. line (smallest line with acceptable velocity). Then determine the equivalent length of the segment to calculate the pressure drop.

10 feet of pipe, plus one tee (line side of tee at 0.8 equivalent feet) = 10.8 equivalent feet length (round up to 11 equivalent feet).

From figure 2, 5/8 inch O.D. liquid line with 7 tons capacity has 2.3 psi drop per 100 feet. When we multiply 2.3/100 by 11 equivalent feet, we see that the total friction loss is 0.25 psi.

Now, we must add the pressure drop for vertical lift. R22 pressure drop is 1/2 psi per foot of vertical lift. When multiplied by 10 feet vertical lift we find that pressure drop due to lift = 5 psi.

When the components of pressure drop are added together we find that the total pressure drop in this 5/8 inch line = 5.25 psi.

Segment D to E

D to E has a capacity of five tons. Select from figure 2 a 1/2 inch O.D. line (smallest line with acceptable velocity). Then determine the equivalent length of the segment to calculate the pressure drop.

40 feet of pipe, plus one tee (branch side of tee at 2.0 equivalent feet each) = 42 equivalent feet length.

From figure 2, 1/2 inch O.D. liquid line with 5 tons capacity has 4.6 psi drop per 100 feet. When we multiply 4.6/100 by 42 equivalent feet, we see that the total friction loss is 1.93 psi.

Vertical lift = 0.

In this segment, the only component of pressure drop is the equivalent length; 1.93 psi.

Segment D to F

D to F has a capacity of two tons. Select from figure 2 a 3/8 inch O.D. line (smallest line with acceptable velocity). Then determine the equivalent length of the segment to calculate the pressure drop.

12 feet of pipe, plus one 90° elbow (0.8 equivalent feet each) = 12.8 equivalent feet length (round up to 13 equivalent feet).

From figure 2, 3/8 inch O.D. liquid line with 2 tons capacity has 4 psi drop per 100 feet. When we multiply 4/100 by 13 equivalent feet, we see that the total friction loss is 0.52 psi.

Now, we must add the pressure drop for vertical lift. R22 pressure drop is 1/2 psi per foot of vertical lift. When multiplied by 10 feet vertical lift we find that pressure drop due to lift = 5 psi.

When the components of pressure drop are added together we find that the total pressure drop in this 3/8 inch line = 5.52 psi.

Putting the Segments Together

Next, we must determine if the line sizes we selected will result in satisfactory pressure drop between the condensing unit and *each evaporator.* To do this we simply add the total pressure drop of each line segment between the condensing unit and each evaporator. Remember the total pressure drop between the condensing unit and evaporator should be less than 30 psi.

Total pressure drop A to C = A to B plus B to C.
Total pressure drop = 6 + 0.33 = 6.33 (Acceptable).

Total pressure drop A to E = A to B plus B to D plus B to C.
Total pressure drop = 6 + 5.25 + 1.93 = 6.33
(Acceptable).

Total pressure drop A to F = A to B plus B to D plus D to F.
Total pressure drop = 6 + 5.25 + 5.52 = 16.77
(Acceptable).

H–Complex Suction Line Sizing

When a single condenser is connected to more than one evaporator, there are additional rules which must be followed when designing the refrigerant piping. These rules apply to separate coils in separate air handlers as well as to split coils in a single air handler.

First, the total evaporator load must at least equal the condensing unit capacity. Next, when evaporators in different levels are connected to a single main, the suction line from each coil must rise to the top of that coil before joining the main. Finally, all connections to a suction main must loop over and enter the top of the main to avoid the gravity draining of oil into the suction risers during off cycles.

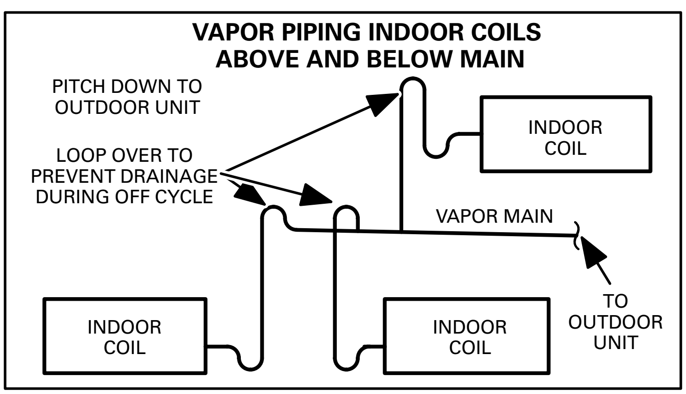


FIGURE 19

Example - Suction Sizing with Multiple Evaporators

On systems with multiple evaporators operating simultaneously connected to a single condensing unit, suction lines are sized similar to the method used for sizing liquid lines. Each line segment is sized based on the tons of refrigerant flowing in the segment.

In this example, all the evaporators are located above the condensing unit so that none of the evaporators experience the effects of suction lift. The system is equipped with a 2 ton, 5 ton and 3 ton evaporator in order from top to bottom.

Given: 10 ton condensing unit with three evaporators, higher than condenser, operating simultaneously,

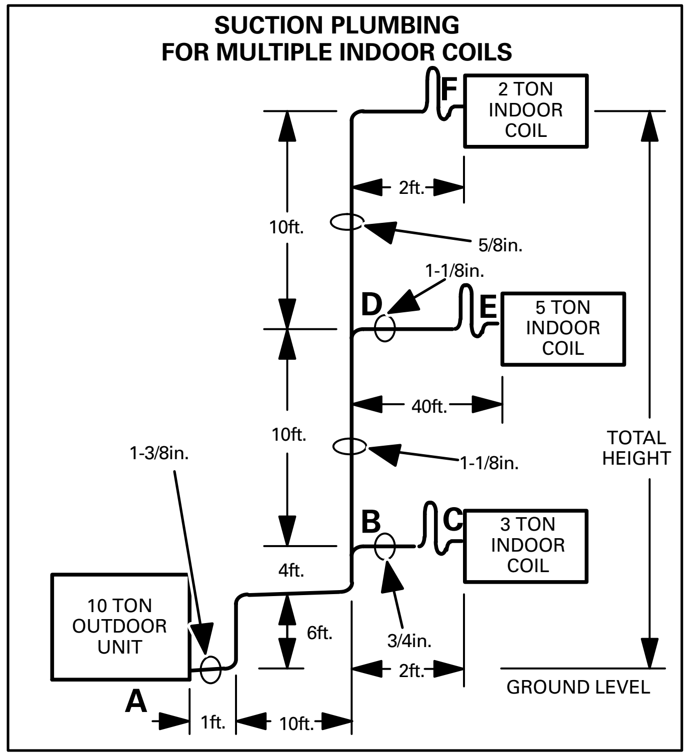


FIGURE 20

Find: Select tube size from figure 5.

Solution: Size each segment based on the tons of refrigerant that will flow in the segment.

Segment A to B

First solve segment A to B (10 tons). Select from figure 5 a 1-3/8 inch O.D. line (smallest suction line with acceptable velocity). Then determine the equivalent length of the segment to calculate the pressure drop.

21 feet of pipe, plus three 90° elbows (2.4 equivalent feet each), plus one tee (line side of tee at 1.8 equivalent feet each) = 30 equivalent feet length.

From figure 5, 1-3/8 inch O.D. suction line with 10 tons capacity has 3.3 psi drop per 100 feet. When we multiply 3.3/100 by 30 equivalent feet, we see that the total friction loss is 0.99 psi.

Vertical lift or drop has no effect on pressure in a vapor line.

Segment B to C

B to C has a capacity of three tons. Select from figure 5 a 3/4 inch O.D. line (smallest line with acceptable velocity yet with minimum capacity loss). Note figure 5 shows that 3/4 inch line has significant pressure drop per 100 feet when combined with 3 ton capacity. If segment B to C were much longer, the pressure drop would significantly reduce capacity and a larger (7/8 inch) line would have to be selected.

Determine the equivalent length of the segment to calculate the pressure drop.

Two feet of pipe, plus one tee (branch side of tee at 3.5 equivalent feet each), plus six ells (1.25 equivalent feet each) = 13 equivalent feet length.

From figure 5, 3/4 inch O.D. suction line with 3 tons capacity has 8.5 psi drop per 100 feet. When we multiply 8.5/100 by 13 equivalent feet, we see that the total friction loss is 1.11 psi.

Segment B to D

B to D has a capacity of seven tons. Select from figure 5 a 1-1/8 inch O.D. line (smallest line with acceptable velocity). Then determine the equivalent length of the segment to calculate the pressure drop.

10 feet of pipe, plus one tee (line side of tee at 1.5 equivalent feet each) = 11.5 equivalent feet length.

From figure 5, 1-1/8 inch O.D. suction line with 7 tons capacity has 5.2 psi drop per 100 feet. When we multiply 5.2/100 by 11.5 equivalent feet, we see that the total friction loss is 0.6 psi.

Segment D to E

D to E has a capacity of five tons. Select from figure 5 a 1-1/8 inch O.D. line (smallest line with acceptable velocity). Then determine the equivalent length of the segment to calculate the pressure drop.

40 feet of pipe, plus one tee (branch side of tee at 4.5 equivalent feet each), plus six ells (1.8 equivalent feet each) = 55.3 equivalent feet length.

From figure 5, 1-1/8 inch O.D. suction line with 5 tons capacity has 2.8 psi drop per 100 feet. When we multiply 2.8/100 by 44.5 equivalent feet, we see that the total friction loss is 1.55 psi.

Segment D to F

D to F has a capacity of two tons. Select from figure 5 a 5/8 inch O.D. line (smallest line with acceptable velocity). Then determine the equivalent length of the segment to calculate the pressure drop.

12 feet of pipe, plus seven 90° elbow (1.3 equivalent feet each) = 21.1 equivalent feet length.

From figure 5, 5/8 inch O.D. suction line with 2 tons capacity has 12 psi drop per 100 feet. When we multiply 12/100 by 21.1 equivalent feet, we see that the total friction loss is 2.53 psi. Here also, the pressure drop and resulting capacity loss are approaching significant levels.

It might be more appropriate to select 3/4 inch line in order to limit the losses. Equivalent length now equals 20.75 feet. From figure 5, 3/4 inch O.D. suction line with 2 tons capacity has 4.2 psi drop per 100 feet. When we multiply 4.2/100 by 20.75 equivalent feet, we see that the total friction loss is only 0.87 psi.

Putting the Segments Together

Next, we must determine if the line sizes we selected will result in satisfactory pressure drop between the condensing unit and *each evaporator.* To do this we simply add the total pressure drop of each line segment between the condensing unit and each evaporator. Then we convert the pressure drop into a capacity loss for each coil. Remember, there is approximately 1% loss in capacity for each pound of pressure lost to the line.

3 ton evaporator:

Total pressure drop A to C = A to B plus B to C.
Total pressure drop = 0.99 + 1.11 = 2.1 psi

1% capacity loss for each pound pressure drop
0.01 x 2.1 x 36,000 Btuh = 756 Btuh lost.

5 ton evaporator:

Total pressure drop A to E = A to B plus B to D plus D to E.
Total pressure drop = 0.99 + 0.6 + 1.55 = 3.14 psi

1% capacity loss for each pound pressure drop
0.01 x 3.14 x 60,000 Btuh = 1884 Btuh lost

2 ton evaporator:

Total pressure drop A to F = A to B plus B to D plus D to F.
If 5/8 inch O.D. line is used from D to F:
Total pressure drop = 0.99 + 0.6 + 2.53 = 4.12
If 3/4 inch O.D. line is used from D to F:
Total pressure drop = 0.99 + 0.6 + 0.87 = 2.46

1% capacity loss for each pound pressure drop
0.01 x 2.46 x 24,000 Btuh = 590 Btuh lost if 3/4 inch line is used.
0.01 x 4.12 x 24,000 Btuh = 989 Btuh lost if 5/8 inch line is used.

When deciding which line should be used from D to F, compare the capacity loss to the capacity required. Use the larger line size only if the additional capacity is needed to satisfy the job requirements.

If the line segments to these evaporators were significantly longer resulting in excessive capacity loss, larger suction lines could be selected as long as satisfactory velocities for oil entrainment were maintained.

I–Types of Expansion Devices

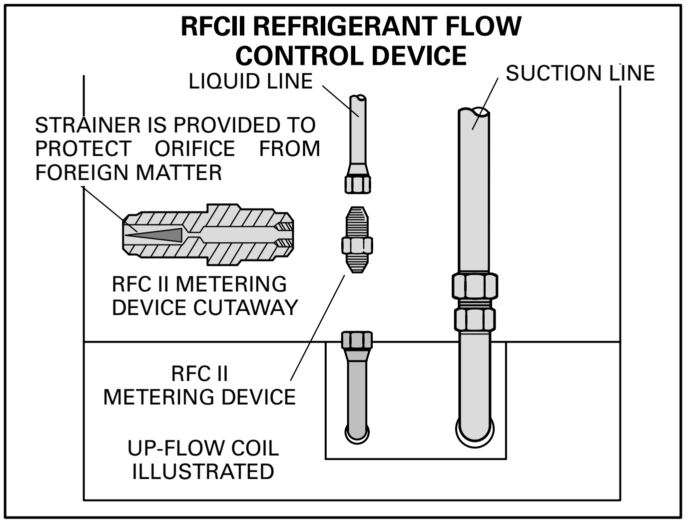


FIGURE 21

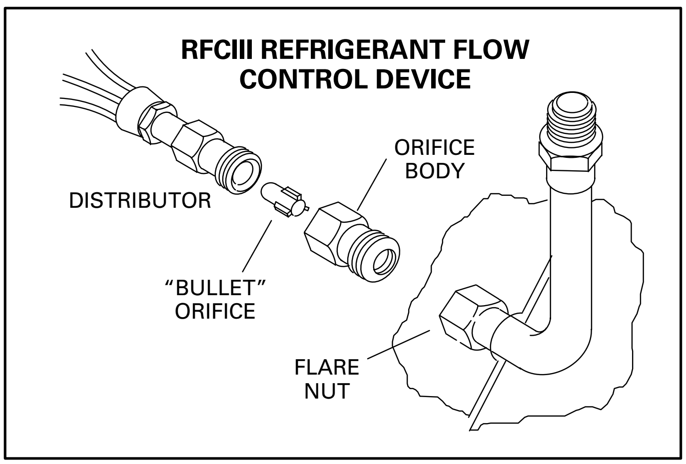


FIGURE 22

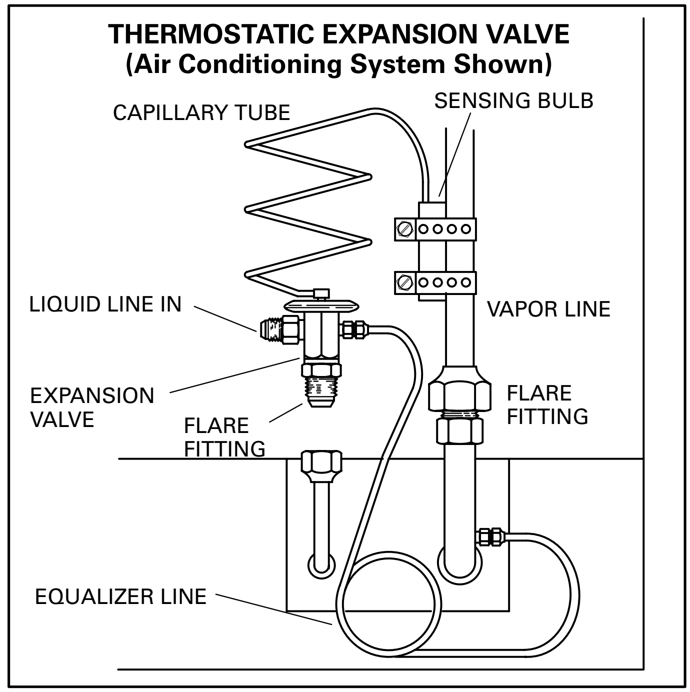


FIGURE 23

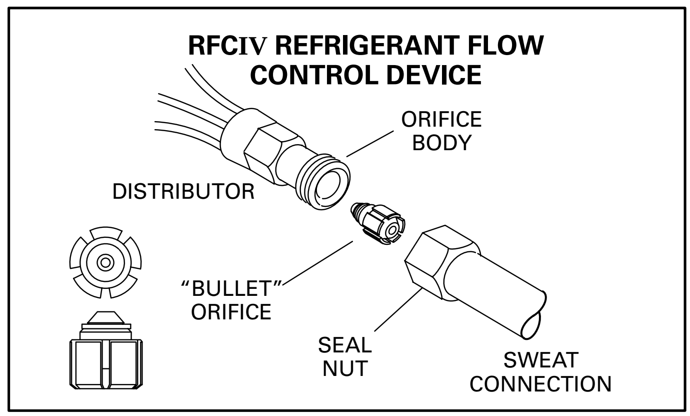


FIGURE 24

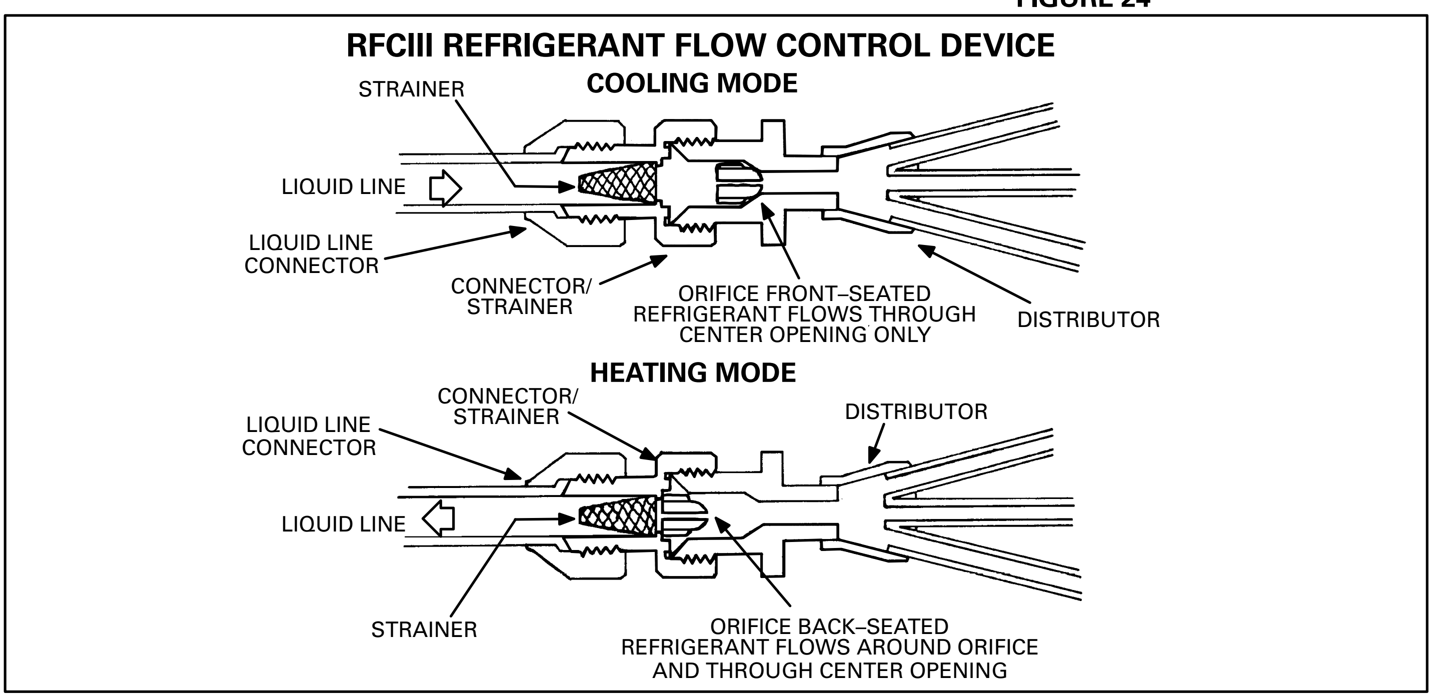
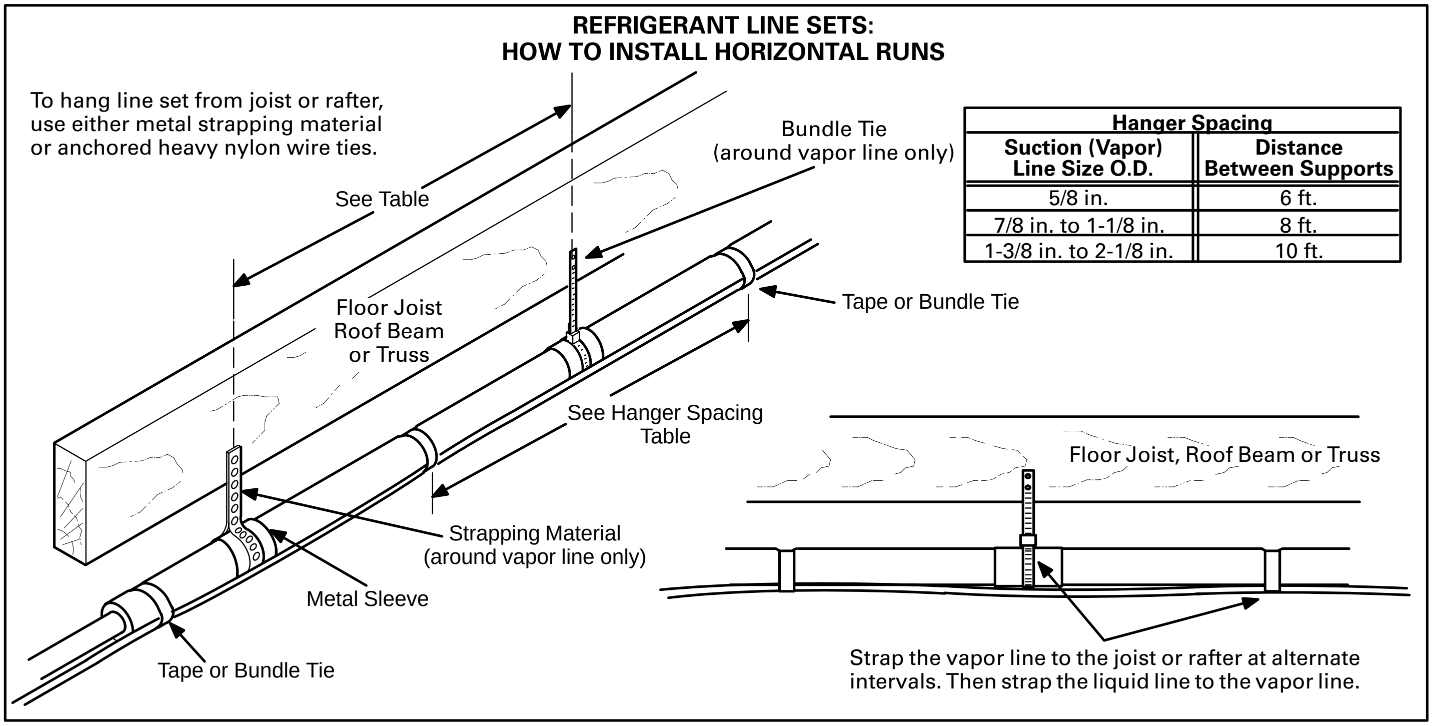


FIGURE 25

J– Piping Support

Refrigerant lines must not transmit equipment vibration to any part of the structure. Lines should be supported by isolation hangers. See figure 26. In no case should refrigeration lines be left unsupported and free to touch the structure at any point. Where lines pass through roofs, walls, floors or sills, or where they come in contact with duct work, they should be properly isolated. If outside, the isolation material should be properly waterproofed.

The piping must be supported securely at the proper places. All piping should be supported with hangers that can withstand the combined weight of pipe, fittings, refrigerant and insulation. The hangers must be able to keep the pipe in proper alignment, thus preventing any droop.



Hanger Spacing	
Suction (Vapor) Line Size O.D.	**Distance Between Supports**
5/8 in.	6 ft.
7/8 in. to 1-1/8 in.	8 ft.
1-3/8 in. to 2-1/8 in.	10 ft.

FIGURE 26

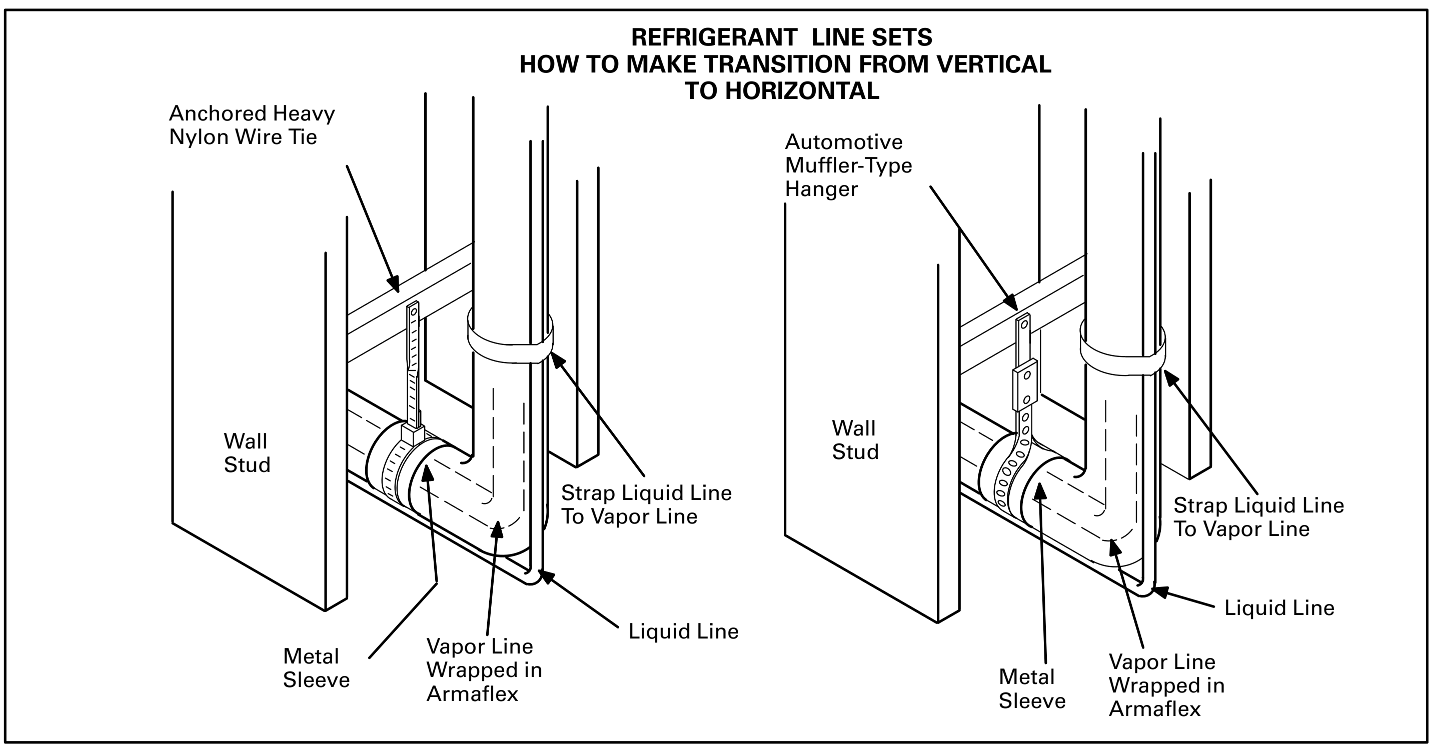


FIGURE 27

REFRIGERANT LINE SETS
HOW TO INSTALL VERTICAL RUNS (typical new construction shown)

NOTE-Similar installation practices should be used if line set is to be installed on exterior of outside wall.

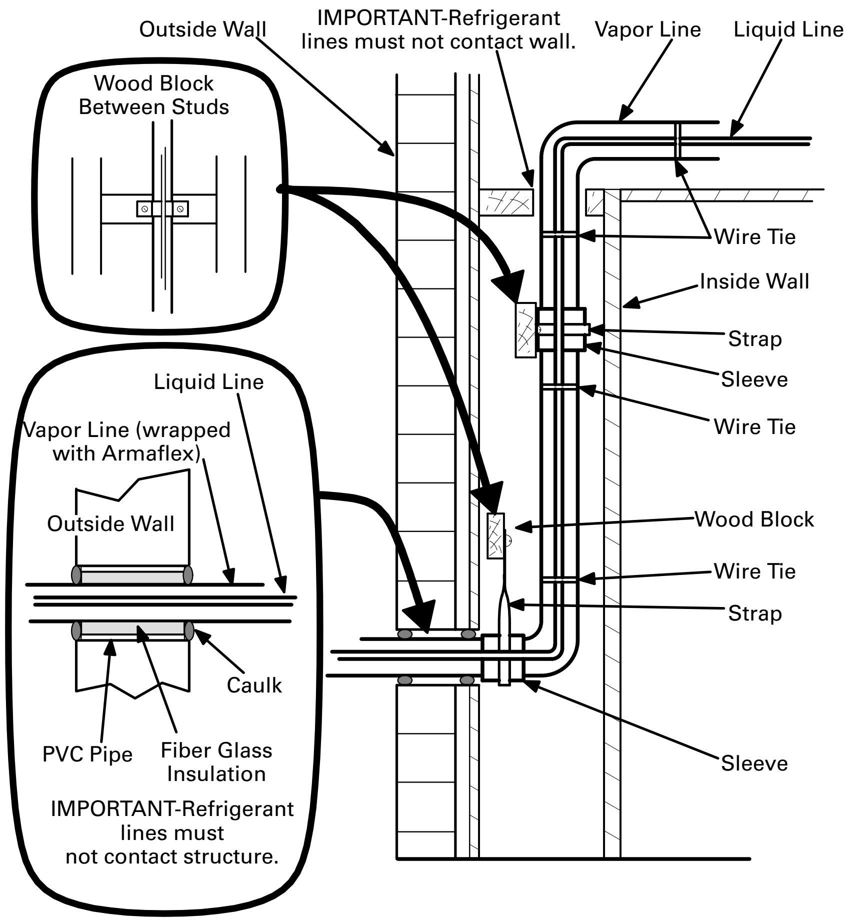


FIGURE 28

VII–Glossary of Terms

accumulator A tank located in the suction line just ahead of the compressor. The purpose of the accumulator is to prevent liquid from entering the compressor.

ambient The temperature of the air surrounding an object. For a liquid line passing through an attic, the ambient can approach 180°F. Lennox cooling and heat pump equipment is designed to provide adequate cooling when the outdoor ambient is 115°F.

bypass See Hot Gas Bypass.

bypass valve A valve used in hot gas bypass systems. The valve is plumbed so that when the unit is operating at reduced capacity, liquid refrigerant and hot gas are metered into the suction line. See also Hot Gas Bypass.

capillary tube (cap tube) Refrigerant metering device consisting of several small diameter tubes feeding liquid refrigerant into the evaporator. Cap tubes must never be used in long refrigerant line applications as they provide fair to poor refrigerant control in extreme conditions.

capacity (capacity loss) A measure of the quantity of refrigeration available, measured in Btu per hour or watts.

capacity reduction Air conditioning and heat pump systems designed to operate at reduced capacity. Lennox two speed equipment is designed to operate at 60% of full capacity during low speed operation. Some commercial systems use hot gas bypass as a form of capacity reduction. A form of capacity reduction is used in almost all zoning systems.

column of liquid A length of liquid refrigeration line completely filled with 100% liquid (no bubbles).

condenser A heat transfer device which removes heat from refrigerant gas, reduces its temperature, removes latent heat from the refrigerant converting the gas into liquid, then subcools the liquid.

condensing temperature The temperature in the condenser coil below which latent heat is removed and gas is converted into liquid.

distributor A manifold located at the outlet of an expansion valve designed to feed multiple circuits through the evaporator.

double suction riser A type of suction riser used in capacity reduction systems to improve oil entrainment during reduced capacity operation. A double suction riser consists of a small riser sized for the capacity of the system when operating at reduced capacity. A second larger riser is plumbed in parallel with the small riser to handle the increased flow when the system is operating at full capacity.

drier See Filter Drier.

drop 1) A measure of the downward vertical distance (measured in feet) liquid refrigerant must travel in order to reach the coil. The weight of the liquid refrigerant increases the liquid line pressure 1/2 pound per foot. 2) See pressure drop.

ell Wrought copper 90° or 45° elbows. Only long radius elbows should be used as fittings in long refrigerant lines used with Lennox equipment.

entrainment The process of moving oil along the inside surface of a refrigerant vapor line. Oil droplets/film attach to the inner surface of the pipe. The refrigerant velocity must be sufficient to sweep the oil along (entrain the oil) so it may be returned to the compressor.

expansion valve See Thermostatic Expansion Valve.

equivalent length (total equivalent length) Wrought copper fittings, filter driers and other devices placed in the refrigerant line add restriction to the line. The restriction added to the line is expressed in terms of equivalent feet. The total equivalent length of a line is equal to the length of the pipe plus the equivalent length of all the fittings, filter driers, etc. placed in the line.

evaporator A heat transfer device (coil) which adds heat to liquid refrigerant, increases its temperature, adds latent heat to the refrigerant converting the liquid into gas, then superheats the gas.

filter drier A device placed in the liquid or suction refrigerant lines to filter contaminants from the system and protect the expansion valve and compressor from potential damage.

flash gas In a liquid refrigerant line, liquid which has lost temperature and pressure to the point that gas bubbles begin to form significantly reducing the efficiency of the system. Flash gas can form as a result of friction losses or running the liquid line through areas with extremely high ambients or both.

friction loss See Pressure Drop.

hammer See Liquid Hammer.

hard copper Type L refrigeration grade copper tubing.

hot gas bypass A form of capacity reduction. The system diverts hot discharge gas and liquid into the suction line bypassing the evaporator coil. The most desirable form of hot gas bypass is the type which feeds hot gas into a side tap on the distributor on the evaporator coil.

indoor coil The name given to the coil in the indoor unit in heat pump systems.

lift A measure of the upward vertical distance liquid refrigerant must travel in order to reach the coil measured in feet. The weight of the liquid refrigerant reduces the liquid line pressure 1/2 pound per foot. In air conditioning systems, lift is a factor only if the evaporator is located above the condenser. In heat pump systems, lift is always a factor due to the system's ability to reverse refrigerant flow.

line size The outside diameter (O.D.) of copper pipe used in refrigeration.

liquid hammer An audible sound heard in liquid refrigerant lines when solenoid valves close. The noise is a result of liquid refrigerant travelling at high velocity then stopping abruptly when the valve closes.

low ambient (temperature) The use of the compressor for cooling when outdoor temperature is below 50°F. Field installed kits are required to protect the compressor and ensure proper operation in the event low ambient cooling below 50°F is required.

main In systems with multiple refrigerant lines, the name given to the line which feeds or collects refrigerant from multiple smaller refrigerant lines.

mass velocity The average velocity of refrigerant in a pipe expressed in feet per minute (fpm).

maximum allowable pressure drop The amount of pressure drop a liquid line can experience before flash gas will begin to form. This number can be calculated if the amount of subcooling leaving the condenser is known by subtracting the subcooling temperature from the summer operating temperature then converting the results into a pressure on the R22 saturation chart. The difference in pressure between summer operating temperature and the subcooling temperature is equal to the maximum allowable pressure drop.

If the outdoor unit is charged to operate with 10°F subcooling at 115°F summer operating conditions, the maximum allowable pressure drop will be 35 psi.

metering (metering device) Any device which regulates the flow of liquid refrigerant into an evaporator.

migrate (migration) The tendency of refrigerant gas to slowly travel to the coldest part of the piping system during the off-cycle and condense and collect as liquid.

multiple evaporators Piping arranged so that a single condenser can operate several evaporators at the same time.

non-recycling pump-down control See Pump Down Control.

oil trap A small U bend located in the suction line where it exits the indoor coil. The purpose of the U bend is to trap oil and prevent the oil from filling the suction line.

outdoor coil The name given to the coil in the outdoor unit in heat pump systems.

pressure drop (pressure loss) The loss of refrigerant pressure experienced in copper pipe, usually expressed in terms of pounds (psi) per 100 feet.

pump-down control A field installed kit consisting of a solenoid valve located in the liquid line before the expansion valve. At the end of a cooling cycle, the controls close the valve. The compressor continues to run until all refrigerant is returned into the condenser where it is stored as a liquid. The valve remains closed until the next cooling demand.

RFC (refrigerant flow control device) Lennox' trademark protected name for various types of refrigerant metering devices with fixed orifice size –
RFC: Liquid line serves as the expansion device. It has a precisely sized inside diameter and length which matches the capacity of the condensing unit and evaporator.
RFCII: Fixed orifice for air conditioners located at evaporator.
RFCIII: Floating bullet type orifice for heat pump coils which front seats for cooling and back seats for heating.
RFCIV: Fixed bullet orifice for air conditioners.

riser The name of any length of refrigerant pipe which transports refrigerant vertically upward.

run-around hot gas bypass A type of hot gas bypass system that diverts hot discharge gas and liquid directly into the suction line inside the condensing unit. Although this type of system requires no piping external to the unit, it is least desirable and should not be used.

saturation temperature The temperature at which a gas begins to turn into liquid.

sight glass A glass window type device placed in a liquid line and used for visual inspection of the liquid. It can also be used to determine the point at which all gas bubbles are removed from the liquid line. A sight glass is not a good indicator of subcooling and cannot be used to determine charge.

sil-phos Brazing solder composed of silver, phosphorous, and copper and used for welding joints of copper pipe.

slug A column of liquid refrigerant returned to the compressor in the suction line. A slug which enters the compressor can cause permanent compressor damage due to non-compressability of liquids.

solenoid valve An electromechanical valve located in the refrigerant lines and used to shut-off refrigerant flow.

split-coil A single evaporator or condenser coil which is plumbed so that a single coil can serve two or more independent refrigeration circuits.

subcooling Cooling of refrigerant liquid below its saturated temperature while holding it at saturated pressure.

suction riser See Riser.

superheat Heating of refrigeant gas above its saturated temperature while holding it at saturated pressure.

thermometer well A device located in the liquid line of most Lennox equipment which allows a thermometer to be inserted into the liquid line. The well is used for accurately measuring the temperature of the liquid line for charging purposes.

thermostatic expansion valve (TXV) An extremely precise type of expansion device which regulates refrigerant flow into the evaporator based on the amount of superheat exiting the coil. An expansion valve is desirable in long line set applications because it can maintain control of superheat in extremes of operating conditions.

trap See Oil Trap.

two speed Condensing (or heat pump) outdoor units equipped with a two speed compressor. Generally, the compressor operates at 60% capacity on low speed and 100% capacity on high speed.

TXV See Thermostatic Expansion Valve.

unload (unloading) See Capacity Reduction.

variable capacity See Capacity Reduction.

velocity A measure of the speed at which refrigerant travels through a pipe.

wrought copper Hammered refrigeration grade copper used in refrigerant fittings.

PLAN

6 Lines per Inch

CALCULATIONS