



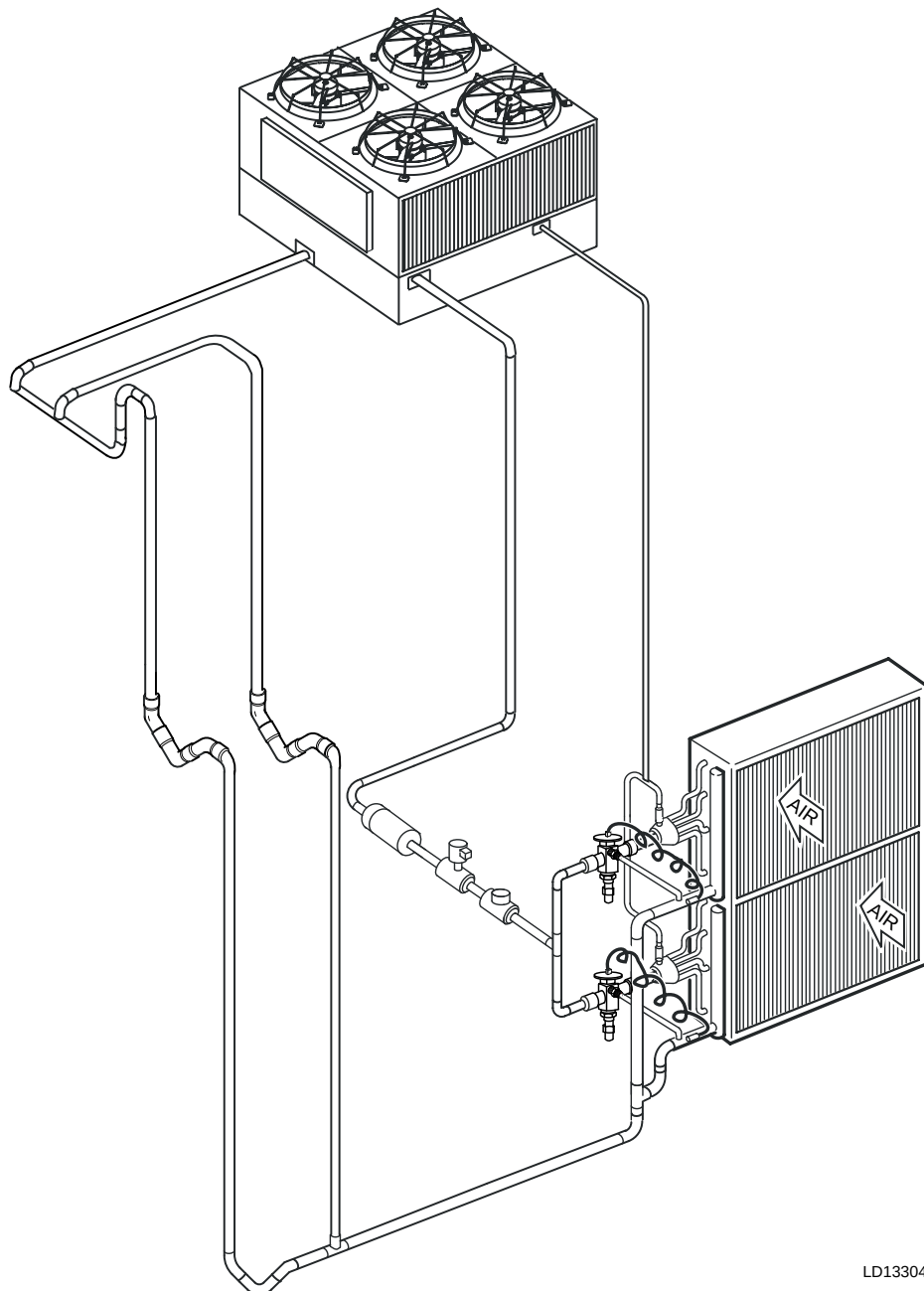
**AIR COOLED CONDENSING UNIT
DX COIL SPLIT SYSTEM
APPLICATIONS AND PIPING GUIDELINES**

ENGINEERING SUPPLEMENT

Supersedes: 050.40-ES3 (408)

Form 050.40-ES3 (212)

**GUIDELINES FOR PROPER APPLICATION PIPING AND
GUIDELINES FOR SPLIT SYSTEMS
(R-22, R-407c, AND R-410a)**



LD13304

Issue Date:
February 23, 2012

IMPORTANT!

READ BEFORE PROCEEDING!

GENERAL SAFETY GUIDELINES

This equipment is a relatively complicated apparatus. During installation, operation maintenance or service, individuals may be exposed to certain components or conditions including, but not limited to: refrigerants, materials under pressure, rotating components, and both high and low voltage. Each of these items has the potential, if misused or handled improperly, to cause bodily injury or death. It is the obligation and responsibility of operating/service personnel to identify and recognize these inherent hazards, protect themselves, and proceed safely in completing their tasks. Failure to comply with any of these requirements could result in serious damage to the equipment and the property in

which it is situated, as well as severe personal injury or death to themselves and people at the site.

This document is intended for use by owner-authorized operating/service personnel. It is expected that these individual possess independent training that will enable them to perform their assigned tasks properly and safely. It is essential that, prior to performing any task on this equipment, this individual shall have read and understood this document and any referenced materials. This individual shall also be familiar with and comply with all applicable governmental standards and regulations pertaining to the task in question.

SAFETY SYMBOLS

The following symbols are used in this document to alert the reader to specific situations:



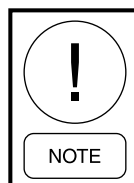
Indicates a possible hazardous situation which will result in death or serious injury if proper care is not taken.



Identifies a hazard which could lead to damage to the machine, damage to other equipment and/or environmental pollution if proper care is not taken or instructions are not followed.



Indicates a potentially hazardous situation which will result in possible injuries or damage to equipment if proper care is not taken.



Highlights additional information useful to the technician in completing the work being performed properly.

CHANGEABILITY OF THIS DOCUMENT

In complying with Johnson Controls' policy for continuous product improvement, the information contained in this document is subject to change without notice. Johnson Controls makes no commitment to update or provide current information automatically to the manual owner. Updated manuals, if applicable, can be obtained by contacting the nearest Johnson Controls Service office.

Operating/service personnel maintain responsibility for the applicability of these documents to the equipment. If there is any question regarding the applicability of these documents, the technician should verify whether the equipment has been modified and if current literature is available from the owner of the equipment prior to performing any work on the chiller.

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LEGENDS AND NOTES

The following defines some of the non-script abbreviations listed in this document along with notes to better clarify their use.

ACCU	Air Cooled Condensing Unit identifying product including but not limited to YCUL, YLUA, etc.
AHU	Air Handling Unit
ASC	Auxiliary Side Connector
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAS	Building Automation System
CF	Correction Factor
CT	Condensing Temperature
CTP	Saturated Condensing Temperature
DAT	Discharge Air Temperature
DX	Direct Expansion (Coil)
EEV	Electronic Expansion Valve
EF	Equivalent Feet (Pipe)
ETP	Saturated Evaporator Temperature
HGBP	Hot Gas Bypass
IOM	Installation, Operating and Maintenance (Manual)
JCI	Johnson Controls Incorporated
LLSV	Liquid Line Solenoid Valve
MOP	Maximum Operating Pressure
PD	Pump down (Or Pumpdown)
MSDS	Material Safety Data Sheet
PWM	Pulse Width Modulation (Signal)
SP	Suction Pressure
SQ	Special Quotation (Used by Sales in YORKworks)
SST	Saturated Suction Temperature
TR	Temperature Rise
TXV	Thermal Expansion Valve
VAV	Variable Air Volume
VSD	Variable Speed Drive

Notes:

1. Application Guidelines outlined herein are in part based on ASHRAE Refrigeration standards. Manufacturers requirements are also incorporated herein that are important to system and component reliability. Any deviations to those outlined can affect system operation and reliability.
2. Split-System external piping (Between ACCU and AHU) is the responsibility of the Installing Contractor. Split-System piping details are out-

lined herein and are a requirement by Johnson Controls. Any deviations or shortcomings must be addressed at startup and corrected prior to leaving the system on. Uncorrected shortcomings can affect certain warranties (Reference the Installation Guide form 050.40-CL1 that ships with every ACCU).

SECTION 1 - EQUIPMENT LOCATION

1

INTRODUCTION

This document will help you avoid the many pitfalls facing application engineers and installation contractors who design and install piping and control systems for remote condensing and/or DX coil applications. These pitfalls, if not avoided, can result in functional problems during commissioning or hidden problems that, although not noticeable now, could result in long-term system reliability issues.

This document is divided into sections that cover various types of interconnecting piping, system components and controls. The document provides pertinent information that Johnson Controls considers the best practice in regard to the specific application.

It is difficult to describe best practices based on rules and procedures since there will always be situations that either you have never encountered or a combination of factors that make the rules difficult to interpret. It is very important to remember that all of the rules and advice contained here are based on the common sense application of basic refrigeration and air conditioning design and installation theory.

Using this document in conjunction with a solid background in HVAC fundamentals will provide a much-improved methodology for an ultimately reliable design. Conversely, you should not use this document as the sole source of knowledge with respect to a fairly complex system design.

The bottom line is that the inter-connected components, when properly designed and controlled, keep the refrigerant and oil in the proper locations in the system during operation and shut-down, while allowing the equipment to perform its designed performance for its expected life.

This may sound like an over simplification, but that is our system design goal. We hope this document compliments your existing HVAC system knowledge, enabling you to design highly reliable efficient solutions using YORK equipment.

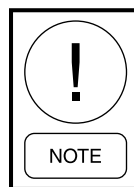
GENERAL EQUIPMENT INSTALLATION AND LOCATION

It is recommended that only experienced engineers design remote piping systems. Experience in all aspects of piping design, airside components, controls, and Air

* Applies to YCUL and YLUA

Cooled Condenser Unit (ACCU)* components is required to assure a successful application. The designer assumes responsibility that the piping is installed correctly, that oil return is assured, and refrigerant liquid over-feed to the compressors is not a problem due to component selections, piping or controls. The designer must make it clear that any deviations from the original component and piping layout must be approved, before the change is made.

In addition, experienced and certified contractors must install the refrigerant piping in accordance with the consulting engineer's design using the best industry practices as listed in this manual and the ASHRAE Handbook. This is required to assure a successful application and installation. The designer and contractor are responsible to insure oil is properly returned to the compressors and refrigerant liquid is prevented from entering the compressors. The contractor is responsible for obtaining the designer's approval for any deviations in the piping layout.



Johnson Controls is not responsible for compressor failures that result from poor piping design, component selection, installation or system control problems.

WHERE SHOULD THE COMPONENTS BE LOCATED

As a starting point, advise the owner or consulting engineer to locate the air-cooled condensing unit as close to the DX-AHU as possible. **It is generally required that the total equivalent feet of piping be 150 feet or less (Always refer to IOM for specifics on maximum equivalent feet). The following benefits can be realized by doing this.**

- Electrical operating costs will be at their lowest level. This is the result of maximizing system efficiency by minimizing suction and liquid refrigerant piping losses and penalties.
- The refrigerant charge requirement is minimized, reducing initial system cost.
- This promotes environmental design responsibility. Less refrigerant is available to escape into the environment, if a leak would occur.
- The system benefits because the piping design is simpler, more direct, less complicated, and promotes oil return.

LOCATION AND CLEARANCES

Condensing units are designed for rooftop or ground level outdoor installations. The following points should be considered when locating the condensing unit:

- Suction line must not create a liquid/oil trap (i.e. eliminate any oil or liquid refrigerant unwanted traps on suction lines between the DX coil and the compressor).
- Minimal direct exposure to the sun.
- Sufficient clearances for air entrance to the condenser coil.
- Air discharge away from the condenser.
- Service access to the ACCU mechanical components and electrical panel.
- Avoid condenser air re-circulation. Recommended the ACCU minimum clearances are:
 - Side to wall – 6 feet
 - Rear to wall – 6 feet
 - Control panel to end wall – 4 feet
 - Top – no obstructions allowed
 - Distance between adjacent units – 10 feet
 - No more than one adjacent wall may be higher than the unit

In installations where winter operation is intended and snow accumulations are expected, the condensing unit should be elevated to insure normal condenser airflow.

Air-handling units can be mounted outdoors or indoors. The location of the air-handling unit should allow for unobstructed airflow through the outside air and exhaust air openings, as well as easy access to the electrical box and all access doors. Location of the units should also be away from building flue stacks or exhaust ventilators to prevent reintroduction of contaminated air through the outside air intakes.

FOUNDATION

The unit should be mounted on a flat and level foundation, floor, or rooftop capable of supporting the entire operating weight of the equipment. If the unit is elevated beyond the normal reach of service personnel, a suitable catwalk must be installed and capable of supporting service personnel, their equipment, and the compressors.

GROUND LEVEL LOCATIONS

It is important that the units be installed on a substantial base that will not settle. A one-piece concrete slab with footers extended below the frost line is highly recommended. Additionally, the slab should not be tied to the main building foundations as noise and vibration may be transmitted. Mounting holes are provided in the steel base channel for bolting the unit to its foundation.

For ground level installations, take precautions to protect the unit from tampering by, or injury to, unauthorized persons. Screws and/or latches on access panels will prevent casual tampering. However, further safety precautions such as a fenced-in enclosure or locking devices on the panels may be advisable.

For grassy areas; it is highly recommended that grass areas surrounding a condensing unit or chiller, be far enough away so that there is no possibility of grass clippings fouling the condenser coils. It is recommended a slab be poured, that would also offer a service area.

ROOFTOP LOCATIONS

The roof structure must be capable of safely supporting the entire operating weight of the unit and service personnel. A consulting engineer should review/approve the location.

Take care not to damage the roof. Consult the building contractor or architect, if the roof is bonded. Isolators should be mounted under the base of the unit to minimize vibration.

NOISE SENSITIVE LOCATIONS

Assure that the unit is not located next to occupied spaces or noise sensitive areas where noise would be a problem. Unit noise is a result of compressor and fan operation. The ASHRAE Applications Handbook states that sound data for outdoor equipment is obtained in accordance with ARI Standard 370, which requires that the A-weighted and octave band Sound Power Levels be provided. Considerations should be made utilizing the Sound Power Data published in YORKworks. Optional low sound fans and compressor sound options are available to help lower the equipment sound.

Air-handling unit noise is a result of supply fan and return fan operation. Consult YORK publication 100.00-AG2 (303) *Acoustic Checks for Air Handling Projects* for project design guidelines.

CONDENSER COIL PROTECTION

Standard condenser coil construction materials include aluminum fins, copper tubes and galvanized tube supports for generally good corrosion resistance. However, these materials are not adequate for all environments. The system designer can take steps to inhibit coil corrosion in coastal or harsh applications and enhance equipment life by choosing from YORK condenser coil options, based on project design parameters and related environmental factors.

Options available are black fin, copper fin, and coated condenser coils. Coils constructed with corrosion resistant copper fins are applicable for coastal locations, but are not recommended in areas where units may be exposed to acid rain. Pre-coated aluminum fin coils are a cost effective way of increasing condenser coil durability and should be offered as a minimum for near sea-shore applications. Post dipped coated condenser coils can be the best choice for seashore or where salt spray may hit the fins and other acid, solvent, and alkaline environments within a 3.0 to 12.0 pH range.

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SECTION 2 - EQUIPMENT SELECTION

SYSTEM COMPONENTS

To correctly match a condensing unit with a DX coil, it is important to understand the components of the refrigeration system and their functions. A refrigeration system consists of four major components: the compressor, condenser, expansion device and evaporator. Each of these components shown in *Figure 1 on page 17* must be properly sized and installed in order to operate together and perform correctly.

Compressor

The function of a compressor is to raise the pressure of the refrigerant gas to a point where the temperature at which the gas will condense is higher than the ambient temperature of the air being used to condense it. For example, if the ambient design air temperature is 95°F, the refrigerant gas will typically be compressed to a pressure where the condensing, or saturation, temperature is 120°-130°F.

In scroll compressors, the refrigerant gas is compressed between the faces of two interlocking scrolls, one of which orbits while the other remains stationary.

Condenser

An air-cooled condenser typically has one or more heat transfer coils and one or more fans. The fans draw ambient air through the coils, which causes the hot refrigerant gas inside the tubes to condense. The capacity of an air-cooled condenser depends upon the temperature and flow rate of the ambient air and the surface area of the coil.

As the high-pressure refrigerant flows through the coil, it begins to condense, but remains at a steady temperature and pressure (for R-22) while for R-407c the temperature and pressure will drop slightly due to the glide of the refrigerant (R-410a Glide is minimal). The condenser coils are sized such that the refrigerant gas has completely condensed and more heat will be removed from it. This process is known as sub-cooling. Sub-cooling the liquid refrigerant prevents it from flashing back to its vapor state as its pressure drops between the condenser and the expansion device. Sub-cooling also improves the cooling capability of the refrigerant.

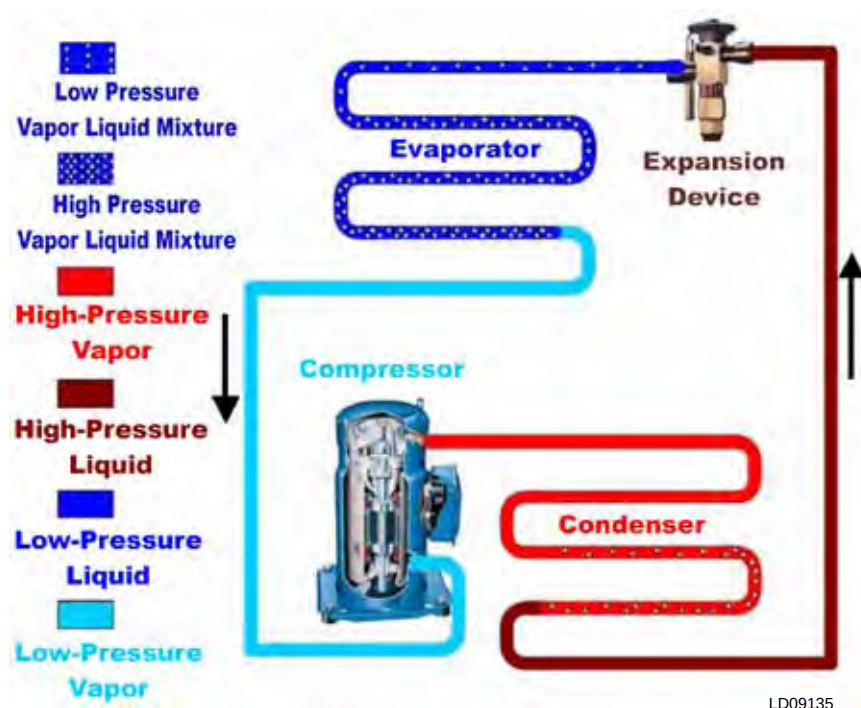
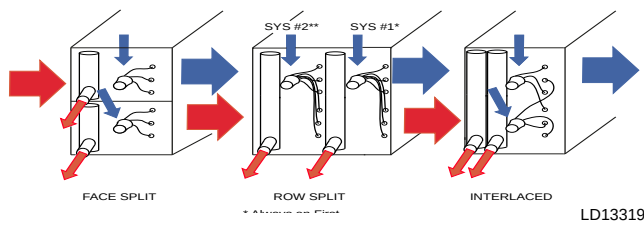


FIGURE 1 - MAJOR SYSTEM COMPONENTS

**FIGURE 2 - EVAPORATOR COIL TYPES**

Evaporator

The evaporator coil removes heat from the supply air stream, cooling the supply air in the process. The evaporator coil generally consists of several rows of copper tubing mechanically bonded to aluminum (or copper) heat transfer fins. Depending on the size and capacity of the coil it may consist of one, or several refrigerant circuits (see *Figure 2 on page 18*).

A refrigerant distributor on each DX evaporator coil circuit feeds low pressure, low temperature liquid refrigerant to the coil tubes. It is critical that all the distributor tubes are the same length so the pressure drop across them will be equal and the refrigerant will be evenly distributed to the coil tubes.

As the liquid refrigerant passes through the coil tubes, heat is transferred from the supply air stream to the refrigerant. As heat is added to the liquid refrigerant, it begins to evaporate much like water boiling on a stove. The liquid-vapor mixture remains at a constant temperature and pressure until it completely vaporizes (for R-22), while for R-407c the temperature and pressure will drop slightly due to the glide of the refrigerant

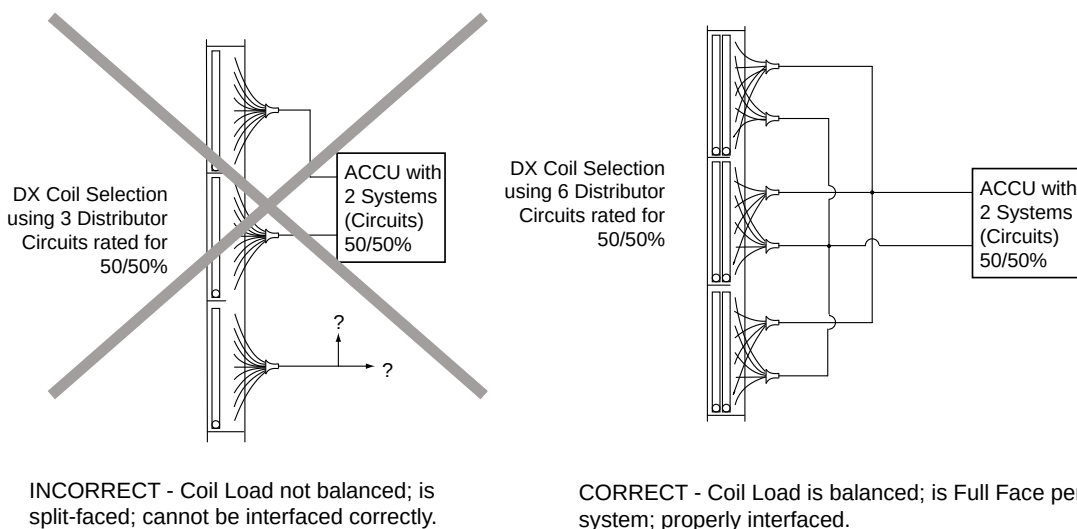
(R-410a Glide is minimal). The coil capacity is determined by the type and amount of refrigerant used, the temperature difference between the air and the liquid refrigerant, and the amount of air passing over the coil.

Once the refrigerant has completely evaporated, its ability to cool the air decreases dramatically. If too little refrigerant is fed to the coil, it will evaporate quickly and the air will not be adequately cooled. If too much refrigerant is fed to the coil it will not evaporate at all and liquid refrigerant will return to the compressor. Direct expansion (DX) evaporator coils are designed to evaporate all refrigerant in the coil and then “super-heat” the refrigerant gas in the last row or two of coil tubes. The refrigerant gas is superheated to ensure it does not condense back to its liquid state in the suction line. Superheat is also used to control the expansion device.

With regards to DX coil circuits – it is very important that the number of Air Cooled Condenser Systems (or circuits) be “interfaced” with the correct quantity of DX coil distributors (can be multiple), while allowing full face coverage and balanced capacity. *See Figures 3, 4 and 5(also reference SECTION 3 - COIL SELECTION/CONFIGURATION for additional detail/clarifications).*

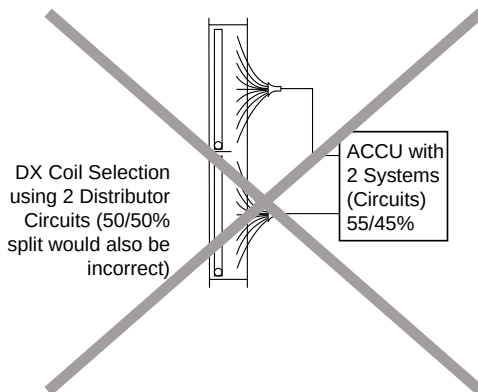
Example #1

Figure 3 on page 18 is for illustration purposes only. DX coil circuits may vary from “correct” version illustration shown below as long as load is balanced and full face coverage is maintained.

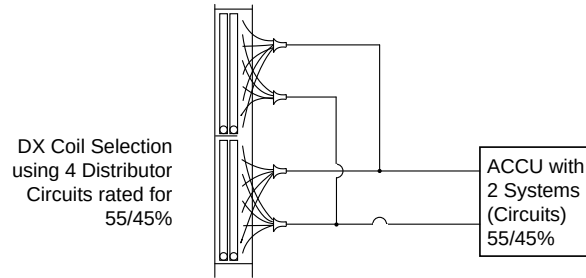
**FIGURE 3 - DX COIL SELECTION EXAMPLES WITH CIRCUITS RATED 50/50%**

Example #2

Figure 4 on page 19 is for illustration purposes only. DX coil circuits may vary from “correct” version illustration shown below as long as load is balanced and full face coverage is maintained.



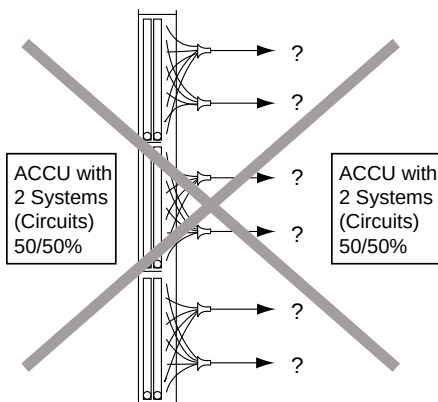
INCORRECT - Coil Load not balanced; is split-faced; cannot be interfaced correctly.



CORRECT - Coil Load is balanced; is Full Face per system; properly interfaced.

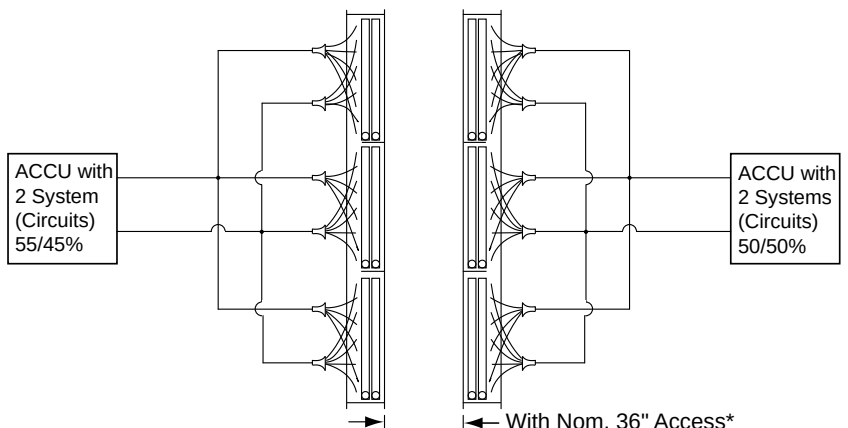
FIGURE 4 - DX COIL SELECTION EXAMPLES WITH CIRCUITS RATED 50/45%

Single DX Coil selection using 6 distributor circuits selected 50/50% in YORKworks.



INCORRECT - Coil Load not balanced; is split-faced; cannot be interfaced correctly.

(2) Separate DX Coil selections with access, each having 6 distributors.



CORRECT - Coil Load is balanced; is Full Face per system; properly interfaced.

* Access Provision

FIGURE 5 - DX COIL SELECTION EXAMPLES FOR DUAL ACCU'S

Expansion Device

The expansion device controls the flow of liquid refrigerant to the evaporator coil. YORK uses temperature controlled, (thermostatic) expansion valves (TXV's) as shown in *Figure 6 on page 20*. The TXV has two primary components: the valve body and the sensing bulb.

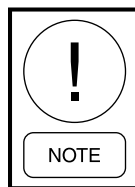
The valve regulates the flow of refrigerant to the evaporator coil. As refrigerant passes through the valve it is adiabatically expanded (that is, without the addition of energy). This causes the pressure and temperature of the liquid refrigerant to drop, making it suitable for cooling the air.

The amount of refrigerant fed to the coil is based on the cooling load of the supply air and the resultant amount of superheat created. As the cooling load increases, the liquid refrigerant absorbs more heat and evaporates more quickly. This means that more of the evaporator coil is available to superheat the refrigerant vapor and it leaves the coil at a higher temperature. Conversely as the cooling load decreases, the liquid refrigerant does not evaporate as quickly so less superheating occurs and the refrigerant leaves the coil at a lower temperature.

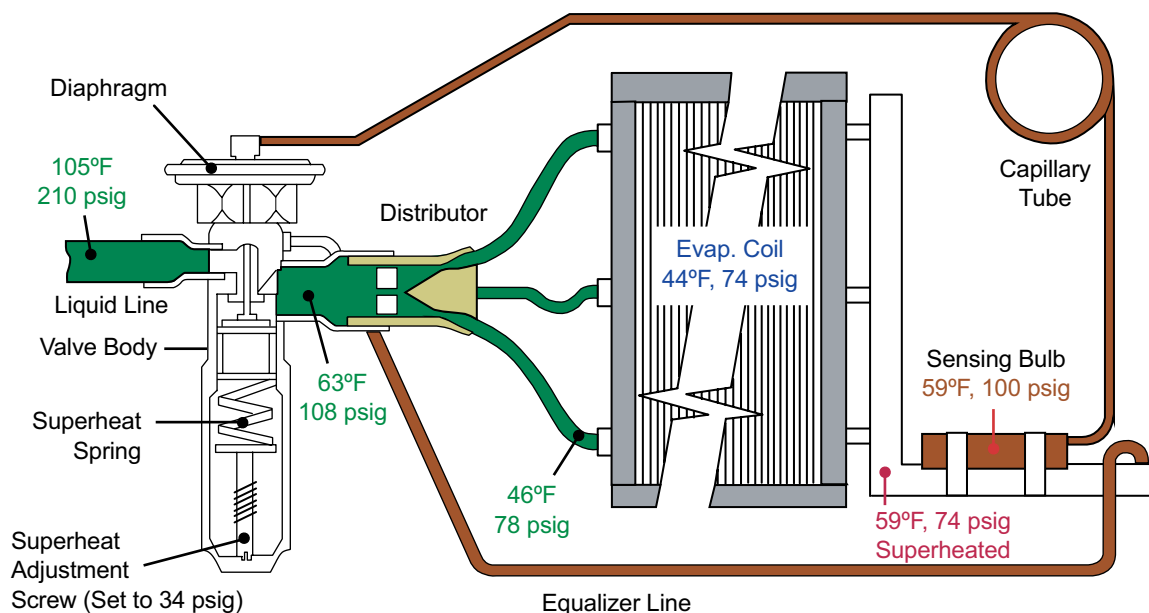
The sensing bulb attached to the valve is charged with a mix of liquid and vapor refrigerant. This refrigerant must be the same type as that in the system. The refrigerant vapor in the sensing bulb exerts pressure on a diaphragm in the valve body, which causes the valve to open or close.

As the temperature of the superheated suction gas leaving the evaporator rises due to an increase in the cooling load, refrigerant in the sensing bulb evaporates increasing the pressure on the valve diaphragm. The increased pressure causes the valve to open and allows more refrigerant to flow into the coil to meet the higher cooling demand. When the temperature of the suction gas drops due to a decrease in the cooling load, the gas in the sensing bulb condenses reducing its pressure on the valve diaphragm. This allows the valve to restrict the flow of refrigerant into the coil until the lower cooling demand is adequately met.

The valve body contains a superheat spring that keeps everything in balance. By turning a screw in the bottom of the valve the spring can be set for a certain amount of superheat. For example, if the superheat spring is set for 15°F of superheat it will exert a pressure on the valve equal to the pressure the vaporized gas in the sensing bulb will exert on the valve diaphragm when the suction gas is superheated by 15°F. The equalizer line is used to prevent the pressure drop that occurs across the distributor and DX coil from affecting the operation of the expansion valve.



Johnson Controls generally recommends setting the superheat for 15°F of superheat (Always refer to IOM for specifics on superheat recommendations). The superheat should always be set when the unit is operating at or close to design conditions. With a system at minimum load, superheat should never drop below 10°F.



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FIGURE 6 - THERMAL EXPANSION VALVE (TXV) COMPONENTS (CONDITIONS ARE WITH R-22)

YCUL0056EC

SST (°F)	AIR TEMPERATURE ON CONDENSER (°F)																	
	75°F			80°F			85°F			90°F			95°F			100°F		
	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER
35.0	47.8	40.1	12.6	46.7	42.2	11.7	45.6	44.5	10.9	44.5	47.0	10.2	43.3	49.6	9.4	42.0	52.4	8.7
37.0	49.6	40.4	12.9	48.5	42.5	12.1	47.3	44.8	11.3	46.1	47.3	10.5	44.9	49.9	9.7	43.6	52.7	9.0
39.0	51.4	40.8	13.3	50.3	42.9	12.4	49.1	45.1	11.6	47.8	47.6	10.8	46.5	50.3	10.0	45.2	53.1	9.2
41.0	53.3	41.1	13.7	52.1	43.2	12.8	50.9	45.5	11.9	49.6	47.9	11.1	48.2	50.6	10.3	46.9	53.4	9.5
43.0	55.2	41.4	14.1	54.0	43.5	13.2	52.7	45.8	12.3	51.3	48.3	11.4	50.0	50.9	10.6	48.6	53.8	9.8
45.0	57.2	41.8	14.5	55.9	43.9	13.5	54.5	46.2	12.6	53.2	46.6	11.8	51.7	51.3	10.9	50.3	54.1	10.1
47.0	59.2	42.2	14.9	57.8	44.3	13.9	56.4	46.5	13.0	55.0	49.0	12.1	53.5	51.7	11.2	52.0	54.5	10.4
49.0	61.2	42.6	15.3	59.8	44.6	14.3	58.4	46.9	13.3	56.9	49.4	12.4	55.4	52.0	11.5	53.8	54.9	10.7
51.0	63.3	43.0	15.6	61.8	45.0	14.7	60.4	47.3	13.7	58.8	49.8	12.8	57.2	52.4	11.8	55.7	55.3	11.0
53.0	65.5	43.4	16.0	63.9	45.4	15.0	62.4	47.7	14.0	60.8	50.1	13.1	59.2	52.8	12.2	57.5	55.7	11.3
55.0	67.6	43.8	16.4	66.1	45.9	15.4	64.4	48.1	14.4	62.8	50.6	13.4	61.1	53.2	12.5	59.4	56.1	11.6

FIGURE 7 - COOLING CAPACITY RATING CHART (SHOWN FOR R-22)

APPLICATION DESIGN CONDITIONS

Before selecting equipment, you must first establish these basic working parameters:

- The design cooling load
- The design outdoor air temperature
- The refrigerant saturated suction temperature

The design-cooling load is typically found on the job schedule. The design outdoor air temperature may also be listed on the job schedule. If it isn't, it can be estimated from the climate data found in Chapter 28 (Climatic Design Information) of the 2005 ASHRAE Fundamentals Handbook. If the ACCU saturated suction temperature (SST) is not known, assume it is in the range of 40°F to 45°F. This represents the standard industry approach.

ACCU Condensing Unit Performance Information

When using a pre-engineered condensing unit, for example a YORK Model ACCU, you can use ratings such as those shown in *Figure 7 on page 21* (Example for R-22) to determine which condensing unit size will satisfy the cooling capacity of the system. This rating chart is in the Engineering Guide.

ACCU* computer ratings are also available from YORKworks or the *design03 dxchill* mainframe program.

DX Coil Performance Information

The direct expansion (DX) evaporator coil can be selected using the YORKworks program. To select the DX coil, you enter the cooling capacity or the leaving air temperature, and the saturated evaporating temperature (ETP). It is important to realize the ETP is the temperature at which the refrigerant gas evaporates (it does not include superheat).

It is equally important to note that the ETP of the DX coil will typically be 1°F to 2°F higher than the SST of the condensing unit. This is because as suction gas flows from the DX coil to the compressor, its pressure drops slightly and therefore, its temperature decreases by 1°F to 2°F. The evaporator coil ETP will typically be 45°F, if the ACCU SST is 43°F.

ETP's up to 50°F may be acceptable for certain applications, but humidity control becomes difficult at ETP's higher than 50°F. Likewise, design ETP's below 37°F can result in ice building up on the evaporator during periods of reduced load and should be avoided unless provisions are made for periodic coil defrost.

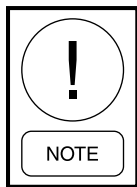
* ACCU Applies to YCUL and YLUA and other similar air cooled condensing units.

SYSTEM BALANCE POINT

It is essential to establish a system balance point between the ACCU and the DX evaporator coil. This balance point assures that both the ACCU and DX evaporator coil will provide the performance duty specified (as selected in YORKworks), and that the DX evaporator coil has been properly interfaced performance wise. There are two methods for determining and documenting the system balance point:

- Method #1 – Balance Point/Cross Plot Method
- Method#2 – Balance Point/Catalogued Data Method

Either method first requires a calculation of the suction line loss. Suction line loss can be determined by a thorough review of the piping (i.e. equivalent length Vs diameter used). This procedure is outlined in *SECTION 4 - PIPING*, under “Selecting Suction Lines” through “Suction Piping Penalty” which offers an example. Suction line penalties (or line loss) should not exceed a nominal 2°F.



As a rule of thumb, on short equivalent runs of say 75 feet you can use 1°F line loss for rough estimating purposes. On equivalent lengths between 75 – 150 feet, use a 1°F – 2°F ratio respectively. Again, these are rough estimated line loss only (always consult with Application Engineering over 150 equivalent feet).

METHOD #1 – BALANCE POINT/CROSS PLOT METHOD

A precise system balance point can be obtained by plotting the capacity of the DX coil versus the capacity of the condensing unit at various saturated temperatures. The point at which the two capacity lines cross is the system balance point.

The initial balance point of the system occurs where the saturated temperature of the condensing unit's capacity and the saturated suction temperature (SST) intersects with the DX coil's capacity and ETP. Thus, the condensing unit SST and the DX coil ETP are equal at this initial balance point without any consideration for suction line penalty.

For example, consider an approximate 50-ton R-22 system, using a “Solution” DX coil and YCUL0056EC condensing unit. The typical outdoor design temperature of 95°F is used in this example for the ACCU and being matched to a Solution DX coil cooling 18,000 CFM 80°F, EAT-DB and 67°F, EAT-WB with a 57.5" x 90", 4 row, 12 FPI, ½" aluminum fin coil.

ACCU Capacity Ratings

Since 95°F outdoor ambient temperature is typically used in many locations, capacity data can be taken from the Engineering Guide at several SSTs for the YCUL0056EC (e.g. R-22; 35°F SST/43.3 tons; 55°F SST/61.1 tons, as shown in *Figure 8 on page 22*).

The ACCU performance ratings are available from YORKworks as shown in *Figure 9 on page 23* and *Figure 10 on page 23*.

YCUL0056EC

AIR TEMPERATURE ON CONDENSER (°F)

SST (°F)	75°F			80°F			85°F			90°F			95°F			100°F		
	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER
35.0	47.8	40.1	12.6	46.7	42.2	11.7	45.6	44.5	10.9	44.5	47.0	10.2	43.3	49.6	9.4	42.0	52.4	8.7
37.0	49.6	40.4	12.9	48.5	42.5	12.1	47.3	44.8	11.3	46.1	47.3	10.5	44.0	49.9	9.7	43.6	52.7	9.0
39.0	51.4	40.8	13.3	50.3	42.9	12.4	49.1	45.1	11.6	47.8	47.6	10.8	46.5	50.3	10.0	45.2	53.1	9.2
41.0	53.3	41.1	13.7	52.1	43.2	12.8	50.9	45.5	11.9	49.6	47.9	11.1	48.2	50.6	10.3	46.9	53.4	9.5
43.0	55.2	41.4	14.1	54.0	43.5	13.2	52.7	45.8	12.3	51.3	48.3	11.4	50.0	50.9	10.6	48.6	53.8	9.8
45.0	57.2	41.8	14.5	55.9	43.9	13.5	54.5	46.2	12.6	53.2	46.6	11.8	51.7	51.3	10.9	50.3	54.1	10.1
47.0	59.2	42.2	14.9	57.8	44.3	13.9	56.4	46.5	13.0	55.0	49.0	12.1	53.5	51.7	11.2	52.0	54.5	10.4
49.0	61.2	42.6	15.3	59.8	44.6	14.3	58.4	46.9	13.3	56.9	49.4	12.4	55.4	52.0	11.5	53.8	54.9	10.7
51.0	63.3	43.0	15.6	61.8	45.0	14.7	60.4	47.3	13.7	58.8	49.8	12.8	57.2	52.4	11.8	55.7	55.3	11.0
53.0	65.5	43.4	16.0	63.9	45.4	15.0	62.4	47.7	14.0	60.8	50.1	13.1	59.2	52.8	12.2	57.5	55.7	11.3
55.0	67.6	43.8	16.4	66.1	45.9	15.4	64.4	48.1	14.4	62.8	50.6	13.4	61.1	53.2	12.5	59.4	56.1	11.6

Typical OAT

FIGURE 8 - CONDENSING UNIT CAPACITY AT 95° F (EXAMPLE FOR R-22)



Air Cooled Scroll Condensing Unit Performance Specification

BY JOHNSON CONTROLS

Unit Tag	Qty	Model No.	Capacity (Tons)	Volts/Ph/Hz	Refrigerant
	1		43.3	460/3/60	R-22
Pin No: YCUL0056EC46XCASXXXXXXLXXXX35XXXXXXXXXXXXXXXXXXXXXXXXXXXX					

Evaporator Data		Condenser Date		Performance Data	
SST (°F)	35.0	Ambient Temp. (°F)	95.0	EER	9.4
		Altitude (ft.)	0.0	NPLV	13.6
				Rigging Wt. (lbs.)	4057.0
				Operating Wt. (lbs.)	4057.0
				Pumping Down (gal.)	58.4

Electrical Data				
Circuit	1	2	3	4
Compressor RLA	19.9/19.9	19.9/19.9		
Compressor Start Current (LRA)	167.0/167.0	167.0/167.0		
Fan FLA (each)	4.0	4.0		

Single Point				
Min. Circuit Ampacity	101.0			
Min. Non-Fused Disconnect (Amps)	150.0			
Min. Dual Element Fuse Size (Amps)	110.0			
Max. Dual Element Fuse Size (Amps)	110.0			
Min. Circuit Breaker (Amps)	110.0			
Max. Circuit Breaker (Amps)	110.0			
Wire Range (Lug Size)	#10 - #1			

Total Amps	95.6	Inrush (PW) Amps	167.0	Starter Type	Across the Line
Compressor kW	49.6	Total Fan kW	5.6	Total kW	55.2

Notes:

FIGURE 9 - YORKWORKS CAPACITY RATING AT 95°F AIR TEMPERATURE AND 35°F SST



Air Cooled Scroll Condensing Unit Performance Specification

BY JOHNSON CONTROLS

Unit Tag	Qty	Model No.	Capacity (Tons)	Volts/Ph/Hz	Refrigerant
	1		61.1	460/3/60	R-22
Pin No: YCUL0056EC46XCASXXXXXXLXXXX55XXXXXXXXXXXXXXXXXXXXXXXXXXXX					

Evaporator Data		Condenser Date		Performance Data	
SST (°F)	55.0	Ambient Temp. (°F)	95.0	EER	12.5
		Altitude (ft.)	0.0	NPLV	17.9
				Rigging Wt. (lbs.)	4057.0
				Operating Wt. (lbs.)	4057.0
				Pumping Down (gal.)	58.4

Electrical Data				
Circuit	1	2	3	4
Compressor RLA	19.9/19.9	19.9/19.9		
Compressor Start Current (LRA)	167.0/167.0	167.0/167.0		
Fan FLA (each)	4.0	4.0		

Single Point				
Min. Circuit Ampacity	101.0			
Min. Non-Fused Disconnect (Amps)	150.0			
Min. Dual Element Fuse Size (Amps)	110.0			
Max. Dual Element Fuse Size (Amps)	110.0			
Min. Circuit Breaker (Amps)	110.0			
Max. Circuit Breaker (Amps)	110.0			
Wire Range (Lug Size)	#10 - #1			

Total Amps	95.6	Inrush (PW) Amps	167.0	Starter Type	Across the Line
Compressor kW	53.2	Total Fan kW	5.6	Total kW	58.8

Notes:

FIGURE 10 - YORKWORKS CAPACITY RATING AT 95°F AIR TEMPERATURE AND 55°F SST

SMALL TONNAGE
SCROLL CHILLER RATINGDXCHILLF
Jan 10, 2003
REV. v4_30.yau
Issue date: 12/02

EXCLUSIVELY FOR: CROSS PLOT DATA EXAMPLE

JOB NAME: AIR COOLED CONDENSING UNIT SATURATED SUCTION PERFORMANCE

MODEL YCUL0056EC VOLTAGE 460-3-60 REFRIGERANT R22
UNIT
TONS 43.3 TOTAL KW = COMPRESSOR 49.6 + FANS 5.6 = 55.2 EER 9.4

SATURATED SUCTION TEMP SYSTEM 1 35.0 F
SYSTEM 2 35.0 F

CONDENSER: DESIGN AIR TEMPERATURE 95.0 F. ALTITUDE 0. FT

FANS IN OPERATION 4 TOTAL CFM 47360.

CONDENSER TEMP SYSTEM 1 117.1 F
SYSTEM 2 117.1 F

FIGURE 11 - DX CHILL CAPACITY RATING AT 95°F AIR TEMPERATURE AND 35°F SSTSMALL TONNAGE
SCROLL CHILLER RATINGDXCHILLF
Jan 10, 2003
REV. v4_30.yau
Issue date: 12/02

EXCLUSIVELY FOR: CROSS PLOT DATA EXAMPLE

JOB NAME: AIR COOLED CONDENSING UNIT SATURATED SUCTION PERFORMANCE

MODEL YCUL0056EC VOLTAGE 460-3-60 REFRIGERANT R22
UNIT
TONS 61.1 TOTAL KW = COMPRESSOR 53.2 + FANS 5.6 = 58.8 EER 12.5

SATURATED SUCTION TEMP SYSTEM 1 55.0 F
SYSTEM 2 55.0 F

CONDENSER: DESIGN AIR TEMPERATURE 95.0 F. ALTITUDE 0. FT

FANS IN OPERATION 4 TOTAL CFM 47360.

CONDENSER TEMP SYSTEM 1 123.5 F
SYSTEM 2 123.5 F

FIGURE 12 - DX CHILL CAPACITY RATING AT 95°F AIR TEMPERATURE AND 55°F SST

The same performance could be provided from the *dx-chill* computer program, as shown in *Figure 11 on page 24* and *Figure 12 on page 24* for 35°F and 55°F SSTs.

The ACCU data points (from either the Engineering Guide chart, YORKworks or the dxchill computer rating) can be used to construct the condensing unit cross plot.

Solution DX Coil Capacity Ratings

The YORKworks program is used to obtain a typical rating. In this case, a “Solution” with 4 row, 12 fins per inch DX coil was rated. The YORKworks performance specifications are shown in *Figure 13 on page 25* and *Figure 14 on page 25* for the entering air temperature of 80°F dry bulb/67°F wet bulb with 37°F and 49°F suction ETP's. These data points can be used to construct the DX coil cross plot in *Figure 15 on page 26*.



BY JOHNSON CONTROLS

LOOSE COIL PERFORMANCE SPECIFICATION

Unit Tag	Quantity	Coil Type	Air Flow (cfm)	Function
Solution	1	BDX (DX)	18000	Rate

Input Data				
General		Air Side		Fluid Side
Application:	Cooling	Altitude (ft.):	0	Refrigeration
Tube Diameter:	1/2"	Air Flow (cfm)	18000	Suction Temp. (°F)
Tube Wall Thickness:	0.016"	Face Velocity (ft/min):	501	No. Distributors:
Casing Material:	Galvanized Steel	EAT-DB (°F):	80.0	Capacity Split:
Fin Material:	Aluminum	EAT-WB (°F):	67.0	Ref. Vol. (ft. ³):
Fin Thickness:	0.006"	Max. APD (in. w.g):	2.00	
Fin Height:	57.50"	Req. LAT-WB (°F)	n/a	
Fin Length:	90"	Req. TMBH	n/a	
Dry Weight (lbs):	385.7			
Note: Coil is not coated				

Output Data				
General		Air Side Performance		Fluid Side Performance
Rows:	4	LAT-DB (°F):	50.51	RPD (PSI):
FPI:	12	LAT-WB (°F)	49.65	6.7
No. of Circuits:	46	TMBH (°F)	910.0	
Suction:	2-1/8"	SMBH	574.2	
Liquid:	1-3/8" and 1-3/8"	APD (in. w.g):	0.45	
Distributor(s): 1126-11-5/16-25-30(ASC-11-7),1126-12-5/16-25-34				

Note(s): All water, R22 DX and steam coils are certified in accordance to ARI Standard 410.

910.0 MBH/12 = 75.8 Tons

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FIGURE 13 - YORKWORKS "SOLUTION" RATING - ENTERING AIR TEMP. 80°F DB/67°F WB AND 37°F ST



BY JOHNSON CONTROLS

LOOSE COIL PERFORMANCE SPECIFICATION

Unit Tag	Quantity	Coil Type	Air Flow (cfm)	Function
Solution	1	BDX (DX)	18000	Rate

Input Data				
General		Air Side		Fluid Side
Application:	Cooling	Altitude (ft.):	0	Refrigeration
Tube Diameter:	1/2"	Air Flow (cfm)	18000	Suction Temp. (°F)
Tube Wall Thickness:	0.016"	Face Velocity (ft/min):	501	No. Distributors:
Casing Material:	Galvanized Steel	EAT-DB (°F):	80.0	Capacity Split:
Fin Material:	Aluminum	EAT-WB (°F):	67.0	Ref. Vol. (ft. ³):
Fin Thickness:	0.006"	Max. APD (in. w.g):	2.00	
Fin Height:	57.50"	Req. LAT-WB (°F)	n/a	
Fin Length:	90"	Req. TMBH	n/a	
Dry Weight (lbs):	385.7			
Note: Coil is not coated				

Output Data				
General		Air Side Performance		Fluid Side Performance
Rows:	4	LAT-DB (°F):	57.34	RPD (PSI):
FPI:	12	LAT-WB (°F)	56.30	2.3
No. of Circuits:	46	TMBH (°F)	592.1	
Suction:	2-1/8"	SMBH	437.9	
Liquid:	1-1/8" and 1-1/8"	APD (in. w.g):	0.44	
Distributor(s): 1116-11-1/4-15-30(ASC-9-5),1116-12-1/4-15-34				

Note(s): All water, R22 DX and steam coils are certified in accordance to ARI Standard 410.

592.1 MBH/12 = 49.3 Tons

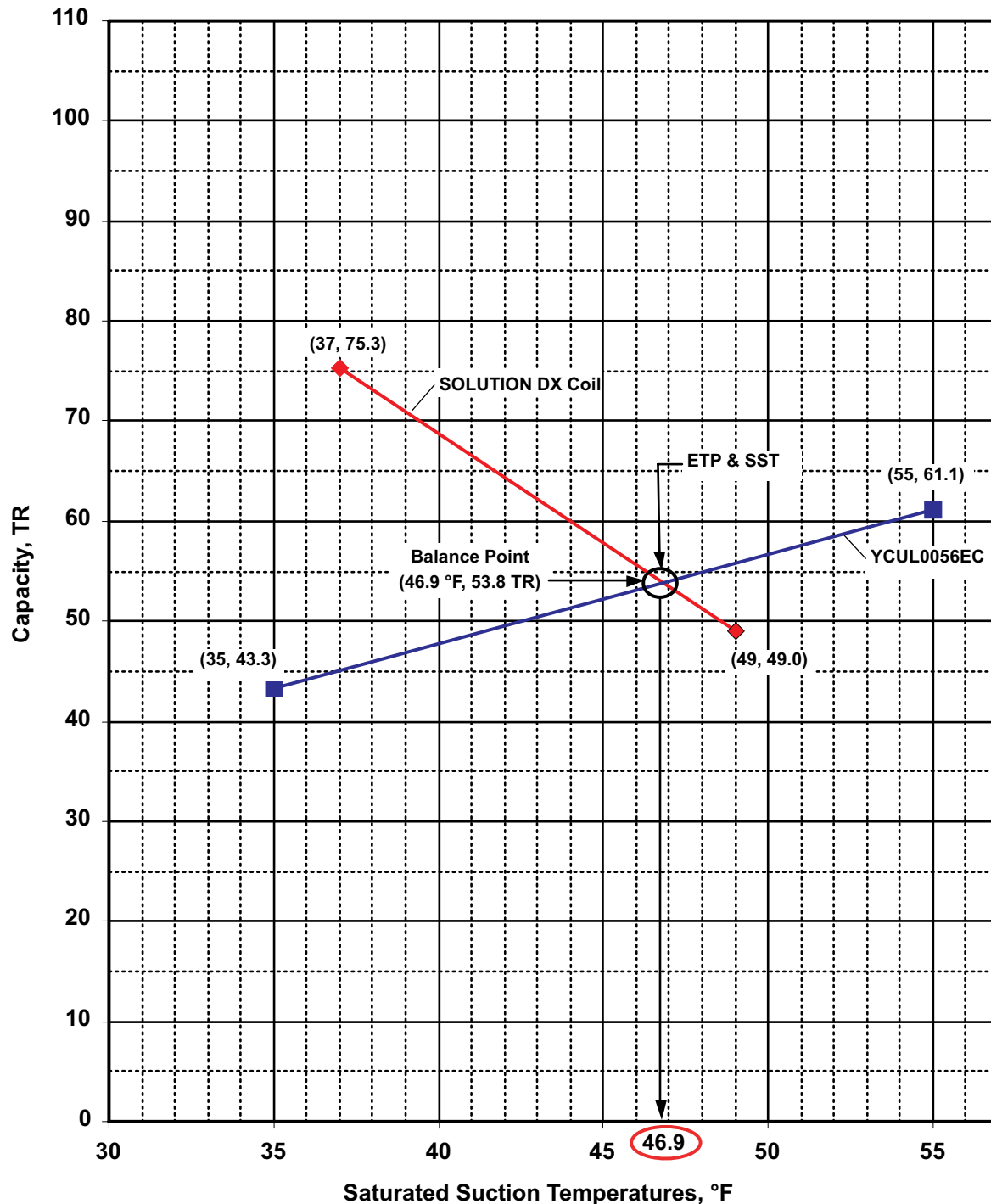
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FIGURE 14 - YORKWORKS "SOLUTION" RATING - ENTERING AIR TEMP. 80°F DB/67°F WB AND 49°F ST

ACCU and DX Coil Balance Point Without Suction Line Penalty

When the capacities of the ACCU and Solution DX coil are plotted (*Figure 15 on page 26*), the balance

point occurs at 53.8 tons and 46.9°F (SST and ETP*) saturated temperature. This following cross plot does not take the suction line penalty (losses) into account.

ACCU/DX Coil Cross Plots - Without Suction Line Losses

LD09139

FIGURE 15 - ACCU/DX COIL CROSS PLOTS - WITHOUT SUCTION LINE LOSSES (SHOWN FOR R-22)

*Both SST and ETP (*saturated evaporating temperature*) represent the actual design pressure/temperature relationship of the refrigerant (by definition, when refrigerant liquid and vapor exist together, the condition is known as “saturated”). “ETP” indicates the DX coil saturated evaporating temperature, while “SST” represents the ACCU design saturated suction temperature taking “line loss” into account. (*Reference Figure 16: 46.9°F ETP – 2°F Line Loss = 44.9°F SST ACCU Design*).

ACCU and DX Coil Adjusted Balance Point After Suction Line Penalty

After the ETP has been determined from the cross plot, the suction line penalty (which is typically 1°F to 2°F) is subtracted from the ETP. To determine the adjusted balance point, follow the steps below.

1. From the intersection of the ETP and SST, proceed vertically down to the °F saturated temperature axis.
2. Then proceed horizontally 2°F to the left due to the suction line penalty.

3. Next proceed vertically up to intersect with the ACCU plot. This is the adjusted balance point after the suction line penalty.

Plotting a line through this point and in parallel to the initial DX coil line provides the new “system” line. The adjusted balance point occurs at 52.0 tons capacity for the 44.9°F ACCU SST. This results in about a 3% reduction in system capacity. This provides a balance point in the 40°F to 45°F range, which is preferred for both constant volume and variable air volume applications (see *Figure 16 on page 27*).

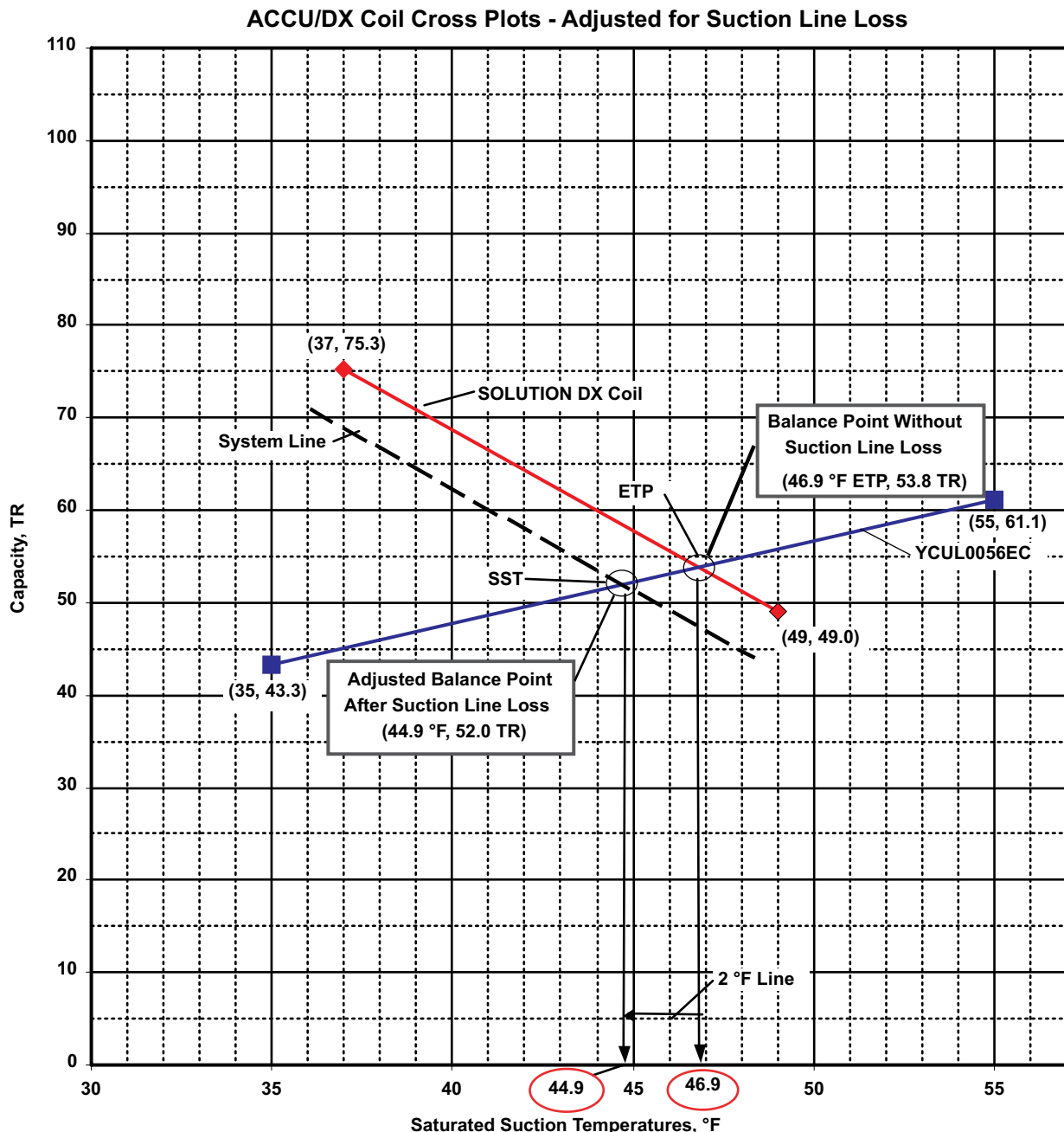
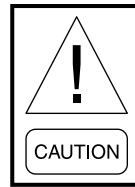


FIGURE 16 - ACCU/DX COIL CROSS PLOTS - ADJUSTED FOR SUCTION LINE LOSS (SHOWN FOR R-22)

Summary

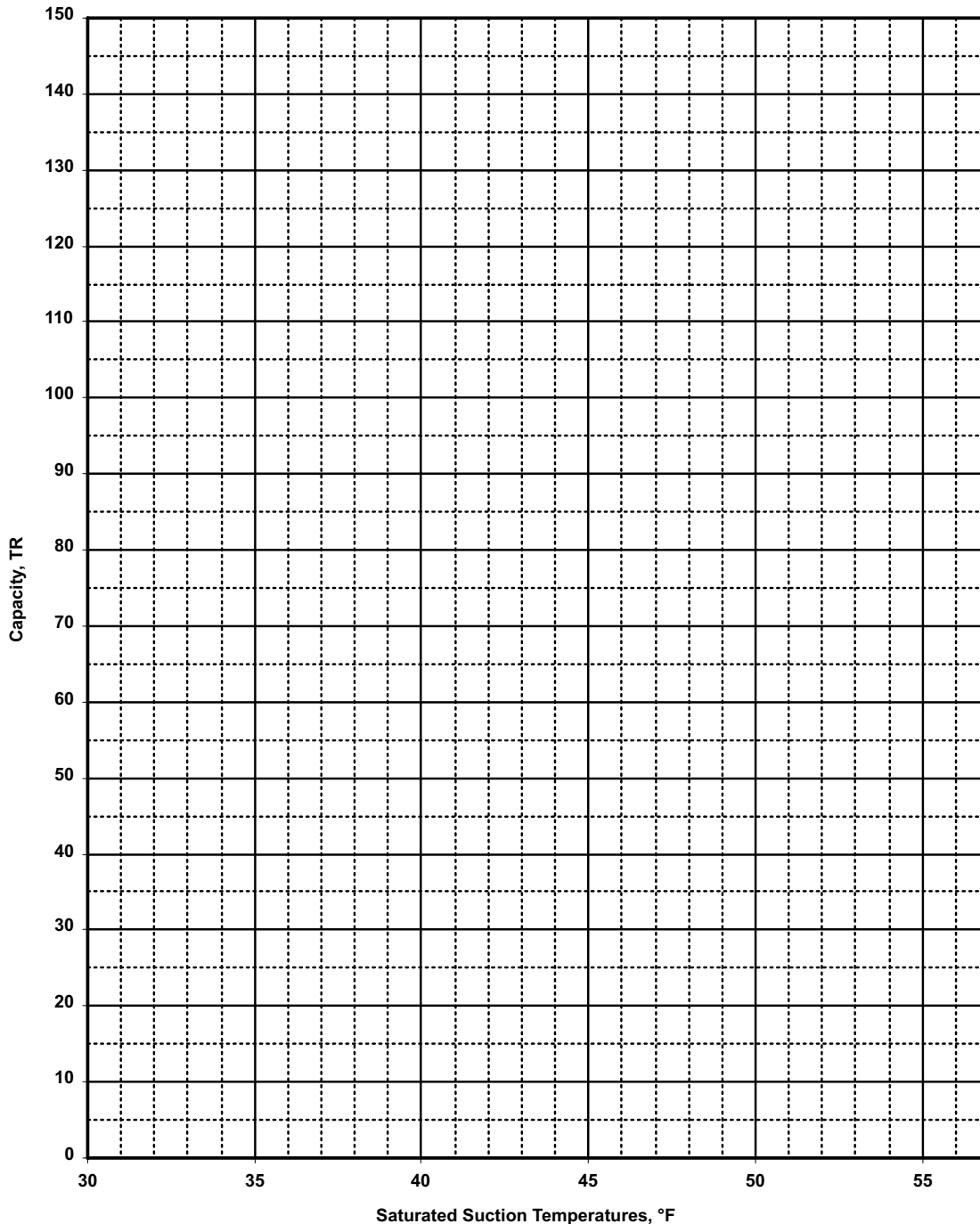
A final evaluation of this cross plot shows this YCU-L0056EC and Solution coil adjusted balance point is satisfactory. This provides a SST balance point in the desirable 40°F to 45°F range. If the balance point is below 40°F, consideration needs to be given to selecting a larger coil to raise the balance point.



Over-sizing the DX coil and distributor will cause poor refrigerant distribution within the DX coil, which will cause the TXV control to become unstable. This will result in liquid slugging and compressor failures.

Blank Graph

The blank graph below is included to perform cross plots.



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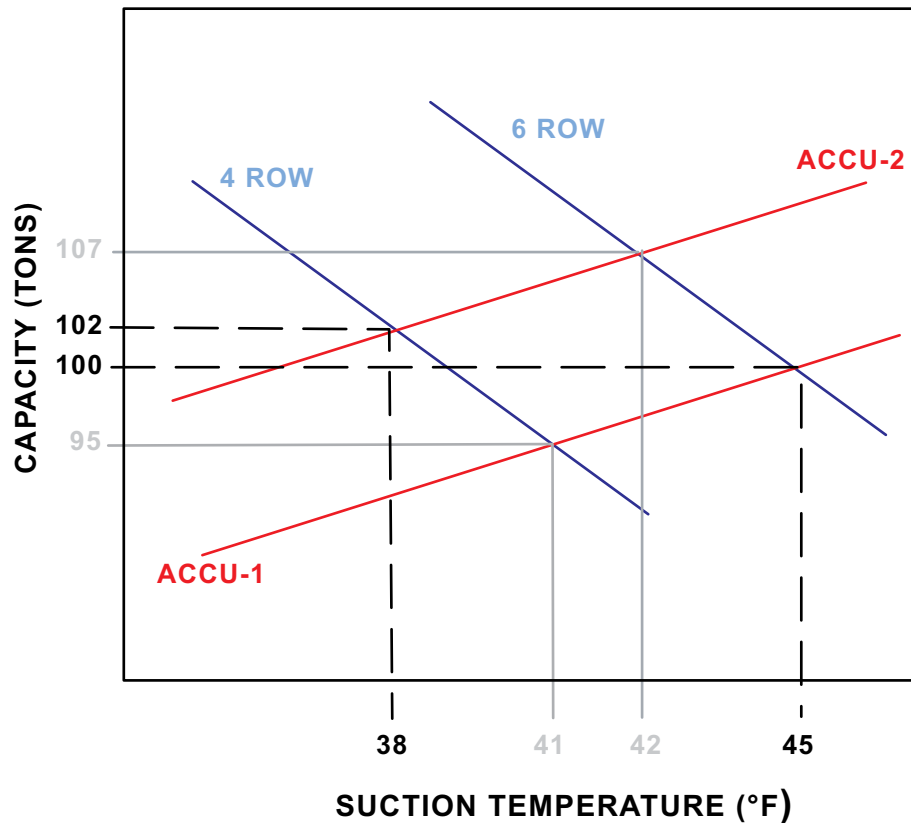
FIGURE 17 - ACCU/DX COIL CROSS PLOTS

SYSTEM COMPARISON CONSIDERATION

If the desired capacity falls between two condensing unit sizes, it is preferable to use the smaller condensing unit. For example, it may be possible to achieve a capacity of 100 tons with more than one condensing unit-DX coil combination. *Figure 18 on page 29* shows that a small condensing unit coupled with a deep (6-Row) cooling coil at a higher SST will provide nearly the same capacity as a larger condensing unit coupled with a shallower (4-row) coil at a lower suction temperature.

In this example, the smaller condensing unit (ACCU-1) and the 6-row coil should be selected. This will result in a more acceptable suction temperature of 45°F rather than 38°F. The benefits of using a higher suction temperature include:

- Lower unit first cost;
- Better full load efficiency with higher condensing unit EER;
- Expanded part load flexibility with VAV systems by moving the system balance point away from region of potential coil freeze-up;
- Better humidity control and reduced compressor cycling.



LD09142

FIGURE 18 - CAPACITY COMPARISON OF CONDENSING UNITS/COILS

**METHOD #2 – BALANCE POINT/
CATALOGUED DATA METHOD**

As an alternate to Method #1 Cross Plot, you can achieve virtually the same cross plot data by using the Method #2, **Catalogued Data Method**. This is a two step method utilizing the Engineering Guide “Ratings Data”, and the design DX coil run from **Solution YORKworks** (or **Loose Coils** in YORKworks), also taking into account the suction line loss.

The following offers an example using the same design as in Method #1:

Step 1 – Using the Engineering Guide “Ratings”, pick a ACCU that can handle the tons load specified* (example: 52 Tons). In this case we will use the same R-22 YCUL0056EC Air Cooled Condensing Unit at 95°F ambient, as selected in Method #1. The resultant SST of the ACCU through interpolation is 45.3°F as referenced in *Figure 19 on page 30*.

YCUL0056EC

SST (°F)	AIR TEMPERATURE ON CONDENSER (°F)																	
	75°F			80°F			85°F			90°F			95°F			100°F		
	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER
35.0	47.8	40.1	12.6	46.7	42.2	11.7	45.6	44.5	10.9	44.5	47.0	10.2	43.3	49.6	9.4	42.0	52.4	8.7
37.0	49.6	40.4	12.9	48.5	42.5	12.1	47.3	44.8	11.3	46.1	47.3	10.5	44.9	49.9	9.7	43.6	52.7	9.0
39.0	51.4	40.8	13.3	50.3	42.9	12.4	49.1	45.1	11.6	47.8	47.6	10.8	46.5	50.3	10.0	45.2	53.1	9.2
41.0	53.3	41.1	13.7	52.1	43.2	12.8	50.9	45.5	11.9	49.6	47.9	11.1	48.2	50.6	10.3	46.9	53.4	9.5
43.0	55.2	41.4	14.1	54.0	43.5	13.2	52.7	45.8	12.3	51.3	48.3	11.4	50.0	50.9	10.6	48.6	53.8	9.8
45.0	57.2	41.8	14.5	55.9	43.9	13.5	54.5	46.2	12.6	53.2	48.6	11.8	51.7	51.3	10.9	50.3	54.1	10.1
47.0	59.2	42.2	14.9	57.8	44.3	13.9	56.4	46.5	12.9	55.0	49.0	12.1	53.5	51.7	11.2	52.0	54.5	10.4
49.0	61.2	42.6	15.3	59.8	44.8	14.3	58.4	46.9	13.2	56.8	49.3	12.4	55.4	52.0	11.5	53.8	54.9	10.7
51.0	63.3	43.0	15.6	61.8	45.0	14.7	60.4	47.3	13.5	58.8	49.6	12.8	57.2	52.4	11.8	55.7	55.3	11.0
53.0	65.5	43.4	16.0	63.9	45.4	15.0	62.5	47.7	13.8	60.2	50.1	13.1	59.2	52.8	12.2	57.5	55.7	11.3
55.0	67.6	43.8	16.4	66.1	45.9	15.4	64.6	48.1	14.1	62.4	50.6	13.4	61.1	53.2	12.5	59.4	56.1	11.6

Interpolation
52 Tons =
45.3 SST

FIGURE 19 - ENGINEERING GUIDE (SHOWN FOR R-22)

Step 2 – Select the DX coil from YORKworks Solution Product or from Loose Coils using the ACCU design SST plus the line loss (i.e. 45.3°F SST + 2.0°F Line Loss = 47.3°F ETP (DX Coil Saturated Suction Temperature); at the design 52.0 ton load (The load in tons should match closely the specified EAT Vs LAT Vs CFM). See Example *Figure 20 on page 31*.

* As a rule-of-thumb (**ROT**), the ACCU design saturated suction temperature (SST) is a nominal 8°F to 10°F below the DX Coil Leaving Air Temperature

(LAT), “plus” any line loss (i.e. 56.1°F LAT – (8.8 °F **ROT** + 2 °F **Line Loss**) = a nominal 45.3°F SST at the ACCU. Obviously the **ROT** factor can vary beyond 8°F – 10°F, noting that a variance upward will produce lower operating saturated suction temperature/pressures; larger ACCU selections; and smaller row/fin DX coils while a variance downward will produce higher saturated suction pressure/temperatures; smaller ACCU selections; and larger row/fin DX coils.

2

YORKworks Report Viewer

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A JOHNSON CONTROLS COMPANY

LOOSE COIL PERFORMANCE SPECIFICATION

Unit Tag	Quantity	Coil Type	Air Flow (cfm)	Function
COIL-1	1	BDX (DX)	16520	Select

Input Data

General		Air Side		Fluid Side	
Application:	Cooling	Altitude (ft.):	0	Refrigerant:	R-22
Tube Diameter:	1/2"	Air Flow (cfm):	16520	Suction Temp.(°F):	47.3
Tube Wall Thickness:	0.016"	Face Velocity (ft/min):	526	No. Distributors:	4
Casing Material:	Galvanized Steel	EAT-DB (°F):	80.0	Capacity Split:	50-50
Fin Material:	Aluminum	EAT-WB (°F):	67.0	Ref. Vol. (ft.³):	3.41
Fin Thickness:	0.006"	Max. APD (in. w.g):	3.00		
Fin Height:	67.50"	Req. LAT-WB (°F):	35.0		
Fin Length:	67"	Req. TMBH:	n/a		
Connection Material:	Copper	Air Flow Direction	Horizontal		
Connection Type:	Sweat				
Dry Weight (lbs.):	606.6				

Note: Coil is not coated.

Output Data

General		Air Side Performance		Fluid Side Performance	
Rows:	8	LAT-DB (°F):	55.08	RPD (PSI):	2.7
FPI:	9	LAT-WB (°F):	54.55		
No. of Circuits:	54	TMBH:	624.3		
Suction:	2-1/8"	SMBH:	444.7		
Liquid:	1-1/8" and 1-1/8"	APD (in. w.g):	0.77		
Distributor(s): 1116-13-1/4-6-21-60(ASC-9-5), 1116-13-1/4-6-21-60 1116-14-1/4-8-23-56(ASC-9-5), 1116-14-1/4-8-23-56					

DX Note Distributor has 67% turn down ... Auxiliary side connectors for hot gas bypass are provided for one circuit only.

Note(s): All water, R-22 DX and steam coils are certified in accordance to ARI Standard 410.

FIGURE 20 - EXAMPLE FROM YORKWORKS LOOSE COILS PROGRAM (SHOWN FOR R-22)

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SECTION 3 - COIL SELECTION/CONFIGURATION

DX COIL TYPES

There are three basic types of coil arrangements used in field erected split systems in conjunction with the ACCU product.

Interlaced

Interlaced coils are the most desirable type of coil "field erected" designs. Interlaced coils ensure the entire face of the coil is active with any number of compressors operating. Interlaced circuitry interweaves coil tubing in both circuits across the entire face of the coil assuring uniform cooling of the air by the refrigerant. This type of coil also allows one circuit to operate while the other circuit is turned off. Interlaced coils provide excellent temperature control at full and part loads as well as good TXV superheat control. TXV control is essential for compressor reliability.

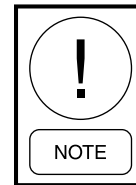
Row Split

Row split coils arrangements place coils back to back in the air stream. Air passes through one coil before passing through the next. Generally, the last coil in the air stream is activated first. Each circuit may be controlled independently in this arrangement. When both coils are operating, the coil closest to the leaving air will operate at a lower temperature. This type of coil may not permit lead lag of the circuits and it may be difficult to balance the capacity between the coils.

Face Split

On a face split coil, the circuiting is divided between two separate coils. In field erected systems, this arrangement may suffer from TXV superheat control problems and compressor reliability. At low airflow, low load situations, the TXV may have difficulty controlling system superheat.

Air stratification, poor humidity control and condensation on downstream components can also occur when using face split coils.

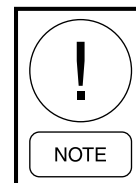


Face-split coils must be configured to provide full-face coverage. Any coil bank piped split-face will void the compressor warranty.

Face dampers have been known to be a compromised solution to split-faced coils when properly applied. However, face dampers offer challenges in terms of control and balancing the load with the CFM. Always contact Application Engineering for review and approval of any systems with face dampers. *Reference Figure 21 on page 33 for an example of face dampers.*

Combined Coil Types

Coil types may be combined in some systems. This requires special care. Control sequences and piping tying the multiple systems and coils together should be well thought out and advice from an experienced design engineer is necessary.



On any face damper arrangement, CFM (DX coil FV) as well as load must be interfaced and designed to assure the DX coil face damper is not closed when the coil is active, and face dampers, when closed, do not produce active face velocities that produce moisture carryover. Engineering design must be worked out before considering bidding this arrangement. Always consult with Application Engineering to validate the design.

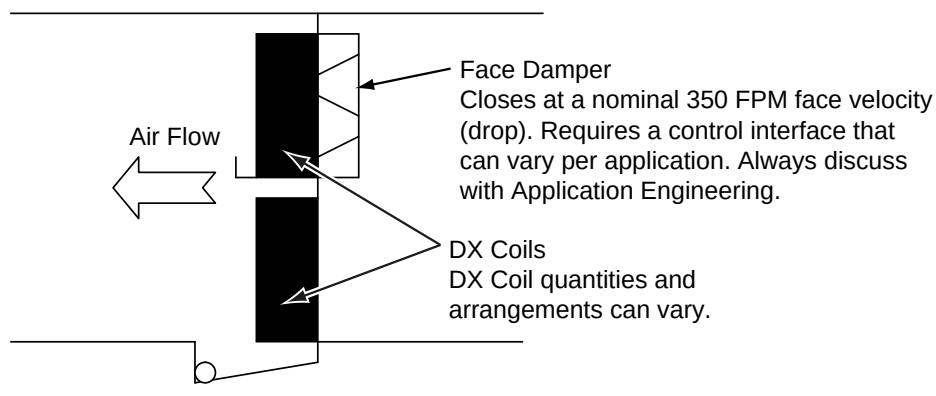
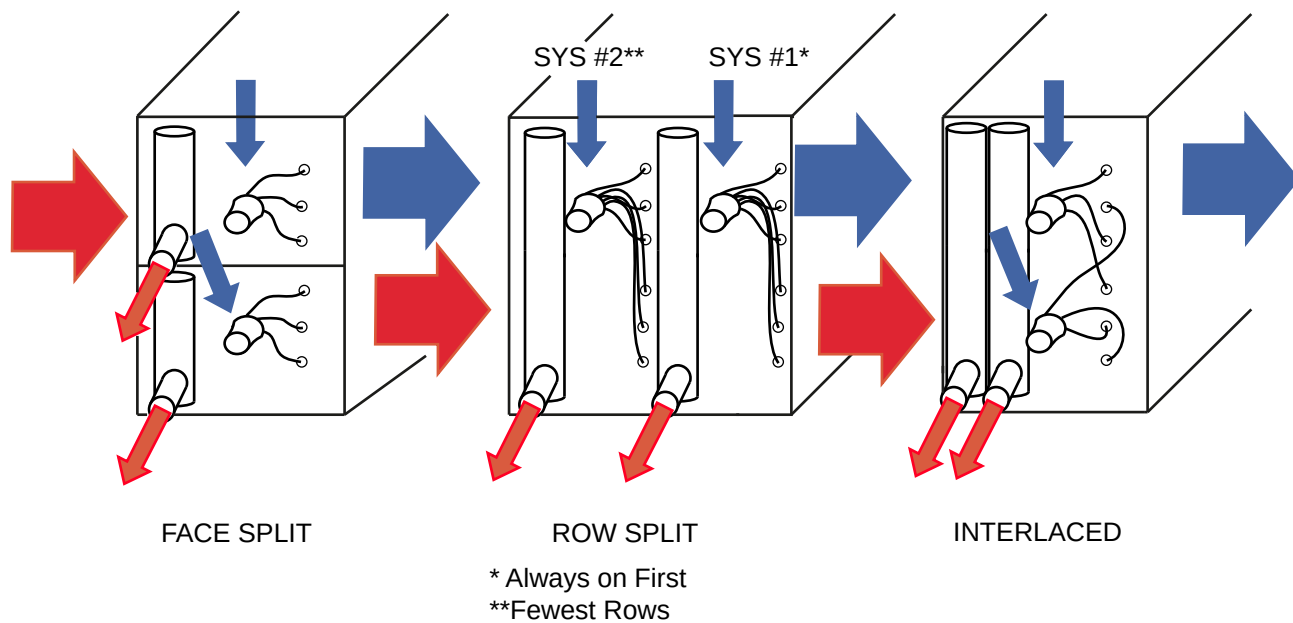


FIGURE 21 - FACE DAMPER EXAMPLE

Id13290



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FIGURE 22 - DX COIL CIRCUITING TYPES**ACCU to DX Coil, Circuiting Interface**

Always verify that the number of ACCU systems (or circuits) will properly interface with the DX coil circuit quantities and allow full face coverage. Any one system must operate through a single LLSV located just ahead of the TXV (or branch).

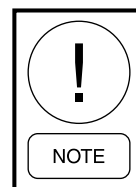
DX COIL CIRCUITING

On many coil banks, two, or even all three of the methods of circuiting may be combined depending upon the cooling capacity and the level of control required. However, coil sections must be married or combined so that they provide for full-face operation (see *Figure 22 on page 34*).

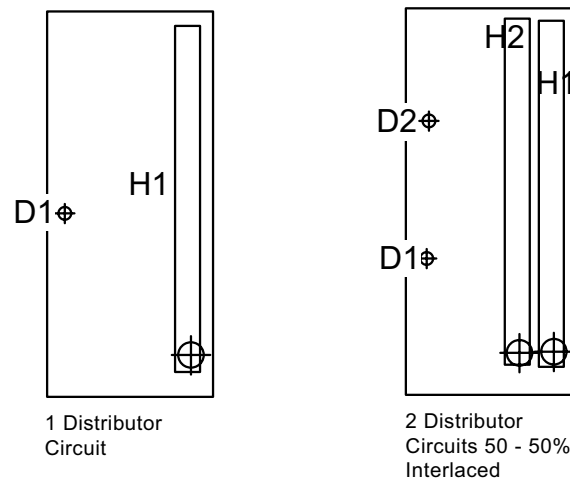
There are numerous arrangements selectable through YorkWorks (JCI Sales Selection Program). JCI Sales can also request special quotation designs through their factory Applications Engineering Group (Outside Designers can contact their local Sales JCI office to assist in this). The coil designs fall into the two following categories.

Coil Design	Fin Height
Non-tall/stacked	48" and less
Tall/stacked	Greater than 48"

Figures 23-27 illustrate the available coil arrangements. Contact coil marketing for other arrangements not shown.

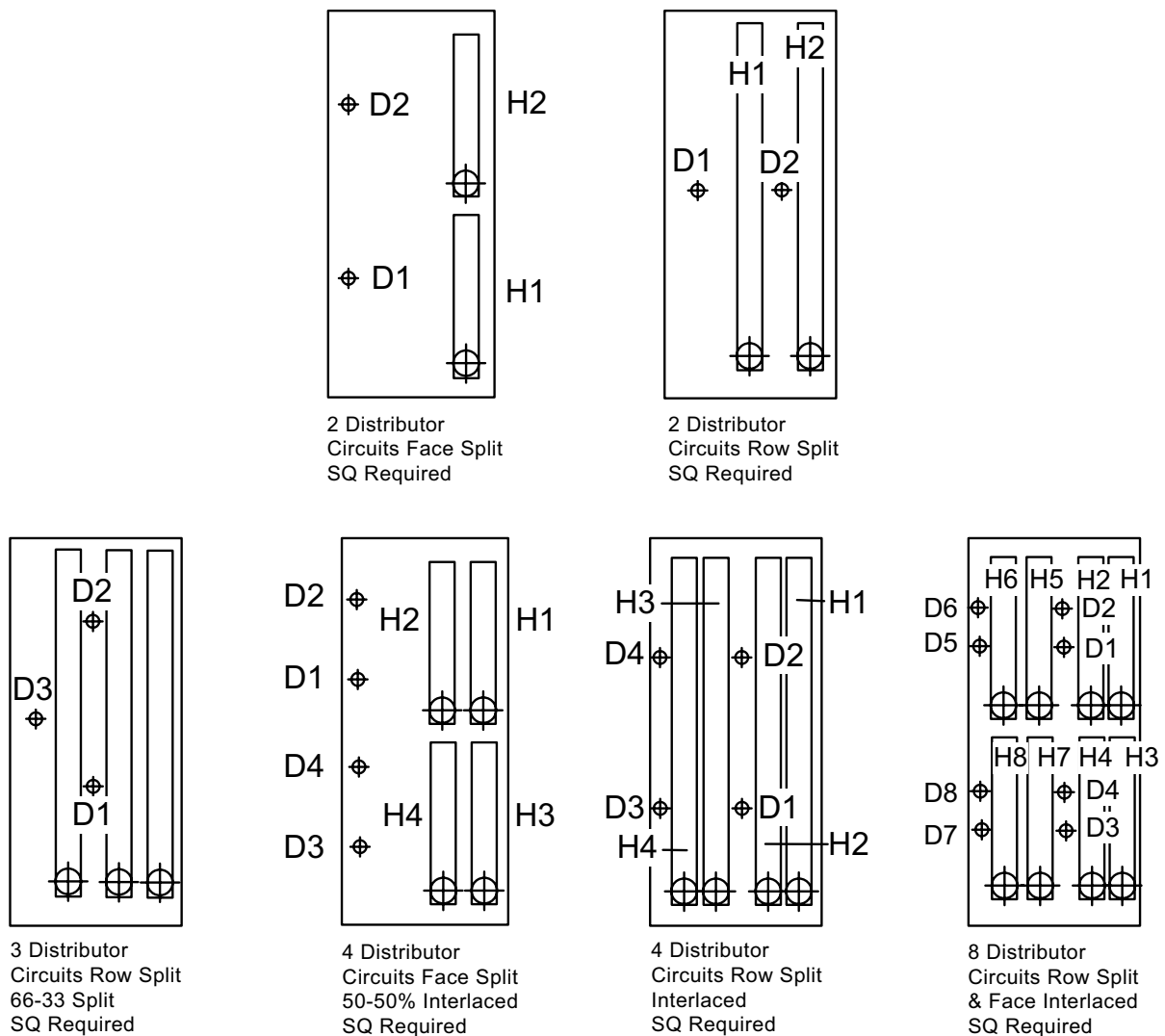


Face-split DX coils must be configured to provide full-face coverage at all condensing unit load steps. Johnson Controls assumes no responsibility for compressor failure if full-face coverage is not applied. Consult the factory, if application assistance is needed to convert split face to full-face operation.



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FIGURE 23 - NON-TALL/STACKED COIL DESIGN - STANDARD

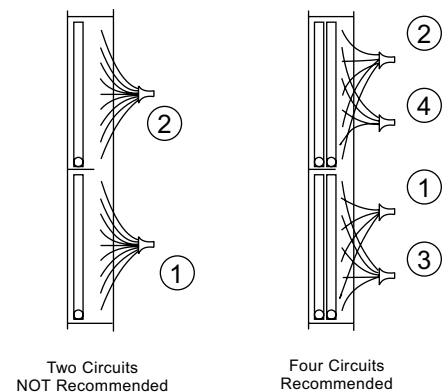


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FIGURE 24 - NON-TALL/STACKED COIL DESIGN - SQ SPECIAL (REQUIRES IN DEPTH INTERFACE WITH ACCU ALLOWING FULL FACE COVERAGE.)

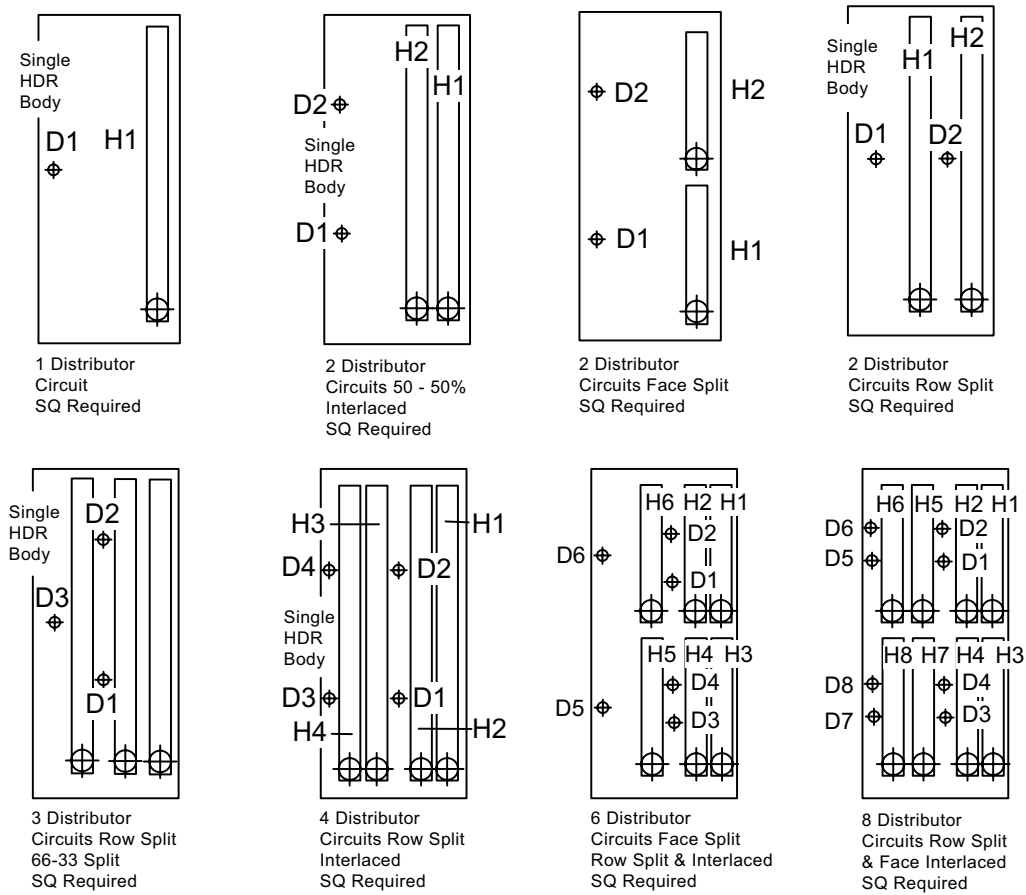
DX COIL CIRCUITING AND STAGING

On tall/stacked coils a minimum of four coil circuits should be used to achieve full-face control (*Figure 25 on page 35*). Each coil distributor circuit requires its own thermostatic expansion valve (TXV). Each condensing unit circuit requires its own liquid line solenoid valve (LLSV). When the condensing unit has two compressors per refrigerant circuit, either one or two coil circuits may be used for each refrigerant circuit depending upon the cooling capacity.



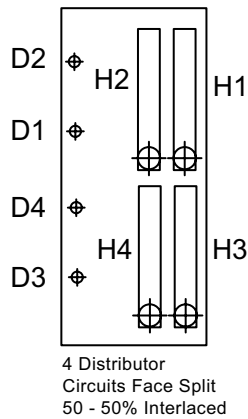
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FIGURE 25 - TALL/STACKED COIL CIRCUITING



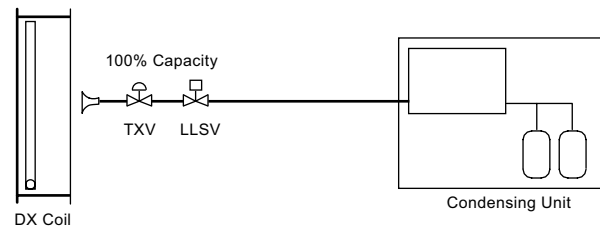
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FIGURE 26 - TALL/STACKED COIL DESIGNS - SQ SPECIAL (REQUIRES IN DEPTH INTERFACE WITH ACCU ALLOWING FULL FACE COVERAGE.)



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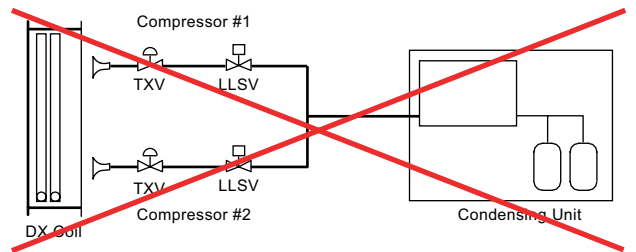
FIGURE 27 - TALL/STACKED COIL DESIGN - STANDARD



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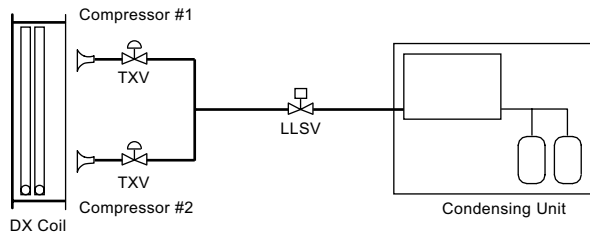
FIGURE 28 - ONE COIL CIRCUIT PER REFRIGERANT CIRCUIT

If one coil circuit is used (*Figure 28 on page 36*), the LLSV and TXV must be sized to handle the full capacity of the refrigerant circuit. When two coil circuits are used per refrigerant circuit (*Figure 29 on page 37*), each TXV should be sized to handle half of the capacity of the refrigerant circuit and the LLSV should be sized to handle the full capacity of the refrigerant circuit.



Do NOT use the above configuration.

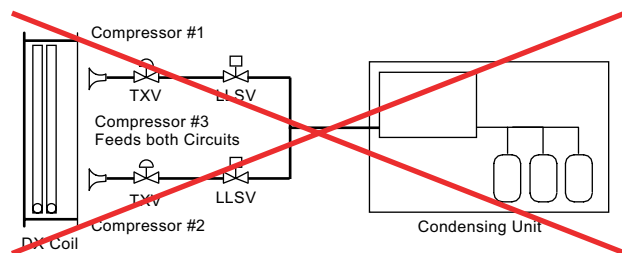
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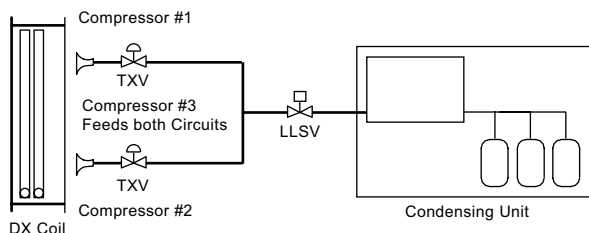
**FIGURE 29 - TWO COIL CIRCUITS PER REFRIG-
ERANT CIRCUIT**

When the condensing unit has three compressors per circuit, two coil circuits should be used for each refrigerant circuit (*Figure 30 on page 37*). Each coil circuit must have a dedicated TXV and distributor to handle one coil circuit and the LLSV should be sized to handle the full capacity of the refrigerant circuit. The hot gas bypass line should be connected to all of the distributors in the coil circuit.



Do NOT use the above configuration.

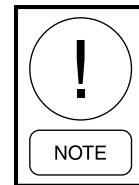
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FIGURE 30 - THREE COMPRESSOR ACCU

In the case of a tall/stacked coil with four coil circuits piped to a ACCU with six compressors, the coil circuits would be face-split and interlaced with two interlaced circuits on the lower coil section and two on the upper (Figure 31 on page 38).

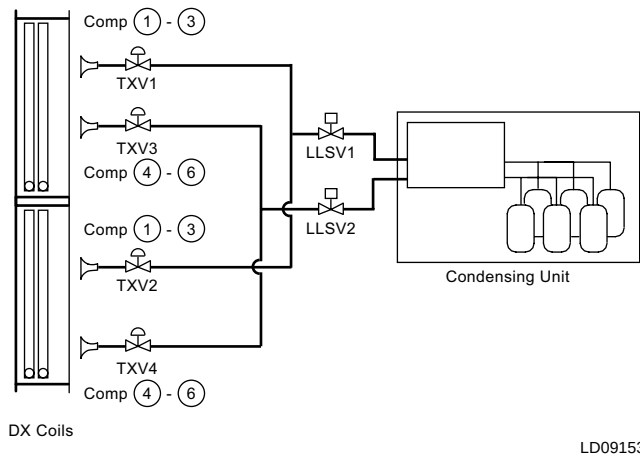


When sizing TXV's, each TXV must be sized for the refrigerant circuit tonnage divided by the number of DX coil liquid distributors. The TXV should be equal to or smaller than the calculated value.

The first three compressors (see *Figure 31 on page 38*) would be tied into LLSV1, TXV1 and TXV2. This would provide full-face control of the coil at even the lowest cooling loads. Both distributors on each of the coil circuits would include auxiliary side connectors for HGBP.

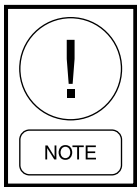
The second circuit of the ACCU would be tied into LLSV2, TXV3 and TXV4 to maintain full-face control at higher loads. *SECTION 9 - CONDENSING UNIT OPERATION* of this document contains more detailed information on compressor staging (Sequencing and Lead/Lag) for the various ACCU models.

The more control stages used, the more precise the control of the air temperature will be. Smaller incremental changes in capacity will result in a more consistent DX coil leaving air temperature. This will eliminate temperature swings in the conditioned space and improve the comfort level, but more importantly a consistent space temperature is crucial to many process applications. The smaller changes in capacity that result from using a greater number of control stages will also extend equipment life. The most important thing to remember is to maintain full-face control of the coil at all cooling loads. When row split coils are used, make sure that the first LLSV is energized with the last coil circuit in the leaving air stream. This is also always the last one de-energized.

**FIGURE 31 - SIX COMPRESSOR ACCU**

HOT GAS BYPASS

When using discharge air temperature control or systems with outside air economizer cooling, always include hot gas bypass (HGBP). It is not as critical to use HGBP with return duct air temperature control, or suction pressure control, but it provides better capacity control at low loads.

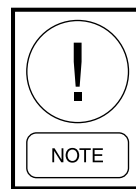


The HGBP line should be sized for 100% of the capacity of one compressor and the hot gas lines must be insulated. ACCU discharge head pressure control is required on hot gas bypass applications. At low ambient temperatures, the condensing unit is very efficient and there is very little hot gas available for capacity control. Discharge pressure control assures enough differential pressure to push sufficient hot gas from the high side to the low side of the system.

Typical distributors utilize a selectable nozzle versus the older venturi type. Either device requires the use of an auxiliary side connector (ASC) for introducing the hot gas into the system and mixing it with saturated liquid refrigerant just ahead of the distributor. Most distributors are ordered with an integral ASC. Where multiple coils are stacked (or side by side), and ASC must be provided on all coils for that ACCU system. When ASC's are field installed, the ASC must be located direct to the distributor, or a maximum of 2" to 3" away. Additionally, the side connection must be positioned upward to eliminate oil and refrigerant logging in the hot gas line when not in operation.

Hot gas must be fed to all coils to assure that full-face operation is achieved. Since all applications have job specific operating characteristics, the hot gas bypass valve setting must be field adjusted for the proper setting, after the system has been put into operation.

Hot gas piping must never be designed that traps liquid. If the hot gas line traps liquid during off periods, it will send a large slug of liquid into the DX coil when the hot gas is activated. This slug of liquid will not be fully evaporated in the DX coil and a liquid slug will be fed to the compressor, potentially causing damage. A hot gas line should be sloped so that it drains into the DX coil distributor from above the distributor, which also promotes oil return.



Local, state and federal energy standards such as ASHRAE 90.1 may limit the use of hot gas bypass in some applications. Be sure to consult local code requirements before installing the system.

All multiple HGBP auxiliary connections on a single circuit MUST include check valves as outlined on the cover of this guide. The use of these valves prevents one coil circuit from short circuiting to the other and influencing its operating pressure. This short circuiting produces unwanted TXV hunting and refrigerant over and under feed.

Check valves shall be refrigeration grade selected for suitable pressures involved. Valve bodies shall be constructed of copper with an integral check ball permitting flow only to the distributor (not reversed). Valves installed in the near horizontal must include a spring-loaded design. Valves must not exceed a 1 psi pressure drop at the design flow-tons for hot gas applications.

DX COIL DISTRIBUTOR NOZZLES

Distributor nozzles must be sized based on the capacity and suction temperature of the DX coil circuit and a pressure drop of approximately 25, 35 and 45 PSI: Respectively for R-22, R-407c and R-410a across the distributor nozzle to keep balance in the system. If a nozzle is oversized, it will over-feed some tubes in the DX coil and underfeed others.

MAINTAINING ADEQUATE AIRFLOW

An electrical interlock between the AHU and the ACCU must be included for permissive run of the ACCU. In addition, a differential pressure switch mounted across the supply fan must always be included to ensure air-

flow across the coil before the condensing unit is energized. The ACCU must never be operated unless the AHU fan is operating and air is flowing across the active coil. Insufficient airflow will result in liquid refrigerant returning to the condensing unit, which could damage the compressors by liquid slugging or washing oil from the bearing surfaces. In variable volume systems the minimum acceptable airflow for fixed speed or VAV systems is 350 FPM face velocity across each DX coil, as applied to split DX systems. (This may be slightly different for standardized factory packages such as packaged rooftops, which are designed, qualified and tested under more controlled conditions.) This is critical to assure that the TXV does not over-feed, causing compressor failure.

VAV SYSTEMS

Overhead variable air volume systems have been the preferred method of air distribution since the early 1970 's. Overhead VAV systems offered greater energy efficiency and better control of building diversity than constant volume systems. Unlike a constant volume system, in which the leaving air temperature is adjusted to satisfy the cooling load, in a VAV system the air temperature remains constant and the air volume is varied to meet the cooling requirements.

There are four basic components in a VAV system - an air-handling unit with airflow control (i.e., variable-speed drives), VAV boxes, zone thermostats and duct static pressure sensors. All of these components must work together to provide good temperature control and a comfortable environment. The zone thermostats control the VAV boxes. As the zone temperature increases, the VAV boxes open to allow greater airflow into the space and as the zone temperature decreases, the VAV boxes close to decrease the airflow to the space.

As the VAV boxes in the system open and close the static pressure in the ductwork changes. When a box opens, the duct static pressure decreases, and when a box closes, the duct static pressure increases. The duct static pressure sensor controls the air handling unit supply fan. Since an increase in duct pressure relates to a decrease in the zone airflow required, the

supply fan volume decreases in response. Conversely a lower duct static pressure indicates a need for increased zone airflow; therefore the supply fan volume increases in response. The change in supply air volume is accomplished using a variable frequency drive or similar device.

In the air-handling unit a decrease in airflow through the DX coil will result in a corresponding decrease in the suction gas pressure while an increase in airflow will result in an increase in the suction gas pressure. Since the system is designed to maintain a constant suction gas pressure, the compressors will be staged on or off as needed to meet the increase or decrease in load demand. The system should be designed to operate smoothly avoiding transients that could upset system balance and cause liquid flood back. Problems can arise if the airflow decreases more quickly than the compressor control can respond to the load change. Therefore, consideration and limitations must be given to VSD Accel/Decel times, with regard to extending the timing to a point that will accommodate proper chiller compressor cycling, system temperature swings, etc. This limitation will promote stable control of the Air Cooled Condensing Unit and minimize fluctuations in zone temperature. Review must also be given to VSD ramp-down speed with regard to smoke/fire damper closure, so as not to produce excessive duct pressures that can damage the AHU or system. Under any circumstances, a minimum of 350 FPM face velocity across the coil must be maintained for field erected DX split systems.

BUILDING AUTOMATION SYSTEM INTERFACE

Control schemes involving complex Building Automation Systems (BAS) are beyond the basic equipment or optional factory packaged design capabilities. In these cases, please contact the Field Support Center for assistance. This group provides solutions for expanded interfacing with a third party BAS. They can also solve unique sequencing challenges of the air handling unit and matching condensing unit combination. BAS control must adhere to all control guidelines outlined in this manual.

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SECTION 4 - PIPING

DX LINE SIZING RECOMMENDATIONS

The piping must conform to the local codes. *For the best pipe sizing and design practices, refer to either the information in this manual or the ASHRAE Refrigeration Handbook.* These contain refrigerant line sizing for full and minimum capacities and other pertinent engineering information for a wide application range. The tables listed below are presented for the 35, 45 and 55°F saturated suction temperatures, which are typical for these systems. The tables are included at the end of this manual in the Appendix.

- Table 23 – Suction Line Capacities in Tons for Refrigerant R-22**
- Table 24 – Discharge and Liquid Line Capacities in Tons for Refrigerant R-22**
- Table 25 – Suction Line Capacities in Tons for Refrigerant R-407c**
- Table 26 – Discharge and Liquid Line Capacities in Tons for Refrigerant R-407c**
- Table 27 – Suction Line Capacities in Tons for Refrigerant R-410c**
- Table 28 – Discharge and Liquid Line Capacities in Tons for Refrigerant R-410a**
- Table 29 – Minimum Refrigeration Capacity in Tons for Oil Entrainment Up Suction Risers (Type L Copper Tubing)**
- Table 30 – Minimum Refrigeration Capacity in Tons for Oil Entrainment Up Hot Gas Risers (Type L Copper Tubing)**
- Table 31 – Fitting Losses in Equivalent Feet of Pipe (Screwed, Welding, Flanged and Brazed Connections)**
- Table 32 – Special Fitting Losses in Equivalent Feet of Pipe (ASHRAE)**
- Table 33 – Valve Losses in Equivalent Feet of Pipe (ASHRAE)**
- Table 34 – Refrigerant Charge in Pounds Per 100 Feet of Suction Line**
- Table 35 – Refrigerant Charge in Pounds Per 100 Feet of Discharge Line**
- Table 36 – Refrigerant Charge in Pounds Per 100 Feet of Liquid Line**
- Table 37 – HGBP Quick Line Selection)**
- Table 38 – HGBP Line Sizing for R-22, R-407c and R-410a Refrigerants**

Keeping the condensing unit and air-handler as close together as possible is recommended. This is important for assuring oil return and compressor reliability.

It is also important that the total equivalent feet of piping be 150 feet or less (Always review IOM for maximum limitations).

ACTUAL PIPING ROUTING VERSUS ORIGINAL PIPING DESIGN

It is extremely important that the piping design on a ACCU system is correct to assure oil is returned and liquid slugging does not result. Often during installation, piping is not routed according to the original designer's specifications. Problems can often result when piping is rerouted around obstacles. Whenever a change is made to the routing of the piping, the installer should consult with the designer prior to making the change. This will assure that the change will not affect system oil return or cause liquid slugging.

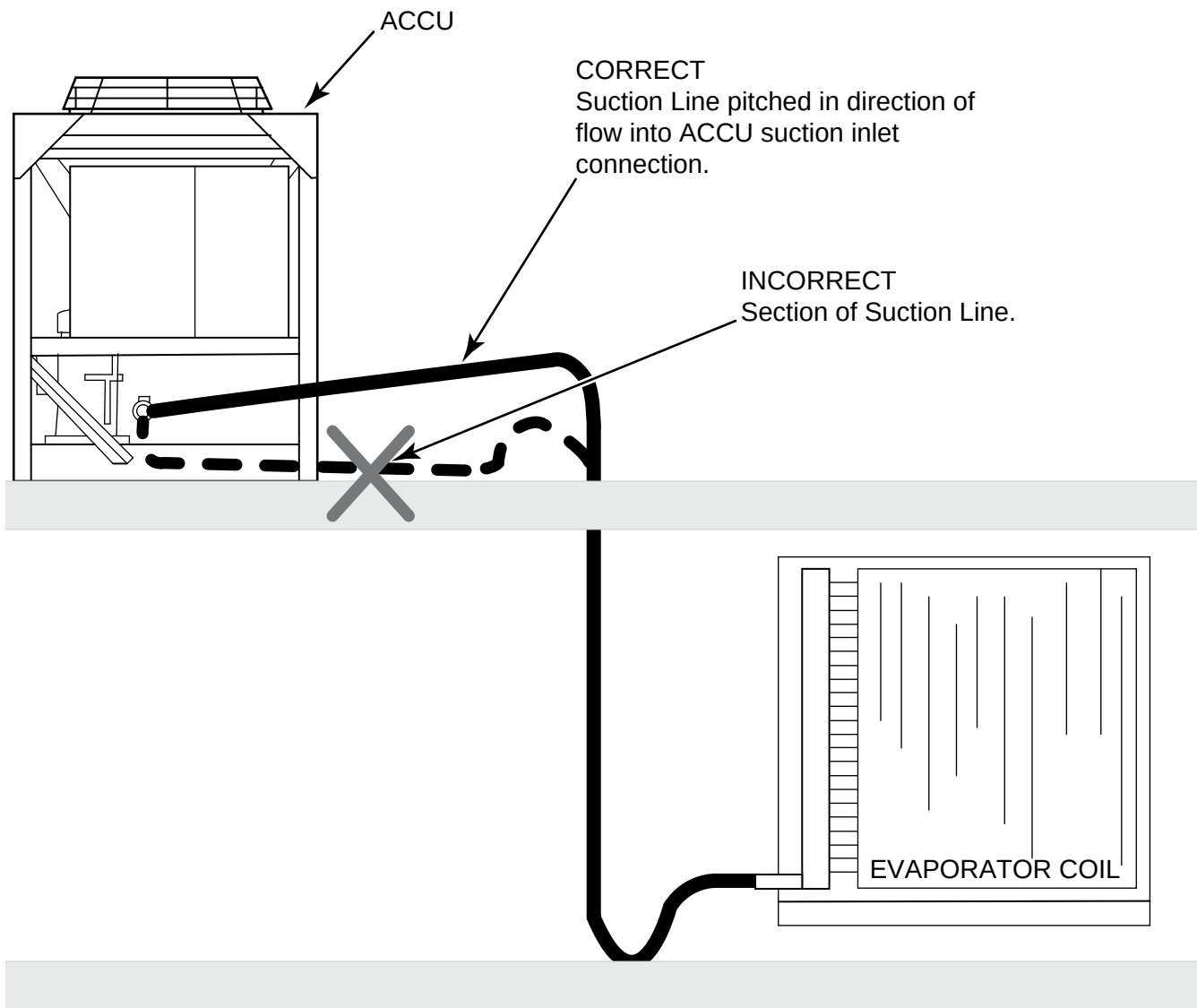
Proper refrigerant pipe selection and design is crucial for efficient and reliable operation of the refrigeration system. It is also important to keep liquid refrigerant/oil slugs from entering the compressor and for assuring oil return. Over-sizing the piping reduces the refrigerant pressure drop, but can inhibit oil return and adds unnecessary first cost. On the other hand, under-sizing the piping increases the refrigerant pressure drop, which affects system performance and lowers the efficiency.

For best results, use long radius elbows (short radius elbows have higher pressure drops) for everything except oil traps. Also, clean copper tubing for refrigeration and air conditioning application should be used throughout. Provisions must be made for piping contraction and expansion of 3/4" per 100' of pipe.

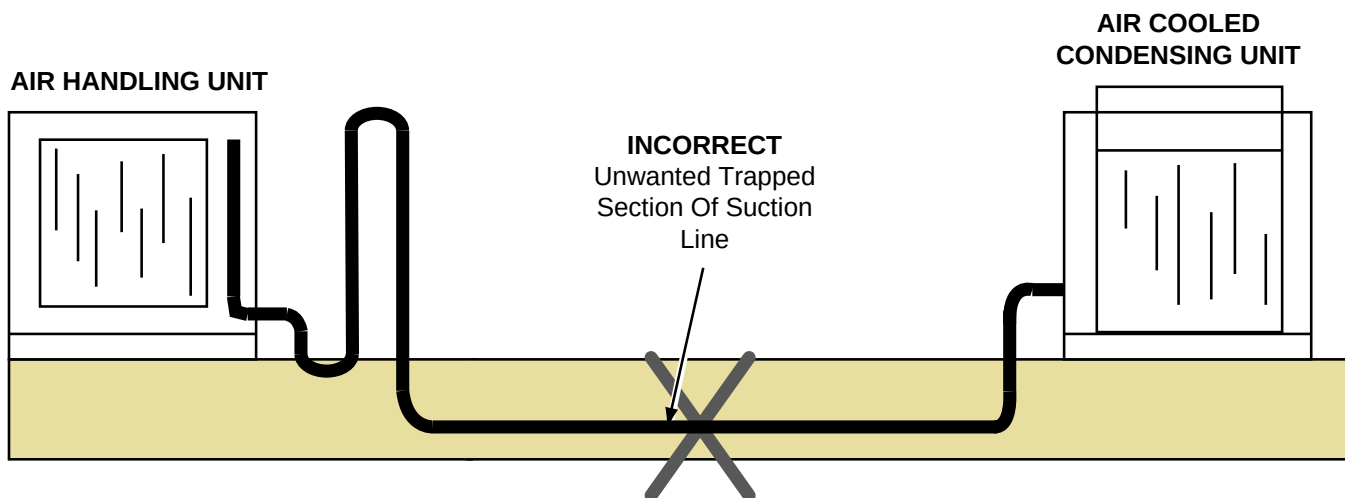
SUCTION LINES

Figure 21 on page 33 (see Appendix) shows suction line sizing recommendations, which are typically based on 2°F (nominal 3 PSI for R-22 and R-407c, and 4.5 PSI for R-410a) loss. As was illustrated in *SECTION 2 - EQUIPMENT SELECTION*, a typical 2°F drop in suction pressure can reduce the system capacity by about 3%. Therefore, it is good practice to design the suction piping with no more than a 2°F line loss at full load.

Additionally, care must be taken not to oversize the suction piping, because oil return can be compromised to the compressors. The horizontal suction line runs should be sloped 1/2" per 10 linear feet in the direction of refrigerant flow to promote moving oil toward the compressors. Trapped sections of the suction line must be avoided.

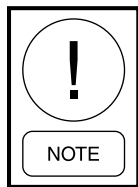


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FIGURE 32 - EXAMPLES OF CORRECT AND INCORRECT TRAPPED SECTIONS OF SUCTION LINE

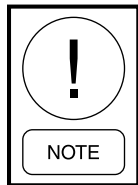
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FIGURE 33 - EXAMPLE OF NON-ACCEPTABLE UNDERGROUND (OR ABOVE GROUND) PIPING



Trapped sections of suction line must not be formed between the DX coil suction riser and the ACCU suction inlet. Suction lines should pitch directly into the Air Cooled Condensing Unit (ACCU) suction inlet. Also, lack of a riser just off the DX coil (where DX coil is above ACCU) can produce compressor crankcase oil dilution during the off cycle by allowing refrigerant vapor to condense and drain excessive liquid refrigerant into the compressor. Examples of “correct and incorrect trapped sections of suction line” are shown in Figure 32.

Oil and refrigerant, which condenses in the line during off periods, must drain into the compressor and will be boiled off by the compressor heater. This prevents oil and liquid refrigerant slugging of the compressors.



It is recommended that a suction line should never be run under ground. Underground runs cause problematic refrigerant condensation in suction lines and often create suction line traps. Always consult Application Engineering when underground piping is specified. Other means, above ground piping, should always be presented at the bidding stage.

Orders should never be accepted without underground piped details worked out, and having Application Engineering SQ (Special Quotation) acceptance. Figure 33 on page 42 offers an example of when underground piping is never acceptable.

Many systems require suction risers, because the DX coil is located at a lower level than the condensing unit. These suction risers must be sized to ensure oil entrainment up the riser at the lowest step of loading. In some cases double suction risers may be required. Refer to Table 29 on page 122 and Table 30 on page 123 (see Appendix) or the ASHRAE Refrigeration Handbook for oil return at the minimum STEP to find the minimum capacity which is required to maintain good oil entrainment for a given line size. Also, see *Determining the Need for Double Suction Risers* on Page 62.

All suction lines with a vertical rise exceeding 3' should have an oil trap at the bottom and top (inverted) of the riser. A maximum suction line rise of 40' is recommended (Always consult Application Engineering on risers over 40 feet). Any riser in excess of 20' should have a trap installed mid-way up the riser (e.g. 14' for a 28' total rise). An inverted trap should be placed at the top of a single suction riser. Use long radius elbows wherever possible, except when fabricating oil return traps at the bottom of the vertical riser, which should use short radius 45° street elbows. Short radius elbows will minimize the amount of oil trapped in the system. See Figure 34 on page 43.

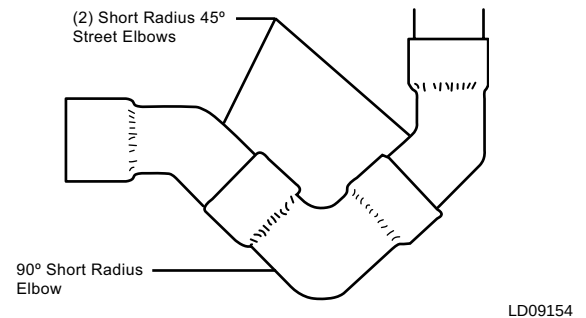


FIGURE 34 - SUCTION OIL LINE TRAP

If the DX coil is above the ACCU, the suction piping must rise above the top of the coil to form an inverted trap. See Figure 35 on page 43. The inverted trap will keep liquid refrigerant from condensing in the evaporator, during the off cycle, and draining into the compressors. An oil trap should be installed at the bottom of the vertical rise. This is recommended by expansion valve manufacturers to keep the oil away from the bulb during operation.

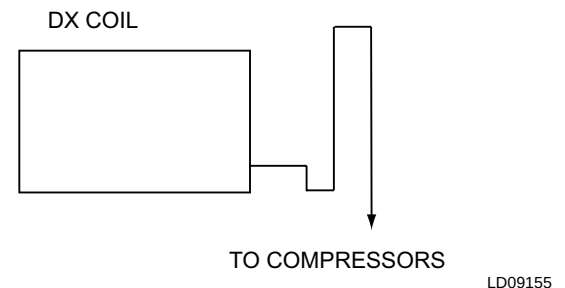


FIGURE 35 - PIPING WITH DX COIL ABOVE COMPRESSOR

LIQUID LINES

Table 24 on page 119 (see Appendix) provides liquid line sizing recommendations, which is typically based on 1°F (3 PSI) line loss for R-22 (3.5 PSI for R-407a and 4.75 PSI for R-410a). Liquid lines carry liquid refrigerant from the condensing unit to the DX coil. Liquid line routing is typically not as crucial as suction line routing, since oil is flowing with the liquid refrigerant, oil movement is not a problem. However, the line slope should always be in the direction of refrigerant flow to assure oil flow during off periods is toward the compressors. Pressure losses occur due to the filter drier, liquid line solenoid valve, sight glass, and friction in the piping. Typical pressure loss can be found in SECTION 6 - NECESSARY COMPONENTS for the liquid line solenoid valve, filter/drier, and sight glass.

If the pressure of the liquid refrigerant falls below its saturation temperature, some of the liquid will flash into vapor and bubbles will develop in the liquid. Such vapor bubbles cause the TXV to operate erratically, which reduces not only performance and capacity, but can cause reliability problems. Therefore, it is important that only liquid refrigerant reaches the TXV. To ensure this, the liquid refrigerant should be sub-cooled by 15-17°F, before it leaves the condenser. The sub-cooling should be adjusted when the ACCU is operating fully loaded at the 95°F ambient and saturated suction temperature design conditions. Keep in mind that lower ambient temperatures will reflect higher subcooling numbers.

The liquid line piping and components must be properly sized not to exceed 40 PSI for R-22, 47 PSI for R-407c, and 63 PSI for R-410a (maximum limits based on 11% safety at 15°F subcooling design). Liquid pressure drop (or gain) due to a vertical section of liquid line must be taken into consideration when determining total pressure drop (or gain) of the liquid line. The nominal value that must be included in the liquid line loss (or gain) is 0.5 PSI/foot of rise or gain (typical R-22, R-407c or R-410a). To assure sub-cooled liquid to the TXV, it is recommended that the DX coil be no more than the distances above the condensing unit shown in Table 1.

TABLE 1 - MAXIMUM VERTICAL LIQUID LINE RISERS

REFRIGERANT	LINE LOSS (°F MAX)	MAXIMUM RISERS (FT.)* (DX COIL ABOVE ACCU)
R-22	2	30**
R-407c	2	30**
R-410a	2	50**

* Includes allowance for loss on liquid line solenoid valve, filter/dryer and sight glass. (Total 5 PSI)

** Contact application engineer when over these limits.

BASIC TIPS FOR SUCCESSFUL DESIGNS

The following tips apply to all piping examples shown in Figure's 36-43.

Liquid Line Piping, Liquid Line Solenoid Valve, and TXV's

- The total equivalent feet of piping should be 150 feet or less.
- Slope piping toward coils for oil return during the off cycle.
- Use long radius elbows to reduce pressure drop.
- Use only one liquid line solenoid valve per ACCU Refrigerant System
- Size TXV's according to individual coil capacity. Minimum capacity must not exceed 30% of valves rated capacity.
- Mount TXV bulb on clean pipe at 4 or 8 o'clock position with 2 copper straps on the outlet of the respective coil. Insulate the TXV bulb.
- The equalizing line for each TXV must enter the top of the suction pipe.
- See Table 1 on page 44 for the Maximum Vertical Height (ft.) for the DX Coil above the ACCU.

DX Coils

- DX coils in a system should always be configured for full face operation. Otherwise, TXV control and liquid slugging will damage compressors.
- Assure distributor nozzles are properly sized for the coil capacity.

Suction Line Piping

- The total equivalent feet of piping should be 150 feet or less. (Always refer to IOM).
- Slope suction piping toward the compressors for oil return and to assure that liquid condensing in the suction line drains into the compressors and is boiled off by the heaters. Do not allow the suction line to create a liquid and oil trap between the coil and the compressors.
- Use long radius elbows to reduce pressure drop except for oil traps.
- Install a P-trap on the outlet of the DX coil.
- Insulate the suction line.
- Never run suction piping underground.
- Use double risers whenever minimum step tons are less than Tables 12 and 13, or if refrigerant velocity falls below 1000 FPM.
- Use inverted traps at the top of suction risers.
- Always consult Application Engineering on risers that exceed 40 feet.
- Make oil traps as small as possible in suction risers.
- Use intermediate oil traps on suction risers greater than 20 ft, located midway on the riser.
- If the DX coil is above the ACCU, the Suction Piping must rise above the top of the Coil to form an inverted trap. See *Figure 35 on page 43*.

Hot Gas Bypass

- Assure hot gas piping enters the distributor (or auxiliary side connection-ASC) tap on each coil from the top.
- Hot gas piping should always slope to drain into the coils.
- Hot gas piping should be designed to not allow oil and refrigerant to be trapped during the off cycle. Trapping liquid and oil creates the danger of a liquid slug when the hot gas is energized.
- Size hot gas to approx. 100% capacity of the minimum stage of cooling.
- Activate hot gas whenever any compressor is running. This may involve rewiring the HGBP to be in parallel with the LLSV, providing full time HGBP.
- Insulate the hot gas bypass line.
- Always install check valves at the ASC side connection when multiple branch circuits are utilized.

Controls

- Avoid, when possible, running the ACCU when in economizer mode. If operating the ACCU in economizer mode, hot gas must be installed to assure a minimum load.

EXAMPLES OF ACCU-DX COIL PIPING ARRANGEMENTS

When the ACCU is located above the AHU, DX coil, double suction risers may be required to ensure good oil return to the ACCU, if there is not adequate tonnage and velocity up a single riser. Most applications will only need single suction risers; however, double risers are shown in the following diagrams for illustration purpose only. Only one refrigerant circuit is illustrated. This will be similar for the second circuit.

The illustration below shows one refrigerant circuit, when the ACCU is less than 20 feet above the AHU interlaced DX coil. The horizontal suction line run should be sloped a minimum of $\frac{1}{2}$ inch per 10 feet from the suction riser, toward the compressors to proper oil flow. Double suction risers are shown for illustration only. Most applications will need only single risers. In lieu of double suction risers, the vertical suction riser can be downsized for proper oil entrainment at minimum reduced load, providing the overall suction line pressure drop doesn't exceed a nominal 2°F.

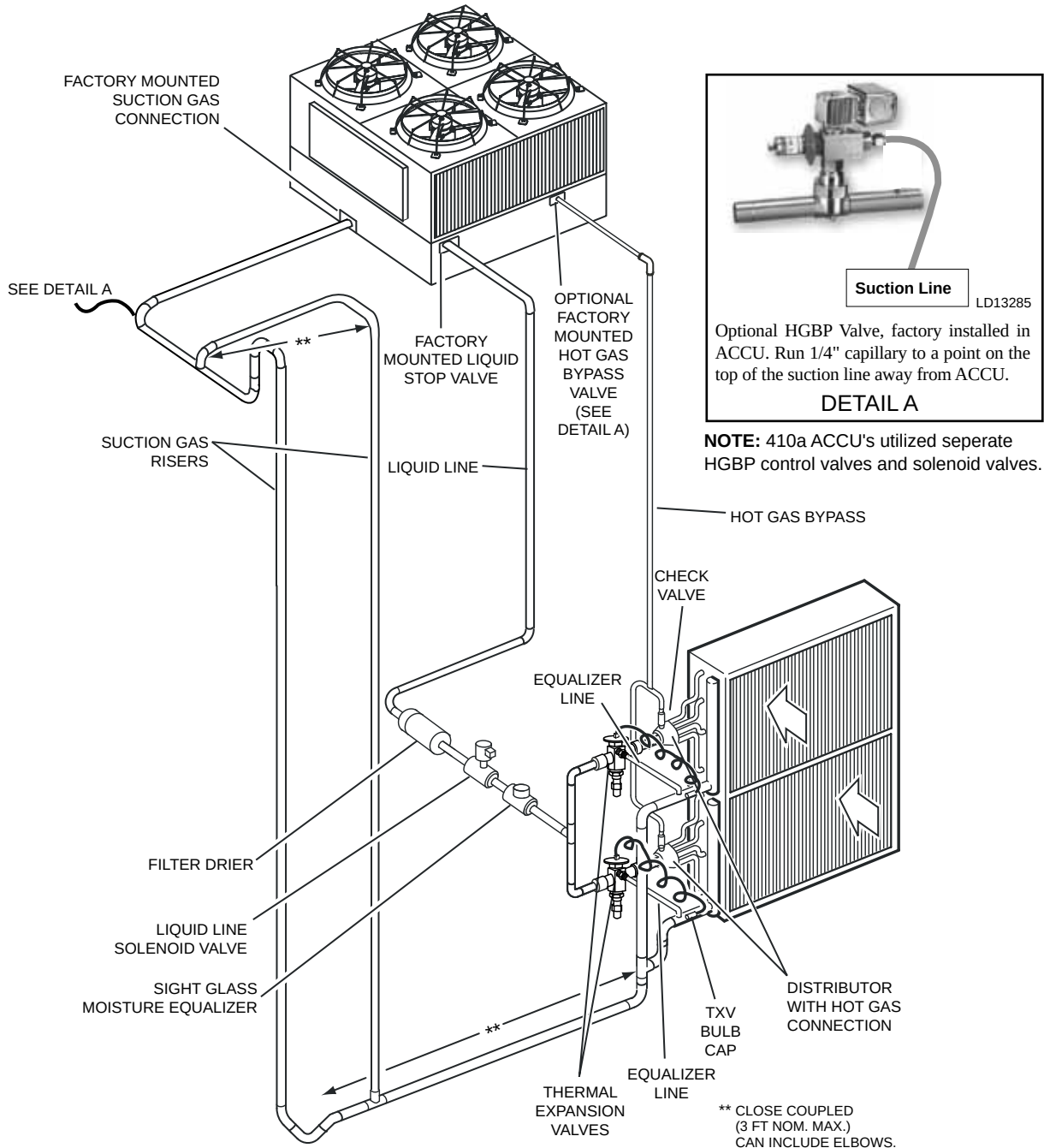


FIGURE 36 - PIPING WHEN ACCU IS LESS THAN 20 FT. ABOVE THE DX COIL

This illustration shows one refrigerant circuit when the ACCU is 20 feet or more above the AHU, DX coil. An oil trap is required mid way up the vertical rise. The horizontal suction line must be sloped a minimum of ½" per 10 ft. toward the compressors for oil flow.

Double suction risers are shown for illustration only. Most applications will need only single risers. In lieu of double suction risers, the vertical suction riser can be downsized for proper oil entrainment at minimum reduced load, providing the overall suction line pressure drop doesn't exceed a nominal 2°F.

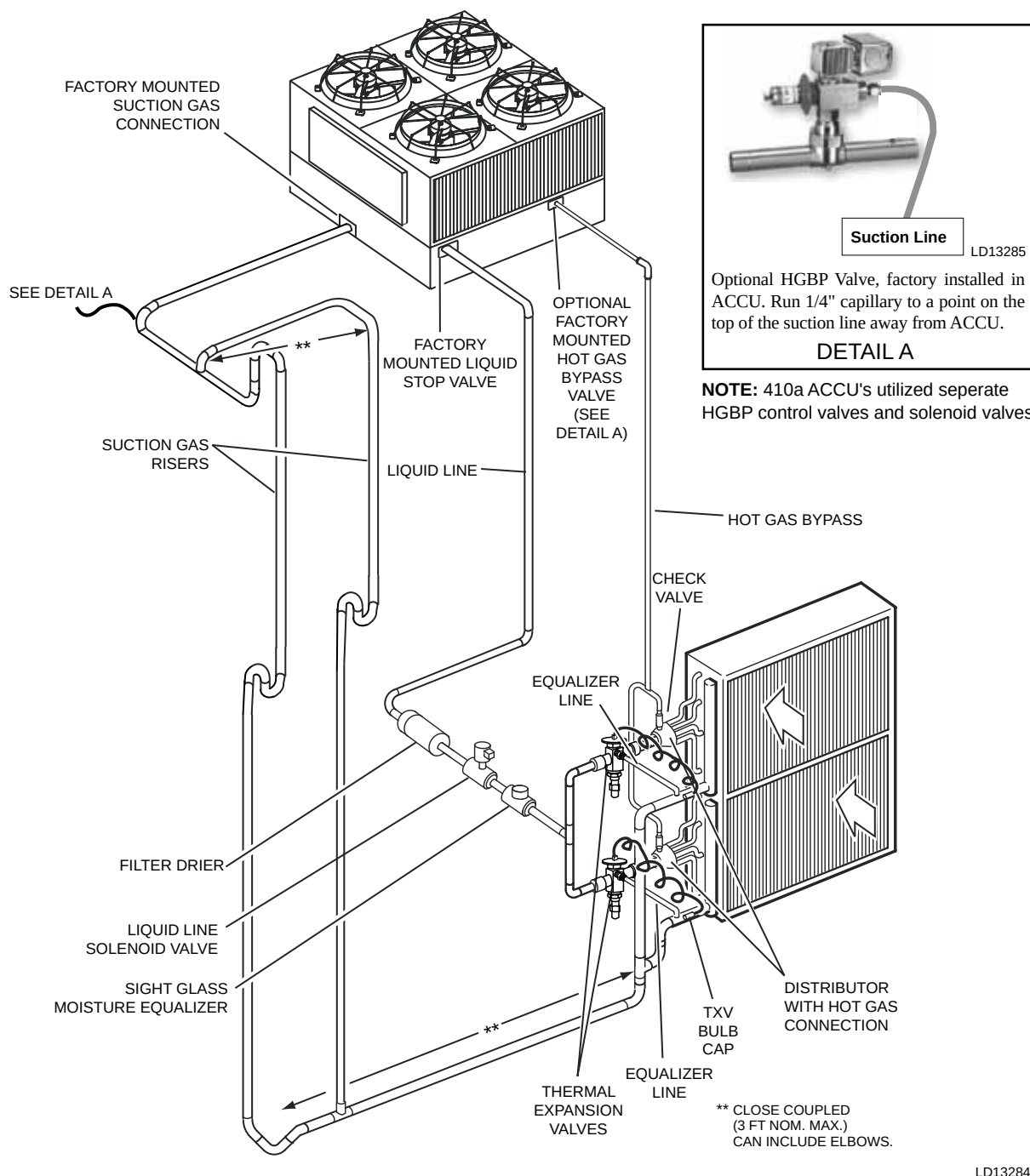


FIGURE 37 - PIPING WHEN ACCU IS 20 FT. OR MORE ABOVE THE DX COIL

This illustration shows one refrigerant circuit when the ACCU is at the same level as the AHU interlaced DX coil. Again the horizontal suction line must be sloped a minimum of $\frac{1}{2}$ " per 10 ft. toward the compressors for oil flow. In lieu of double suction risers, the vertical suction riser can be downsized for proper oil entrainment at minimum reduced load, providing the overall suction line pressure drop doesn't exceed a nominal 2°F.

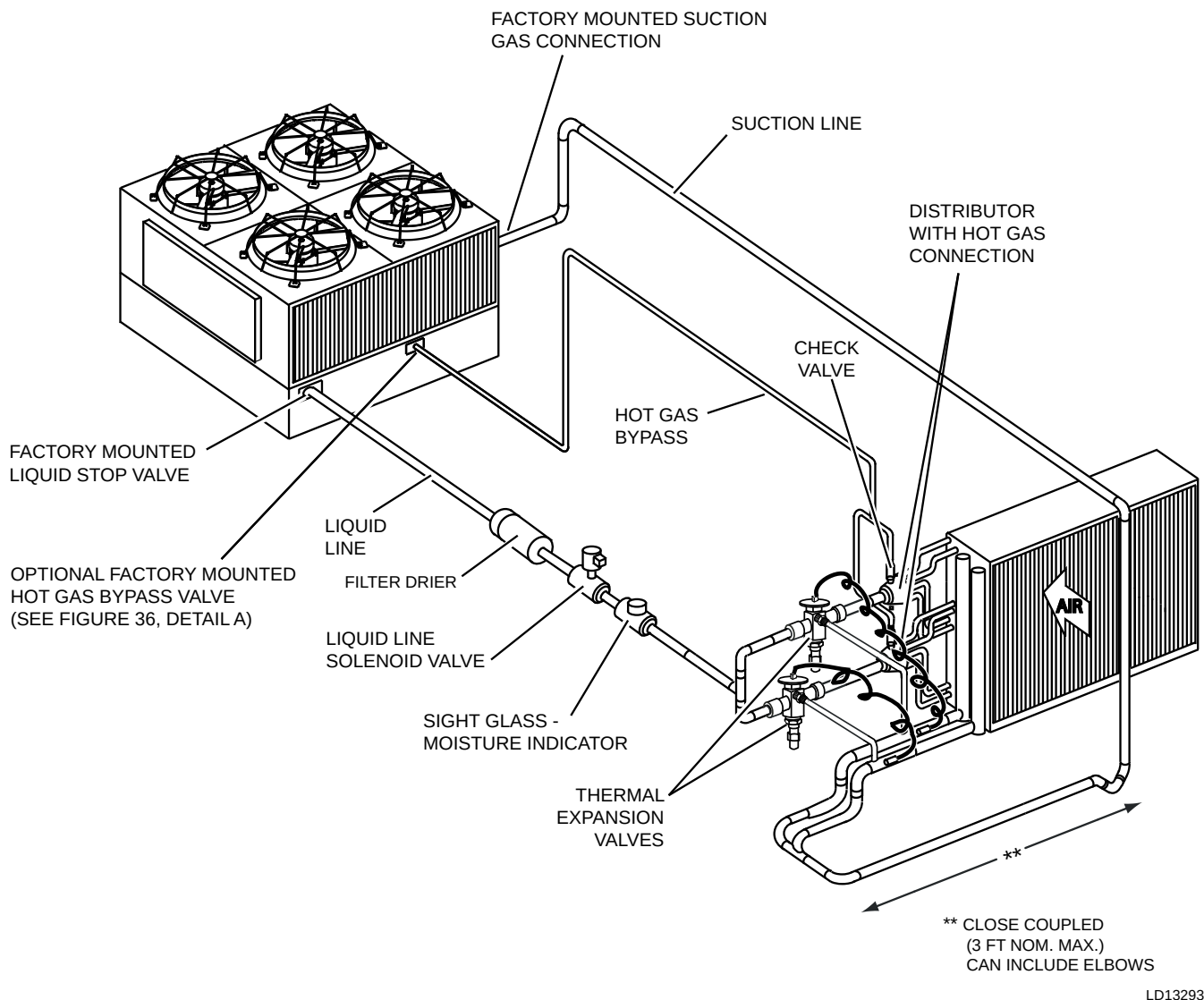
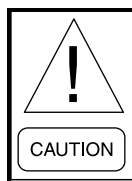


FIGURE 38 - PIPING WHEN ACCU IS AT THE SAME LEVEL AS THE DX COIL

This illustration shows one refrigerant circuit when the ACCU is lower than the AHU interlaced DX coil. Again the horizontal suction line must be sloped a minimum of $\frac{1}{2}$ " per 10 ft. toward the compressors for oil flow. In lieu of double suction risers, the vertical suction riser can be downsized for proper oil entrainment at minimum reduced load, providing the overall suction line pressure drop doesn't exceed a nominal 2°F.



Use Table 1 - Maximum Vertical Distance for DX Coil Above the ACCU for the total equivalent piping lengths.

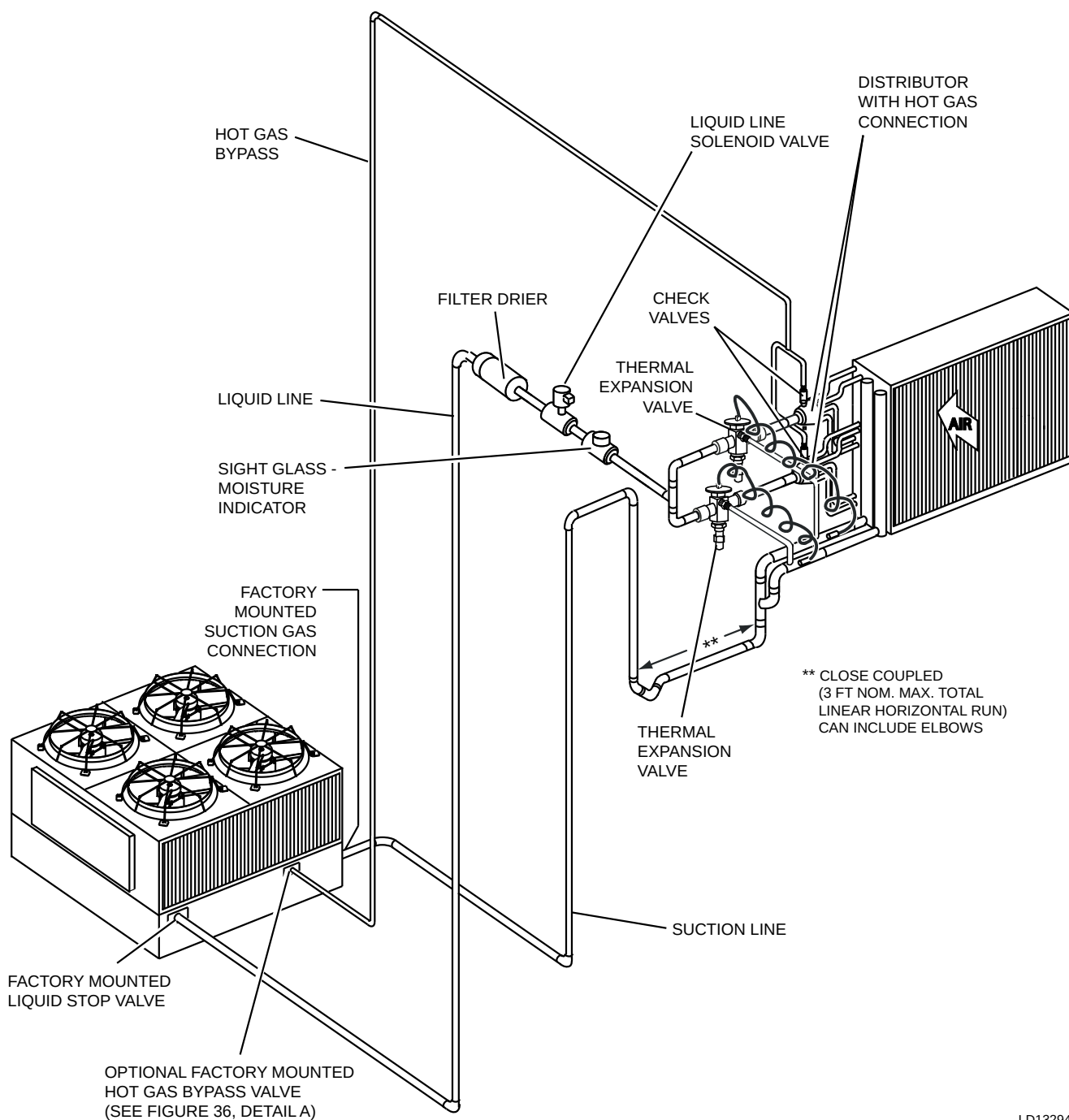
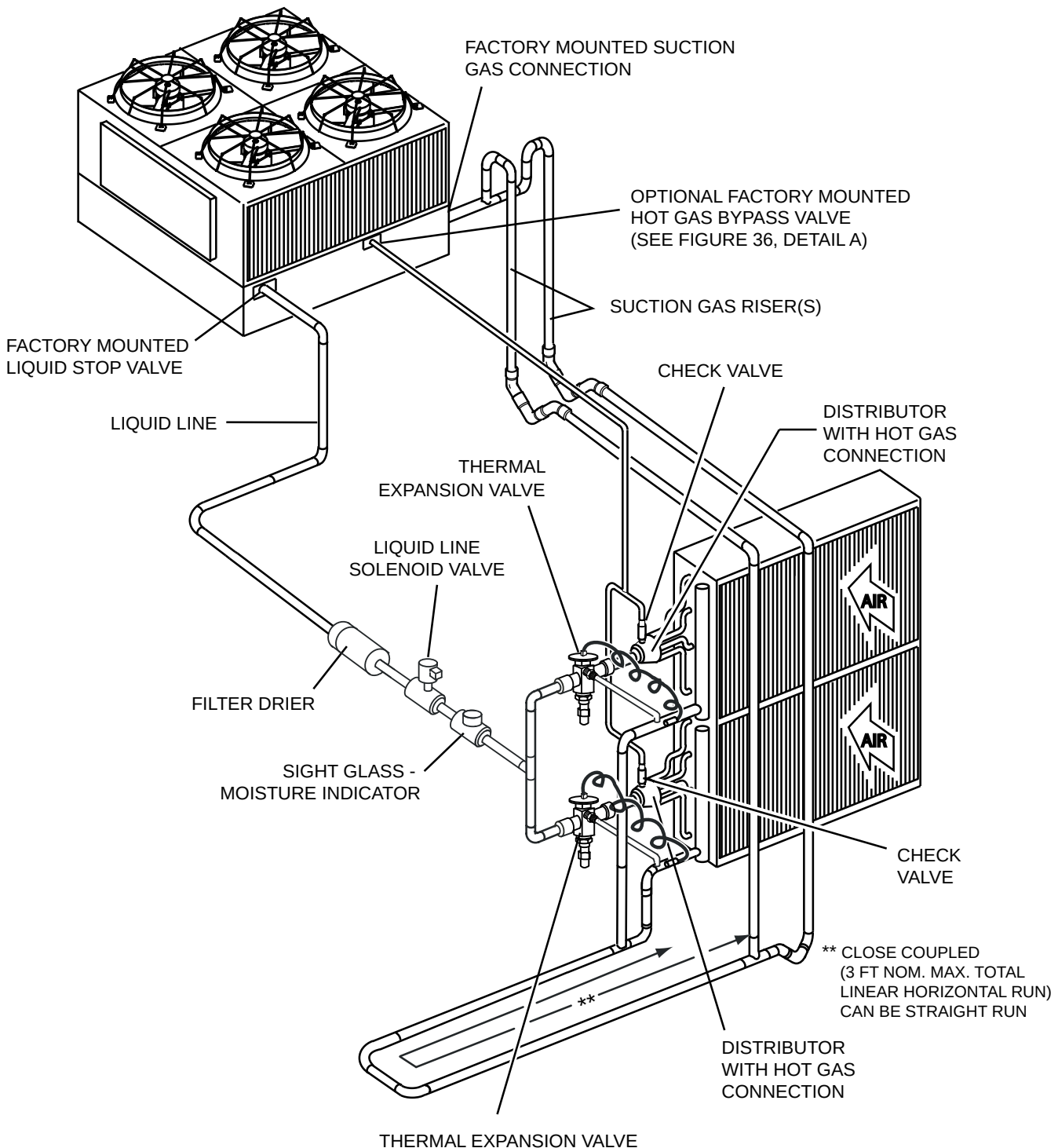


FIGURE 39 - PIPING WHEN ACCU IS LOWER THAN THE DX COIL

This illustration shows one refrigerant circuit when the ACCU is less than 20 ft. above the AHU with two stacked interlaced DX coils for full face coverage. The horizontal suction line must be sloped a minimum of $\frac{1}{2}$ " per 10 ft. from the suction riser toward the compressors for oil flow. Double suction risers are shown for il-

lustration only. Most applications will need only single risers. In lieu of double suction risers, the vertical suction riser can be downsized for proper oil entrainment at minimum reduced load, providing the overall suction line pressure drop doesn't exceed a nominal 2°F.



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FIGURE 40 - PIPING WHEN ACCU IS LESS THAN 20 FT. ABOVE STACKED DX COILS

This illustration shows one refrigerant circuit when the ACCU is more than 20 ft. above the AHU with two stacked interlaced DX coils for full face coverage. An oil trap is required mid way up the vertical rise. The horizontal suction line must be sloped a minimum of 1/2" per 10 ft. from the suction riser toward the compressors for oil flow.

Double suction risers are shown for illustration only. Most applications will need only single risers. In lieu of double suction risers, the vertical suction riser can be downsized for proper oil entrainment at minimum reduced load, providing the overall suction line pressure drop doesn't exceed a nominal 2°F.

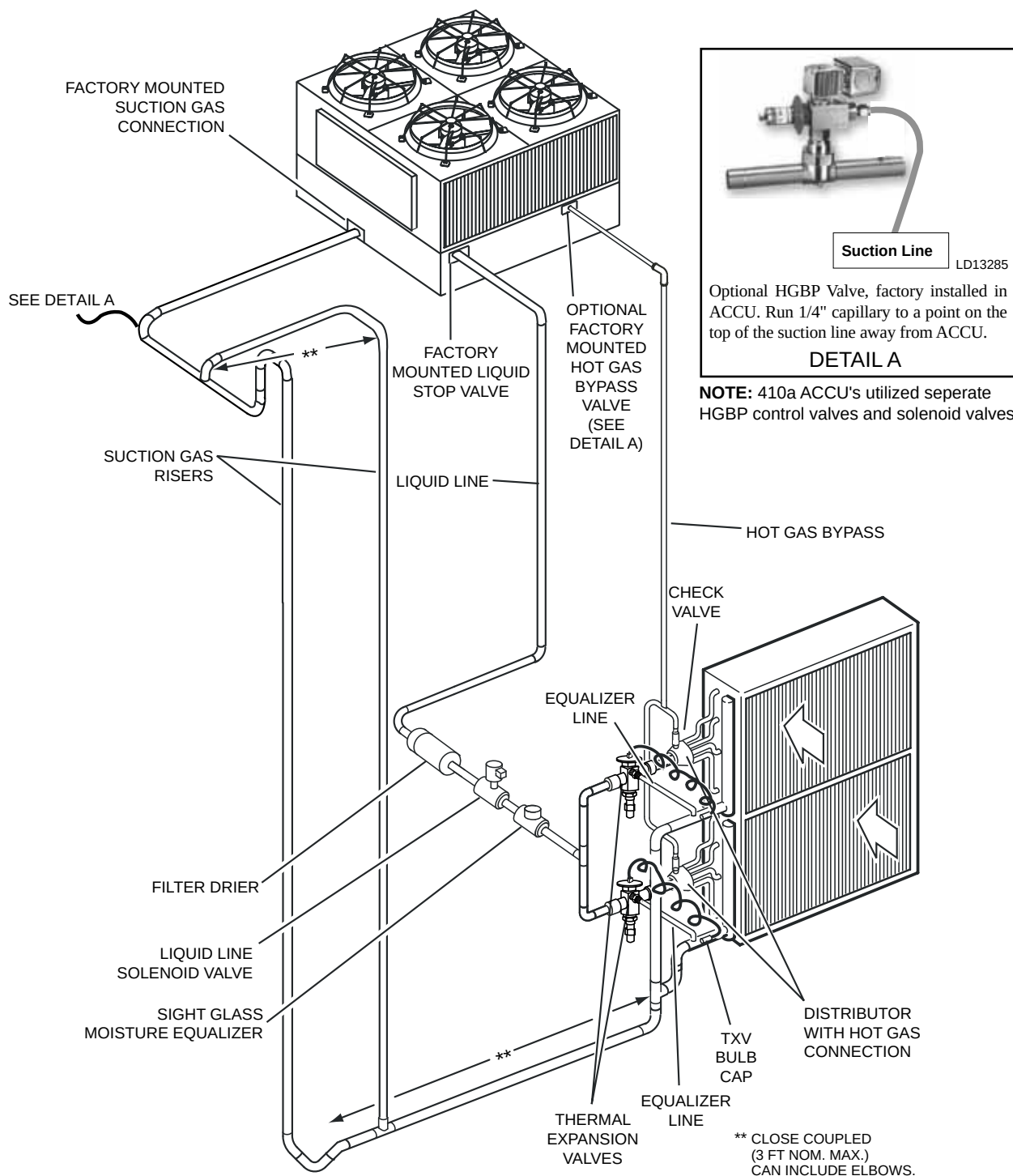
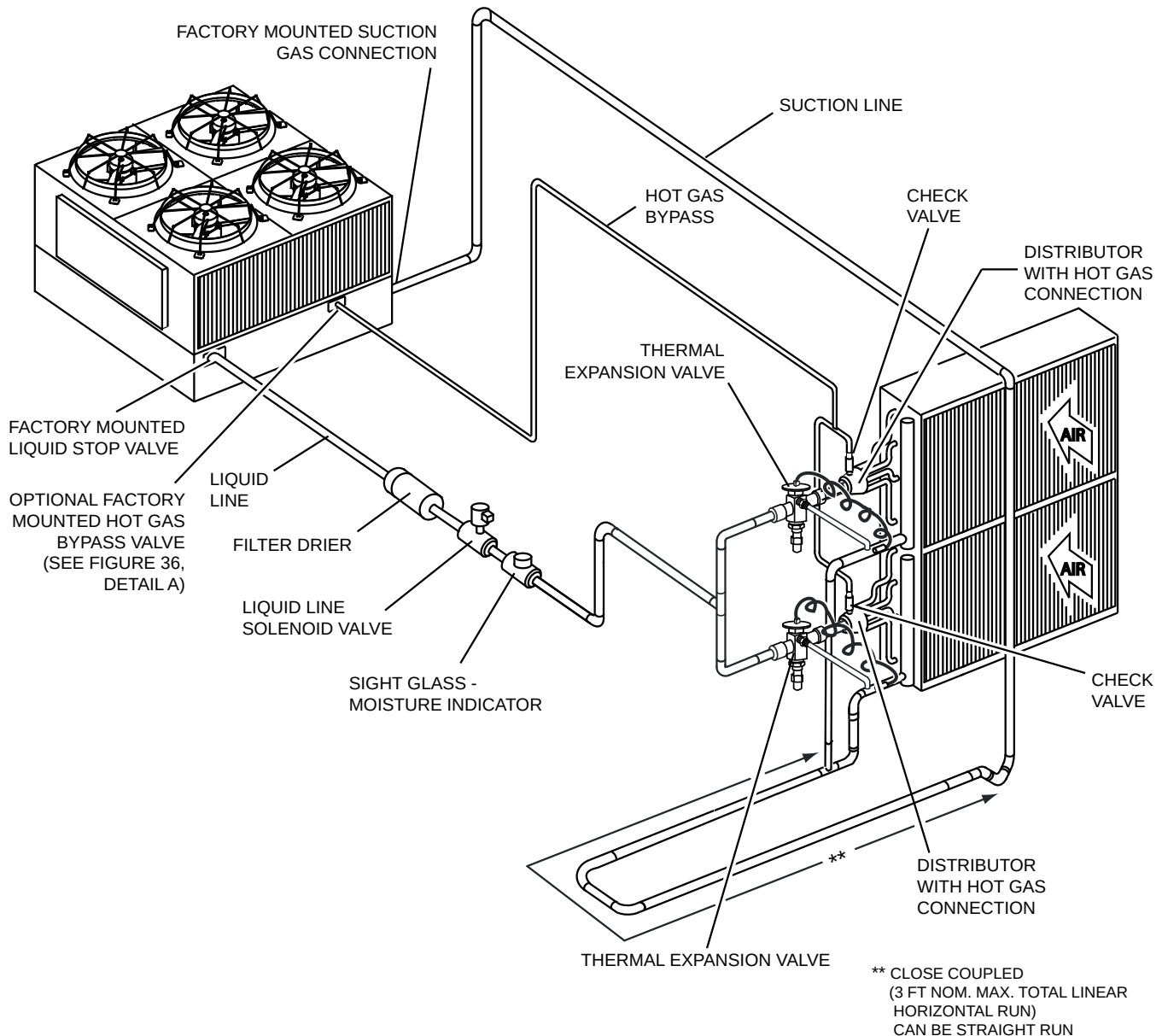


FIGURE 41 - PIPING WHEN ACCU IS MORE THAN 20 FT. ABOVE STACKED DX COILS

This illustration shows one refrigerant circuit when the ACCU is at the same level as the AHU with two stacked interlaced DX. The horizontal suction line must be sloped a minimum of $\frac{1}{2}$ " per 10 ft. from the suction riser toward the compressors for oil flow. In

lieu of double suction risers, the vertical suction riser can be downsized for proper oil entrainment at minimum reduced load, providing the overall suction line pressure drop doesn't exceed a nominal 2°F.



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FIGURE 42 - PIPING WHEN ACCU IS AT SAME LEVEL AS DX COIL

This illustration shows one refrigerant circuit when the ACCU is lower than the AHU with two stacked inter-laced coils. The horizontal suction line must be sloped a minimum of $\frac{1}{2}$ " per 10 ft. from the suction riser toward the compressors for oil flow. In lieu of double suction risers, the vertical suction riser can be down-sized for proper oil entrainment at minimum reduced load, providing the overall suction line pressure drop doesn't exceed a nominal 2°F.



Use Table 1 - Maximum Vertical Distance for DX Coil Above the ACCU for the total equivalent piping lengths.

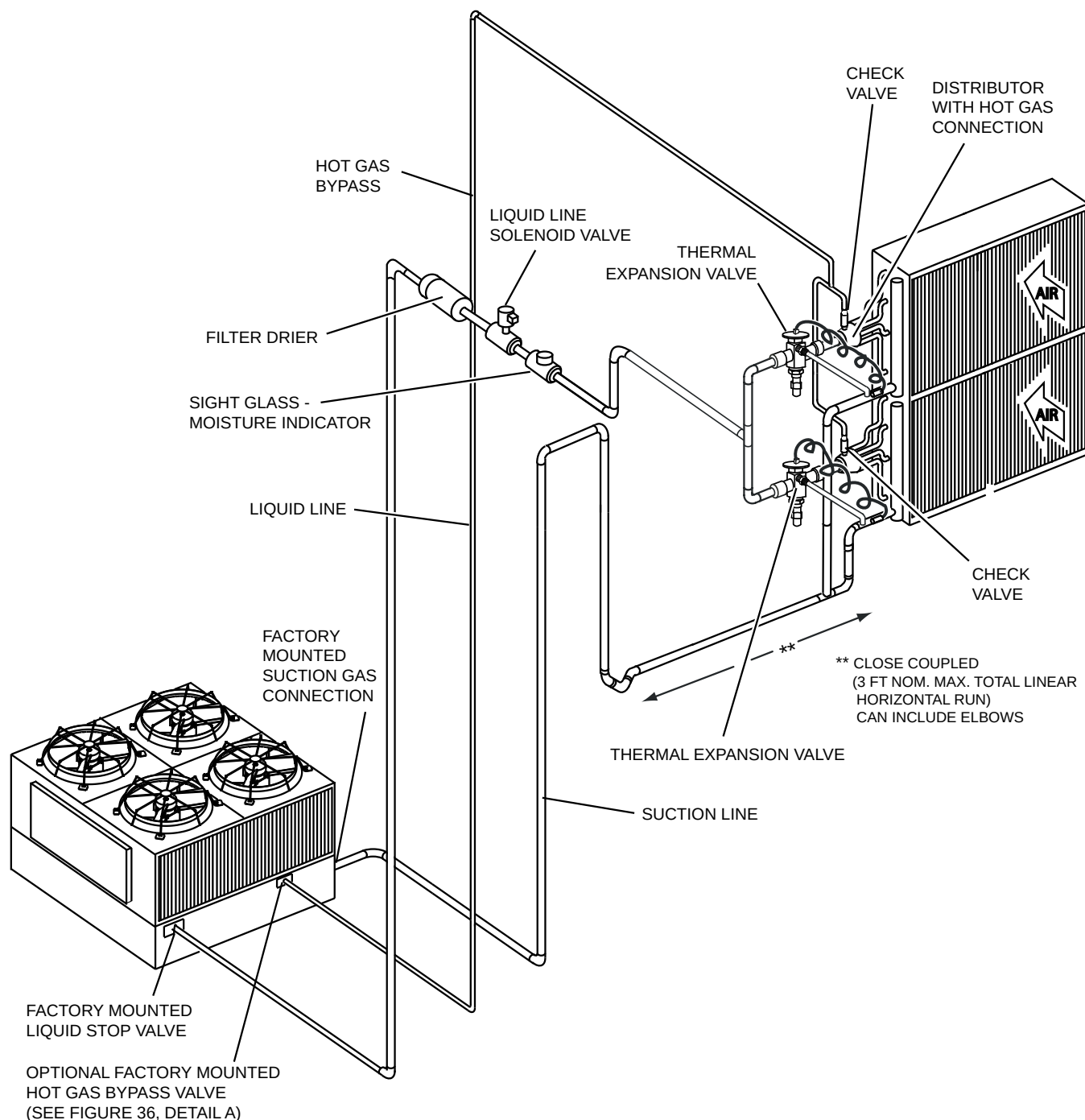


FIGURE 43 - PIPING WHEN ACCU IS LOWER THAN DX STACKED COILS

LD13297

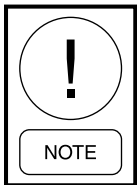
PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT**PIPING – SIZE AND SELECTION PRACTICES
OVERVIEW**

Pipe sizing is critical to oil management as well as line loss considerations. Oil management states that oil should return to the compressor at the same rate that it leaves the compressor. Line loss limitations protect the chiller against low suction pressure faults as well as an excessive loss in capacity at the ACCU.

The following JCI pipe line loss limitations parallel ASHRAE refrigeration standards. Practices base line sizing as follows:

- Liquid Lines not to exceed a value of about 1°F line loss
- Suction Lines not to exceed a value of about 2°F line loss
- Hot Gas Bypass (HGBP) line sizing is outlined in Table 37 and 38 of this form
- Maximum Suction, Liquid and Hot Gas Bypass (HGBP) line equivalent feet allowed is a nominal 150 equivalent feet (100 EF on YCAV/YCIV product – HGBP is not applicable).

The following paragraphs and pages offer line sizing examples using R-410a and R-22/R-407c refrigerant, as well as specific table references found in the back of this guide.



If YORKworks is not available, you can use the Sales Engineering Guide in part to acquire the initial data mentioned. Engineer Guides can be downloaded from the www.JCI.com website.

Making the Initial YORKworks Selection

Given the following required initial data, acquire the YORKworks ACCU selection for this project:

- Refrigerant Type (This example uses the more current R-410a)
- Capacity required (73.5 tons)
- Design Ambient Temperature (95°F)
- Design ACCU Saturated Suction Temperature (SST). Generally a nominal 10°F below the LAT of the DX Coil can be assumed. Note the following:
 - This example will assume 55°F LAT - 10°F = 45° SST at the ACCU.
 - It should be noted here that if DX Coil Rows and FPI, or airside PD are already specified, you can select the DX Coil first to identify the DX Coil SST and then subtract the industry standard 2°F suction line loss to acquire the estimated SST design of the ACCU.

This example offers model YCUL0072EE46 from YORKworks Sales/Marketing Electronic Tool. (see following and *Figure 44 on page 55*). This example also notes the minimum tons for HGBP (optional).

PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT

Sales/Marketing
YORKworks Program
Electronic Tool

4

LD15947

Unit Tag	Qty	Model No.	Capacity (Tons)	Volts/Ph/Hz	Refrigerant
	1	YCUL0072EE46	73.5	460/3/60	R410A
Pin No: YCUL0072EE46XEASXXXXXXRLXXXX45XXXXXXXXXXXXXXXXXXXXXXXBXXXXX					

Evaporator Data		Condenser Data		Performance Data	
SST (°F)	45.0	Ambient Temp. (°F)	95.0	EER	10.8
		Altitude (ft.)	0.0	IPLV	0.0
		Pump Down. (lbs.)	0.0	Physical Data	
				Rigging Wt. (lbs.)	3897
				Operating Wt. (lbs.)	3897

Electrical Data				
Data omitted in this example				

Single Point				
Data omitted in this example				

Part Load Rating Data					
	Load %	Ambient (°F)	Capacity (Tons)	Compressor kW	Unit Efficiency
5	100.0	95.0	73.5	75.1	10.8
4	71.5	80.0	59.7	43.3	14.3
2	50.0	80.0	40.2	31.1	14.0
1	21.5	80.0	17.7	13.0	14.5

Note: Compressors 5, 4, 2, & 1 shown in this sequence. Compressors 6 & 3 N/A in this system.

Note - Select HGBP line size based on the minimum/nominal part load rating of 17.7 tons

LD16013

FIGURE 44 - EXAMPLE – FROM SALES YORKWORKS PERFORMANCE DATA

PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT



BY JOHNSON CONTROLS

FORM 150.68-EG1 (509)



Sales Engineering Guide –
Alternate means for acquiring
catalogue ratings and design data

**Model YCUL Air-Cooled Scroll Compressor Condensing Units
Style E**



50 AND 60HZ
50 – 90 TON
175 – 316 KW
R-410A



LD15949

FIGURE 45 - ALTERNATE EXAMPLE – USING THE SALES ENGINEERING GUIDE

TABLE 2 - RATINGS - R-410A (60HZ - ENGLISH UNITS)

MODEL: YCUL0072EE															
AIR TEMPERATURE ON - CONDENSER (°F)															
SST (°F)	75.0			80.0			85.0			90.0			95.0		
	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER
35.0	69.9	58.2	12.9	67.9	61.1	12.0	65.8	64.2	11.1	63.7	67.7	10.3	61.6	71.4	9.5
37.0	72.5	58.9	13.2	70.4	61.8	12.3	68.2	64.9	11.4	66.1	68.3	10.6	63.9	72.1	9.7
39.0	75.1	59.6	13.6	72.9	62.5	12.6	70.7	65.6	11.7	68.5	69.0	10.8	66.2	72.8	10.0
41.0	77.7	60.4	13.9	75.5	63.2	12.9	73.2	66.4	12.0	70.9	69.8	11.1	68.6	73.5	10.3
43.0	80.4	61.1	14.2	78.1	64.0	13.3	75.8	67.1	12.3	73.4	70.6	11.4	71.0	74.3	10.5
45.0	83.2	61.9	14.5	80.8	64.8	13.6	78.4	67.9	12.6	75.9	71.4	11.7	73.5	75.1	10.8
47.0	86.0	62.7	14.9	83.5	65.6	13.9	81.0	68.8	12.9	78.5	72.2	11.9	76.0	75.9	11.0
49.0	88.9	63.5	15.2	86.3	66.4	14.2	83.8	69.6	13.2	81.2	73.1	12.2	78.6	76.8	11.3
51.0	91.8	64.4	15.5	89.2	67.3	14.5	86.5	70.5	13.4	83.9	73.9	12.5	81.2	77.7	11.5
53.0	94.8	65.3	15.8	92.1	68.2	14.7	89.4	71.4	13.7	86.6	74.9	12.7	83.9	78.6	11.8
55.0	97.8	66.2	16.1	95.1	69.2	15.0	92.2	72.4	14.0	89.4	75.8	13.0	86.6	79.6	12.0

TABLE 3 - REFRIGERANT LINE CONNECTIONS

MODEL NUMBER	TONS	SYSTEM NUMBER	REFRIGERANT LINE CONNECTION		SUCTION LINE COPPER TYPE L INCHES OD	LIQUID LINE	
			SUCTION	LIQUID		NOMINAL TONS UNLOADED	COPPER TYPE L INCHES OD
0045EE	41.6	1	2.1	1.1	2-1/8	10.4	1-1/8
		2	2.1	1.1	2-1/8	10.4	1-1/8
0051EE	44.1	1	2.1	1.1	2-1/8	11.7	Nominal unloaded tons may vary somewhat from YORK-works vs Sales Engineering Guide but has no real affect on HGBP Valve selection.
		2	2.1	1.1	2-1/8	10.4	
0055EE	51.6	1	2.1	1.1	2-1/8	12.9	
		2	2.1	1.1	2-1/8	12.9	
0065EE	59.5	1	2.1	1.1	2-1/8	14.9	
		2	2.1	1.1	2-1/8	14.9	1-1/8
0072EE	73.5	1	2.3	1.1	2-3/8	21.9	1-1/8
		2	2.1	1.1	2-1/8	14.9	1-1/8

PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT

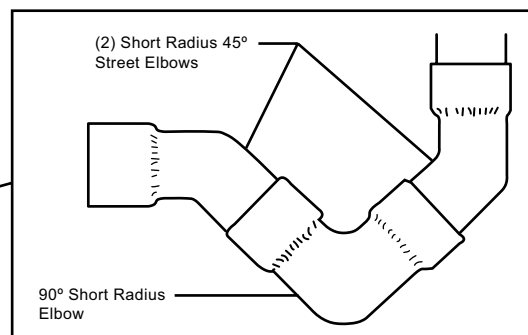
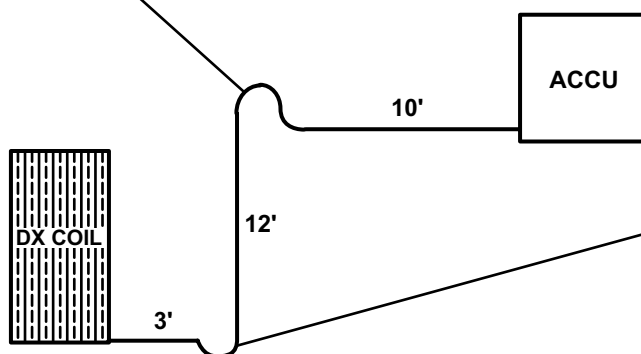
Piping Arrangement

Various piping arrangements are outlined on *Figures 36 through 43* of this guide. This continued example will cover suction line and the liquid line arrangements, as well as the optional HGBP. *Figures 46 and 47* will itemize the number of fittings, traps and linear line length for further use in determining the total equivalent feet of pipe run.

The Following is Referenced for Determining Equivalent Feet of Pipe:

- 3' horizontally from the DX coil to the vertical suction riser
- 12' up the vertical suction riser with bottom trap as outlined
- 10' horizontally to the ACCU suction connections.

(3) 90° LONG RADIUS ELBOWS/INVERTED TRAP



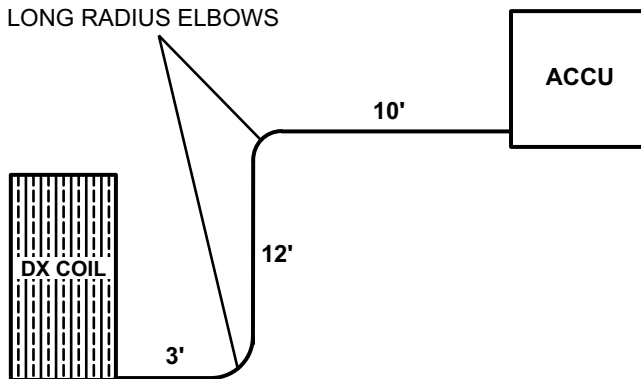
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FIGURE 46 - EXAMPLE SUCTION LINE ARRANGEMENT

The Following is Referenced for Determining Equivalent Feet of Pipe:

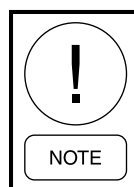
- 3' horizontally
- 12' vertically up
- 10' horizontally
- (2) 90° long radius elbows

LONG RADIUS ELBOWS

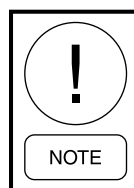


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FIGURE 47 - EXAMPLE LIQUID LINE ARRANGEMENT



All Refrigerant Lines must be sloped ½" per 10 feet minimum in direction of refrigerant flow to support good oil management (Oil comes back to the compressor at the same rate that it leaves the compressor).



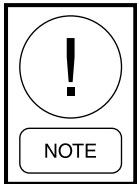
Maximum allowable pipe runs must not exceed 150 equivalent feet (100 Equivalent feet for YCAV and YCIV). Reference "Dealing with Excessive Line Lengths" on page 59 of this guide.

PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT**Determining Percent System Splits**

This example maintains the YCUL0072EE R-410a refrigerant ACCU having two different nominal tonnage systems as outlined in *Figure 48 on page 58*, noting that not all ACCU's have unequal system tons.

In this continued example, we have System #1 at a nominal 40 tons (20 + 20 tons) and System #2 at a nominal 30 tons (15 + 15 tons). This example will address system #1 only, noting that system #2 is selected in the same manner.

These and other ACCU system splits are outlined in the Sales Engineering Guides, as well as in the IOM's (Service Installation, Operating and Maintenance Manuals) under the Physical Data portions.



Reference PIPING EXAMPLE #2 for R-22 and R-407c Refrigerants.

Refrigerant System (Circuit) % Split Determination

Note: System #1 is generally the larger compressor system and compressor #1, 2 and 3 are always considered system #1

Total Nom. Tons = System #1 nom tons @ (2 x 20) + System #2 nom tons @ (2 x 15) = 70 Nom. Tons

% Split System #1 = (2 x 20) / 70 = (40 / 70) = 57%

% Split System #2 = (2 x 15) / 70 = (30 / 70) = 43%

Physical Data - English Units

		60Hz				
Model No. YCUL		0045	0051	0055	0065	0072
Length		144.8	144.8	148.8	148.8	153.6
Width		90.6	90.6	90.6	90.6	90.6
Height		47.8	47.8	62.6	62.6	62.6
Nominal Tons		41.6	44.1	51.6	59.5	73.5
Number of Refrigerant Circuits		2	2	2	2	2
Refrig. Chg. Opt. R-410A (lbs) ckt1/ckt2		35/35	40/35	45/45	50/50	65/65
Oil Charge, gallons ckt1/ckt2		1.8/1.8	1.8/1.8	1.7/1.7	1.7/1.7	2.3/2.2
Shipping Weight	Alum. Fin Coils, lbs	2942	2968	3196	3208	4097
	Copper Fin Coils, lbs	3300	3326	3673	3685	4703
Operating Weight	Alum. Fin Coils, lbs	2967	3001	3233	3245	4142
	Copper Fin Coils, lbs	3325	3359	3710	3722	4748
Nominal Comp. Capacity	Comp. 1	10	12	13	15	20
	Comp. 2	10	12	13	15	20
	Comp. 3	—	—	—	—	—
	Comp. 4	10	10	13	15	15
	Comp. 5	10	10	13	15	15
	Comp. 6	—	—	—	—	—

FIGURE 48 - DETERMINING REFRIGERANT CIRCUIT % SPLIT

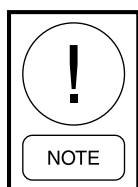
PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT

Calculating the Final System Capacity

Given the total ACCU capacity of 73.5 tons (Reference *Figures 44 or 45*), and the percent split for system #1 of 57% (Reference *Figure 48*), the system #1 capacity to size for is (73.5×0.57) 41.9 tons. System #2 would be calculated in the same manner.

Design Data and Assumptions

The following offers the accumulated design data and assumptions from the previous example pages. Note that this is the required minimum information necessary for determining piping line sizing requirements.



Reference PIPING EXAMPLE #2 for R-22 and R-407c Refrigerants.

Example Design Data/Assumptions

- ACCU: R-410a, YCUL0072EE, 73.5 tons @ full load (System #1 is only addressed in this example).
- 95°F ambient (*the condensing temperature is typically about 25°F above the design ambient temperature or about 120°F in this example. This is generally the same for other ACCU refrigerant types . . . always verify if uncertain*).

- 45°F saturated suction temperature.
- System #1 capacity of 41.9 tons.
- System #1 minimum capacity of 17.7 tons.
- Arrangement - DX Coil below the ACCU with lengths, traps and fittings count as outlined in *Figures 45 and 46*).

Example Design Data – Computer Rating

See previous *Figure 44 on page 55* for computer rating.

Dealing with Excessive Line Lengths

In estimating the line size diameter it is important to note that the “maximum” equivalent pipe length must not exceed a nominal 150 equivalent feet (**100 equivalent feet for YCAV or YCIV**). Note also that any change in your initial pipe diameter will vary the equivalent feet of pipe for any fixed pipe length and trap/fitting count. Also, when pipe run initial estimates exceed the maximum 150’ equivalent lengths (**100 equivalent feet for YCAV or YCIV**), always contact JCI Application Engineering for direction. **In virtually all cases the direction will be to move the DX Coil and the ACCU closer together, or the pipe run will need to be re-routed and shortened following practices outlined in this guide.**

PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT**Suction Line Full Load Duty Selection Procedure**

Continuing the R-410a example above as outlined in the assumptions on page 57 and percent system split on page 58, make an initial system #1 suction line selection using *Table 27 on page 121* in the Appendix (Also *Table 4 on page 60* of this example).

Given the 41.9 actual tons in this example, the initial line size selection would suggest a 1-5/8" suction line at the design 45° SST assumption, based on the short equivalent feet run in this example. The initial line capacity per 100 equivalent feet of 1-5/8" pipe shows 27.5 tons.

Condensing Temperature Correction

The 1-5/8" line size capacity is next corrected for the actual 120°F condensing temperature noted in the assumption example. The correction factor is selected from bottom of *Table 27 on page 121*, also listed in this example under *Table 5 on page 60* (i.e. 27.5 Table tons x 0.89 = 24.47 adj. tons).

TABLE 4 - DETERMINE SUCTION LINE SIZE/CAPACITY IN TONS R-410A

Line Size	Saturated Suction Temperature, °F -R-410a		
	35	45	55
Type L Cooper OD Inches	$\Delta t = 2^\circ\text{F}$ $\Delta p = 4.11$	$\Delta t = 2^\circ\text{F}$ $\Delta p = 4.87$	$\Delta t = 2^\circ\text{F}$ $\Delta p = 5.34$
7/8	4.06	5.00	6.10
1 1/8	8.20	10.00	13.00
1 3/8	14.27	17.50	20.70
1 5/8	22.50	27.50	32.60
2 1/8	46.51	56.50	67.50
1 5/8	81.96	96.50	118.00
3 1/8	130.50	157.00	187.50

NOTES:

1. Δp = Pressure drop due to line friction, psi per 100 feet equivalent length.
2. Δt = Change in saturation temperature corresponding to pressure drop, per 100 feet.
3. Line capacity for other saturation temperatures Δt and equivalent lengths L_e .

$$\text{Line capacity} = \text{Table capacity} \left(\frac{\text{Table } L_e}{\text{Actual } L_e} \right) \times \left(\frac{\text{Actual } \Delta t}{\text{Table } \Delta t} \right)^{0.55}$$
4. Saturation temperature Δt for other capacities and equivalent lengths L_e .

$$\Delta t = \text{Table } \Delta t \left(\frac{\text{Actual } L_e}{\text{Table } L_e} \right) \times \left(\frac{\text{Actual Capacity}}{\text{Table Capacity}} \right)^{1.8}$$

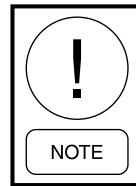
Equivalent Feet of Pipe Correction

In this example, the equivalent feet of pipe length from the following page shows 41 equivalent feet using the 1-5/8" suction line selected. This, along with the actual tonnage will be used in calculating the final line loss.

Calculating Final Line Loss - Calculating the actual Δt line loss using the formula under note 4 of *Table 4 on page 60* calculates to 2.16°F line loss (Loss from DX Coil to ACCU):

$\Delta t = 2.16^\circ\text{F}$ falls at about the 2°F allowable line loss, and is best suited in this example. An initial check would show going one size larger at 2-1/8 would push the Δt well **under** the design 2°F line loss to 0.69°F and although would work, is not the best selection in this example.

This line loss is used to determine the required suction temperature design of the DX Coil (i.e. 45°F @ ACCU + 2.16°F = 47.16°F SST DX Coil Design). This line loss can also be used to determine the ACCU SST with a given DX Coil SST (i.e. DX Coil °F SST – calculated line loss °F = °F SST @ ACCU).



Reference PIPING EXAMPLE #2 for R-22 and R-407c Refrigerants.

Suction Line Equivalent Feet Review

In this example the Suction Line Equivalent Feet Estimation comes to 41 Equivalent Feet (Reference *Figure 49 on page 61*).

TABLE 5 - SUCTION LINE CONDENSER TEMPERATURE CORRECTION FACTOR R-410A

CONDENSING TEMPERATURE °F	SUCTION LINE	DISCHARGE LINE
80	1.17	0.82
90	1.10	0.89
100	1.04	0.96
110	0.96	1.03
120	0.89	1.10
130	0.81	1.16

NOTE: Some tables may present the data differently, but through the formulas the output is the same.

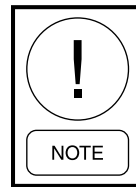
PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT

Suction Line Piping Equivalent Feet Estimation

Line Sizing (Diameter) is based on the total equivalent feet of pipe run for each given suction line. Any change in the selected pipe size diameter will vary the equivalent feet of pipe (See *Figure 49 on page 61* losses for various pipe diameters). So it is important to revisit *Table 4 on page 60* and *Figure 49 on page 61* if the line size diameter selection has changed. In this example the **linear** feet estimation and fittings BOM are outlined in *Figure 46 on page 57* with equivalent feet estimates tabulated below.

Suction Piping Equivalent Feet Tabulation Using 1-5/8" Diameter Pipe:

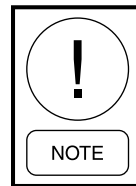
Linear Length Feet = 3' + 12' + 10' = 25'
Total Estimated Equivalent Length Feet =
+ 3.0' [horizontally]
+ 4.2' [(2) 45° Street fittings]
[~2.1 eq. feet/elbow*]
+ 4.0' [(1) 90° Standard fitting]
[~4.0 eq. feet/elbow*]
+ 7.8' [(3) 90° Long radius elbows]
[~2.6 eq. feet /elbow*]
+ 12' [vertically]
+ 10' [horizontally]
= 41.0' → equivalent



Equivalent Feet of pipe is used in determining the final line loss on the previous page 60, as well as to assure you are within the maximum 150 equivalent feet design criteria.

Determining Pipe Fitting Loss

From *Figure 49* tabulate the equivalent feet loss for each fitting itemized (see left). Keep in mind vertical suction “risers” in excess of 20’ must include an intermediate trap at mid point, and if suction risers exceed 40’, always discuss with JCI Application Engineering (or Include in Special Quotation in YORKworks - SQ).



When using Figure 49, note that the tube size is listed as nominal. Always use the size closest to the actual (i.e. Actual 1-5/8" would use a nominal 1-1/2" size as in this example).

4

Nominal Pipe or Tube Size, in.	Smooth Bend Elbows						Smooth Bend Tees			
	90° Std. ^a	90° Long Radius ^b	90° Street ^a	45° Std. ^a	45° Street ^a	180° Std. ^a	Flow Through Branch	Straight-Through Flow		
								No Reduction 	Reduced 1/4 	Reduced 1/2
3/8	1.4	0.9	2.3	0.7	1.1	2.3	2.7	0.9	1.2	1.4
1/2	1.6	1.0	2.5	0.8	1.3	2.5	3.0	1.0	1.4	1.6
3/4	2.0	1.4	3.2	0.9	1.6	3.2	4.0	1.4	1.9	2.0
1	2.6	1.7	4.1	1.3	2.1	4.1	5.0	1.7	2.2	2.6
1-1/4	3.3	2.3	5.6	1.7	3.0	5.6	7.0	2.3	3.1	3.3
1-1/2	4.0	2.6	6.3	2.1	3.4	6.3	8.0	2.6	3.7	4.0
2	5.0	3.3	8.2	2.6	4.5	8.2	10.0	3.3	4.7	5.0
2-1/2	6.0	4.1	10.0	3.2	5.2	10.0	12.0	4.1	5.6	6.0
3	7.5	5.0	12.0	4.0	6.4	12.0	15.0	5.0	7.0	7.5
3-1/2	9.0	5.9	8.2	4.7	7.3	15.0	18.0	5.9	8.0	9.0
4	10.0	6.7	10.0	5.2	8.5	17.0	21.0	6.7	9.0	10.0
5	13.0	8.2	12.0	6.5	11.0	21.0	25.0	8.2	12.0	13.0
6	16.0	10.0	15.0	7.9	13.0	25.0	30.0	10.0	14.0	16.0

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FIGURE 49 - SUCTION PIPING FITTING LOSSES

PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT**Determining the Need for Double Suction Risers**

Double suction risers are required where the turndown capacity of the ACCU system is less than the suction line piping minimum refrigerant capacity for oil entrainment up a vertical riser, as outlined in the appendix *Table 29 on page 122* (Also *Table 6 on page 62* in this example).

In this continued example, referencing *Figure 44 on page 55* shows a minimum load for system #1 at 17.7 tons. Using *Table 6 on page 62*, for the 1-5/8" suction line selected in this example (With 45°F SST and 55°F Suction Gas Temp assuming 10°F suction superheat at minimum load), use the value closest to the 45°F SST of 40°F (In chart), with a suction gas temperature of (40 + 10) 50°F. This offers a 4.73 nominal ton minimum allowable turndown based on a 90°F liquid condensing temperature. Our Design criteria/assumptions on page 59 show the liquid condensing temperature to be 120°F.

We must now adjust for the actual liquid temperature leaving the condenser. Using *Table 6 on page 62* "Liquid Temperature, °F" chart/note, we find the correction factor for 105°F liquid condensing temperature (120°F CT - 15° Sub Cooling) to be 0.915 times the 4.73 = 4.33 ton minimum allowable turndown. With the actual minimum load being 17.7 tons > the adjusted 4.33 minimum, the need for double suction risers is not required in this example.

It should be noted here that over sizing a suction line can lead to the possible need for double suction risers, keeping in mind that any unnecessary piping is unwanted piping. While accepting a slightly higher (Say less than 10% higher than the 2.0°F target) °F suction line loss can possibly eliminate the need for double suction risers. You can also consider downsizing the vertical riser portion.

TABLE 6 - MINIMUM REFRIGERANT CAPACITY IN TONS FOR OIL ENTRAINMENT UP SUCTION RISERS R-410A

REFRIGERANT	SATURATION SUCTION TEMP., °F	SUCTION GAS TEMP., °F	PIPE O.D., IN.											
			1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8	3-1/8	3-5/8	4-1/8
			AREA, IN ²											
R-410A	-40	-30	0.09	0.16	0.26	0.39	0.76	1.29	2.00	3.98	6.84	10.68	15.58	21.61
		-10	0.09	0.16	0.26	0.40	0.78	1.32	2.04	4.07	6.99	10.90	15.90	22.06
		10	0.09	0.16	0.27	0.41	0.79	1.34	2.08	4.15	7.12	11.12	16.22	22.50
	-20	-10	0.11	0.20	0.33	0.50	0.98	1.66	2.56	5.12	8.79	13.72	20.01	27.76
		10	0.11	0.21	0.34	0.51	1.00	1.69	2.62					
		30	0.12	0.21	0.35	0.52	1.02	1.73	2.67					
	0	10	0.14	0.25	0.42	0.63	1.23	2.08	3.21					
		30	0.14	0.26	0.43	0.64	1.26	2.12	3.28					
		50	0.15	0.26	0.44	0.65	1.28	2.17	3.35					
	20	30	0.19	0.34	0.56	0.85	1.65	2.79	4.32					
		50	0.19	0.35	0.57	0.87	1.69	2.85	4.41					
		70	0.20	0.35	0.58	0.88	1.72	2.91	4.50					
	40	50	0.21	0.37	0.61	0.93	1.81	3.06	4.73					
		70	0.21	0.38	0.63	0.95	1.85	3.12	4.84					
		90	0.20	0.39	0.64	0.97	1.88	3.19	4.93					

Note - Liquid Correction Factor: Based on the assumption 120°F condensing temperature minus the normal design 15°F sub-cooling @ 95°F ambient = (120 - 15) = 105°F Liquid Temperature. By interpolation the correction factor = 0.915 in this example.

Refrigeration capacity in tons is based on 90°F liquid temperature and superheat as indicated by the temperature in the table. The saturated condensing and suction conditions are referenced to the dewpoint for R-407C. For other liquid line temperatures, use correction factors to the capacity given in the table below.

REFRIGERANT	LIQUID TEMPERATURE, °F								
	50	60	70	80	100	110	120	130	140
R-410A	1.21	1.16	1.11	1.05	0.94	0.89	0.82	0.76	0.68

PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT

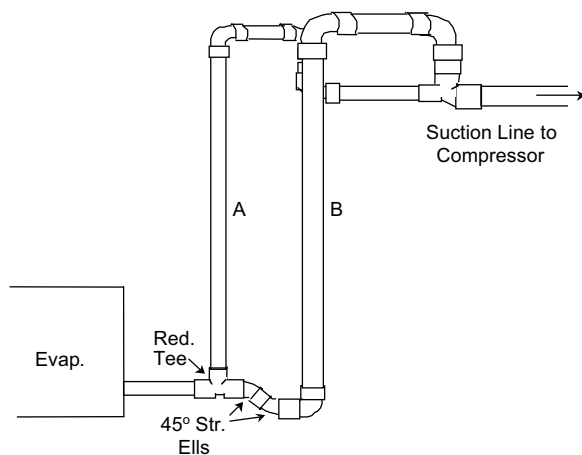
Double Suction Riser Design and Selection Practices

When applying double suction line risers the combined cross sectional area of the two risers should be similar to the cross sectional area of a correctly sized single riser.

As a rule of thumb, the smaller riser 'A' would be sized to handle about 25% to 45% of the total area of the originally selected line size and 'B' the rest.

Offering a "Side" Example – Using *Table 6 on page 62* (Also *Table 29 on page 122* in the Appendix), a 2-1/8" Main suction line would have a 3.094 sq in. area. Selecting riser 'A' would suggest a 1-3/8" O.D. line with a 1.256 sq in. area, or roughly 41% of the 2-1/8" Main. The larger 'B' would suggest a 1-5/8" size with 1.780 sq in. This would result in a 3.036 sq in. cross section area for 'A' and 'B'.

The 1-3/8" and 1-5/8" double risers, with a total area of 3.036 square inches, would be acceptably close to the 2-1/8" (3.094 square inches) Main selected suction line size and reflect a properly sized double suction riser.



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FIGURE 50 - DOUBLE SUCTION RISER

SELECTING LIQUID LINES

Liquid lines are less critical on oil return concerns, given the oil readily mixes with the liquid refrigerant. However, line "size" has a greater impact on refrigerant volume in the system, and should be guarded against and not oversized. Oversized lines with greater refrigerant volume can increase the potential for refrigerant leaks, along with unnecessary added refrigerant cost. Sizing should generally be based on line loss not exceeding about 1°F.

Liquid Line Selection Procedure

Continuing the R-410a example above as outlined in the assumptions on page 59 and percent system split on page 58, make an initial system #1 liquid line selection using *Table 28 on page 121* in the Appendix (Also shown in *Table 7 on page 64* of this example).

Given the total ACCU capacity of 73.5 tons (Reference *Figure 44 on page 55*), and the percent split for system #1 of 57% (Reference *Figure 48 on page 58*), the system #1 capacity to size for is (73.5×0.57) 41.9 tons (Note – This exercise has already been completed and can be referenced on page 65 of this guide under "Calculating the Final System Capacity").

In reviewing *Table 7 on page 64* the initial line size selection would suggest a 7/8" liquid line, based on the shorter equivalent feet line length, at about a 1°F line loss Δt . This initial selection must be reviewed at the actual equivalent line length, which follows.

PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT**TABLE 7 - DISCHARGE AND LIQUID LINE CAPACITIES IN TONS FOR REFRIGERANT R-410A**

LINE SIZE	DISCHARGE LINES ($\Delta t = 1^{\circ}\text{F}$, $\Delta p = 4.75\text{psi}$)			LINE SIZE	LIQUID LINES	
TYPE L COPPER, OD	SATURATED SUCTION TEMPERATURE, $^{\circ}\text{F}$			TYPE L COPPER, OD	Vel. = 100 FPM	$\Delta t = 1^{\circ}\text{F}$ $\Delta p = 4.75$
	35	45	55			
1/2	1.30	1.35	1.37	1/2	2.00	4.60
5/8	2.50	2.55	2.60	5/8	3.20	8.60
3/4	4.20	4.25	4.30	3/4	4.70	14.30
7/8	6.50	6.60	6.75	7/8	6.70	22.60
1 1/8	13.10	13.25	13.40	1 1/8	11.40	45.80
1 3/8	22.80	23.00	23.35	1 3/8	17.40	79.70
1 5/8	36.00	36.45	37.00	1 5/8	24.60	125.90
2 1/8	72.00	75.00	77.00	2 1/8	42.80	260.70
2 5/8	135.00	137.00	138.00	2 5/8	66.00	459.70
3 1/8	210.00	215.00	216.00	3 1/8	94.20	733.00
3 5/8	310.00	315.00	318.00	3 5/8	127.40	1087.50

NOTES:

Capacities are in tons of refrigeration.

 Δp = Pressure drop due to line friction, psi per 100 feet equivalent length. Δt = Change in saturation temperature corresponding to pressure drop, per $^\circ\text{F}$ per 100 feet.Line capacity for other saturation temperatures Δt and equivalent lengths L_e .

Line capacity = Table capacity

$$\left(\frac{\text{Table } L_e}{\text{Actual } L_e} \right) \times \left(\frac{\text{Actual } \Delta t}{\text{Table } \Delta t} \right)^{0.55}$$

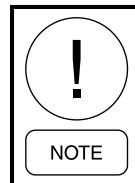
Saturation temperature Δt for other capacities and equivalent lengths L_e

$$\Delta t = \text{Table } \Delta t \left(\frac{\text{Actual } L_e}{\text{Table } L_e} \right) \times \left(\frac{\text{Actual Capacity}}{\text{Table Capacity}} \right)^{1.8}$$

Liquid Line Piping Equivalent Feet Estimation

Line Sizing (Diameter) is based on the total equivalent feet of pipe run for each given liquid line. Any change in the selected pipe size diameter will vary the equivalent feet of pipe (See *Figure 51 on page 65* losses for various pipe diameters). So it is important to revisit *Figure 51 on page 65* and the “Calculated Final Liquid Line Loss” on the following page if the line size diameter has changed.

In this example the linear feet estimation and fittings BOM are outlined in *Figure 47 on page 57* with equivalent feet estimates tabulated as on the following page.



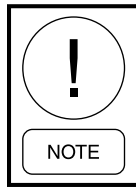
Equivalent Feet of pipe is used in determining the final line loss on the following page 65, as well as to assure you are within the maximum 150 equivalent feet design criteria (100 equivalent feet on YCAV and YCIV product).

PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT

Liquid Piping Equivalent Feet Tabulation using 7/8" Diameter Pipe

Linear Length Feet = 3' + 12' + 10' = 25'
Total Estimated Equivalent Length Feet =

+ 3.0' [horizontally]
+ 3.4' [(2) 90° Long radius elbows
[~1.7 eq. feet /elbow*]
+ 12.0' [vertically]
+ 10.0' [horizontally]
= 28.4' → say 29' equivalent



When using Figure 51, note that the tube size is listed as nominal. Always use the size closest to the actual (i.e. Actual 7/8" would use a nominal 1" size as in this example). When closest to the actual size is split as in this case, always use the larger loss value.

Determining Pipe Fitting Loss

From *Figure 51 on page 65* tabulate the equivalent feet loss for each fitting itemized (See left). Keep in mind vertical liquid "risers" must not exceed the maximum distances outlined in *Table 1 on page 44* of this guide. When risers exceed these values, always discuss with JCI Application Engineering.

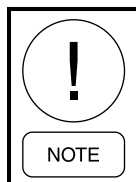
Nominal Pipe or Tube Size, in.	Smooth Bend Elbows						Smooth Bend Tees			
	90° Std. ^a	90° Long Radius ^b	90° Street ^a	45° Std. ^a	45° Street ^a	180° Std. ^a	Flow Through Branch	Straight-Through Flow		
								No Reduction 	Reduced 1/4 	Reduced 1/2
3/8	1.4	0.9	2.3	0.7	1.1	2.3	2.7	0.9	1.2	1.4
1/2	1.6	1.0	2.5	0.8	1.3	2.5	3.0	1.0	1.4	1.6
3/4	2.0	1.4	3.2	0.9	1.6	3.2	4.0	1.4	1.9	2.0
1	2.6	1.7	4.1	1.3	2.1	4.1	5.0	1.7	2.2	2.6
1-1/4	3.3	2.3	5.6	1.7	3.0	5.6	7.0	2.3	3.1	3.3
1-1/2	4.0	2.6	6.3	2.1	3.4	6.3	8.0	2.6	3.7	4.0
2	5.0	3.3	8.2	2.6	4.5	8.2	10.0	3.3	4.7	5.0
2-1/2	6.0	4.1	10.0	3.2	5.2	10.0	12.0	4.1	5.6	6.0
3	7.5	5.0	12.0	4.0	6.4	12.0	15.0	5.0	7.0	7.5
3-1/2	9.0	5.9	8.2	4.7	7.3	15.0	18.0	5.9	8.0	9.0
4	10.0	6.7	10.0	5.2	8.5	17.0	21.0	6.7	9.0	10.0
5	13.0	8.2	12.0	6.5	11.0	21.0	25.0	8.2	12.0	13.0
6	16.0	10.0	15.0	7.9	13.0	25.0	30.0	10.0	14.0	16.0

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FIGURE 51 - LIQUID PIPING FITTING LOSSES

Calculating Final Liquid Line Loss

Calculating the actual Δt line loss using the formula under Δt of *Table 7 on page 64* calculates to 0.88°F line loss and approximates the 1.0°F design loss and validates the selection (See right):



Reference PIPING EXAMPLE #2 for R-22 and R-407c Refrigerants.

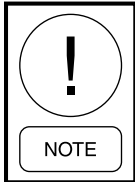
$$\Delta t = \text{Table } \Delta t \left(\frac{\text{Actual } L_e}{\text{Table } L_e} \right) \left(\frac{\text{Actual capacity}}{\text{Table capacity}} \right)^{1.8}$$

$$\Delta t = 1 \left(\frac{29}{100} \right) \left(\frac{41.9}{22.6} \right)^{1.8}$$

$\Delta t = 0.88^\circ\text{F}$ which is close to the 1°F design

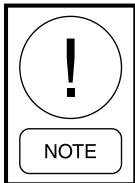
PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT**Determining “Optional” Hot Gas Bypass (HGBP) Line Size**

Reference the Sales YORKworks Performance Data sheet (See example *Figure 44 on page 55*). Review the minimum part load rating data, capacity tons.



Typically compressors 6, 5, and 4 are for system #2 and compressors 3, 2, and 1 are for system #1 (Respective to the declining Part Load Rating Data shown in Figure 44 . . . compressors 6 and 4 are N/A in this example and not shown). Also note that typically the larger compressor is on system #1, but always verify through the IOM or the in-place ACCU.

Referencing *Figure 44 on page 55*, YCUL0072 Style E with R-410a refrigerant having HGBP on system #1 would indicate a 17.7 ton minimum compressor load rating. This is the tonnage used in selecting the HGBP line size in *Table 8 on page 66*.



When applying HGBP to both systems, keep in mind that System #2 may have a different compressor capacity (Smaller tonnage compressors are typically on system #2) as in this example of a nominal 14.9 tons (Refer to Table 3 on page 56).

Equivalent Feet

In determining the HGBP line size, you will need to tabulate the equivalent feet of pipe run. Equivalent feet of pipe is determined in the same manner as the suction and liquid line (Reference *Figures 46 and Figure 47 on page 57* examples).

In this example we will base the HGBP line arrangement, lengths and fittings with the same values as the liquid line (Same 7/8" line size assumed). Referencing *Table 8 on page 66* (Less than 50'), an initial line size selection would suggest a 7/8" line size, based on the short run. Equivalent feet tabulation would be as follows:

HGBP Piping Equivalent Feet Tabulation

Linear Length Feet = 3' + 12' + 10' = 25'

Total Estimated Equivalent Length Feet =

$$\begin{aligned}
 &+ 3.0' \quad [\text{horizontally}] \\
 &+ 3.4' \quad [(2) 90^\circ \text{ Long radius elbows}] \\
 &\quad \quad [\sim 1.7 \text{ eq. feet /elbow*}] \\
 &+ 12.0' \quad [\text{vertically}] \\
 &+ 10.0' \quad [\text{horizontally}] \\
 &= 28.4' \rightarrow \text{say } 29' \text{ equivalent}
 \end{aligned}$$

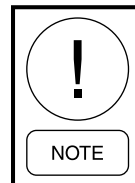
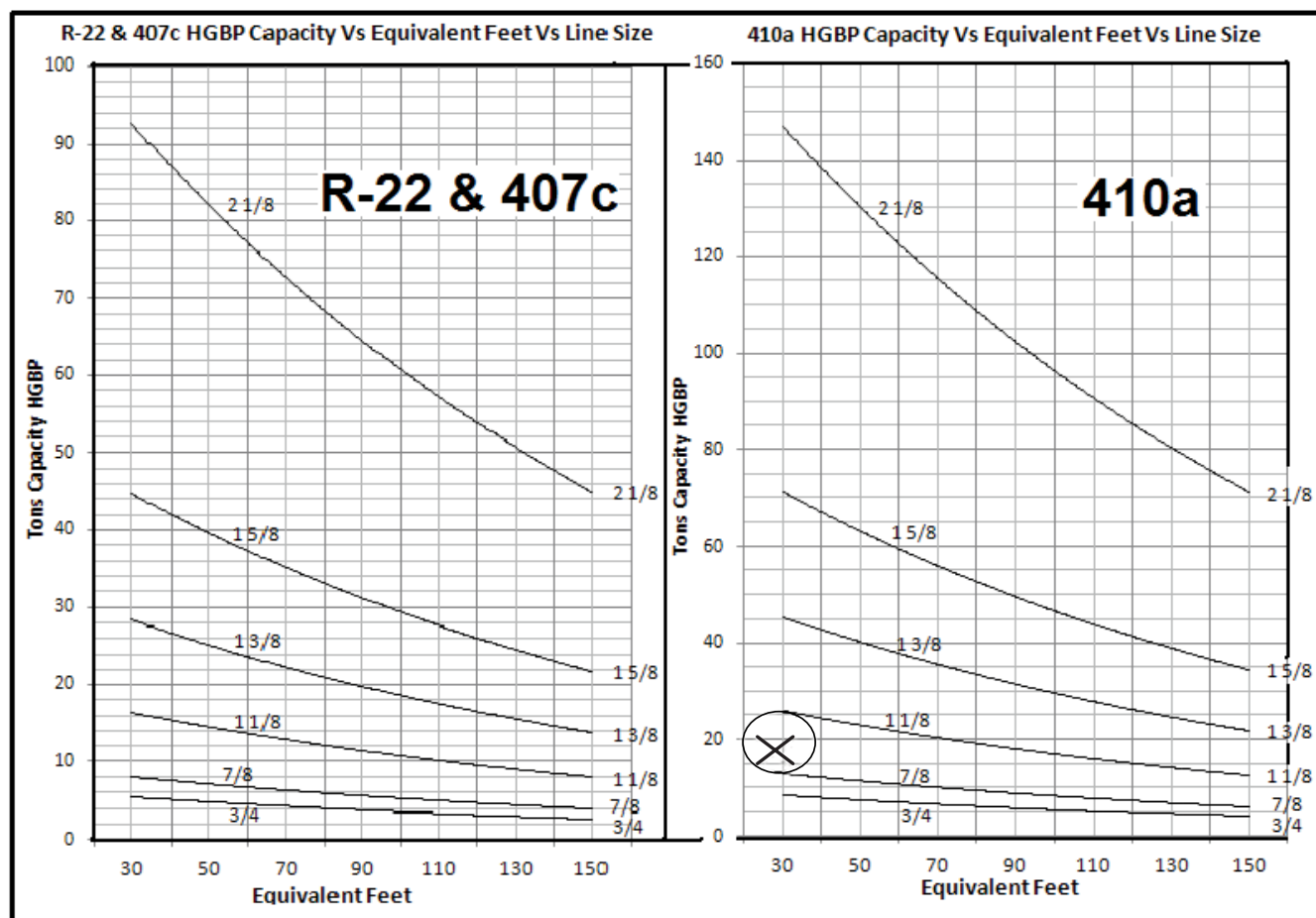


Figure 52 offers the same Line Size Recommendations as Table 8, except in Line Chart Form.

TABLE 8 - HGBP LINE SIZE RECOMMENDATIONS

LINE SIZE (TYPE "L" REFRIGERATE GRADE)	R-22 and (R-407c) - MAX TONS, CAPACITY @ EQUIVALENT FT. (EF)		R-410a - MAX TONS, CAPACITY @ EQUIVALENT FT. (EF)	
	150 EF	50 EF	150 EF	50 EF
3/4	2.6	4.7	4.0	7.4
7/8	3.9	7.1	6.2	11.4
1 - 1/8"	7.9	14.4	12.6	23.0
1 - 3/8"	13.7	25.1	21.8	40.0
1 - 5/8"	21.7	39.6	34.5	63.1
2 - 1/8"	44.9	82.1	71.1	130.2

PIPING EXAMPLE #1 – LINE SIZING PRACTICE USING R-410A REFRIGERANT



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FIGURE 52 - HGBP LINE SIZE RECOMMENDATIONS LINE GRAPHS FOR R-22, R-407C AND R-410A

Determining Final HGBP Line Sizing

Given the design of 29 equivalent feet (EF) of HGBP pipe run, and the minimum turndown capacity of 17.7 tons, determine from either *Table 8 on page 66* or *Figure 52 on page 67* the best line size using R-410a.

Using *Table 8 on page 66* would suggest an initial selection of 7/8" given the short equivalent feet of pipe run. Referencing *Figure 52 on page 67* allows a more detailed view of the selection.

Looking at 17.7 tons @ 29 EF plots a point between a 7/8" line size and a 1-1/8". Given the minimum tons are offered as 100% of the minimum turndown compressor, the selection is somewhat conservative and would suggest the closer of the two curves. In this case the final HGBP selection would suggest a 7/8" line size as acceptable.

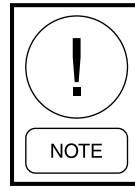
PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT**PIPING – SIZE AND SELECTION PRACTICES
OVERVIEW**

Pipe sizing is critical to oil management as well as line loss considerations. Oil management states that oil should return to the compressor at the same rate that it leaves the compressor. Line loss limitations protect the chiller against low suction pressure faults as well as an excessive loss in capacity at the ACCU.

The following JCI pipe line loss limitations parallel ASHRAE refrigeration standards. Practices base line sizing as follows:

- Liquid Lines not to exceed a value of about 1°F line loss
- Suction Lines not to exceed a value of about 2°F line loss
- Hot Gas Bypass (HGBP) line sizing is outlined in *Table 14 on page 80* or *Figure 60 on page 80* of this form
- Maximum Suction, Liquid and Hot Gas Bypass (HGBP) line equivalent feet allowed is a nominal 150 equivalent feet (100 EF on YCAV/YCIV product – HGBP is not applicable).

The following paragraphs and pages offer line sizing Example #2 using R-22 (R-407c refrigerant is virtually the same and will not be covered as an example), as well as specific table references found in the back of this guide. Reference Example #1 for R-410a Refrigerant Systems.



YORKworks has discontinued selections for R-22 and R-407c in light of the more current R-410a refrigerant. This example will focus on the Engineering Guide as the selection tool. Engineering Guide can be downloaded from the www.jci.com website.

Making the Initial YORKworks Selection

Given the following required initial data, acquire the ACCU selection for this project:

- Refrigerant Type (This example uses R-22)
- Capacity required (70 tons)
- Design Ambient Temperature (95°F)
- Design ACCU Saturated Suction Temperature (SST). Generally a nominal 10°F below the LAT of the DX Coil can be assumed. Note the following:
 - This example will assume 55°F LAT - 10°F = 45° SST ESTIMATE at the ACCU
 - It should be noted here that if DX Coil Rows and FPI, or airside PD are already specified, you can select the DX Coil first to identify the DX Coil SST and then subtract the industry standard 2°F suction line loss to acquire the estimated SST design of the ACCU.

This example offers model YCUL0076EC46 out of the Sales Engineering Guide. See below and Figure 53. Figure 53 also notes under Physical Data the minimum nominal tons for HGBP (Optional).

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT

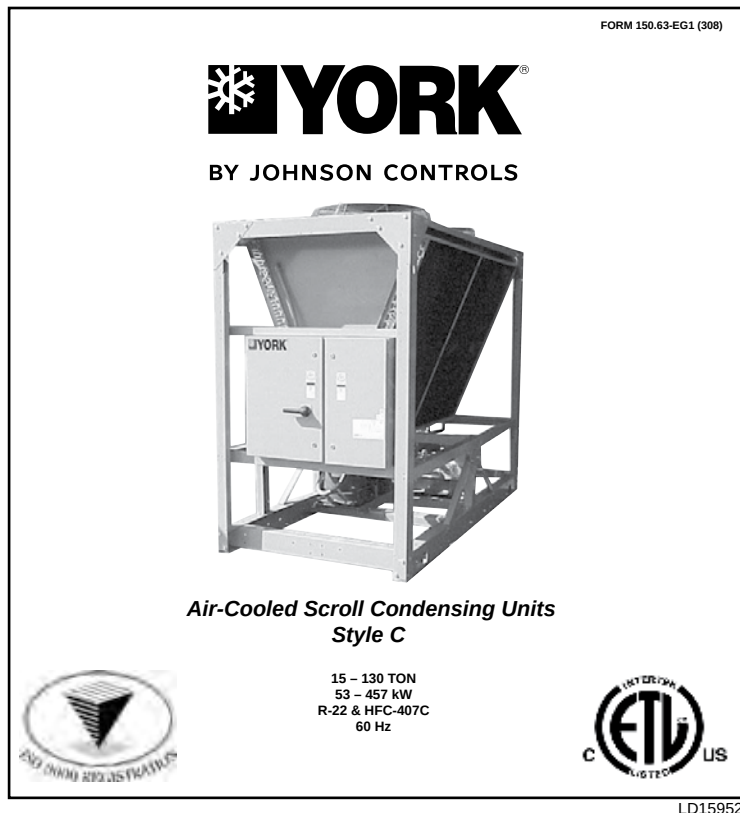


FIGURE 53 - EXAMPLE – USING THE SALES ENGINEERING GUIDE

TABLE 9 - RATINGS - R-22 (ENGLISH UNITS)

MODEL: YCUL0076EC																		
AIR TEMPERATURE ON - CONDENSER (°F)																		
SST (°F)	75°F			80°F			85°F			90°F			95°F			100°F		
	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER	TONS	KW	EER
35.0	64.2	55.4	12.4	62.6	58.6	11.5	61.0	61.9	10.7	59.4	65.5	9.9	57.7	69.2	9.1	55.9	73.1	8.4
37.0	66.6	55.9	12.7	64.9	59.0	11.8	63.3	62.4	11.0	61.6	65.9	10.2	59.8	69.7	9.4	58.0	73.7	8.6
39.0	69.0	56.3	13.1	67.3	59.5	12.2	65.6	62.8	11.3	63.8	66.4	10.5	62.0	70.2	9.7	60.1	74.2	8.9
41.0	71.4	56.8	13.5	69.7	60.0	12.5	67.9	63.4	11.6	66.1	67.0	10.8	64.2	70.8	9.9	62.3	74.8	9.2
43.0	74.0	57.3	13.8	72.2	60.5	12.9	70.3	63.9	11.9	68.5	67.5	11.1	66.5	71.3	10.2	64.5	75.4	9.4
45.0	76.6	57.8	14.2	74.7	61.0	13.2	72.8	64.4	12.3	70.8	68.0	11.4	68.9	71.9	10.5	66.8	75.9	9.7
47.0	79.2	58.4	14.6	77.3	61.5	13.6	75.3	64.9	12.6	73.3	68.6	11.7	71.2	72.4	10.8	69.1	76.5	10.0
49.0	81.9	58.9	15.0	79.9	62.1	13.9	77.9	65.5	12.9	75.8	69.1	12.0	73.6	73.0	11.1	71.5	77.1	10.2
51.0	84.6	59.5	15.3	82.6	62.6	14.3	80.5	66.1	13.3	78.3	69.7	12.3	76.1	73.6	11.4	73.9	77.7	10.5
53.0	87.4	60.1	15.7	85.3	63.2	14.6	83.1	66.6	13.6	80.9	70.3	12.6	78.6	74.2	11.6	76.3	78.4	10.8
55.0	90.3	60.7	16.1	88.1	63.8	15.0	85.8	67.3	13.9	83.5	70.9	12.9	81.2	74.9	11.9	78.8	79.0	11.0

Through interpolation the 70 tons required equates to a 46°F SST vs the original estimate of 45°F SST.

It is noted that the 70 tons specified in this example has a slightly warmer SST but is acceptable for this design LAT of 55°F.

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT**TABLE 9 - RATINGS - R-22 (ENGLISH UNITS) (CONT'D)****Physical Data - English Units**

	MODEL NUMBER YCUL					
	0066	0076	0080	0086	0090	0096
GENERAL UNIT DATA						
Nominal Tons, R-22	62.2	68.9	77.0	83.6	90.1	90.8
Nominal Tons, R-407C	61.3	66.5	74.9	81.8	88.5	87.2
Number of Refrigerant Circuits	2	2	2	2	2	2
Refrigerant Charge, Operating						
R-22, ckt1 / ckt2, lbs	56.2/56.2	58.5/48.4	64.7/64.7	71.8/64.7	78.0/78.0	86.3/73.2
R-407C, ckt1 / ckt2, lbs	54.2/54.2	56.4/46.7	62.4/62.4	69.2/62.4	75.2/75.2	83.2/70.5
Pumpdown Capacity						
R-22, ckt1 / ckt2, lbs	87.6/87.6	68.1/68.1	102.2/102.2	102.2/102.2	102.2/102.2	150.0/150.0
R-407C, ckt1 / ckt2, lbs	84.4/84.4	65.6/65.6	98.5/98.5	98.5/98.5	98.5/98.5	145.8/145.8
Oil Charge, ckt1 / ckt2, gallons	2.2/2.2	3.3/3.3				
Operating / Shipping Weight						
Aluminum Fin Coils, lbs	4175	4842				
Copper Fin Coils, lbs	4475	5142				
COMPRESSORS, SCROLL TYPE						
Compressors per circuit	2	3		3	3	2
Compressors per unit	4	6	6	6	6	4
Nominal Tons per compressor	15/15	13/10	13/13	15/13	15/15	25/20

Respectively system #1 is 13 tons minimum load and system #2 is 10 tons. These values are used for selecting the HGBP option

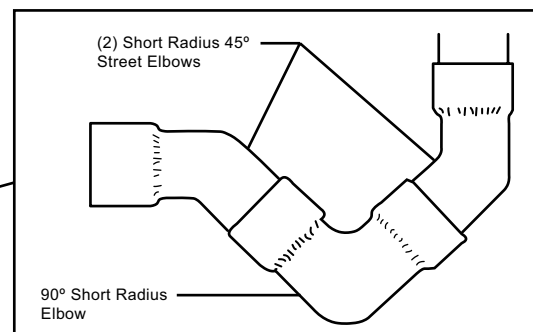
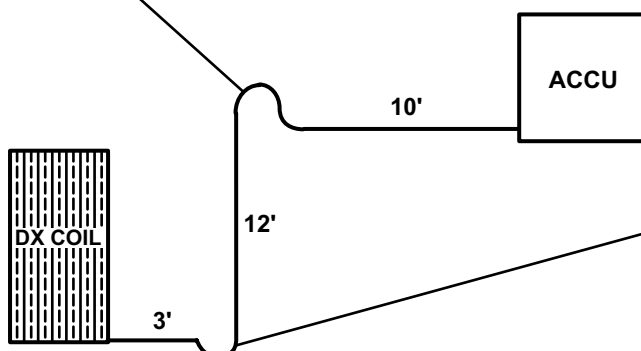
Piping Arrangement

Various piping arrangements are outlined on Figures 36 through 43 of this guide. This continued example will cover both suction and liquid line arrangements, as well as the optional HGBP. Figures 54 and 55 will itemize the number of fittings, traps and linear line length for further use in determining the total equivalent feet of pipe run.

The Following is Referenced for Determining Equivalent Feet of Pipe:

- 3' horizontally from the DX coil to the vertical suction riser
- 12' up the vertical suction riser with bottom trap as outlined
- 10' horizontally to the ACCU suction connections.
- (3) 90° long radius elbows
- (2) short radius 45° street elbows
- (1) 90° short radius elbow

(3) 90° LONG RADIUS ELBOWS/INVERTED TRAP



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FIGURE 54 - EXAMPLE SUCTION LINE ARRANGEMENT

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT

The Following is Referenced for Determining Equivalent Feet of Pipe:

- 3' horizontally
- 12' vertically up
- 10' horizontally
- (2) 90° long radius elbows

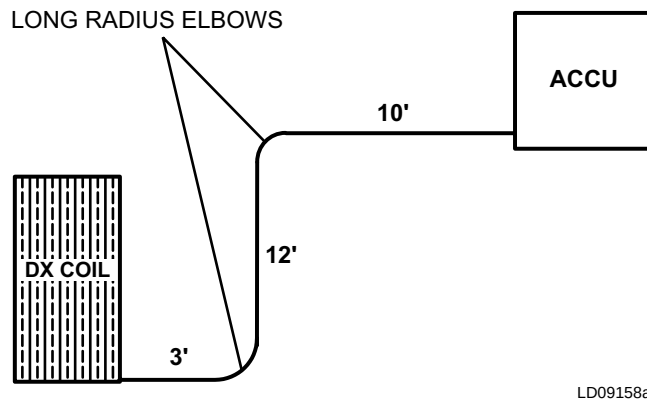


FIGURE 55 - EXAMPLE LIQUID LINE ARRANGEMENT

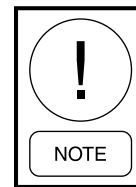
Determining Percent System Splits

This example maintains the YCUL0076EC R-22 refrigerant ACCU having two different nominal tonnage systems as outlined in Figure 56, noting that not all ACCU's have unequal system tons.

In this continued example, we have System #1 at a nominal 39 tons (3 nominal 13 ton scrolls) and System #2 at a nominal 30 tons (3 nominal 10 tons scrolls). This example will address system #1 only, noting that system #2 is selected in the same manner.

1. All Refrigerant Lines must be sloped $\frac{1}{2}$ " per 10 feet minimum in direction of refrigerant flow to support good oil management (Oil comes back to the compressor at the same rate that it leaves the compressor).
2. Maximum allowable pipe runs must not exceed 150 equivalent feet (100 Equivalent feet for YCAV and YCIV). Reference "Dealing with Excessive Line Lengths" on page 72 of this guide.

These and other ACCU system splits are outlined in the Sales Engineering Guides, as well as in the (Service Installation, Operating and Maintenance Manuals) under the Physical Data portions.



Reference PIPING EXAMPLE #1 for R-410a Refrigerants noting that R-407c refrigerants are very similar to R-22 as in this example.

Physical Data - English and SI

	MODEL NUMBER ACCU					
	0066	0076	0080	0086	0090	0096
GENERAL UNIT DATA						
Nominal Tons, R-22	62.2	68.9	77.0	83.6	90.1	90.8
Nominal Tons, R-407C	61.3	66.5	74.9	81.8	88.5	87.2
Number of Refrigerant Circuits	2	2	2	2	2	2
Refrigerant Charge, Operating						
R-22, ckt1 / ckt2, lbs	56.2/56.2	58.5/48.4	64.7/64.7	71.8/64.7	78.0/78.0	86.3/73.2
R-407C, ckt1 / ckt2, lbs	54.2/54.2	56.4/46.7	62.4/62.4	69.2/62.4	75.2/75.2	83.2/70.5
Pumpdown Capacity						
R-22, ckt1 / ckt2, lbs	87.6/87.6	68.1/68.1	102.2/102.2	102.2/102.2	102.2/102.2	150.0/150.0
R-407C, ckt1 / ckt2, lbs						145.8
Oil Charge, ckt1 / ckt2, lbs						54.2
Operating / Ship						
Aluminum Fin Co						82
Copper Fin Co						94
COMPRESSORS, SCROLL TYPE						
Compressors per circuit	2	3	3	3	3	2
Compressors per unit	4	6	6	6	6	4
Nominal Tons per compressor	15/15	13/10	13/13	15/13	15/15	25/20

Refrigerant System (Circuit) % Split determination:

Note: Minimum nominal load for system #1 is 13 nominal tons and system #2 is 10 tons respectively

Total Nominal Tons = System #1 nom tons @ (3 x 13) + System #2 nom tons @ (3 x 10) = 69 Nominal Tons

% Split System #1 = (3 x 13) / 69 = (39 / 69) = 57%

% Split System #2 = (3 x 10) / 69 = (30 / 69) = 43%

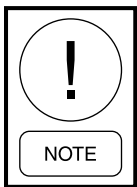
FIGURE 56 - DETERMINING REFRIGERANT CIRCUIT % SPLIT

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT**Calculating the Final System Capacity**

Given the specified total ACCU capacity of 70 tons (Reference *Table 9 on page 69*), and the percent split for system #1 of 57% (Reference *Figure 56 on page 71*), the system #1 capacity to size for is (70 x 0.57) 39.9 tons. System #2 would be calculated in the same manner.

Design Data and Assumptions

The following offers the accumulated design data and assumptions from the previous example pages. Note that this is the required minimum information necessary for determining piping line sizing requirements.



Reference PIPING EXAMPLE #1 for R-410a Refrigerants noting that R-407c refrigerants are very similar to R-22 as in this example.

Example Design Data/Assumptions

- ACCU: R-22, YCUL0076EC, 70.0 tons @ full load (System #1 is only addressed in this example)
- 95°F ambient (the condensing temperature is typically about 25°F above the design ambient temperature or about 120°F in this example. This is generally the same for other ACCU refrigerant types . . . always verify if uncertain)
- 46°F saturated suction temperature
- System #1 capacity of 39.9 tons
- System #1 minimum capacity of 13.0 tons
- Arrangement - DX Coil below the ACCU arrangement with lengths, traps and fittings count as outlined in *Figure 54 on page 70* and *Figure 55 on page 71*)

Example Design Data – Computer Rating

Not field available for R-22 and R-407c (Contact Application Engineering).

Dealing with Excessive Line Lengths

In estimating the line size diameter it is important to note that the “maximum” equivalent pipe length must not exceed a nominal 150 equivalent feet (**100 equivalent feet for YCAV or YCIV**). Note also that any change in your initial pipe diameter will vary the equivalent feet of pipe for any fixed pipe length and trap/fitting count. Also, when pipe run initial estimates exceed the maximum

150’ equivalent lengths (**100 equivalent feet for YCAV or YCIV**), always contact JCI Application Engineering for direction. **In virtually all cases the direction will be to move the DX Coil and the ACCU closer together, or the pipe run will need to be re-routed and shortened following practices outlined in this guide.**

Suction Line Full Load Duty Selection Procedure

Continuing the R-22 example above as outlined in the assumptions on page 72 and percent system split on page 71, make an initial system #1 suction line selection using *Table 23 on page 119* in the Appendix (Also *Table 10 on page 73* of this example).

Given the 39.9 actual tons in this example, the initial line size selection would suggest a 2-1/8” suction line at the design 46° SST assumption, based on the short equivalent feet run in this example. The initial line capacity per 100 equivalent feet of 2-1/8” pipe shows 36.85 tons by interpolation.

Condensing Temperature Correction

The 2-1/8” line size capacity is next corrected for the actual 120°F condensing temperature noted in the assumption example. The correction factor is selected from *Table 11 on page 73* (i.e. 36.85 Table tons x 0.92 = 33.9 adj. tons).

Equivalent Feet of Pipe Correction

In this example, the equivalent feet of pipe length from the following page shows 45.1 equivalent feet using the 2-1/8” suction line selected. This, along with the actual tonnage will be used in calculating the final line loss.

Calculating Final Line Loss - Calculating the actual Δt line loss using the formula under note 4 of *Table 10 on page 73* calculates to 1.2°F line loss (Loss from DX Coil to ACCU):

$$\Delta t = \text{Table } \Delta t \left(\frac{\text{Actual } L_e}{\text{Table } L_e} \right) \left(\frac{\text{Actual capacity}}{\text{Table capacity}} \right)^{1.8}$$

$$\Delta t = 2 \left(\frac{45.1}{100} \right) \left(\frac{39.9}{33.9} \right)^{1.8}$$

$\Delta t = 1.2^\circ\text{F}$ falls within the 2°F allowable line loss, and is best suited in this example. An initial check would

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT

show going one size smaller at 1-5/8 would push the Δt well over the design 2°F line loss to around 3.5°F and would create excessive suction line pressure losses and a potential for low suction faults and reduced capacity.

1. This line loss is used to determine the required suction temperature design of the DX Coil (i.e. 46°F @ ACCU + 1.2°F = 47.2°F SST DX Coil Design. This line loss can also be used to determine the ACCU SST with a given DX Coil SST (i.e. DX Coil °F SST – calculated line loss °F = °F SST @ ACCU.
2. Reference PIPING EXAMPLE #1 for R-410a Refrigerants noting that R-407c refrigerants are very similar to R-22 as in this example.

TABLE 11 - SUCTION LINE CONDENSER TEMPERATURE CORRECTION FACTOR R-22

CONDENSING TEMPERATURE °F	SUCTION LINE	DISCHARGE LINE
80	1.12	0.82
90	1.07	0.89
100	1.03	0.96
110	0.97	1.03
120	0.92	1.10
130	0.87	1.16
140	0.82	1.22

TABLE 10 - DETERMINE SUCTION LINE SIZE CAPACITY IN TONS FOR R-22

Line Size	Saturated Suction Temperature, °F - R-22		
	35	45	55
Type L Cooper OD Inches	$\Delta t = 2^\circ\text{F}$ $\Delta p = 2.69$	$\Delta t = 2^\circ\text{F}$ $\Delta p = 3.06$	$\Delta t = 2^\circ\text{F}$ $\Delta p = 3.47$
7/8	2.7	3.2	3.7
1 1/8	5.4	6.4	7.5
1 3/8	9.3	11.1	13.1
1 5/8	14.8	17.5	20.7
2 1/8	30.5	36.2	42.7
1 5/8	53.8	63.9	75.2
3 1/8	85.7	101.6	119.7

By interpolation 46°F SST = 36.85

NOTES:

1. Δp = Pressure drop due to line friction, psi per 100 feet equivalent length.
2. Δt = Change in saturation temperature corresponding to pressure drop, per 100 feet.
3. Line capacity for other saturation temperatures Δt and equivalent lengths L_e .

$$\text{Line capacity} = \text{Table capacity} \left(\frac{\text{Table } L_e}{\text{Actual } L_e} \right) \times \left(\frac{\text{Actual } \Delta t}{\text{Table } \Delta t} \right)^{0.55}$$

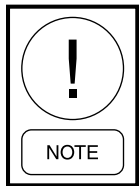
4. Saturation temperature Δt for other capacities and equivalent lengths L_e

$$\Delta t = \text{Table } \Delta t \left(\frac{\text{Actual } L_e}{\text{Table } L_e} \right) \times \left(\frac{\text{Actual Capacity}}{\text{Table Capacity}} \right)^{1.8}$$

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT**Suction Line Piping Equivalent Feet Estimation**

Line Sizing (Diameter) is based on the total equivalent feet of pipe run for each given suction line. Any change in the selected pipe size diameter will vary the equivalent feet of pipe (See *Figure 57 on page 74* losses for various pipe diameters). So it is important to re-visit *Table 10 on page 73* and *Figure 57 on page 74* if the line size diameter selection has changed.

In this example the linear feet estimation and fittings BOM are outlined in *Figure 55 on page 71* with equivalent feet estimates tabulated below.



Equivalent Feet of pipe is used in determining the final line loss (Δt) on the previous page 72, as well as to assure you are within the maximum 150 equivalent feet design criteria (100 EF for YCAV and YCIV product).

Suction Line Equivalent Feet Review

In this example the Suction Line Equivalent Feet Estimation comes to 45.1 Equivalent Feet (Reference Page 74).

Suction Piping Equivalent Feet Tabulation using 2 1/8" Diameter Pipe

Linear Length Feet = 3' + 12' + 10' = 25'

Total Estimated Equivalent Length Feet =

- + 3.0' [horizontally]
 - + 5.2' [(2) 45° Street fittings]
[~2.6 eq. feet /elbow*]
 - + 5.0' [(1) 90° Street fittings]
[~5.0 eq. feet /elbow*]
 - + 9.9' [(3) 90° Long radius elbows]
[~3.3 eq. feet /elbow*]
 - + 12.0' [vertically]
 - + 10.0' [horizontally]
- = 45.1' Equivalent Feet Pipe Length

Determining Pipe Fitting Loss

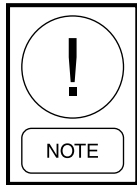
From *Figure 57 on page 74* tabulate the equivalent feet loss for each fitting itemized (see left). Keep in mind vertical suction “risers” in excess of 20’ must include an intermediate trap at mid point, and if suction risers exceed 40’, always discuss with JCI Application Engineering (or Include in Special Quotation in YORKworks - SQ).

Nominal Pipe or Tube Size, in.	Smooth Bend Elbows						Smooth Bend Tees			
	90° Std. ^a	90° Long Radius ^b	90° Street ^a	45° Std. ^a	45° Street ^a	180° Std. ^a	Flow Through Branch	Straight-Through Flow		
								No Reduction 	Reduced 1/4 	Reduced 1/2
3/8	1.4	0.9	2.3	0.7	1.1	2.3	2.7	0.9	1.2	1.4
1/2	1.6	1.0	2.5	0.8	1.3	2.5	3.0	1.0	1.4	1.6
3/4	2.0	1.4	3.2	0.9	1.6	3.2	4.0	1.4	1.9	2.0
1	2.6	1.7	4.1	1.3	2.1	4.1	5.0	1.7	2.2	2.6
1-1/4	3.3	2.3	5.6	1.7	3.0	5.6	7.0	2.3	3.1	3.3
1-1/2	4.0	2.6	6.3	2.1	3.4	6.3	8.0	2.6	3.7	4.0
2	5.0	3.3	8.2	2.6	4.5	8.2	10.0	3.3	4.7	5.0
2-1/2	6.0	4.1	10.0	3.2	5.2	10.0	12.0	4.1	5.6	6.0
3	7.5	5.0	12.0	4.0	6.4	12.0	15.0	5.0	7.0	7.5
3-1/2	9.0	5.9	8.2	4.7	7.3	15.0	18.0	5.9	8.0	9.0
4	10.0	6.7	10.0	5.2	8.5	17.0	21.0	6.7	9.0	10.0
5	13.0	8.2	12.0	6.5	11.0	21.0	25.0	8.2	12.0	13.0
6	16.0	10.0	15.0	7.9	13.0	25.0	30.0	10.0	14.0	16.0

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FIGURE 57 - SUCTION PIPING FITTING LOSSES

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT



When using Figure 57, note that the tube size is listed as nominal. Always use the size closest to the actual (i.e. Actual 2-1/8" would use a nominal 2" size as in this example)

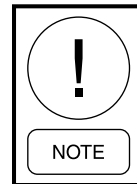
Determining the Need for Double Suction Risers

Double suction risers are required where the turndown capacity of the ACCU system is less than the suction line piping minimum refrigerant capacity for oil entrainment up a vertical riser, as outlined in the appendix Table 29 on page 122 (also Table 12 on page 75 in this example).

In this continued example, referencing Table 9 on page 69, "Physical Data" shows a minimum load for system #1 at 13 tons. Using Table 12 on page 75, for the 2-1/8" suction line selected in this example (with 46°F SST and 56°F Suction Gas Temp assuming 10°F superheat at minimum load), use the value closest to the 46°F SST of 40°F (in chart), with a suction gas temperature of (40 + 10) 50°F. This offers a 7.7 nominal ton minimum allowable turndown based on a 90°F

liquid condensing temperature. Our Design criteria/assumptions on page xx show the liquid condensing temperature to be 120°F.

We must now adjust for the actual liquid temperature leaving the condenser. Using Table 12 on page 75 "Liquid Temperature, °F" chart/note, we find the correction value for 105°F liquid condensing temperature (120°F CT - 15°F sub cooling) to be 0.935 times the 7.7 = 7.2 ton minimum allowable turndown. With the actual minimum load being 13 tons > the adjusted 7.2 minimum, the need for double suction risers is not required in this example.



It should be noted here that over sizing a suction line can lead to the possible need for double suction risers, keeping in mind that any unnecessary piping is unwanted piping. While accepting a slightly higher (say less than 10% higher than the 2.0°F target) °F suction line loss can possibly eliminate the need for double suction risers. You can also consider just downsizing the vertical riser portion.

TABLE 12 - MINIMUM REFRIGERANT CAPACITY IN TONS FOR OIL ENTRAINMENT UP SUCTION RISERS (TYPE L COPPER TUBING)

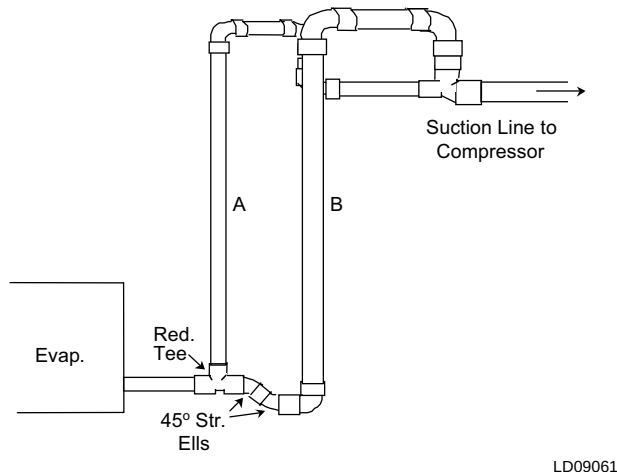
REFRIGERANT	SATURATION SUCTION TEMP., °F	SUCTION GAS TEMP., °F	PIPE O.D., IN.											
			1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8	3-1/8	3-5/8	4-1/8
			AREA, IN ²											
			0.233	0.348	0.484	0.825	1.256	1.780	3.094	4.770	6.812	9.213	11.97	
R-22	-40	-30	0.07	0.12	0.20	0.30	0.59	0.99	1.53	3.05	5.25	8.19	11.95	16.57
		-10	0.07	0.12	0.20	0.30	0.58	0.97	1.51	3.00	5.16	8.06	11.75	16.30
		10	0.07	0.12	0.20	0.30	0.58	0.98	1.52	3.02	5.19	8.11	11.82	16.40
	-20	-10	0.09	0.16	0.26	0.39	0.76	1.28	1.97	3.94	6.77	10.57	15.41	21.38
		10	0.09	0.15	0.25	0.38	0.74	1.26	1.95	3.89	6.68	10.42	15.20	21.09
		30	0.09	0.15	0.26	0.39	0.75	1.27	1.96	3.92	6.73	10.51	15.33	21.26
		10	0.11	0.20	0.33	0.49	0.96	1.63	2.52	5.03	8.63	13.48	19.65	27.26
	Liquid Correction Factor: Based on the assumption 120°F condensing temperature minus the normal design 15°F sub-cooling @ 95°F ambient = (120 - 15) = 105°F Liquid Temperature. By interpolation the correction factor = 0.935 in this example.											3.22	19.29	26.75
												3.33	19.44	26.96
												6.84	24.56	34.06
												6.65	24.28	33.68
		70	0.14	0.23	0.37	0.54	1.07	1.78	2.81	5.61	9.68	14.52	21.38	29.64
		50	0.17	0.30	0.48	0.71	1.28	2.09	3.28	6.56	11.21	16.63	24.25	33.64
		70	0.17	0.30	0.48	0.71	1.28	2.09	3.28	6.56	11.21	16.63	24.25	33.64
	90	0.17	0.30	0.48	0.71	1.28	2.09	3.28	6.56	11.21	16.63	24.25	33.64	

Refrigeration capacity in tons is based on 90°F liquid temperature and 10°F superheat. The saturated condensing and suction conditions are referenced to these temperatures, use correction factors to the capacity given in the table below.

REFRIGERANT	LIQUID TEMPERATURE, °F								
	50	60	70	80	100	110	120	130	140
R-22	1.16	1.12	1.08	1.04	0.98	0.91	0.87	0.82	0.78

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT**Double Suction Riser Design and Selection Practices**

When applying double suction line risers the combined cross sectional area of the two risers should be similar to the cross sectional area of a correctly sized single riser.

**FIGURE 58 - DOUBLE SUCTION RISER**

As a rule of thumb, the smaller riser 'A' would be sized to handle about 25% to 45% of the total area of the originally selected line size and 'B' the rest.

Offering a "Side" Example – Using *Table 12 on page 75* (Also *Table 29 on page 122* in the Appendix), a 2-1/8" Main suction line would have a 3.094 Sq In area. Selecting riser 'A' would suggest a 1-3/8" O.D. line with a 1.256 Sq In area, or roughly 41% of the 2-1/8" Main. The larger 'B' would suggest a 1-5/8" size with 1.780 Sq Inches. This would result in a 3.036 Sq In cross section area for 'A' and 'B'.

The 1-3/8" and 1-5/8" double risers, with a total area of 3.036 square inches, would be acceptably close to the 2-1/8" (3.094 square inches) Main selected suction line size and reflect a properly sized double suction riser.

SELECTING LIQUID LINE

Liquid lines are less critical on oil return concerns, given the oil readily mixes with the liquid refrigerant. However, line "size" has a greater impact on refrigerant volume in the system, and should be guarded against and not oversized. Oversized lines with greater refrigerant volume can increase the potential for refrigerant leaks, along with unnecessary added refrigerant cost. Sizing should generally be based on line loss not exceeding about 1°F.

Liquid Line Selection Procedure

Continuing the R-22 example above as outlined in the assumptions on page 72 and percent system split on page 71, make an initial system #1 liquid line selection using *Table 24 on page 119* in the Appendix (Also shown in *Table 13 on page 77* of this example).

Given the total ACCU capacity of 70 tons (Reference page 72), and the percent split for system #1 of 57% (Reference *Figure 56 on page 71*), the system #1 capacity to size for is (70×0.57) 39.9 tons (Note – This exercise has already been completed and can be referenced on page 72 of this guide under "Calculating the Final System Capacity").

In reviewing *Table 24 on page 119* in the Appendix (or *Table 13 on page 77*) the initial line size selection would suggest a 1-1/8" liquid line, based on the shorter equivalent feet line length, at about a 1°F line loss Δt . This initial selection must be reviewed at the actual equivalent line length, which follows.

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT

TABLE 13 - DISCHARGE AND LIQUID LINE CAPACITIES IN TONS FOR REFRIGERANT R-22

LINE SIZE	DISCHARGE LINES ($\Delta t = 1^\circ\text{F}$, $\Delta p = 3.03$ psi)			LINE SIZE	LIQUID LINES	
TYPE L COPPER, OD	SATURATED SUCTION TEMPERATURE, $^\circ\text{F}$			TYPE L COPPER, OD	Vel. = 100 FPM	$\Delta t = 1^\circ\text{F}$ $\Delta p = 3.03$
	35	45	55			
1/2	0.85	0.86	0.87	1/2	2.4	3.7
5/8	1.6	1.6	1.6	5/8	3.8	7.0
3/4	2.7	2.7	2.8	3/4	5.7	12.0
7/8	4.2	4.2	4.3	7/8	8.0	18.6
1 1/8	8.4	8.6	8.7	1 1/8	13.6	37.8
1 3/8	14.7	14.9	15.1	1 3/8	20.7	66.1
1 5/8	23.2	23.5	23.8	1 5/8	29.3	104.7
2 1/8	48.0	48.6	49.2	2 1/8	51.0	217.5
2 5/8	84.7	85.8	86.8	2 5/8	78.7	385.0
3 1/8	135.0	136.7	138.3	3 1/8	112.3	615.0
3 5/8	200.3	202.8	205.2	3 5/8	151.8	914.6
4 1/8	282.1	285.6	289.0	4 1/8	197.4	1291.0
5 1/8	503.2	509.5	515.4	5 1/8	307.6	2309.0
6 1/8	807.2	807.3	826.9	6 1/8	442.2	3714.0

NOTES:

Capacities are in tons of refrigeration.

Δp = Pressure drop due to line friction, psi per 100 feet equivalent length.

Δt = Change in saturation temperature corresponding to pressure drop, per $^\circ\text{F}$ per 100 feet.

Line capacity for other saturation temperatures Δt and equivalent lengths L_e .

Line capacity = Table capacity

$$\left(\frac{\text{Table } L_e}{\text{Actual } L_e} \right) \times \left(\frac{\text{Actual } \Delta t}{\text{Table } \Delta t} \right)^{0.55}$$

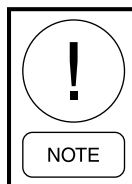
Saturation temperature Δt for other capacities and equivalent lengths L_e

$$\Delta t = \text{Table } \Delta t \left(\frac{\text{Actual } L_e}{\text{Table } L_e} \right) \times \left(\frac{\text{Actual Capacity}}{\text{Table Capacity}} \right)^{1.8}$$

Liquid Line Piping Equivalent Feet Estimation

Line Sizing (Diameter) is based on the total equivalent feet of pipe run for each given liquid line. Any change in the selected pipe size diameter will vary the equivalent feet of pipe (See *Figure 57 on page 74* losses for various pipe diameters). So it is important to re-visit *Figure 57 on page 74* and the “Calculating Final Liquid Line Loss” on page 79 if the line size diameter has changed.

In this example the linear feet estimation and fittings BOM are outlined in *Figure 55 on page 71* with equivalent feet estimates tabulated as follows.



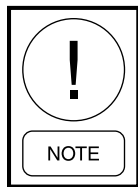
Equivalent Feet of pipe is used in determining the final line loss as outlined below, as well as to assure you are within the maximum 150 equivalent feet design criteria (100 equivalent feet on YCAV and YCIV product).

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT**Liquid Piping Equivalent Feet Tabulation
using 1-1/8" Diameter Pipe**

Linear Length Feet = 3' + 12' + 10' = 25'

Total Estimated Equivalent Length Feet =

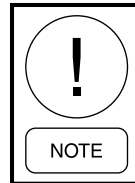
+ 3.0' [horizontally]
 + 3.4' [(2) 90° Long radius elbows
 [-1.7 eq. feet /elbow*]
 + 12.0' [vertically]
 + 10.0' [horizontally]
 = 28.4' → say 29' equivalent



When using Figure 59, note that the tube size is listed as nominal. Always use the size closest to the actual (i.e. Actual 1-1/8" would use a nominal 1-1/4" size as in this example).

Determining Pipe Fitting Loss

From *Figure 59 on page 78* tabulate the equivalent feet loss for each fitting itemized. Keep in mind vertical liquid "risers" must not exceed the maximum distances outlined in *Table 1 on page 44* of this guide. When risers exceed these values, always discuss with JCI Application Engineering.



When closest to the actual size is split as in this case, always use the larger line loss.

Nominal Pipe or Tube Size, in.	Smooth Bend Elbows						Smooth Bend Tees			
	90° Std. ^a	90° Long Radius ^b	90° Street ^a	45° Std. ^a	45° Street ^a	180° Std. ^a	Flow Through Branch	Straight-Through Flow		
								No Reduction 	Reduced 1/4 	Reduced 1/2
3/8	1.4	0.9	2.3	0.7	1.1	2.3	2.7	0.9	1.2	1.4
1/2	1.6	1.0	2.5	0.8	1.3	2.5	3.0	1.0	1.4	1.6
3/4	2.0	1.4	3.2	0.9	1.6	3.2	4.0	1.4	1.9	2.0
1	2.6	1.7	4.1	1.3	2.1	4.1	5.0	1.7	2.2	2.6
1-1/4	3.3	2.3	5.6	1.7	3.0	5.6	7.0	2.3	3.1	3.3
1-1/2	4.0	2.6	6.3	2.1	3.4	6.3	8.0	2.6	3.7	4.0
2	5.0	3.3	8.2	2.6	4.5	8.2	10.0	3.3	4.7	5.0
2-1/2	6.0	4.1	10.0	3.2	5.2	10.0	12.0	4.1	5.6	6.0
3	7.5	5.0	12.0	4.0	6.4	12.0	15.0	5.0	7.0	7.5
3-1/2	9.0	5.9	8.2	4.7	7.3	15.0	18.0	5.9	8.0	9.0
4	10.0	6.7	10.0	5.2	8.5	17.0	21.0	6.7	9.0	10.0
5	13.0	8.2	12.0	6.5	11.0	21.0	25.0	8.2	12.0	13.0
6	16.0	10.0	15.0	7.9	13.0	25.0	30.0	10.0	14.0	16.0

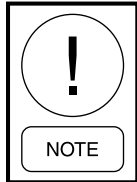
LD09160

FIGURE 59 - LIQUID PIPING FITTING LOSSES

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT

Calculating Final Liquid Line Loss

Calculating the actual Δt line loss using the formula under Δt of *Table 13 on page 77* calculates to 0.33°F line loss and approximates the 1.0°F design loss and validates the selection (See following):



Reference PIPING EXAMPLE #1 for R-410a Refrigerant.

$$\Delta t = \text{Table } \Delta t \left(\frac{\text{Actual } L_e}{\text{Table } L_e} \right) \left(\frac{\text{Actual capacity}}{\text{Table capacity}} \right)^{1.8}$$

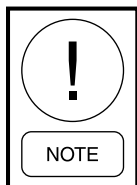
$$\Delta t = 1 \left(\frac{30}{100} \right) \left(\frac{39.9}{37.8} \right)^{1.8}$$

$\Delta t = 0.33^\circ\text{F}$ which is close to the 1°F design

A quick check shows a smaller 7/8" line would considerably exceed the nominal 1° Design standard.

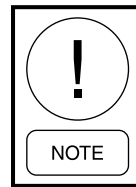
Determining "Optional" Hot Gas Bypass (HGBP) Line Size

Reference the Sales Engineering Guide Physical Data sheet (See *Table 9 on page 69*, "Physical Data"). Review the minimum part load rating data, capacity tons.



Typically compressors 6, 5, and 4 are for system #2 and compressors 3, 2, and 1 are for system #1. (Respective to the declining Part Load Rating Data shown in YORKworks . . "if available"). Also note that typically the larger compressor is on system #1, but always verify through the IOM or the in-place ACCU. This example uses the Sales Engineering Guide.

Referencing *Table 9 on page 69*, "Physical Data", YCUL0076 style C with R-22 refrigerant having HGBP on system #1 shows a 13 ton minimum compressor load rating. This is the tonnage used in selecting the HGBP line size in *Table 14 on page 80* or *Figure 60 on page 80*.



When applying HGBP to both systems, keep in mind that System #2 may have a different compressor capacity as in this example of a nominal 10 tons as referenced in *Table 9*.

Equivalent Feet

In determining the HGBP line size, you will need to tabulate the equivalent feet of pipe run. The equivalent feet of pipe is determined in the same manner as the suction and liquid line (Reference page 74 and 78 examples).

In this example we will base the HGBP line arrangement, lengths and fittings with the same length values as the liquid line (Same 1-1/8" line lengths and fittings assumed). Referencing *Table 14 on page 80* <50', an initial line size selection would suggest a 1-1/8" line size, based on the short run. Equivalent feet tabulation would be as follows:

Liquid Piping Equivalent Feet Tabulation using 1-1/8" Diameter Pipe

Linear Length Feet = 3' + 12' + 10' = 25'

Total Estimated Equivalent Length Feet =

$$\begin{aligned} &+ 3.0' \quad [\text{horizontally}] \\ &+ 4.6' \quad [(2) 90^\circ \text{ Long radius elbows}] \\ &\quad \quad \quad [\sim 2.3 \text{ eq. feet /elbow*}] \\ &+ 12.0' \quad [\text{vertically}] \\ &+ 10.0' \quad [\text{horizontally}] \\ \hline &= 29.6' \rightarrow \text{say } 30' \text{ equivalent} \end{aligned}$$

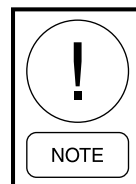
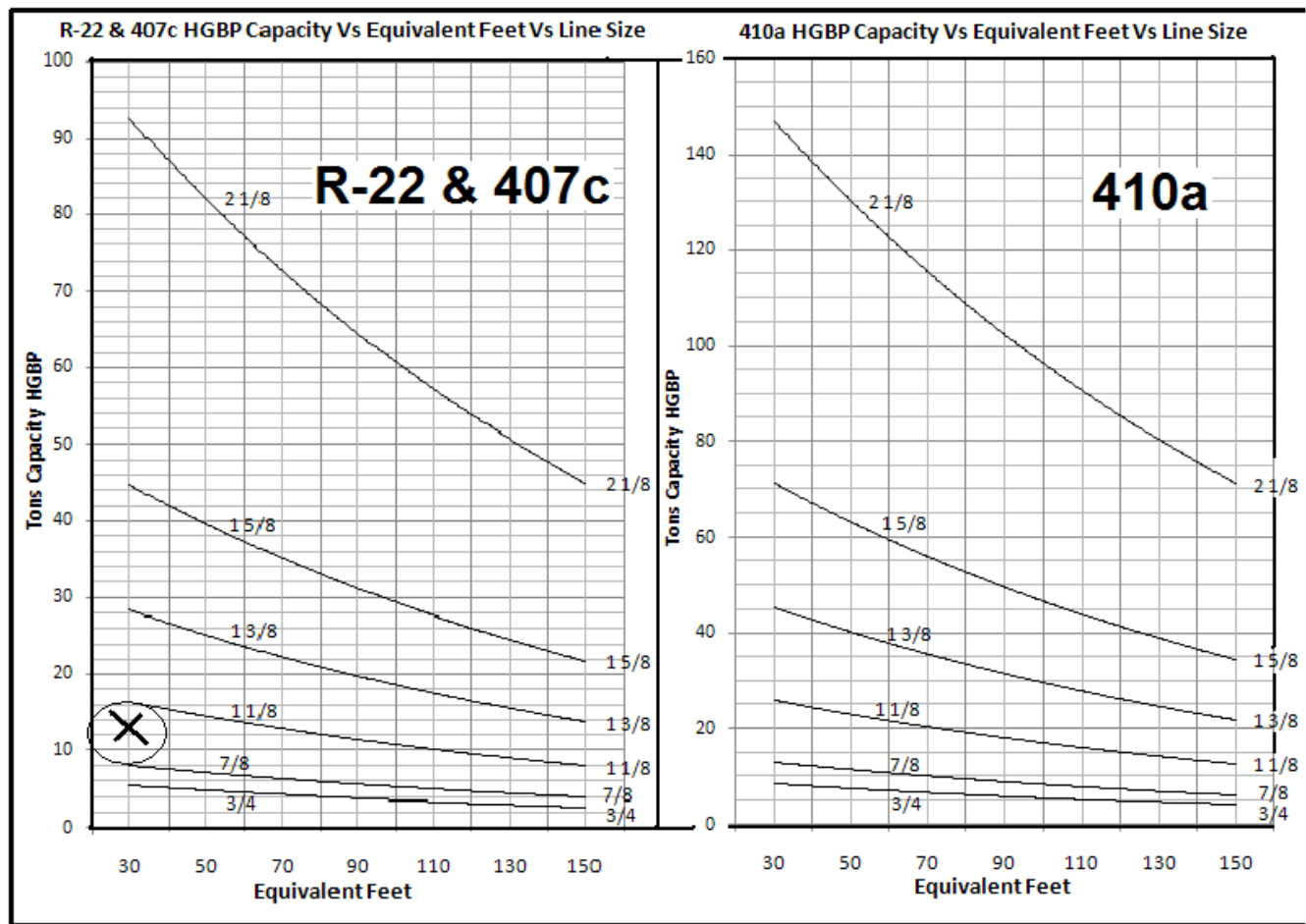


Figure 60 offers the same Line Size Recommendations as *Table 14*, except in Line Chart Form.

PIPING EXAMPLE #2 – LINE SIZING PRACTICE USING R-22 (R-407C SIMILAR) REFRIGERANT**TABLE 14 - HGBP LINE SIZE RECOMMENDATIONS**

LINE SIZE (TYPE "L" REFRIGERATE GRADE)	R-22 and (R-407c) - MAX TONS, CAPACITY @ EQUIVALENT FT. (EF)		R-410a - MAX TONS, CAPACITY @ EQUIVALENT FT. (EF)	
	150 EF	50 EF	150 EF	50 EF
3/4	2.6	4.7	4.0	7.4
7/8	3.9	7.1	6.2	11.4
1 - 1/8"	7.9	14.4	12.6	23.0
1 - 3/8"	13.7	25.1	21.8	40.0
1 - 5/8"	21.7	39.6	34.5	63.1
2 - 1/8"	44.9	82.1	71.1	130.2



LD16017

FIGURE 60 - HGBP LINE SIZE RECOMMENDATIONS LINE GRAPHS FOR R-22, R-407C AND R-410A**Determining Final HGBP Line Sizing**

Given the design of 30 equivalent feet (EF) of HGBP pipe run, and the minimum turndown capacity of 13.0 tons, determine from either *Table 14 on page 80* or *Figure 60 on page 80* the best line size using R-22.

Using *Table 14 on page 80* would suggest an initial selection of 1-1/8". Referencing *Figure 60 on page*

80 allows a more detailed view of the selection. Looking at 13.0 tons @ 30 EF plots a point between a 7/8" line size and a 1-1/8". Given the minimum tons are offered as 100% of the minimum turndown compressor, the selection is somewhat conservative and would suggest the closer of the two curves. In this case the final HGBP selection would suggest a 1-1/8" line size as the best selection.

Setting the System Operating Charge

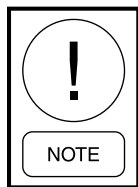
Determining the correct operating charge is important in preventing excessive head pressures if overcharged or low suction faults if undercharged. Either situation can produce issues in terms of system faults as well as compressor wear and tear in the form of liquid slugging or high temperatures if overcharged, or poor motor cooling and loss of capacity if undercharged.

When charging a system it is important to note that the charge is best executed on a “design ambient” day.

When “initially” charging a split system, best practice is to first weigh in the charge estimate, keeping in mind this is only an estimate and is the first step. Once the correct charge is weighed in, a nominal 15°F sub-cooling (Always review target sub-cooling value specified in IOM) at the condenser coil outlet must be measured (nominal 10°F on YCAV and YCIV Product). Special note here is the sub-cooling must also be accompanied by a “clear liquid line site glass”. Increasing the sub-cooling a few degrees may be required to clear the glass (again, on a design ambient day).

Non-Design Ambient Days - On non-design ambient days, some degree of innovativeness must be exercised. Keep in mind that the lower the ambient from design, the higher the sub-cooling (i.e. a properly charged system of say 17°F sub-cooling at 95°F Ambient, might reflect 28°F~ sub-cooling when at 50°F ambient as an example). It should also be noted in the Service Log that this charge should be reviewed again at some closer design ambient (i.e. within 10°F of the design ambient).

A packaged system with an apparent low charge should not have the charge removed and re-weighed as a norm.



When charging a system it should be noted that the initial charge before running a compressor should be at least 80% of the final design charge (Running a compressor with a system under 80% can damage the compressor due to inadequate cooling and poor oil return). Also keep in mind, initial overcharging is also detrimental to the compressor.

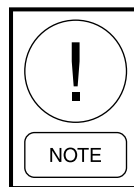
Calculating the Weigh-in Charge

The “initial” weigh-in charge for a split system consists of three areas of review:

1. ACCU Refrigerant Charge
2. Evaporator Coil Refrigerant Charge
3. Split System Line Charges

ACCU Refrigerant Charge

The ACCU refrigerant charge can be taken directly from the IOM under “Physical Data” (Reference *Figure 61 on page 82*). As a rule of thumb, each system condenser coil(s) can hold a pump down charge of approximately 1.5 times the “operating” charge catalogued for the condenser coil system (Reference *Figure 61 on page 82*).



It is important to note here that the placement of the Liquid Line Solenoid valve is critical and must be located at the evaporator, close to the TXV's. This location allows the refrigerant charge to be stored in the Liquid Line as well as the ACCU during pumpdown.

Technical Data

FORM 150.63-NM9 (1109)

PHYSICAL DATA (ENGLISH)
YCUL0045_ -- YCUL0072_
60Hz**TABLE 8 – PHYSICAL DATA (ENGLISH)**

MODEL NO. YCUL	0045	0051	0055	0065	0072
LENGTH (INCHES)	144.8	144.8	148.8	148.8	153.6
WIDTH (INCHES)	90.6	90.6	90.6	90.6	90.6
HEIGHT (INCHES)	47.8	47.8	62.6	62.6	62.6
NOMINAL TONS	41.6	44.1	51.6	59.5	73.5
NUMBER OF REFRIGERANT CIRCUITS	2	2	2	2	2
REFRIG. CHG, OPT, R-410A (LBS) CKT1/CKT2	35/35	40/35	45/45	50/50	65/65
OIL CHARGE, GALLONS CKT1/CKT2	1.8/1.8	1.8/1.8	1.7/1.7	1.7/1.7	2.3/2.2

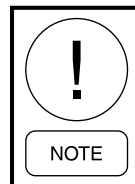
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FIGURE 61 - ACCU REFRIGERANT CHARGE**Evaporator Coil Refrigerant Charge**

The DX Coil evaporator charge is only a rough weight estimate. This weight can vary depending on load, etc. The weight estimate can be acquired through York-Works (See *Figure 62 on page 83*) or by estimating the coil volume in cubic feet and applying the following calculation:

1. [Estimated Refrigerant Weight = Coil Vol. Cu. Ft. calculated x 20% x "Constant" 78 (Refrigerant Density/Cu Ft~)]
2. [This example would calculate [1.37 Cu. Ft. "Fig 62" x 0.20 x 78 = 21.37 lbs Refrigerant Charge estimate per coil] x 2 Coils = 42.7 lbs total Evaporator Coil(s) charge]
3. [(Multiply the % Split x Total calculated charge = charge per system) = 42.7 x 55% = 23.5 lbs charge for System #1]. This may vary somewhat from YORKworks, but again is an estimate.

In replicating the Evaporator Coil selection in York-Works "Loose Coils" to acquire the estimated Refrigerant Charge, reference the selection under "Fluid Weight" as indicated in *Figure 62 on page 83*. Note that the Loose Coil run shows the refrigerant "Fluid Wt." per coil. In this example you must multiply the Fluid Wt. times the total number of coils. Once you determine the total Evaporator Coil(s) weight you must multiply it times the System #1 % Split as shown in *Figure 62 on page 83*:



As in this example some systems (Or circuits) have uneven splits. When splitting the charge per the number of systems, always factor the percent split (i.e. 50/50; 55/45; 60/40, etc.).

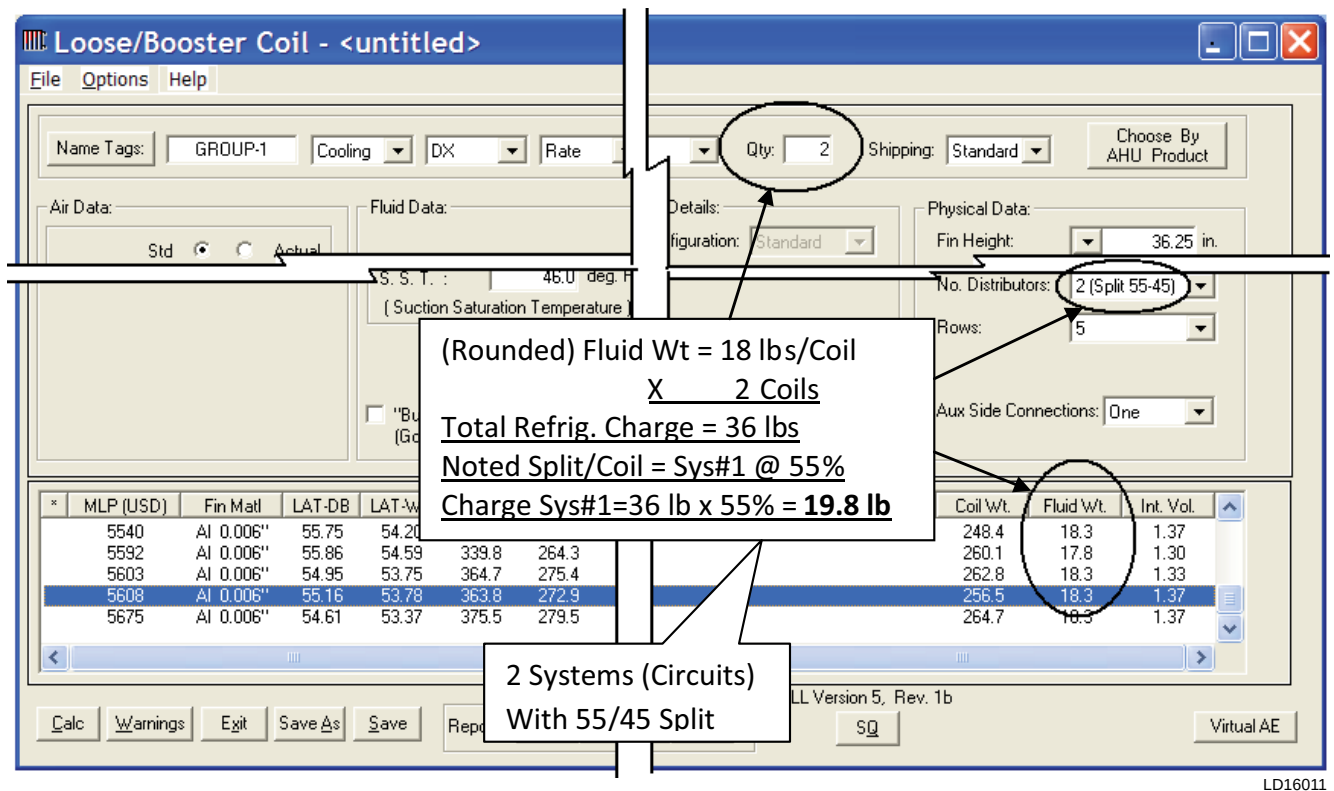


FIGURE 62 - EVAPORATOR COIL CHARGE ESTIMATE (YORKWORKS)

Split System Line Charges

Split-System Line Charge requirements are based on the “linear” feet of pipe run for the:

1. Liquid Line
2. Suction Line

This example is based on the R-410a refrigerant system “Example #1” of this guide. Note that selection procedures would be the same for other refrigerants using the appropriate refrigerant table appendix found in the back of this guide.

Liquid Line Charge Requirements – Referencing *Figure 47 on page 57* in Example #1 of this Guide totals 25 “linear” feet of pipe run, and *Table 7 on page 64* shows a 7/8” liquid line selected. From *Table 15 on page 84* (also *Appendix Table 36 on page 125* of this guide) we see 20.09 lbs refrigerant at 110°F Saturated Discharge Temperature (110°F is generally used as the mid range keeping in mind that saturated discharge temperatures/pressures can and will vary based on the ACCU’s control/operating range). Also note that this charge is based on 100 Ft of piping and must be corrected for actual lengths (to follow).

TABLE 15 - REFRIGERANT CHARGE IN POUNDS PER 100 FEET OF LIQUID LINE

LINE SIZE, OD	SATURATED DISCHARGE TEMPERATURE, F								
	R-22			R-407C			R-410A		
	80	110	140	80	110	140	80	110	140
1/2	7.47	7.03	6.50	7.11	6.64	6.11	6.63	6.03	5.19
5/8	12.01	11.29	10.44	11.42	10.67	9.81	10.66	9.68	8.34
3/4	17.93	16.86	15.59	17.05	15.93	14.65	15.91	14.46	12.45
7/8	24.91	23.42	21.66	23.69	22.14	20.35	22.11	20.09	17.30

Suction Line Charge Requirements

Referencing *Figure 46 on page 57* in Example #1 of this Guide totals 25 “linear” feet of pipe run, and *Table 4 on page 60* lists a 1-5/8” suction line. From *Table 16 on page 84* (Also Appendix *Table 34 on page 125* of this guide) we see 2.72 lbs refrigerant at 40°F Saturated Suction Temperature (40°F is generally used where comfort cooling is the design, keeping in mind that saturated suction temperatures and pressures can and will vary based on the ACCU’s control/operating range). Also note that this charge is based on 100 Ft of piping and must be corrected for actual lengths (To follow).

Liquid and Suction Line Charge Corrections

Given the above liquid and suction line charge estimates at 100 feet, we must now correct for the actual

lengths as outlined in Example 1, *Figure 45 on page 56* and *Figure 46 on page 57* outlined as follows:

- Liquid Line has 25 feet of pipe run (Excluding fittings – Not applicable)
- Suction Line has 25 feet of pipe run (Excluding fittings – Not applicable)

Corrections Applied

Liquid Line = (20.09 LBS)(25’/100’) = 5.03 LBS/
System (Circuit)

Suction Line = (2.72 LBS)(25’/100’) = 0.68 LBS/
System (Circuit)

Total Refrigerant Line Operating Charge = 5.71 LBS/
System (Circuit)

TABLE 16 - REFRIGERANT CHARGE IN POUNDS PER 100 FEET OF SUCTION LINE

LINE SIZE, OD	SATURATED SUCTION TEMPERATURE, F								
	R-22			R-407C			R-410A		
	-40	0	40	-40	0	40	-40	0	40
1/2	0.03	0.07	0.15	0.02	0.06	0.14	0.05	0.11	0.23
5/8	0.05	0.12	0.25	0.04	0.10	0.22	0.07	0.17	0.36
3/4	0.07	0.18	0.37	0.06	0.15	0.33	0.11	0.25	0.53
7/8	0.10	0.24	0.51	0.08	0.21	0.46	0.15	0.35	0.74
1-1/8	1.17	0.42	0.87	0.14	0.36	0.79	0.25	0.60	1.26
1-3/8	0.26	0.64	1.33	0.21	0.55	1.20	0.38	0.92	1.92
1-5/8	0.37	0.90	1.88	0.30	0.78	1.70	0.54	1.30	2.72

Summary: Step #1 Charge Estimates (Weigh-in Charge)

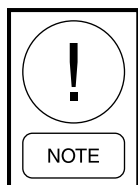
System #1 Summary:

65.00 Lb 410a - ACCU (Figure 61)
19.80 Lb 410a - DX Coil (Evap)
5.71 Lb 410a - Split-System Piping
90.51 Lb 410a Total Weigh-in Charge

System #2 Summary:

65.00 Lb 410a - ACCU (Figure 61)
16.20 Lb 410a - DX Coil (Evap)*
5.71 Lb 410a - Split-System Piping
86.91 Lb 410a Total Weigh-in Charge

*DX Coil Total Charge of 36 lbs – System #1 charge of 19.8 lbs = Sys #2 Charge of 16.2 lbs



This is the approximate operating charge which is estimated for the system. The system should never be started with less than 80% of the operating charge in the system. Following the weigh-in charge estimate, it is essential to then “Trim” to the final system operating charge.

Trimming the Charge

Trimming the charge should be performed on a design ambient day with all condenser fans running, at normal head pressures, and the “system” fully loaded.

Being as much as 10°F below design ambient is acceptable, but it is important to note that a “lower ambient” means “higher” sub-cooling numbers (i.e. If a system is “correctly” charged on a design day of say 16°F sub-cooling, then at 10°F below this ambient the sub-cooling value may read some higher number). Some innovativeness is required on the part of the Technician to produce meaningful numbers, and ultimately a correct charge.

Following Step #1 (Weigh-in Charge), it is essential now to trim the charge using steps #2 and #3:

- Step #2 – Set the Sub-Cooling (Always review target sub-cooling value specified in IOM) at a nominal 15°F - 17°F~ (nominal 10°F on YCAV/YCIV Product).
 - a. Sub-cooling should be reviewed at the condenser coil outlet at the liquid line service valve (except YCAV/YCIV).
 - b. YCAV/YCIV’s with “remote evaporators” or with “packaged evaporators” require Sub-cooling to be measured at or close to the flash tank.
- Step #3 – Clear the Sight Glass with a solid column of liquid (basically add charge to raise the sub-cooling number until glass is clear). DO NOT OVER CHARGE!

ACCU Pumpdown Holding Charge Capability Review

Pumpdown capacity of a system is important in removing the refrigerant from the low side of the system and store it on the high side between the compressor (As applicable, against the Internal Check Valve on Scrolls), up to the LLSV at the DX Coil (The importance of the LLSV being located at the DX Coil is to utilize the liquid line for pump down storage).

Pumpdown minimizes migration of the liquid refrigerant into the compressor and/or unwanted storage in the suction line during the off cycle. Failure to provide proper pump down storage can result in refrigerant liquid slugging and bearing lubrication washout at the compressor.

Generally, most if not all split-systems piped with the above understanding have sufficient high side pump down capability. Those that don’t follow piping guidelines outlined herein, or where oversized evaporator coils come into play, may not have sufficient pump down capability and may require correcting the piping arrangement and/or adding liquid refrigerant receiver (always consult with Application Engineering on Liquid Refrigerant Receivers).

Pumpdown Requirements for Example #1 using R-410a Refrigerant

Rule of Thumb Selection - The YCUL0072EE46 total system #1 operating and pump-down charge is 90.51 lbs (see Step #1 above). As a rule of thumb, each system condenser coil(s) can hold a pump down charge of 1.5 times the “operating” charge catalogued for the condenser coil system (see design data Engineering Guide or IOM). For this YCUL example, the operating charge catalogued is 65 lb as noted in step #1 above. Using the rule-of-thumb of 65 lb x 1.5 allows a holding charge estimate of 98 Lb. Given the proper piping practice of locating the LLSV at the Evaporator Coil, which provides adequate pumpdown storage of the liquid line charge, adjusts the pumpdown volume necessary to 86 lb (65 ACCU + 19.8 Coil + 1.2 Suction Line). The 86 lb is well within the available 98 lb estimate providing adequate pumpdown capacity.

Calculated Selection - A closer estimate of condenser coil charge holding capability would entail calculating the total condenser coil tube volume in cubic feet plus

a 5% factor for return bends and headers, and then applying the refrigerant density/cu ft. The above example calculates to 0.811 cu ft per coil times 2 coils/system = 1.622 cu ft per system x 79.79 refrigerant density for R-410a = 129 lb refrigerant. A typical condenser can only hold 70% of the required charge (allowing 20% for refrigerant gas and 10% for safety margin). This closer review shows an available pumpdown volume of 90 lbs (129 x 70%) which will easily hold the 86 lbs adjusted charge (again, discounting liquid line charge).

Obviously acquiring the correct rows, tube diameter, wall thickness, tube lengths and tube quantities is cumbersome and not an easy undertaking and would require “factory” review by your Sales/Marketing Application Engineering support group.

The following offers an example for calculating the suggested maximum refrigerant pumpdown as outlined above. In this example, there are two coils, so the total refrigerant pumpdown volume is approximately 90 lbs (45.29 x 2 coils):

Refrigerant Charge Available in Condenser Coil for Pumpdown

Example:

Solve for Cubic Inches – Example: 3/8" copper tube with .014" tube wall x 98" long x 144 tubes

Solve $R = 0.375" - (.014" \times 2) = 0.347"$ Inside diameter/2 = 0.1735" Radius

$A = \pi r^2 \times \text{Coil Tube Length} \times \# \text{ of Tubes} \times \text{Return Bend Add-on Factor}$

$A = 3.1416 \times 0.1735^2 \times 98" \times 144 \text{ tubes} = 1334.56 \text{ cubic inches} \times 1.05 \text{ Return Bend Factor} = 1401.28$

Cubic Inches to Cubic Feet = cubic inches $\div$ 1728 = $1401.28 \div 1728 = 0.811$ cubic feet

R-410a Refrigerant Density @ 40°F = 79.79 lb/ft³ (R-22 = 79.05; R134a = 79.90)

Ref. Wt Cond. Coil Can Hold = 79.79 x 0.811 Cubic Foot = 64.71 lb Refrigerant x 70% = 45.29 lb Ref PD/Coil

AIR HANDLING UNIT DX COIL CONDENSATE DRAIN PIPING

The majority of cooling coils are located in the air handling units so that the supply air is drawn through them. This results in the condensate being subjected to negative (-) static pressure. Unless some means of pressure equalization is provided in the condensate drain, the air rushing back through the drain pipe will cause the condensate to build up in the drain pan.

As the unit continues to operate, the accumulated water will be carried with the air stream, overfilling the drain pan causing possible water leaks into the supply duct and/or causing water damage in the building. A trap must be installed to prevent this condensate water build-up. (See *Figure 63 on page 87* and *Figure 64 on page 87*) On initial startup, it may be necessary to fill the trap manually or, after the unit has operated sufficiently for a small amount of condensate to collect in the drain pan, turn off the unit, and the trap will automatically fill.

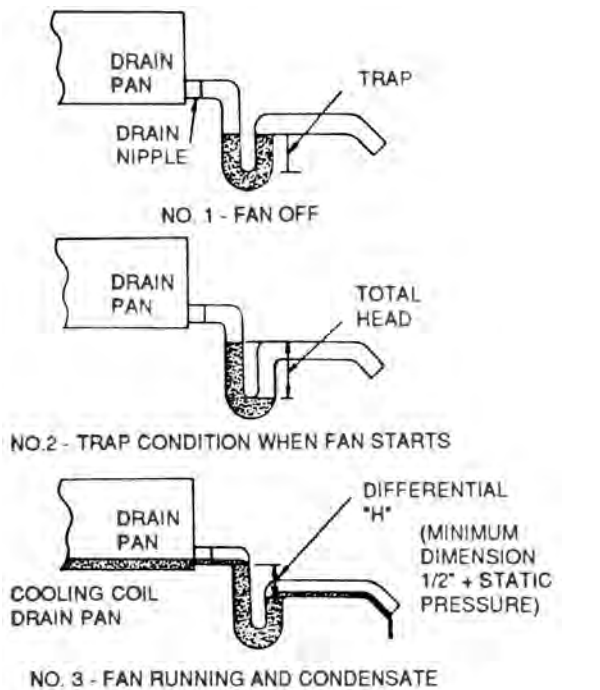


**FIGURE 63 - DRAIN TRAP WATER LOCATION
DURING DRAW THROUGH OPERATION**

Install a trapped condensate drain line at unit drain connection (See *Figure 64 on page 87*) according to all governing codes. "H" dimension must be at least 1/2 inch greater than negative pressure (I.W.G.) in unit drain pan. To determine "H" dimension, first determine the negative static pressure in the unit. Always assume the worst conditions, such as dirty filters in the return air circuit to fan.

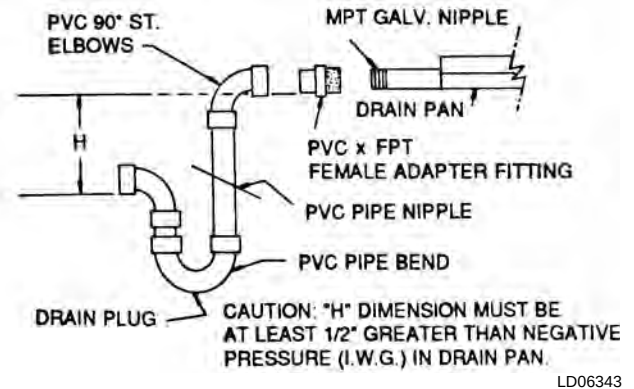


**FIGURE 64 - DRAIN TRAP PIPING FOR DRAW-
THROUGH UNIT**

Example:

Negative Static Pressure = 5.5"

Minimum of 1/2" = 0.5"

"H" Dimension = 6.0"

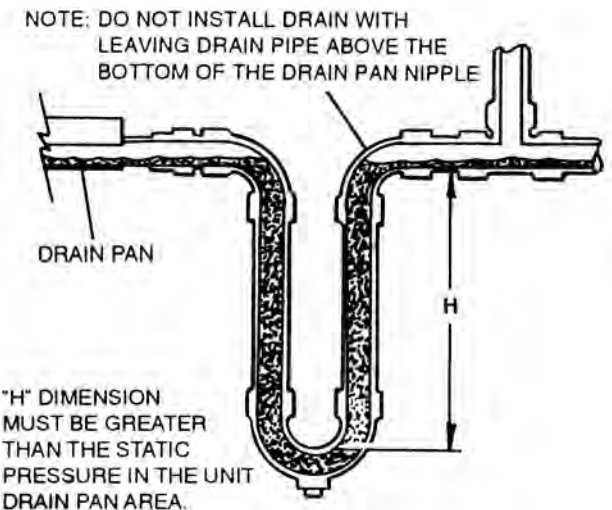


**FIGURE 65 - DRAIN TRAP PIPING FOR BLOW-
THROUGH UNIT (POSITIVE PRESSURE IN UNIT)**

For blow-thru units, the same principles apply, but the leaving pipe must be as shown in *Figure 65 on page 87* for proper trap design for blow-thru unit. Determine design negative static pressure. This pressure is not the same as fan total pressure, which includes pressure losses downstream as well as upstream from the indoor-air fan. Always assume the worst conditions are possible (such as having return-air filters clogged with dirt) and add 1 inch as a safety factor. Two drains on same side of unit must be trapped individually before drain lines can be combined and routed to a suitable drain. (See *Figure 66 on page 88*)

If a drain connection is not used, then it must be capped. This only applies to the continuous drain pan configuration with a drain connection on each side. Main coil drain pans and all auxiliary floor drain pans in the unit must be properly trapped and charged with water before the units are started.

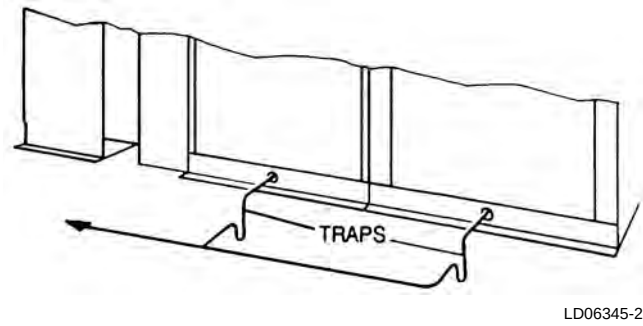
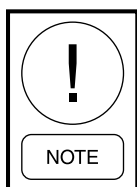


FIGURE 66 - COMBINING DRAIN LINES

SECTION 5 - CONTROLS

CAPACITY CONTROL APPROACHES

Owners and engineers want comfort and stable control from today's VAV and constant volume systems. A combination of an outdoor air economizer and mechanical cooling typically satisfies the building's comfort cooling requirements. *ASHRAE Standard 90.1* details, when an outdoor air economizer is required based on climate and unit capacity. In some cases, it is necessary to integrate the economizer and mechanical cooling controls, so that the single or dual systems can operate simultaneously. When this is done, hot gas bypass must be used to add load.



Temperature reset is not available when using suction pressure control.

Many performance and equipment problems can result if careful attention is not paid to the design and operation of such a system. The ideal control approach depends upon the system design. The following reviews the typical approaches using variable air volume (VAV) and constant volume systems. Other systems, such as the FlexSys underfloor system, have unique design requirements and control strategies; therefore, please contact the Application Engineering for the best design practices for these systems.



When using discharge temperature (supply air temperature) control, never remove the discharge air temp sensor and replace it with a field supplied signal. Failure to follow these guidelines will void the warranty.



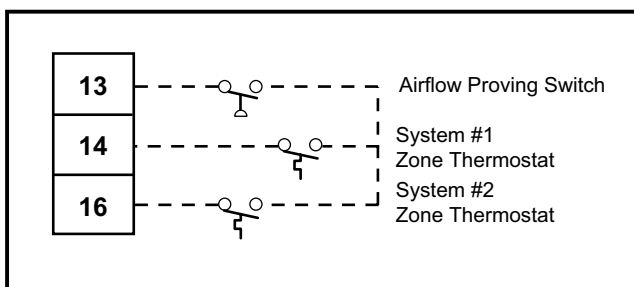
Compressors must always be cycled by the condensing unit microprocessor controller. Never remove total compressor control from the microprocessor. Failure to follow these guidelines will void the warranty.

VARIABLE AIR VOLUME SYSTEM

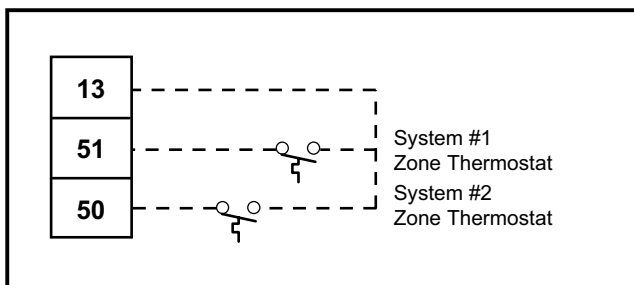
Single or Two Stage (Single System or Dual System) Return Air, Space, or Supply Air Temperature Thermostats with ACCU Suction Pressure Capacity Control.

Variable air volume systems should be controlled based on a single or dual stage space, return, or supply air temperature thermostats where possible, pending determination of the application requirements. This form of suction pressure control provides for a more stable method of operation. The air sensor should be placed in the space where temperatures change slowly and stratified air is not a problem. This is an ideal method of control due to being buffered by the load on the system. It is also suited to a system that has a limited number of steps of capacity. This will provide for minimum compressor cycling, high system stability, and good comfort control. Discharge air temperature (DAT) control is the alternate means of control and is suggested to be limited to systems providing uniform and stable discharge air temperatures. DAT is not a recommended practice if the discharge air sensor senses excessive stratified air temperatures, or where condensate can form on the sensor. DAT, when misapplied, may lead to system and ACCU instability problems.

The use of a single, or two-stage thermostat (or two single stage thermostats) is required to energize the condensing unit refrigerant circuits, based on the return, space, or supply air temperature. If a return duct air temperature thermostat is used, it should be mounted in the return air ductwork and should have a range of 70°F to 80°F. The appropriate thermostat(s) should be wired into system(s) as indicated in *Figure 67 on page 90* (2-stage example shown). This control scheme must be used in conjunction with the suction pressure control of the ACCU.



Above on older 031-02050-000 Control Boards



Above on newer 031-02550-000 Control Boards

LD09163

FIGURE 67 - SUCTION PRESSURE CONTROL WIRING

ACCU Suction Pressure Control

The ACCU will respond to the thermostats call for cooling, after an airflow proving switch is closed (see *Figure 67 on page 90*). When the suction pressure control is used, the ACCU must be equipped with suction pressure (SP) transducers. When using suction pressure control, the goal is to maintain the coil temperature in a stable temperature band by cycling compressors by suction pressure. If the coil temperature is maintained within a certain range, other system components such as dampers, inverters, vanes, etc., should be controlled to fine tune the system.

The SP set point and range must be field programmed into the microprocessor. The SP set point is the pressure that corresponds to the adjusted ACCU-DX coil balance saturated suction temperature (SST), after considering the suction line penalty. The condensing unit then loads and unloads to maintain the suction pressure within the programmed control range.

When the space temperature is above the set-point, one or both of the thermostats close signaling one or both of the refrigerant circuits that cooling is needed, giving the circuit(s) the command to operate. With warm air flowing across the DX coil, the suction pressure is above the SP control range. As successive steps of cooling are energized the suction pressure will fall within

the programmed control range, satisfying the cooling requirements.

CONSTANT VOLUME SYSTEM

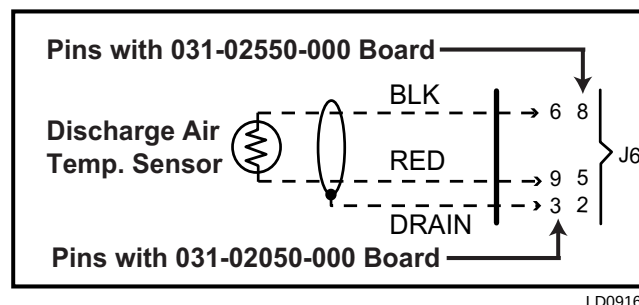
Supply Air Temperature Control

For the constant volume system, a supply discharge air temperature (DAT) sensor can be mounted in the supply air duct. The farther down the duct the air temperature is sensed, the better the air mix and the more stable the control. The most common problem, which can result from mounting the temperature sensor on or near the coil, is air stratification. The instability caused by air stratification and poorly mixed air can cause compressor cycling and compressor lubrication problems.

Constant volume systems can be used for comfort cooling applications where the building load tends to change gradually and where slight air variations are satisfactory. The DAT control range programmed should have a wide enough range to prevent compressor cycling.

ACCU Discharge Temperature Control

A DAT sensor is shipped loose with the ACCU for field mounting and wiring. The DAT sensor does a good job, but improper mounting can result in unstable system loading and unloading. Wiring between the DAT sensor and the ACCU (*Figure 68 on page 90*) is the responsibility of others in the field using shielded cable (e.g. Quabbin 930421-2 or equivalent).



LD09164

FIGURE 68 - DISCHARGE AIR TEMPERATURE CONTROL WIRING

ACCU Constant Volume Utilizing Suction Pressure Control

Suction pressure control is also a viable control approach for constant volume systems, noting that this approach does not allow temperature reset. This approach does allow either room, return air, or supply air enabling as outlined under *Variable Air Volume System on Page 89*.

ECONOMIZER OPERATION

The following applies to both variable air volume and constant volume systems.

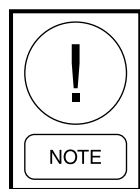
The building system controls should incorporate an outside air temperature or enthalpy sensor (an enthalpy sensor allows use of the lowest load air which can save energy for the customer) to sequence economizer or mechanical cooling operation. ASHRAE 90.1 requires that mechanical cooling be available, while the economizer is operating above 25% system load. The economizer can and should be locked out when the ACCU mechanical cooling system load drops to 25% or lower. This is to prevent coil frosting and liquid slugging at the lowest step of compressor unloading (4, 5 or 6 compressor units only).

When incorporating economizer operation, the hot gas bypass valve(s) on the ACCU condensing units should be energized during all steps of loading. This will reduce compressor cycling and allow the TXV to control satisfactorily at reduced cooling loads on the DX coil.

EXTERNAL BAS AND OTHER CONTROL INTERFACES

Dry contacts can be wired in series with the zone input thermostats (*Figure 67 on page 90*) to permit remote control from a separate building automation system, if desired.

If remote unit start-stop is desired, a separate set of dry contacts can be wired in series with the air-proving switch (*Figure 67 on page 90*) in the condensing unit.



On newer 031-02550-000 Control Boards utilizing DAT control, there is a separate run permissive provision (Start-stop) between terminals 13 and 51 that must be utilized in lieu of “in series with the Flow Switch”.

An air-proving switch is required to confirm that sufficient air is flowing across the DX coil, whether at the full load design CFM or the minimum allowable CFM for the selected coil in VAV applications. Enough air must flow over the coil at the minimum condition to assure that there is no liquid refrigerant carry-over to the compressor, which will cause potential mechanical wear and compressor failure.

The remote unit start-stop allows for connection to external devices. Compressors or systems should never be repeatedly cycled off and on using cycling contacts. Excessive cycling may cause lubrication problems in the compressors resulting from insufficient run time. The same logic should be applied when using a BAS system. The same logic should be applied when using a BAS system that talks directly to the microprocessor, using the RS485 port.

Additionally, condensing unit dry contacts are available, as standard, for compressor run indication and unit alarm identification. (Note that alarm contacts "OPEN" on a fault).

REMOTE SETPOINT RESET

If remote set point reset is utilized with ACCU discharge air temperature control, do not reset the set point repeatedly to control temperature. Using this method may cause excessive cycling of the compressors. Compressor cycling with very short run periods can cause compressors to fail due to lack of lubrication.

The rule to follow is to adjust the control of dampers, fans, vanes, etc., and not the ACCU set point to control air temperature. If remote set point is utilized, it should be used to adjust capacity as a result of load changes, which may occur as building occupancy changes. Remote set point reset is also commonly used for night or weekend setback. These are examples of occasional changes, which are typically used for temperature reset.

ACCU Condensing Unit Ambient Control

The standard units are designed to operate in outdoor ambient temperatures of 25°F (-3.9°C) to 115°F (46.1°C). When the ACCU operates with an economizer system, experience suggests that the low ambient control should be programmed to the 40 F to 45 F range. Extremely low loads will cause refrigerant control and compressor cycling problems. (See the *Hot Gas Bypass on Page 98* in **SECTION 3 - COIL SELECTION/CONFIGURATION**) For those applications where these units can operate below 25°F or with economizer systems below the 40 F outdoor range, the ACCU must include the optional low ambient kit. For operation above 115°F, the optional high ambient kit is needed for operation up to 125°F.

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SECTION 6 - NECESSARY COMPONENTS

THERMAL EXPANSION VALVE (TXV)

The sizing and application of the TXV is crucial to the operation of the system. Incorrect sizing could allow liquid over feeding and subsequent compressor failures. Each TXV should be sized for the maximum load of the coil it is feeding. This does not mean that the TXV must have a nominal capacity greater than the maximum load. A valve with a lower nominal capacity could be selected because typically TXV's are capable of providing 15% more capacity than the rated value. For example, if a coil has a design cooling load of 31.2 TR, a nominal 30 or 40 TR valve might be considered. In this case a nominal 30 TR valve could be a better selection.

If two distributors are applied to one refrigerant circuit, the TXV should be sized to match the capacity of the evaporator coil and distributor that it feeds. Taking the example above, if a condensing unit circuit of 31.2 TR supplied two evaporator coils with equal capacity, each TXV should be sized for 15.6 TR. Each coil would require a distributor and each distributor requires its own TXV.

An important factor in valve selection is the amount of capacity reduction available on the system. Typically, the minimum capacity at which a TXV can maintain stable refrigerant flow is approximately 30% of its nominal rating. Thus, if a TXV has a nominal capacity of 40.3 TR, it should not be applied to any system with a part load capacity less than 12.1 TR. Operating a TXV at capacities less than 30% can result in TXV overfeeding and lead to a compressor failure (due to refrigerant slugging, oil dilution, or liquid refrigerant washout of the compressor).

Selection of the correct TXV is essential for proper operation of the refrigeration system. Fortunately, it is not a difficult procedure.

As a minimum, the following details must be known in order to select and size the TXV:

- refrigerant used
- capacity of the DX coil circuit
- saturated evaporating temperature of the DX coils
- liquid refrigerant temperature at the inlet of the TXV

- pressure drop in the liquid line and the liquid line components

The refrigerant type (i.e. 410a, R-22, R-407C, etc.) can usually be found on the job schedule or in the specification. The DX coil capacity and saturated evaporating temperature should be taken from the coil selection (remember, one TXV is used per distributor). The liquid temperature at the inlet of the TXV can be calculated starting with the design ambient temperature. If the design ambient temperature isn't available, the ambient temperature can be estimated using the climate data found in Chapter 27 of the ASHRAE Fundamentals Handbook (use the 1% Cooling DB/MWB temperature for the city closest to the jobsite). The pressure drop in the liquid line and the liquid line components should be calculated, or at least estimated with the greatest accuracy possible.

Example

Size a R-22 thermostatic expansion valve for each circuit of a YCUL0076EC condensing unit. For this example:

- Each of the two evaporating coils has a design saturated evaporating temperature of 47°F (ETP).
- The design ambient outside air temperature is 95°F
- Each liquid line pressure drop is 10 PSI (including piping, valves, filter-driers and sight glasses).
- Circuit #1 has a capacity of 37.5 TR
- Circuit #2 has a capacity of 31.2 TR (based on 45°F SST, 2°F suction line loss).

1. Calculate the pressure drop across the TXV's at the design condition as follows:

design ambient temperature	Add 25°F to obtain saturated condensing temperature.		
95°F	+	25°F	= 120°F

Condensing pressure at 120°F	→	260 PSIG
Evaporating pressure at 47°F	→	- 79 PSIG
Difference	→	181 PSI (at design conditions)
		initial pressure drop across TXV (without component pressure drops)

However, the *maximum load* for the TXV's will occur at the *minimum operational discharge pressure* (typically 200 psig) which is based on the fan cycling set points for the ACCU condensing unit. Thus, the pressure drop across the valve at maximum TXV load becomes:

Condensing pressure	→	200 PSIG
Evaporating pressure at 47°F	→	- 79 PSIG
Difference	→	121 PSI
initial pressure drop across TXV at maximum load/low differential pressure (without component pressure drops)		

Add in the liquid piping, liquid line components, distributor and coil pressure drops:

Liquid line and components pressure drop	→	10 PSI
Distributor pressure drop	→	30 PSI (typical)
DX coil pressure drop	→	+4 PSI (from coil selection)
Total component pressure drop	→	44 PSI

Subtract the total component pressure drop from the initial pressure drop across the TXV to obtain the actual pressure drop across the TXV.

Inlet pressure	→	121 PSI
Pressure drop	→	- 44 PSI
Actual pressure drop across the TXV.	→	77 PSI

2. Knowing the saturated evaporator temperature (47°F ETP) and the actual pressure drop across the TXV (77 PSI), find the pressure drop correction factor from the TXV manufacturer's catalog. (Use the 40°F ETP row for any ETP between 40°F and 55°F.) By interpolating between the values shown in *Table 17 on page 94* (shaded blocks), it can be determined that the factor for this example will be approximately **0.88** (*CF Pressure Drop*).

3. Next, determine the liquid refrigerant temperature entering the TXV when the discharge pressure is 200 psig (101°F CTP or saturated condensing temperature).

saturated condensing temperature	-	sub-cooling temperature	=	liquid refrigerant temperature
101°F	-	15 °F (15-17°F typical)	=	86°F

4. Find the liquid refrigerant temperature correction factor for the TXV's in the manufacturer's catalog. Interpolation between tabulated values may be necessary. For this example based on the values in the shaded blocks found in *Table 18 on page 94*, the correction factor for the liquid temperature will be **1.08** (*CF Liquid Temperature*).

TABLE 17 - PRESSURE DROP CORRECTION FACTOR

EVAPORATOR TEMPERATURE (°F)	PRESSURE DROP ACROSS TXV (PSI)				
	75	100	125	150	175
	CORRECTION FACTOR, CF PRESSURE DROP				
40 °	0.87	1.00	1.12	1.22	1.32
20° and 0°	0.77	0.89	1.00	1.10	1.18
-10° and -20°	0.71	0.82	0.91	1.00	1.08
-40°	0.65	0.76	0.85	0.93	1.00

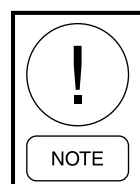
TABLE 18 - TEMPERATURE CORRECTION FACTOR

REFRIGERANT	LIQUID TEMPERATURE ENTERING TXV (°F)				
	80°	90°	100°	110°	120°
	Correction Factor, CF Liquid Temperature				
R-22	1.12	1.06	1.00	0.94	0.88
R-407C	1.14	1.07	1.00	0.93	0.85

TABLE 19 - TXV VALVE SELECTION BASED ON CAPACITY

TYPICAL MANUFACTURER'S TXV SELECTION TABLE							
Valve Type	Nominal Capacity	Refrigerant					
		R-22			R-407C		
		Evaporator Temperature (°F)					
		40°	20°	0°	40°	20°	0°
EBS	8	8.51	8.81	7.30	7.81	7.96	6.48
EBS	11	11.5	11.9	9.86	10.6	10.8	8.77
OVE	15	15.0	15.5	13.0	13.8	14.1	11.6
OVE	20	22.2	23.0	19.3	20.4	20.8	17.1
OVE	30	30.5	31.6	26.5	28.0	28.6	23.6
OVE	40	40.3	43.5	32.0	37.0	39.3	28.5
OVE	55	55.0	59.3	43.7	50.6	53.7	38.9
OVE	70	73.0	78.8	58.0	67.1	71.3	51.6

5. Now, using the design DX coil circuit capacity for each circuit (37.5 and 31.2 TR respectively), find the valves listed in the catalog which have capacities that most closely match the coil capacity for R-22. In this example, the capacities of both circuits fall between the nominal capacities of the OVE 30 and OVE 40 TXV's listed in the *Table 19 on page 95* (see the shaded blocks). Again, for ETP's between 40°F and 55°F ETP, use the 40°F ETP column.



Values in the table above are from the Sporlan Valve catalog and subject to change. See TXV valve manufacturer's catalog for up to date information to size valve and select thermostatic charge type.

In this example, both the OVE 30 and the OVE 40 valves should be considered. First, check for actual capacity after applying correction factors.

Valve Capacity	X	CF, Drop Pressure	X	CF, Liquid Temp	=	Actual Valve Capacity
OVE 30:	30.5	X 0.88	X 1.08	=	29.0 TR	
OVE 40:	40.3	X 0.88	X 1.08	=	38.3 TR	

As mentioned earlier, most TXV 's have some reserve capacity, so it is better to select a valve lower in capacity than the maximum capacity of the system, than to select a valve that has greater capacity than the maximum capacity of the system. Oversized TXV's can cause wide cycle swings resulting in poor temperature and humidity control and lead to liquid carry-over to the compressors at low loads. Thus, in this example:

OVE 30: 29.0 TR X 1.15 = 33.4 TR
OVE 40: 38.3 TR X 1.15 = 44.0 TR

So, based on the capacities calculated for each valve as listed above, the OVE 40 TXV should be selected for Circuit #1 (for 37.5 tons) and the OVE 30 should be selected for Circuit #2 (for 31.2 tons).

6. A check should also be made to make certain that the valve is not oversized at the minimum circuit capacity. An approximation of the minimum circuit capacity can be determined by multiplying the circuit capacity by the ratio of 1 (compressor) over the number of compressors applied on that circuit, which is 3 per circuit for this example.

circuit capacity	x	1/3 compressors per circuit	=	minimum circuit capacity
Circuit 37.5	x	0.33	=	12.5 TR
#1:				
Circuit 31.2	x	0.33	=	10.3 TR
#2				

The minimum capacity of the TXV can be determined by multiplying the nominal TXV capacity by 30% (0.30). This value should be lower than the minimum circuit capacity.

nominal TXV capacity	x	30%	=	minimum circuit capacity
TXV				
Circuit #1: 40.3	x	0.30	=	12.1 TR
TXV				
Circuit #2: 30.5	x	0.30	=	9.2 TR

Thus, for the two valves selected in our example, the valves can operate at the maximum load/minimum discharge pressure condition and minimum circuit capacity condition without any difficulty.

7. Make certain to select the proper thermostatic charge, based on evaporator temperature and refrigerant type.
8. Always include an external equalizer on the TXV. The equalizer will prevent the refrigerant pressure drop across the distributor and coil from affecting the superheat setting of the valve.
9. The TXV should include the maximum operating pressure (MOP) feature. This MOP will restrict the maximum opening of the valve, if the suction pressure becomes too high due to abnormally high suction gas temperatures, which typically occur at start-up. For low ambient applications, the non-migrating bulb charge may be required. If the ambient of the TXV can reach a temperature lower than its sensing bulb temperature, a non-migrating charge must be used. When using a non-migrating charge, the MOP feature may not be available.

Use one TXV for each DX distributor/coil section within the refrigerant circuit, as depicted in *Figure 76 on page 100* and *Figure 77 on page 101*. The TXV should be mounted on the horizontal liquid line as close to the distributor inlet as possible (Not to exceed 24"). The bulb should be mounted on the outlet of the specific coil suction line and never in the common suction line.

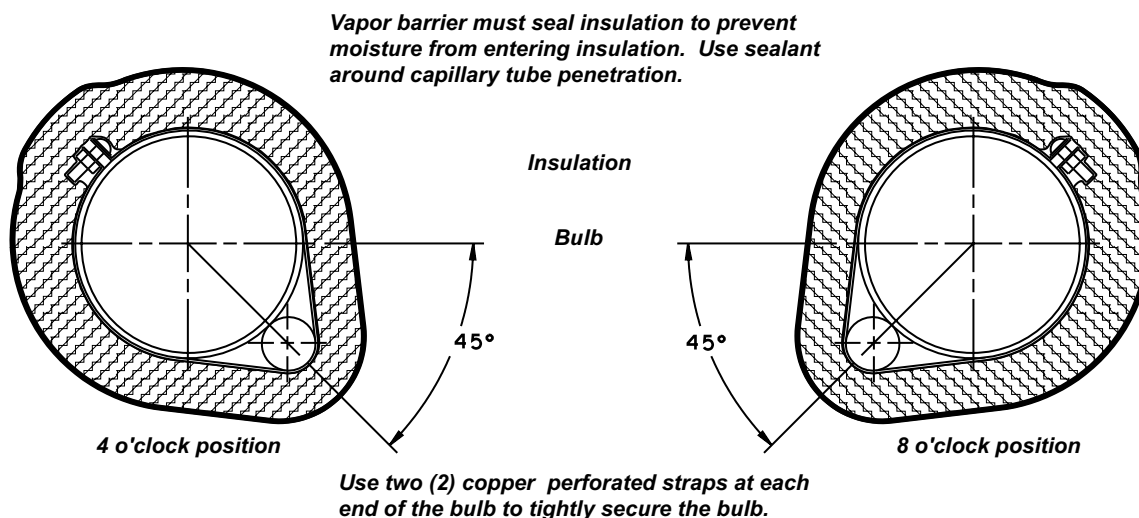
Mounting of the sensing bulb is extremely important. Oil leaving the DX coil must not influence the bulb, which must be mounted radially on the suction line at either the 4 or 8 o'clock position about 6" to 8" from the coil on the horizontal line leaving the coil (*Figure 69 on page 96*). The bulb should be mounted completely flat. Two perforated copper straps should firmly secure the bulb to provide good thermal contact with the suction line. Thermally insulate the bulb from the air with a vapor barrier, so that the ambient air temperature does not affect the bulb sensing. The sub-cooling and superheat should be checked and adjusted when the unit is operating at design conditions. The equalizing line should be piped just downstream of the bulb on the same horizontal line. The equalizing line must enter at the top of the suction line pipe.

LIQUID LINE SOLENOID VALVES

A solenoid valve (*Figure 70 on page 96*) is simply a two-position valve that is electronically actuated by energizing or de-energizing a solenoid coil.



FIGURE 70 - LIQUID LINE SOLENOID VALVE



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FIGURE 69 - THERMAL EXPANSION BULB MOUNTING POSITIONS RADIALLY ON THE SUCTION PIPING

The function of the LLSV is to allow refrigerant to flow through the circuit upon a call for cooling and to prevent refrigerant from flowing through the circuit when no cooling is required. The LLSV is energized by 115-1-50/60 power. They must be wired into the air-cooled condensing unit to receive the energizing signal.

A single liquid line solenoid valve is required for each ACCU circuit and should be located at the air-handling unit. Refer to Figure 76 on page 100 and Figure 77 on page 101, which illustrate the application of the LLSV. To avoid refrigerant management problems, do not use multiple liquid line solenoid valves per ACCU refrigerant circuit. The typical pressure drop of a properly sized LLSV is approximately 2-3 PSI.

SIGHT GLASS

A sight-glass (SG) moisture-indicator (Figure 71 on page 97) is designed to detect moisture in the refrigerant. One sight glass is required in each refrigerant circuit between the LLSV and the TXV. It should be mounted as close to the TXV as possible and downstream of the filter-drier. In cases where long liquid lines are encountered, two glasses, one at the condenser (ACCU) and one at the DX coil, are recommended.



FIGURE 71 - SIGHT GLASS

Typically the sight glass will have a small paper dot in the center of the glass. This dot changes color, from green to yellow, when moisture is present in the system. If bubbles are visible in the liquid refrigerant through the sight glass, the system may be undercharged. However, the bubbles could be indicative of another problem, such as insufficient sub-cooling, or excessive liquid line pressure drop (i.e., dirty filter line drier cores). When charging the system, the sight glass should not be relied upon as overcharging could occur, if non-condensables were present.

Sight glasses are shipped loose for field installation with ACCU condensing units. The pressure drop through a sight glass is typically 0.5 PSI.

FILTER DRIER

The filter-drier (F-D) consists of a metal shell that contains a desiccant core and a metal screen. The desiccant core removes from the refrigerant any moisture that could damage the TXV or compressor motor windings. The metal screen captures any foreign matter such as scale, dirt or solder particles that could foul the coil tubes, the compressor or the TXV. A filter-drier is required in each circuit. Filter-driers are available in two types, sealed (Figure 72 on page 97) and replaceable core (Figure 73 on page 97). Small systems usually include a sealed F-D, while larger systems include a replaceable-core type. The desiccant cores are in a replaceable-core.



FIGURE 72 - SEALED FILTER DRIER



FIGURE 73 - REPLACEABLE CORE FILTER DRIER

F-D can be replaced and the shell can be cleaned out when it becomes fouled. When a sealed F-D becomes fouled the entire device must be replaced. Filter-driers ship loose with YORK ACCU condensing units for field installation. The filter-driers should be installed in the liquid line, upstream of the sight glass and TXV. A filter should always be mounted in a horizontal position as shown in Figure 74 on page 98. This prevents any foreign matter from falling back into the line when the device is removed. A sealed F-D should always be replaced with a replaceable-core F-D when it becomes fouled in the event that any debris is still present in the system.



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FIGURE 74 - FILTER DRIER INSTALLATION

SUCTION FILTER

Suction line filter-driers can be mounted in the suction line, but are not needed on new systems, if care is taken to keep the suction lines clean during installation.

REFRIGERANT LIQUID STOP VALVE

A liquid line shutoff valve with a charging port is required on each refrigerant circuit and is included as standard with ACCU units and packaged equipment.

CHARGING VALVE

A 1/4" or 3/8" charging valve (by others) should be installed between the TXV and distributor. This will allow refrigerant gas to be safely added to the low side of each circuit.

ACCU SUCTION CONNECTION

Copper stub-out suction connections are included as standard on the ACCU. [Optional suction and discharge (ball type) isolation valves are available per refrigerant circuit to further facilitate servicing.]

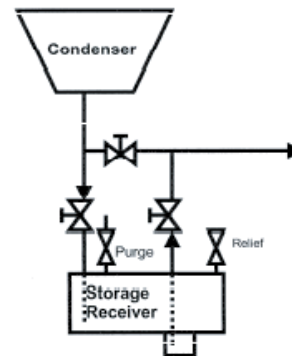
HOT GAS BYPASS

Hot gas is available as an option. The valve is factory mounted, but the piping must be field installed from the valve to the DX coil distributor, as well as the capillary line "External Equalizer" from the valve to its respective suction line (terminate line in top of suction line). See *SECTION 4 - PIPING* for additional details.

RECEIVER

Receivers are not normally needed, since many systems are relatively close coupled and the liquid line is part of the pump-down storage. A review of the DX coil, condensing unit and liquid line operating charges is needed. The pump-down capacities are published in

the Engineering Guide of the condensing units. Consideration should be given to downsizing the liquid line to avoid adding receivers, even though the liquid line pressure drop may increase slightly. If receivers are required, they would need to be added to each refrigerant circuit, as shown in *Figure 75 on page 98*. Contact Johnson Controls for guidance.



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FIGURE 75 - OPTIONAL RECEIVER INSTALLATION

OIL SEPARATOR

Oil separators are not recommended for the ACCU systems. These are not necessary on systems, which have suction lines properly sized per the ASHRAE Refrigerant Handbook and information contained in this guide to assure oil return at all load conditions. While oil separators reduce the rate of oil from being pumped into a system, they cannot be 100 percent efficient. They will still allow all of the oil in the compressor to be eventually pumped into a system, if the system piping is not adequately designed for proper oil return at all capacities. In addition, oil separators add mechanical complexity and potentially could cause more problems than they solve.

SUCTION ACCUMULATOR

Suction line accumulators are not recommended on ACCU systems with interconnecting piping designed and installed per the ASHRAE Refrigeration Handbook and this guide. They are not necessary on systems, which have TXV's, coils, piping and controls properly designed. Additionally, during field piping installation small amounts of debris find their way to the accumulator. This can clog the accumulator and increase the suction line pressure drop, which increases compressor KW input. More importantly, the debris can slow down oil-return to the compressors, which could reduce compressor reliability. Suction line accumulators, like oil separators, may cause more problems than they prevent on this type system.

REFRIGERATION FLOW ILLUSTRATIONS AND SPECIALITIES (R-22 EXAMPLES)

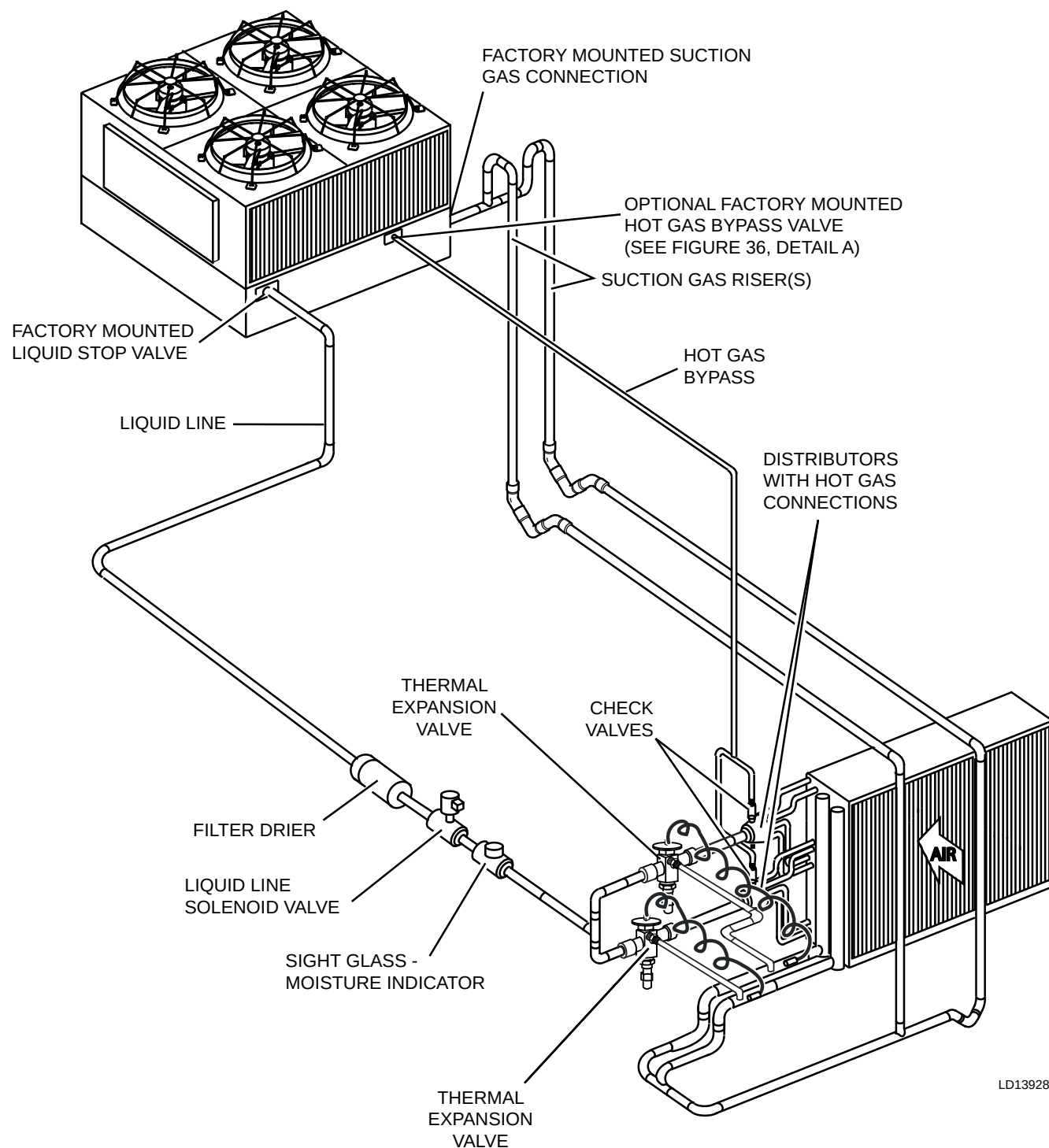
The refrigerant flow diagrams shown in *Figure 76 on page 100* and *Figure 77 on page 101* illustrate two approaches. These arrangements are based on having full-face airflow, which will result in optimum system operation and reliability. Only one refrigerant circuit is illustrated. This will be similar for the second circuit.

Figure 76 on page 100 represents two Interlaced coil sections per refrigerant circuit. Each refrigerant circuit will have one liquid line solenoid with two TXV's per circuit. *Table 20 on page 102* lists the suggested refrigerant components. *Figure 76 on page 100* would also be representative, if one distributor would be used per circuit and *Table 21 on page 104* lists the suggested refrigerant components for this arrangement.

Figure 77 on page 101 illustrates the use of two stacked interlaced coils. This arrangement would use one liquid line solenoid valve with two TXV's applied

per refrigerant circuit. This approach is recommended on larger capacity systems and based on full face air flow across the coils. *Table 20 on page 102* lists the suggested refrigerant components. Double suction risers are shown for illustration only. Most applications will need only single risers.

Obviously there are many examples too numerous to expand on here for the various refrigerant types including 407c and 410a, coupled with various coil arrangements. Generally the Filter Drier and the Site Glass are shipped loose for field installation by the Installing Contractor. These part numbers should also be identified in the Replacement Parts Guide. Generally the TXV and LLSV are furnished and installed by the Installing Contractor. Selection of the later parts is also the responsibility of the Installing Contractor. A cursory review of these parts can be requested through Application Engineering Sales support group (Through your local JCI Sales/Service office).

**FIGURE 76 - INSTALLATION WITH TWO INTERLACED COILS (OR JUST ONE COIL PER CIRCUIT)**

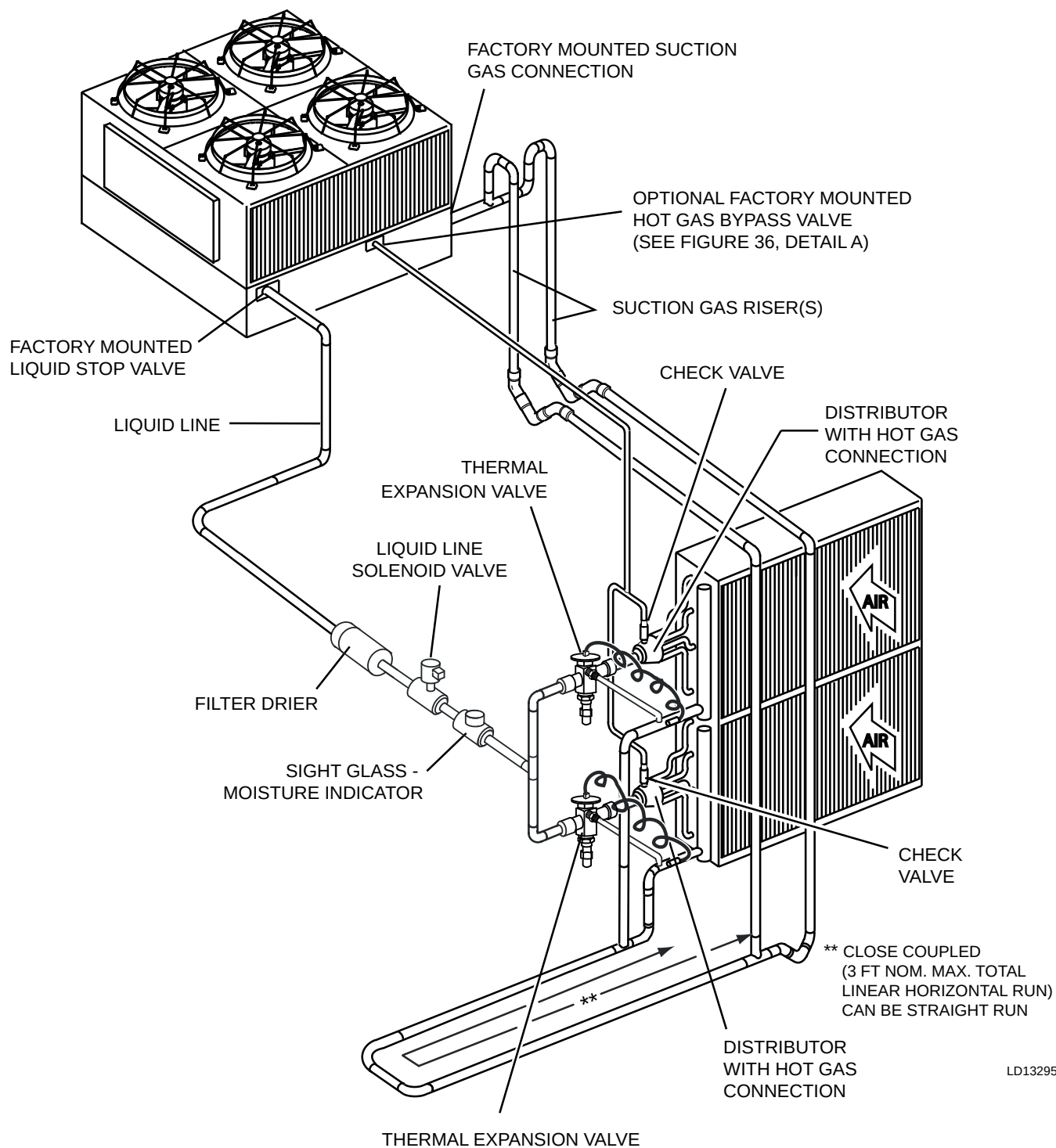


FIGURE 77 - INSTALLATION WITH TWO STACKED INTERLACED COILS PER CIRCUIT

TABLE 20 - REFRIGERANT COMPONENTS, WITH TWO STACKED INTERLACED COILS WITH 2 TXV'S AND 1 LLSV PER REFRIGERANT CIRCUIT R-22 (REFER TO FIGURE 76)

ACCU 60 HZ	Tons a)			Filter-Drier(s) b)				Moisture Indicator b)			
	Unit	SYS #1	SYS #2	SYS #1		SYS #2		SYS #1		SYS #2	
				BODY - Qty	Cores - Qty	BODY - Qty	Cores - Qty	BODY - Qty	CAP - Qty	BODY - Qty	CAP - Qty
				P/N	P/N	P/N	P/N	P/N	P/N	P/N	P/N
0016EC	15.2	15.2	---	1	*	---	---	1	**	---	---
				026-36510	*	---	---	026-15305	**	---	---
0026EC	20.8	20.8	----	1	*	---	---	1	**	---	---
				026-36510	*	---	---	026-15305	**	---	---
0030EC	25.9	25.9	----	1	*	---	---	1	**	---	---
				026-36510	*	---	---	026-15305	**	---	---
0036EC	31.2	31.2	----	1	2	---	---	1	1	---	---
				026-30598	026-18328	---	---	026-32397	026-32800	---	---
0040EC	37.7	37.7	----	1	2	---	---	1	1	---	---
				026-30598	026-18328	---	---	026-32397	026-32800	---	---
0046EC	42.3	21.1	21.1	1	*	1	*	1	**	1	**
				026-36510	*	026-36510	*	026-15305	**	026-15305	**
0050EC	46.9	25.9	21.3	1	*	1	*	1	**	1	**
				026-36510	*	026-36510	*	026-15305	**	026-15305	**
0056EC	51.7	25.9	25.9	1	*	1	*	1	**	1	**
				026-36510	*	026-36510	*	026-15305	**	026-15305	**
0060EC	56.2	30.6	25.6	1	2	1	*	1	1	1	**
				026-30598	026-18328	026-36510	*	026-32397	026-32800	026-15305	**
0066EC	62.2	31.1	31.1	1	2	1	2	1	1	1	1
				026-30598	026-18328	026-30598	026-18328	026-32397	026-32800	026-32397	026-32800
0076EC	68.9	37.5	31.4	1	2	1	2	1	1	1	1
				026-30598	026-18328	026-30598	026-18328	026-32397	026-32800	026-32397	026-32800
0080EC	77.0	38.5	38.5	1	2	1	2	1	1	1	1
				026-30598	026-18328	026-30598	026-18328	026-32397	026-32800	026-32397	026-32800
0086EC	83.6	45.5	38.1	1	2	1	2	1	1	1	1
				026-30598	026-18328	026-30598	026-18328	026-32397	026-32800	026-32397	026-32800
0090EC	90.1	45.0	45.0	1	2	1	2	1	1	1	1
				026-30598	026-18328	026-30598	026-18328	026-32397	026-32800	026-32397	026-32800
0096EC	90.8	50.4	40.4	1	2	1	2	1	1	1	1
				026-21055	026-18328	026-30598	026-18328	026-32398	026-32800	026-32397	026-32800
0100EC	98.4	49.2	49.2	1	2	1	2	1	1	1	1
				026-21055	026-18328	026-21055	026-18328	026-32398	026-32800	026-32398	026-32800
0106EC	108.9	60.5	48.4	1	2	1	2	1	1	1	1
				026-21055	026-18328	026-21055	026-18328	026-32398	026-32800	026-32398	026-32800
0120EC	122.1	61.1	61.1	1	2	1	2	1	1	1	1
				026-21055	026-18328	026-21055	026-18328	026-32398	026-32800	026-32398	026-32800
0130EC	133.6	74.3	59.3	1	3	1	2	1	1	1	1
				026-16960	026-18328	026-21055	026-18328	026-32399	026-32800	026-32398	026-32800
0140EC	144.4	74.2	74.2	1	3	1	3	1	1	1	1
				026-16960	026-18328	026-16960	026-18328	026-32399	026-32800	026-32399	026-32800

* In-Line Type

** Included w/Body

a) R-22, 95° F ambient and 45° SST, TXV's listed in table should be reviewed for SST's more than 3 degrees above or below 45° F

b) YORK P/N shipped loose with the standard ACCU Condensing unit

c) YORK P/N not included with the standard ACCU Condensing unit separately from

Baltimore Parts Center phone 800-932-1701 or fax 800-932-1702

d) Good for the typical 40° F to 50° SST range

e) The above are applicable for R-407C systems too

NOTE: Add -000 suffix to all part numbers in this table

Liquid Line Solenoid Valve Size c)		Expansion Valves a) and c)				Hot Gas By Pass Valves c)		ACCU Liquid Line Connection Size		ACCU Suction Line Connection Size	
SYS #1	SYS #2	SYS #1		SYS #2		SYS #1	SYS #2	SYS #1	SYS #2	SYS #1	SYS #2
LLSV1	LLSV2	TXV #1 f)	TXV #2 f)	TXV #1 f)	TXV #2 f)	HGBP #1	HGBP #2				
SIZE	SIZE	NOM TONS	NOM TONS	NOM TONS	NOM TONS	NOM TONS	NOM TONS				
P/N	P/N	P/N	P/N	P/N	P/N	P/N	P/N				
7/8"	---	8	8	--	--	7/8"	---	7/8"	---	1-5/8"	---
025-34585		025-37346	025-37346	--	--	025-34133-001	---				
7/8"	---	11	11	--	--	7/8"	---	1-1/8"	---	1-5/8"	---
025-34585		025-34155	025-34155	--	--	025-34133-001	---				
7/8"	---	11	11	--	--	7/8"	---	1-1/8"	---	2-1/8"	---
025-34585		025-34155	025-34155	--	--	025-34133-001	---				
1-1/8"	---	15	15	--	--	7/8"	---	1-1/8"	---	2-1/8"	---
025-33705		025-33280	025-33280	--	--	025-34133-001	---				
1-1/8"	---	20	20	--	--	7/8"	---	1-1/8"	---	2-1/8"	---
025-33705		025-27535	025-27535	--	--	025-34133-001	---				
7/8"	7/8"	11	11	11	11	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-34585	025-34585	025-34155	025-34155	025-34155	025-34155	025-34133-001	025-34133-001				
7/8"	7/8"	11	11	11	11	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-34585	025-34585	025-34155	025-34155	025-34155	025-34155	025-34133-001	025-34133-001				
7/8"	7/8"	11	11	11	11	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-34585	025-34585	025-34155	025-34155	025-34155	025-34155	025-34133-001	025-34133-001				
1-1/8"	7/8"	15	15	11	11	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-33705	025-34585	025-33280	025-33280	025-34155	025-34155	025-34133-001	025-34133-001				
1-1/8"	1-1/8"	15	15	15	15	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-33705	025-33705	025-33280	025-33280	025-33280	025-33280	025-34133-001	025-34133-001				
1-1/8"	1-1/8"	20	20	15	15	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-33705	025-33705	025-27535	025-27535	025-33280	025-33280	025-34133-001	025-34133-001				
1-1/8"	1-1/8"	20	20	20	20	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-33705	025-33705	025-27535	025-27535	025-27535	025-27535	025-34133-001	025-34133-001				
1-1/8"	1-1/8"	20	20	20	20	7/8"	7/8"	1-1/8"	1-1/8"	2-5/8"	2-5/8"
025-33705	025-33705	025-27535	025-27535	025-27535	025-27535	025-34133-001	025-34133-001				
1-3/8"	1-1/8"	30	30	20	20	1-1/8"	1-1/8"	1-3/8"	1-1/8"	2-5/8"	2-5/8"
025-33704	025-33705	025-27536	025-27536	025-27535	025-27535	025-39469-001	025-39469-001				
1-3/8"	1-3/8"	30	30	30	30	1-1/8"	1-1/8"	1-3/8"	1-3/8"	2-5/8"	2-5/8"
025-33704	025-33704	025-27536	025-27536	025-27536	025-27536	025-39469-001	025-39469-001				
1-3/8"	1-3/8"	30	30	30	30	1-1/8"	1-1/8"	1-3/8"	1-3/8"	2-5/8"	2-5/8"
025-33704	025-33704	025-27536	025-27536	025-27536	025-27536	025-39469-001	025-39469-001				
1-3/8"	1-3/8"	30	30	30	30	1-1/8"	1-1/8"	1-3/8"	1-3/8"	2-5/8"	2-5/8"
025-33704	025-33704	025-27536	025-27536	025-27536	025-27536	025-39469-001	025-39469-001				
1-5/8"	1-3/8"	40	40	30	30	1-1/8"	1-1/8"	1-3/8"	1-3/8"	2-5/8"	2-5/8"
025-33281	025-33704	025-20213	025-20213	025-27536	025-27536	025-39469-001	025-39469-001				
1-5/8"	1-5/8"	40	40	40	40	1-1/8"	1-1/8"	1-3/8"	1-3/8"	2-5/8"	2-5/8"
025-33281	025-33281	025-20213	025-20213	025-20213	025-20213	025-39469-001	025-39469-001				

f) Bulb charge is type "VN" used primarily when the valve body will see colder temperatures than what the sensing bulb will see, preventing bulb charge migration. You should consider using a VGA or VCP100 charge with the added MOP feature on all applications where the AHU is located indoors and/or if the TXV body will always see warmer temperatures than the bulb.

TABLE 21 - REFRIGERANT COMPONENTS, WITH 1 FULL FACE DX COIL WITH 1 TXV PER REFRIGERANT CIRCUIT R-22 (REFER TO FIGURE 77)

ACCU	Tons a)			Filter-Drier(s) b) & d)				Moisture Indicator b) & d)			
60 HZ	Unit	SYS #1	SYS #2	SYS #1		SYS #2		SYS #1		SYS #2	
				BODY - Qty	Cores - Qty	BODY - Qty	Cores - Qty	BODY - Qty	CAP - Qty	BODY - Qty	CAP - Qty
				P/N	P/N	P/N	P/N	P/N	P/N	P/N	P/N
0016EC	15.2	15.2	---	1	*	---	---	1	**	---	---
				026-36510	*	---	---	026-15305	**	---	---
0026EC	20.8	20.8	----	1	*	---	---	1	**	---	---
				026-36510	*	---	---	026-15305	**	---	---
0030EC	25.9	25.9	----	1	*	---	---	1	**	---	---
				026-36510	*	---	---	026-15305	**	---	---
0036EC	31.2	31.2	----	1	2	---	---	1	1	---	---
				026-30598	026-18328	---	---	026-32397	026-32800	---	---
0040EC	37.7	37.7	----	1	2	---	---	1	1	---	---
				026-30598	026-18328	---	---	026-32397	026-32800	---	---
0046EC	42.3	21.1	21.1	1	*	1	*	1	**	1	**
				026-36510	*	026-36510	*	026-15305	**	026-15305	**
0050EC	46.9	25.9	21.3	1	*	1	*	1	**	1	**
				026-36510	*	026-36510	*	026-15305	**	026-15305	**
0056EC	51.7	25.9	25.9	1	*	1	*	1	**	1	**
				026-36510	*	026-36510	*	026-15305	**	026-15305	**
0060EC	56.2	30.6	25.6	1	2	1	*	1	1	1	**
				026-30598	026-18328	026-36510	*	026-32397	026-32800	026-15305	**
0066EC	62.2	31.1	31.1	1	2	1	2	1	1	1	1
				026-30598	026-18328	026-30598	026-18328	026-32397	026-32800	026-32397	026-32800
0076EC	68.9	37.5	31.4	1	2	1	2	1	1	1	1
				026-30598	026-18328	026-30598	026-18328	026-32397	026-32800	026-32397	026-32800
0080EC	77.0	38.5	38.5	1	2	1	2	1	1	1	1
				026-30598	026-18328	026-30598	026-18328	026-32397	026-32800	026-32397	026-32800
0086EC	83.6	45.5	38.1	1	2	1	2	1	1	1	1
				026-30598	026-18328	026-30598	026-18328	026-32397	026-32800	026-32397	026-32800
0090EC	90.1	45.0	45.0	1	2	1	2	1	1	1	1
				026-30598	026-18328	026-30598	026-18328	026-32397	026-32800	026-32397	026-32800
0096EC	90.8	50.4	40.4	1	2	1	2	1	1	1	1
				026-21055	026-18328	026-30598	026-18328	026-32398	026-32800	026-32397	026-32800
0100EC	98.4	49.2	49.2	1	2	1	2	1	1	1	1
				026-21055	026-18328	026-21055	026-18328	026-32398	026-32800	026-32398	026-32800
0106EC	108.9	60.5	48.4	1	2	1	2	1	1	1	1
				026-21055	026-18328	026-21055	026-18328	026-32398	026-32800	026-32398	026-32800
0120EC	122.1	61.1	61.1	1	2	1	2	1	1	1	1
				026-21055	026-18328	026-21055	026-18328	026-32398	026-32800	026-32398	026-32800
0130EC	133.6	74.3	59.3	1	3	1	2	1	1	1	1
				026-16960	026-18328	026-21055	026-18328	026-32399	026-32800	026-32398	026-32800
0140EC	144.4	74.2	74.2	1	3	1	3	1	1	1	1
				026-16960	026-18328	026-16960	026-18328	026-32399	026-32800	026-32399	026-32800

* In-Line Type

** Included w/Body

a) R-22, 95° F ambient and 45° SST, TXV's listed in table should be reviewed for SST's more than 3 degrees above or below 45° F

b) YORK P/N shipped loose with the standard ACCU Condensing unit

c) YORK P/N not included with the standard ACCU Condensing unit separately from

Baltimore Parts Center phone 800-932-1701 or fax 800-932-1702

d) Good for the typical 40° F to 50° SST range

e) The above are applicable for R-407C systems too

NOTE: Add -000 suffix to all part numbers in this table

Liquid Line Solenoid Valve Size c) and d)		Expansion Valves a) and c)				Hot Gas By Pass Valves c)		ACCU Liquid Line Connec- tion Size		ACCU Suction Line Connec- tion Size	
SYS #1	SYS #2	SYS #1		SYS #2		SYS #1	SYS #2	SYS #1	SYS #2	SYS #1	SYS #2
LLSV1	LLSV2	TXV #1 f)	TXV #2 f)	TXV #1 f)	TXV #2 f)	HGBP #1	HGBP #2				
SIZE	SIZE	NOM TONS	NOM TONS	NOM TONS	NOM TONS	NOM TONS	NOM TONS				
P/N	P/N	P/N	P/N	P/N	P/N	P/N	P/N				
7/8"	---	15	--	--	--	7/8"	---	7/8"	---	1-5/8"	---
025-34585		025-34156	--	--	--	025-34133-001	---				
7/8"	---	20	--	--	--	7/8"	---	1-1/8"	---	1-5/8"	---
025-34585		025-27535	--	--	--	025-34133-001	---				
7/8"	---	30	--	--	--	7/8"	---	1-1/8"	---	2-1/8"	---
025-34585		025-27536	--	--	--	025-34133-001	---				
1-1/8"	---	30	--	--	--	7/8"	---	1-1/8"	---	2-1/8"	---
025-33705		025-27536	--	--	--	025-34133-001	---				
1-1/8"	---	40	--	--	--	7/8"	---	1-1/8"	---	2-1/8"	---
025-33705		025-20213	--	--	--	025-34133-001	---				
7/8"	7/8"	20	--	20	--	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-34585	025-34585	025-27535	--	025-27535	--	025-34133-001	025-34133-001				
7/8"	7/8"	30	--	20	--	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-34585	025-34585	025-27536	--	025-27535	--	025-34133-001	025-34133-001				
7/8"	7/8"	30	--	30	--	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-34585	025-34585	025-27536	--	025-27536	--	025-34133-001	025-34133-001				
1-1/8"	7/8"	30	--	30	--	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-33705	025-34585	025-27536	--	025-27536	--	025-34133-001	025-34133-001				
1-1/8"	1-1/8"	30	--	30	--	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-33705	025-33705	025-27536	--	025-27536	--	025-34133-001	025-34133-001				
1-1/8"	1-1/8"	40	--	30	--	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-33705	025-33705	025-20213	--	025-27536	--	025-34133-001	025-34133-001				
1-1/8"	1-1/8"	40	--	40	--	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-33705	025-33705	025-20213	--	025-20213	--	025-34133-001	025-34133-001				
1-1/8"	1-1/8"	55	--	40	--	7/8"	7/8"	1-1/8"	1-1/8"	2-1/8"	2-1/8"
025-33705	025-33705	025-32904	--	025-20213	--	025-34133-001	025-34133-001				
1-1/8"	1-1/8"	55	--	55	--	7/8"	7/8"	1-1/8"	1-1/8"	2-5/8"	2-5/8"
025-33705	025-33705	025-32904	--	025-32904	--	025-34133-001	025-34133-001				
1-3/8"	1-1/8"	55	--	40	--	1-1/8"	1-1/8"	1-3/8"	1-1/8"	2-5/8"	2-5/8"
025-33704	025-33705	025-32904	--	025-20213	--	025-39469-001	025-39469-001				
1-3/8"	1-3/8"	55	--	55	--	1-1/8"	1-1/8"	1-3/8"	1-3/8"	2-5/8"	2-5/8"
025-33704	025-33704	025-32904	--	025-32904	--	025-39469-001	025-39469-001				
1-3/8"	1-3/8"	70	--	55	--	1-1/8"	1-1/8"	1-3/8"	1-3/8"	2-5/8"	2-5/8"
025-33704	025-33704	025-35757	--	025-32904	--	025-39469-001	025-39469-001				
1-3/8"	1-3/8"	70	--	70	--	1-1/8"	1-1/8"	1-3/8"	1-3/8"	2-5/8"	2-5/8"
025-33704	025-33704	025-35757	--	025-35757	--	025-39469-001	025-39469-001				
1-5/8"	1-3/8"	70	--	70	--	1-1/8"	1-1/8"	1-3/8"	1-3/8"	2-5/8"	2-5/8"
025-33281	025-33704	025-35757	--	025-35757	--	025-39469-001	025-39469-001				
1-5/8"	1-5/8"	70	--	70	--	1-1/8"	1-1/8"	1-3/8"	1-3/8"	2-5/8"	2-5/8"
025-33281	025-33281	025-35757	--	025-35757	--	025-39469-001	025-39469-001				

f) Bulb charge is type "VN" used primarily when the valve body will see colder temperatures than what the sensing bulb will see, preventing bulb charge migration. You should consider using a VGA or VCP100 charge with the added MOP feature on all applications where the AHU is located indoors and/or if the TXV body will always see warmer temperatures than the bulb.

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SECTION 7 - BRAZING

GENERAL

Brazing, for the purpose of this document, is defined as the joining of metals through the use of heat and a filler metal – one whose melting temperature is above 1100°F (593 °C) but below the melting point of the metals being joined. A brazed joint, if properly made will be as strong or stronger than the metals joined.

Brazing works by creating a metallurgical bond between the parent metals and the filler metal. Occasionally brazing may be referred to as “silver soldering”. For consistency sake, we will refer to the term as “brazing” throughout this document, with the understanding that we are referring to a torch brazing process with a silver-bearing filler metal.

The following offers general pipe brazing practices for R-22, 407c and as well as the higher pressures of 410a refrigerants.

BRAZING SAFETY

- Wear suitable protective clothing. Safety goggles with tinted lenses and gloves are required.
- Beware of brazing near combustible materials. If impossible to avoid, use suitable heat shield material to prevent damage or combustion from occurring.
- Be sure to have an adequate means of dealing with a fire, such as fire hose, fire extinguishers, etc.
- Ventilate confined areas. Use ventilating fans and exhaust hoods to carry all fumes and gases away from work, and air supplied respirators as required.
- Clean base metals thoroughly. A surface contaminant of unknown composition on base metals may add to fume hazard and may cause a too rapid breakdown of flux, leading to over heating.
- Use sufficient flux. Flux protects base metals and filler metal during heating cycle. Full flux coverage reduces fuming. Also, consult your MSDS (Material Safety Data Sheet) regarding specific hazards associated with brazing flux.
- Heat metals broadly. Heat the base metals broadly and uniformly. Intense localized heating uses up flux, increases danger of fuming.
- Know your base metals. A cadmium coating on a base metal will volatilize and produce toxic fumes during heating. Zinc coatings (galvanized) will also fume when heated. Learn to recognize these

coatings. It is recommended that they be removed before parts are heated for brazing.

- Know your filler metals. Do not use filler metals containing cadmium. Consult the MSDS for maximum recommended brazing temperatures of a specific filler metal. The filler metal carries a warning label. Be sure to look for it and follow the instructions.

For additional safety considerations, see the American National Standard Z49.1, “Safety in Welding and Cutting”, published by the American Welding Society (AWS), 550 N.W. LeJeune Rd., Miami, Florida 33126.)



LD09165

FIGURE 78 - HAND HELD TORCH

TOOLS AND EQUIPMENT NEEDED

1. Torch and Fuel Source

The heating source most commonly used in brazing is the hand held torch (*Figure 78 on page 107*). The type of torch offering the most versatility is a conventional oxygen-acetylene torch, however, a special swirl-combustion tip torch (TurboTorch™ is one such example) using MAPP (Methyl acetylene-propadiene mixture) or Propane/Air mixtures can be used very effectively on smaller jobs. Oxy-acetylene rigs are the most complex because they require both oxygen and acetylene tanks, regulators for both tanks, hoses, valves and typically a cart to hold the whole apparatus (*Figure 79 on page 108*).

Depending on the size of the tanks, a typical oxy-acetylene rig can weigh quite a bit. The advantage of using the fuel/air mix rig is the size, weight and portability issue. The disadvantage is that they generally are not as effective at quickly heating larger braze joints.



LD09166

FIGURE 79 - HAND HELD TORCH AND TANKS

2. Pipe Joint Tools

- A. **Tubing cutter** - standard tubing cutter with sharp cutting wheel (*Figure 80 on page 108*)



LD09167

FIGURE 80 - TUBING CUTTER

- B. **De-burring tool** - inside and outside burrs should be removed (*Figure 81 on page 108*)



LD09168

FIGURE 81 - TUBING DE-BURRING TOOL

- C. **Flat file** - may be useful to square tubing ends or remove burrs
- D. **Wire brush** - inside and outside diameter brushes can be purchased to facilitate cleaning of various size tubing/fittings
- E. **Crocus Cloth** (YORK Part Number: 041-02729-000)-crocus cloth (*Figure 82 on page 108*), which is essentially jeweler's rouge impregnated cloth is very useful for cleaning copper and brass pipe/fittings. Crocus cloth's unique advantage over other abrasive cloths or papers is that the abrasive material and the abraded material remains attached to the cloth rather than getting into the piping or remaining on the surface.



LD09169

FIGURE 82 - CROCUS CLOTH

Do not use steel wool, sand paper or emery cloth. All of these materials will shed their abrasives and can both compromise the braze joint and get into the system which could cause compressor bearing damage.

3. Solvent

Alcohol or any commercially available, safety approved, non-residue forming solvent that will remove oil or grease from the fittings and pipe.

4. Flux

Flux may be required depending on the two particular metals that will be joined (*Figure 83 on page 109*). The general rule of thumb is that copper/copper joints, when brazed with a Silver/Copper/Phosphorus filler metal do not require flux. Combinations of copper, brass and steel will require flux. Flux performs a rather simple task. It prevents oxides from forming and impeding the brazing process. Flux performs that task by dissolving the oxides. Flux also provides a visual indication of the joint temperature, alerting the brazer that it is time to apply the filler alloy.

The type of flux needed will normally depend on the brazing time and temperatures.



LD09170

FIGURE 83 - FLUX

For light walled joints use a low temperature flux (AWS specification FB3A), generally white in color (YORK part number 044-00372-000).

For heavier wall, higher temperature work, use a black flux. (AWS specification. FB3C) (YORK part number 044-00371-000).

Be sure to follow the manufacturer's instructions and safety recommendations when working with brazing flux. Most fluxes are acidic and can cause skin reactions. Protect exposed skin and always wear eye protection when working with flux.

The flux is generally applied using an acid brush, which may be part of the flux container or if necessary purchase separately.

5. Wet Cloths

A couple of wet cloths soaking in a pail of clean water are always handy to have available. First of all, it may be necessary to wrap a wet cloth around parts of an assembly such as a thermal expansion valve (TXV) or solenoid valve during the brazing operation to prevent the brazing heat from damaging the valve components/gaskets. Second, the wet cloths can be used to carefully wipe a finished braze joint to remove residual flux (if used) and to provide a professional looking finished joint.

6. Filler Metal

Two types of filler metal are recommended by Johnson Controls.

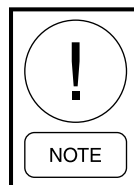
For copper-to-copper joints, use AWS classification "BCuP-3" which has a nominal composition of 5% Silver, 89% Copper and 6% Phosphorous. Popular brand name equivalents are *Handy Harman Sil Fos 5*, *J.W. Harris Stay-Silv 5* and *Englehard Industries Silvaloy 5*. The YORK part number for this material is 001-04708-

000. No flux is required with this filler alloy when using it to braze clean copper to copper joints. This alloy liquefies at 1495° F and has a flow point of 1325° F. The finished joint color will be gray in appearance.



Do not use Silver/Phosphorous materials to join ferrous materials as brittle phosphate compounds will be formed at the interface. Also note that these filler metals have a unique characteristic called the "Flow Point". The "Flow Point" is defined as the temperature at which the filler metal is fluid enough to capillary through a joint even though not completely liquid (i.e. above the liquids temperature).

For brazing copper to brass or steel and any combination of brass and steel together, use AWS classification "BAG-20" which has a nominal composition of 30% silver, 38% Copper and 32% Zinc. Popular brand name equivalents are *Handy Harman Braze 300*, *Engelhard Industries Engelhard No. A-13* and *J.W. Harris Safety Silv 30*. The YORK part number for this filler metal is 001-06056-000. This alloy flows at 1410°F. The finished joint color will be yellow.



Other alloys may be used as substitutes for the above, providing they meet or exceed the specifications of the suggested alloys.

7. Nitrogen MUST Be Used While Brazing!

The importance of brazing with nitrogen cannot be over-emphasized. POE oils used with the newer refrigerants such as R134a or R-407c make this even more important due to their solvent powers. The sludge that will form in the system as a result of brazing without nitrogen is severe and easily identified after a compressor failure. Don't gamble with your compressor warranty, follow proper nitrogen brazing procedures!

A regulated supply of nitrogen must be available to purge the piping and then sustain a small flow of nitrogen through the piping while brazing the fittings, otherwise the heat applied during brazing will cause oxides to form inside the piping which may later promote compressor failures or plug filter driers.

Set up the piping so that the first joint you braze is closest to the supply of nitrogen to the piping assembly and then continue to braze the joints in the direction of the nitrogen flow.



LD09171

FIGURE 84 - PIPE BRAZING WITH NITROGEN

LD09172

FIGURE 85 - PIPE BRAZING WITHOUT NITROGEN

It is very important to mask off openings in the piping to ensure that all oxygen has been completely purged from the assembly and that a small gentle flow of nitrogen is flowing through and past each piping joint while it is being brazed and during the cooling process. If there are branch fittings, be sure you have purged the branch piping section and that there is flow through the branch before brazing. See *Figure 84 on page 110* for results of brazing with nitrogen purge and *Figure 85 on page 110* for results when nitrogen is not used.

Failure to adequately purge the piping or promote flow past branch fittings will have nearly the same effect as no nitrogen at all.

PROCEDURES

1. Cutting tubing

Pipe or tube ends should be cut off square and burrs removed by reaming or filing, taking care that any metal debris or chips fall out of the piping. Reaming and filing should be held to the absolute minimum necessary to remove the burrs. Care should be taken not to taper the

pipe or tube end. If the end of the tubing is deformed during cutting so that it is no longer round, a tubing resizing tool should be used to restore the shape of the tubing otherwise the braze joint may be weakened.



LD09173

FIGURE 86 - CLEAN PIPE AFTER CUTTING AND BEFORE FITTING

2. Cleaning

Brazing surfaces and filler metal must be cleaned to bright metal before brazing (*Figure 86 on page 110*).

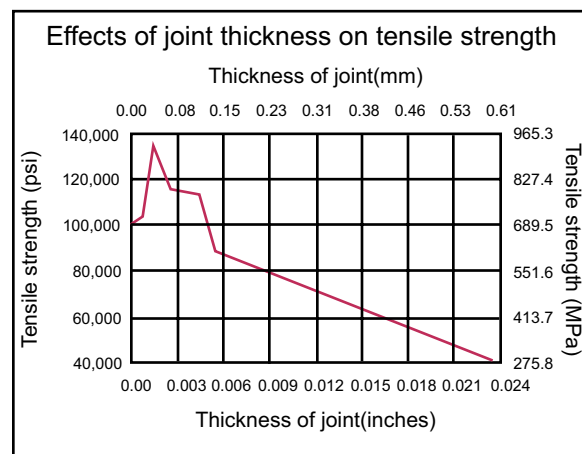
Prior to brazing, oil, grease, etc., should be removed using an approved commercial safety solvent.

Oxides must be removed by wire brushing or crocus cloth.

Do not use steel wool, emery cloth or sandpaper!

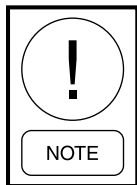
3. Fit-up

Braze joint strength is directly related to fit up clearances. A general rule of thumb is that the joint internal clearance should be 0.002 to 0.005 inch (*Figure 87 on page 110*). This clearance range is necessary for capillary flow of the filler metal into the joint and it is the optimal clearance for joint strength.



LD09174

FIGURE 87 - JOINT THICKNESS VS TENSILE STRENGTH



The piping assemblies that are to be brazed must be supported well enough to maintain the joint alignment and to prevent joint movement until the braze joint has fully solidified.



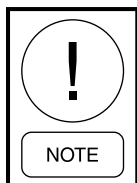
LD09175

FIGURE 88 - CHECKING PIPE FIT

4. Fluxing

If the braze joint is copper to copper and you are using a self-fluxing silver/phosphorous filler metal, flux is not required.

All other situations require flux. Depending on the type of joint, use either low temperature or high temperature flux. High temperature flux should be used where prolonged heating at higher temperatures is required, such as when a heavy wall brass valve is being brazed to copper. If in doubt, use the high temperature flux.



Make sure the flux is stirred well. If the flux is water based it may be necessary to add water if the flux has thickened over time. Flux should have a thin creamy consistency similar to Pepto-Bismol™.

Immediately after cleaning the joint, while exercising care not to touch the clean joint area with bare hands, apply a thin coating of flux to the male portion of the joint so that when assembling the joint, a slight twisting will distribute the flux inside the joint, without allowing the flux to get into the system. Proper application will provide good coverage on the mating portions of the joint only. After seating the two pieces of the joint, apply a thin coating of the flux around the outside of the joint so that the exposed edges of the female part of the joint have flux on them. This will allow the joint to be finished with a professional looking concave fillet and help prevent crystallization of the fitting edges during brazing.



LD09176

FIGURE 89 - APPLYING FLUX TO PIPE

Do not use excessive flux. Flux is acid based and will contribute to system acid formation if allowed to get into the system. See *Figure 89* on page 111 and *Figure 90* on page 111.

Do not apply flux to any surface you do not want the brazing filler metal to flow to and adhere.

For best results, clean the length of the filler alloy you are expecting to use with crocus cloth and then coat the filler metal with a light coating of flux (*Figure 91* on page 112). An old rule of thumb suggests that the diameter of the joint is approximately the length of filler metal needed to properly braze the joint.



LD09177

FIGURE 90 - SEATING PIPE TO FITTING



LD09178

FIGURE 91 - APPLYING FLUX TO FILLER METAL

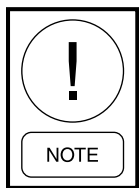
5. Purging

The purpose of Nitrogen purging is to ensure that no oxygen is present inside the piping prior to and during the brazing process, including the cool-down period. Failure to use Nitrogen purging during brazing will cause oxide formation on the inside of the piping and fittings which will accumulate in the system, causing acid and sludge formation which may cause compressor and other component failures in the future.

Keep the area to be purged to a minimum in order to reduce pre-purge time and ensure a quality purge.

Purging is a two stage operation; pre-purge and braze purge. During the first stage prior to brazing, the purge gas is used to remove air from the piping or system that you are working on.

During the second stage the nitrogen flow should be at a rate of approximately 6-8 CFH (cubic feet per hour). This rate can be obtained by adjusting the flow of nitrogen with the nitrogen regulator until you can feel a soft, cool feeling on the inside of your wrist blowing out the outlet of the piping.



It is important for the nitrogen to have free flowing ability from the inlet, which will be upstream of the first joint to be brazed, to the outlet which will be downstream of the last joint to be brazed without causing any pressure build up in the piping system (Figure 85). Any back pressure developed within the piping because of the nitrogen purge will cause pinhole leaks in the braze joints.



LD09179

FIGURE 92 - BRAZING JOINTS IN DIRECTION OF FLOW

When brazing an assembly with a number of joints, the brazing sequence should be in the direction of the nitrogen flow whenever possible (*Figure 84 on page 110*).

6. Brazing

If using oxygen-acetylene gases, a neutral flame should be used. A neutral flame has a well defined inner cone.

Select a torch tip that is adequate for the size piping being brazed. It is important to be able to apply enough heat uniformly around the joint so that the filler metal can free flow into and around the total joint at the same time. Multiple tip torches are often used in production environments to quickly achieve this, but for field use, a single tip, adequately sized will be sufficient.

Ensure that the nitrogen purge gas is flowing through the piping. For copper to copper joints, begin by evenly heating the joint, alternatively around the tube and fitting until both reach the brazing temperature before applying the filler metal into the joint. On copper to copper joints, this should be a pale cherry red color (*Figure 93 on page 113*). While feeding the filler rod into the joint, hold the torch further away, keeping the flame feathering the joint to maintain the temperature. The filler material will flow easily around the joint. Add enough filler metal to provide a slight concave fillet finish on the joint and then remove the torch and allow the joint to cool down.



FIGURE 93 - PROPER TORCH FLAME FOR BRAZING

It is important to note that various joint configurations require the above procedure to be modified slightly. A good rule of thumb to remember is that you want to apply the heat evenly to both the fitting and the tube, but after they are both heated adequately, direct the torch flame toward the area where you want to draw the filler metal into. For example on a horizontal joint you would more preferentially concentrate the torch on the female fitting after heating both the fitting and the tubing. This would tend to draw the filler metal into the fitting. For a vertical “up” joint, where the female fitting opening is facing downward, after heating both the tube and the fitting evenly, the heat should then be concentrated more on the female fitting. Note that it helps to have the torch flame pointed upward toward the opening of the joint as you sweep it around the joint. This methodology tends to facilitate the capillary drawing of the molten metal into the joint, avoiding filler metal running down the outside of the tubing.

It is also important to remember that it is easy to add too much filler metal to vertical “down” joints, where the female fitting opening is facing upward. In this case it helps to point the flame upward also while sweeping around the joint. It helps to prevent over filling the joint with filler metal.

A well made braze joint will have a complete layer of filler metal between the entire outside diameter and inside diameter of the fitting and tubing with no metal past the mating areas of the joint on the inside. The

outside of the joint will have a slightly concave fillet with little or no filler metal on any other surfaces of the tubing or fitting.

A good brazer will move the torch quickly around the joint, so that the joint is evenly brought up to the temperature where the filler metal can flow freely into the joint and then gently cap the joint off as the torch is slowly backed off to make the application of the filler metal cap more of a “laying on” process than a flowing process. Although a nice concave fillet appearance on the braze joint is very professional looking, it offers little to the joint integrity. A mechanically sound braze joint really depends on the free flowing of the filler metal by capillary action completely around the circumference of the mating surfaces of the joint and that can only happen if the joint has been heated evenly to a sufficient temperature to effect the flowing of the filler metal.

The brazing technique on joints other than copper to copper are very similar, however, there it becomes more critical to not overheat the non-copper parts of the joints. Both brass and steel can be easily crystallized if the surfaces are overheated. If that happens, the crystallized parts of the metal must be abraded away, the joint re-fluxed and the process repeated.

Brazing flux, which must be used when brazing anything other than copper to copper, will serve as a temperature indicator. The flux appearance will go through several visual stages.

TABLE 22 - BRAZING FLUX

TEMPERATURE	APPEARANCE OF FLUX
212°F (100 °C)	Water boils off.
600°F (315 °C)	Flux becomes white and slightly puffy, and starts to “work.”
800°F (435 °C)	Flux lies against surface and has a milky appearance.
1100°F (593 °C)	Flux is completely clear and active, looks like water. Bright metal surface is visible underneath. At this point, test the temperature by touching brazing filler metal to base metal. If brazing filler metal melts, assembly is at proper temperature for brazing.

After the flux visual condition tells you the temperature is correct, you can touch the filler metal to the joint. If the joint is at the proper temperature the filler metal will begin to flow into the joint. As the joint fills up, move the flame back, reducing the temperature at the joint slightly and add a little more filler metal to provide a concave fillet. As stated previously, the fillet makes for a professional appearance, but adds very little to the quality of the braze joint (*Figure 94 on page 114*).



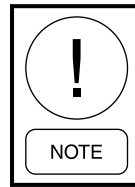
LD09181

FIGURE 94 - PROPERLY BRAZED JOINT

Once the filler metal solidifies, use a wet cloth and while holding both ends of the wet cloth, clean the joint to remove the residual flux, taking care not to disturb adjacent un-brazed joints in the process. The resulting appearance will be a clean, yellowish gold colored braze joint.



To avoid burns, use extreme caution when cleaning a hot braze joint with a wet cloth. The water in the cloth will turn to steam very quickly and if the cloth is allowed to stay in contact with the hot joint for even a short period of time, it will quickly conduct the heat of the braze joint through the wet cloth.



When brazing a device such as a solenoid valve, TXV, hand valve, etc. into a line, follow the manufacturer's recommendation, if one exists. Occasionally it may be required to disassemble the device for brazing purposes in order to avoid damage to the internal parts. In most cases, the device can be wrapped with wet cloths during the brazing and cool down period (Figure 95). It is important that if a solenoid, TXV or other closing device is being brazed, it must be partially open in order to allow Nitrogen to pass through the device during the brazing and cool down period. A manual device such as a hand valve should be partially opened (not backseated) so that the valve seat elastomers are not damaged during brazing. It should also be noted that there are commercially available heat sink materials that can be used to isolate brazing heat from other components.

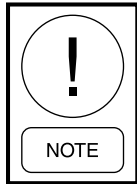


LD09182

FIGURE 95 - USING WET CLOTH TO PROTECT COMPONENTS WHILE BRAZING

SECTION 8 - SYSTEM START-UP

CONDENSING UNIT/AIR HANDLING UNIT SYSTEM START-UP



Johnson Controls Service start-up is recommended and this will benefit the customer, consulting engineer, installing mechanical contractor and YORK.

The following fundamental checks are recommended either prior to or during the system commissioning or start-up:

1. Check that the proper equipment and refrigerant piping components have been installed in accordance with the Consulting Engineer's specifications.
2. Check the refrigerant piping for conformance to the latest ASHRAE Refrigeration Handbook practices and/or 050.40-ES3 Piping Guidelines. As a minimum, things to review for reasonableness are the line sizes, slope, trapping, support, insulation, suction riser (if single or double), and special note to the placement and installation of the TXV Bulb and equalizer line.
3. The refrigerant piping must have been leak checked and evacuated following ASHRAE recommendations. Evacuate the system down to 500 microns. An acceptable leak rate is rise of 100 microns in 10 minutes.
4. The system must be charged with the total system refrigerant charge, which is required for the condensing unit, DX coils and piping. Operating the load condition, a check should be made of the subcooling and superheat. The IOM recommends, at full load design, that the subcooling should be adjusted to 15 – 17°F by adding or removing charge, and the Suction Super Heat be adjusted to 15°F by use of the TXV. The subcooling and superheat are determined as follows:
5. Assure that the ACCU is programmed for the appropriate load control. This will either be based on Suction Pressure (SP) or Discharge Air Temperature (DAT) control. When suction pressure control is used, check to make sure that the suction pressure transducers are installed and the controlling thermostats or dry contacts (by others) are wired into each refrigerant circuit. When DAT control is used, check to make certain that sensor is properly mounted in a thoroughly mixed air-flow location within the air duct or air handling unit.
6. Insure that there is a minimum DX coil face velocity of 350 FPM for proper DX coil operation. The air-proving switch must be wired into the condensing unit control circuit. This is needed to confirm that the air-flow is satisfactory for condensing unit operation.
7. Remote start-stop contacts are properly connected.
8. If desired, a remote emergency cut-off is wired into the condensing unit.
9. Compressors run indication contacts are properly connected, if used.
10. Condensing unit alarm contacts are connected for each refrigerant circuit, if used (N.O. indicates a fault).
11. If remote reset of the DAT is desired, a check should be made to see that the PWM input signal is properly wired (when the condensing unit is programmed for DAT). NOTE that newer 031-02550-000 control boards can directly accept a VDC or MA signal for temperature RESET. Review programming.
12. When remote load limiting is desired, check that the contacts are properly connected to the ACCU condensing unit. This prevents condensing unit from loading beyond a desired value. This will vary with the unit size and depend on the number of compressors (see the condensing unit IOM).

13. The condensing unit is ready to be placed into operation.
14. Leak check the system to assure that there are no leaks at the compressors, fittings, and piping.
15. A check of the oil level should be made after the unit has been put into operation and adding a small amount of oil may be required to accommodate the additional piping runs. Adding about pint for each 100' of piping may be appropriate. Adding too much oil can cause compressor damage and jeopardize the warranty. This can increase condensing unit power consumption too. The oil level should be checked with the compressors off, after the ACCU had been operating near design or full load condition for a minimum of 10 minutes to preferably 30 minutes. The oil level should meet the IOM recommendations.
16. After the system is operating at design or full load condition, a check should be made of the subcooling and superheat. The IOM recommends, at full load design, that the subcooling should be adjusted to 15°F – 17°F by adding or removing charge, and the Suction Super Heat be adjusted to 15°F by use of the TXV. The subcooling and superheat are determined as follows:
 - Sub-cooling = refrigerant liquid pressure converted to temperature minus the liquid line temperature.
 - Superheat = suction temperature minus the suction pressure converted to temperature.

SECTION 9 - CONDENSING UNIT OPERATION

INITIAL SYSTEM COMMISSIONING OR START-UP

The electrical power must be applied for 24 hours prior to starting the ACCU condensing unit. This will insure adequate time for the compressor heaters to boil off the refrigerant in the oil sumps.

Basic ACCU System Requirements

Some basic things must be satisfied in order for the condensing unit to be allowed to operate and provide cooling. These include:

1. The unit switch must be in the ON position.
2. Remote cycling contacts need to be closed.
3. The ACCU microcomputer Daily Schedule must be programmed for the ACCU to operate.
4. The air-proving switch must be satisfied (the evaporator fan blower must be running, when any compressor is operating).
5. A cooling load must be present.
6. The desired setpoint and range must be programmed into the microprocessor based on either Suction Pressure (SP) or Discharge Air Temperature (DAT) control. (*Refer to the ACCU Installation, Operation, and Maintenance, IOM, for the available settings.*)

OPERATING SEQUENCE – CONDENSING UNIT

When Using ACCU Suction Pressure Control

The following points must be recognized when using suction pressure control:

1. The unit start switch needs to be ON.
2. Each condensing unit circuit operates independently for loading and unloading. The loading and unloading will occur on each circuit, based on the suction pressure of that circuit. The condensing unit includes anti-coincident timers (set at 60 seconds) to insure that compressors in systems 1 and 2 will not start at the same time.

3. The first compressor on a circuit will start after the anti-recycle timer counts down, if the Zone Thermostat input is closed and if safeties permit. The liquid line solenoid valve will be energized, when the compressors start.
4. If more cooling is required, the next compressor in the sequence will start after 150 seconds.
5. If more cooling is required, the next compressor (if there are three compressors on the circuit) will start after 150 seconds.

Compressor Lead/Lag Sequence per Circuit

The compressors within a refrigerant system rotate starts in sequence 1-2 (two compressor systems) or 1-2-3 (three compressor systems) in a wrap-around technique and will operate per the following rules of protocol.

1. The longest-off compressor within a system will start first.
2. The longest running compressor within a system will turn off first.
3. Selectable refrigerant system lead-lag is not available, since the refrigerant systems operate independently.

Shutdown and Pump-down

As the cooling load decreases below the programmed setpoint range, the system will unload. The system will not shut off the last compressor until the Zone Thermostat input is opened.

When the last system compressor is cycled off, pump-down occurs. The liquid line solenoid will be deenergized. The last compressor will be allowed to run until either the suction pressure falls below the suction pressure cut-out or for 180 seconds, whichever occurs first. Hot gas bypass is inhibited during pump-down.

When Using ACCU Discharge Air Temperature Control (DAT)

1. The unit start switch is ON.
2. The condensing unit will control both refrigerant circuits for loading and unloading, based on discharge air temperature sensing. The condensing unit includes anti-coincident timers (set at 60 seconds) to insure that compressors in systems 1 and 2 will not start at the same time.
3. The first compressor on the lead circuit will start after the anti-recycle timer counts down, if DAT is above the programmed set-point range and if safeties permit. The liquid line solenoid valve will be energized, when the compressors start.
4. If more cooling is required, the next compressor in the sequence will start, after 180 seconds.
5. If more cooling is required, the next compressor will start, after 180 seconds (if there are three compressors on the circuit).
6. The lag refrigerant circuit will be started 5 minutes after the lead circuit, if the cooling demand requires. The compressor sequencing will occur like the lead circuit.
7. As for unloading, either of the following will occur. The system with the most compressors operating unloads first. Or, the lag system will shut down a compressor first, when an equal number of compressors are operating in each system.

Compressor Lead/Lag Sequence per Circuit

The compressors within a refrigerant system rotate starts in sequence 1-2 (two compressor systems) or 1-2-3 (three compressor systems) in a wrap-around technique and will operate per the following rules of protocol.

1. The longest-off compressor within a system will start first.
2. The longest running compressor within a system will turn off first.

System Lead/Lag Feature

System Lead/Lag is a programmable feature available only in Discharge Air Temp Control Mode. There are 3 choices for Lead/Lag.

AUTO, MANUAL SYS 1, or MANUAL SYS 2 for refrigerant system sequencing. When automatic is selected, this helps to equalize the average run hours between both refrigerant circuits. If one optional hot gas bypass valve is installed on a two-circuited ACCU unit, the MANUAL SYS 1 must be selected. If the optional hot gas bypass valves are installed on both refrigerant circuits, the AUTO or MANUAL SYS 1 or 2 may be selected.

Shutdown and Pump-down

This is similar to that described under the suction pressure control section.

CONTROL FROM OTHER SYSTEMS

Contact the Field Support Center for help, when control schemes are beyond the basic equipment design. This group can provide excellent solutions for expanded interfacing with other manufacturers building automation systems or for unique sequencing of the air-cooled condensing and matching air handling unit combination. If temperature reset is used, it is intended for once or twice a day use and not intended for external temperature control purpose. It must be assured that any external Building Control System should not override the ACCU micro-computer safety control circuitry, which could damage the compressors.

APPLICATIONS AND DESIGN OUTSIDE THE NORM

Applications such as discharge air temperature “flat lining”; Hot Gas Reheat; Tight Humidity Control; as a minimum are not recommended split-system applications. Always contact Application Engineering support on designs specifying unique control and/or design modifications.

APPENDIX

TABLE 23 - SUCTION LINE CAPACITIES IN TONS FOR REFRIGERANT R-22

LINE SIZE	SATURATED SUCTION TEMPERATURE, °F														
	-40			-20			0			20			40		
	t = 2°F	t = 1°F	t = 0.5°F	t = 2°F	t = 1°F	t = 0.5°F	t = 2°F	t = 1°F	t = 0.5°F	t = 2°F	t = 1°F	t = 0.5°F	t = 2°F	t = 1°F	t = 0.5°F
TYPE L COPPER O.D.	p = 0.77	p = 0.39	p = 0.19	p = 1.13	p = 0.57	p = 0.29	p = 1.60	p = 0.81	p = 0.40	p = 2.18	p = 1.1	p = 0.55	p = 2.87	p = 1.45	p = 0.73
1/2	0.10	0.07	0.05	0.17	0.12	0.08	0.27	0.18	0.12	0.40	0.27	0.19	0.58	0.40	0.27
5/8	0.19	0.13	0.09	0.32	0.22	0.15	0.50	0.34	0.23	0.75	0.52	0.35	1.10	0.74	0.51
3/4	0.33	0.23	0.15	0.55	0.38	0.26	0.86	0.59	0.40	1.30	0.88	0.60	1.80	1.30	0.87
7/8	0.52	0.35	0.24	0.85	0.58	0.40	1.30	0.91	0.62	2.00	1.40	0.93	2.90	2.00	1.30
1-1/8	1.10	0.72	0.49	1.70	1.20	0.80	2.70	1.90	1.30	4.00	2.80	1.90	5.80	4.00	2.70
1-3/8	1.80	1.30	0.90	3.00	2.10	1.40	4.70	3.20	2.20	7.00	4.80	3.30	10.00	6.90	4.80
1-5/8	2.90	2.00	1.40	4.80	3.30	2.30	7.40	5.10	3.50	11.10	7.60	5.30	15.90	11.00	7.60
2-1/8	6.10	4.20	2.90	10.00	6.90	4.70	15.40	10.70	7.30	22.90	15.90	10.90	32.80	22.80	15.70
2-5/8	10.80	7.50	5.10	17.70	12.20	8.40	27.30	18.90	13.00	40.50	28.10	19.40	58.00	40.30	27.80
3-1/8	17.30	12.00	8.20	28.20	19.50	13.40	43.60	30.20	20.80	64.60	44.80	31.00	92.30	64.20	44.40
3-5/8	25.80	17.80	12.30	42.00	29.10	20.00	64.80	44.90	31.00	96.00	66.70	46.10	137.00	95.40	66.10
4-1/8	36.50	25.20	17.40	59.30	41.10	28.30	91.40	63.40	43.80	135.20	94.00	65.10	193.00	134.40	93.20
5-1/8	65.30	45.20	31.20	106.10	73.60	50.80	163.30	113.50	78.50	241.50	168.10	116.50	344.40	240.20	166.70
6-1/8	105.20	72.93	50.30	170.70	118.50	81.90	262.50	182.60	126.40	387.90	270.30	187.50	552.70	385.80	268.1

NOTES:

Capacities are in tons of refrigeration.

Dp = pressure drop due to line friction, psi per 100 feet equivalent length.

Dt = change in saturation temperature corresponding to pressure drop, °F per 100 feet.

TABLE 24 - DISCHARGE AND LIQUID LINE CAPACITIES IN TONS FOR REFRIGERANT R-22

LINE SIZE	DISCHARGE LINES (delta t = 1°F, delta p = 3.03 PSI)					LINE SIZE	LIQUID LINES	
TYPE L COPPER, O.D.	SATURATED SUCTION TEMPERATURE, °F					TYPE L COPPER, O.D.	VEL. = 100 FPM	Δt = 1°F Δp = 3.03
	-40	-20	0	20	40			
1/2	0.8	0.8	0.8	0.8	0.9	1/2	2.4	3.7
5/8	1.4	1.5	1.5	1.6	1.6	5/8	3.8	7.0
3/4	2.4	2.5	2.6	2.6	2.7	3/4	5.7	12.0
7/8	3.7	3.8	4.0	4.1	4.2	7/8	8.0	18.6
1-1/8	7.5	7.8	8.0	8.3	8.5	1-1/8	13.6	37.8
1-3/8	13.1	13.5	14.0	14.4	14.8	1-3/8	20.7	66.1
1-5/8	20.6	21.4	22.1	22.8	23.4	1-5/8	29.3	104.7
2-1/8	42.7	44.2	45.7	47.1	48.4	2-1/8	51.0	217.5
2-5/8	75.3	78.0	80.6	83.1	85.3	2-5/8	78.7	385.0
3-1/8	119.9	124.3	128.4	132.3	135.9	3-1/8	112.3	615.0
3-5/8	177.9	184.4	190.6	196.3	201.6	3-5/8	151.8	914.6
4-1/8	250.6	259.7	268.4	276.5	283.9	4-1/8	197.4	1291.0
5-1/8	447.0	463.3	478.7	493.2	506.4	5-1/8	307.6	—
6-1/8	717.1	743.2	768.0	791.2	812.5	6-1/8	442.2	—

1. Table capacities are in tons of refrigeration.

Δp = Pressure drop due to line friction, psi per 100 feet equivalent length.

Δt = Change in saturation temperature corresponding to pressure drop, °F per 100 feet.

2. Line capacity for other saturation temperatures Δt and equivalent lengths.

$$\text{Line capacity} = \text{Table capacity} \times \left(\frac{\text{Table } L_e}{\text{Actual } L_e} \right) \times \left(\frac{\text{Actual } \Delta t}{\text{Table } \Delta t} \right)^{0.55}$$

3. Saturation temperature Δt for other capacities and equivalent lengths L_e Δt

$$= \text{Table } \Delta t \left(\frac{\text{Actual } L_e}{\text{Table } L_e} \right) \times \left(\frac{\text{Actual Capacity}}{\text{Table Capacity}} \right)^{1.8}$$

The refrigerant cycle for determining capacity is based on saturated gas leaving the evaporator and no subcooling in the condenser. Discharge superheat is 105°F. The saturated suction temperature is 40°F for liquid line sizing.

Multiply table capacities by the following factors for condensing temperatures other than 105°F.

CONDENSING TEMPERATURE, °F	SUCTION LINE	DISCHARGE LINE
80	1.12	0.82
90	1.07	0.89
100	1.03	0.96
110	0.97	1.03
120	0.92	1.10
130	0.87	1.16
140	0.82	1.22

TABLE 25 - SUCTION LINE CAPACITIES IN TONS FOR REFRIGERANT R-407C

LINE SIZE	SATURATED SUCTION TEMPERATURE, °F														
	-40			-20			0			20			40		
	t = 2°F	t = 1°F	t = 0.5°F	t = 2°F	t = 1°F	t = 0.5°F	t = 2°F	t = 1°F	t = 0.5°F	t = 2°F	t = 1°F	t = 0.5°F	t = 2°F	t = 1°F	t = 0.5°F
TYPE L COPPER, O.D.	p = 0.69	p = 0.35	p = 0.18	p = 1.04	p = 0.53	p = 0.26	p = 1.50	p = 0.76	p = 0.38	p = 2.08	p = 1.05	p = 0.53	p = 2.81	p = 1.41	p = 0.71
1/2	0.1	0.1	0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.4	0.2	0.2	0.5	0.4	0.3
5/8	0.2	0.1	0.1	0.3	0.2	0.1	0.4	0.3	0.2	0.7	0.5	0.3	1.0	0.7	0.5
3/4	0.3	0.2	0.1	0.4	0.3	0.2	0.7	0.5	0.3	1.1	0.8	0.5	3.7	1.2	0.8
7/8	0.4	0.3	0.2	0.7	0.5	0.3	1.1	0.8	0.5	1.7	1.2	0.8	2.6	1.8	1.2
1-1/8	0.8	0.6	0.4	1.4	1.0	0.6	5.3	1.6	1.1	3.5	2.4	1.7	5.3	3.6	2.5
1-3/8	1.4	1.0	0.7	2.4	1.7	1.1	4.0	2.7	1.9	6.1	4.2	2.9	9.2	6.3	4.4
1-5/8	2.2	1.5	1.0	3.9	2.7	1.8	6.3	4.3	3.0	9.7	6.7	4.6	14.5	10.0	6.9
2-1/8	4.6	3.2	2.2	8.0	5.5	3.8	13.0	9.0	6.2	20.1	13.9	9.6	29.9	20.8	14.3
2-5/8	8.2	5.7	3.9	14.2	9.8	6.7	23.0	15.9	11.0	35.6	24.6	17.0	52.8	36.7	25.4
3-1/8	13.2	9.1	6.2	22.7	15.7	10.8	36.8	25.5	17.5	56.7	39.4	27.2	84.2	58.5	40.5
3-5/8	19.6	13.6	9.3	33.8	23.4	16.1	54.6	37.9	26.1	84.2	58.5	40.5	124.9	87.0	60.2
4-1/8	27.7	19.2	13.2	47.7	33.0	22.7	77.1	53.5	36.9	118.7	82.5	57.1	176.0	122.6	85.0
5-1/8	49.7	34.4	23.7	85.3	59.2	40.8	37.8	95.7	66.2	212.1	147.6	102.3	314.1	219.0	152.0
6-1/8	80.1	55.5	38.3	137.3	95.3	65.8	221.5	154.1	106.6	340.6	237.3	164.6	504.0	351.8	244.5

NOTES:

Capacities are in tons of refrigeration.

Dp = pressure drop due to line friction, psi per 100 feet equivalent length.

Dt = change in saturation temperature corresponding to pressure drop, °F per 100 feet.

TABLE 26 - DISCHARGE AND LIQUID LINE CAPACITIES IN TONS FOR REFRIGERANT R-407C

LINE SIZE	DISCHARGE LINES (delta t = 1°F, delta p = 3.28 PSI)					LINE SIZE	LIQUID LINES	
TYPE L COPPER, O.D.	SATURATED SUCTION TEMPERATURE, °F					TYPE L COPPER, O.D.	VEL. = 100 FPM	Δt = 1°F Δp = 3.5
	-40	-20	0	20	40			
1/2	0.71	0.75	0.78	0.82	0.86	1/2	2.20	4.00
5/8	1.30	1.40	1.50	1.50	1.60	5/8	3.60	7.50
3/4	2.30	2.40	2.50	2.60	2.70	3/4	5.40	12.90
7/8	3.50	3.70	3.90	4.00	4.20	7/8	7.50	19.90
1-1/8	7.00	7.40	7.80	8.20	8.50	1-1/8	12.70	40.30
1-3/8	12.30	12.90	13.60	14.30	14.90	1-3/8	19.40	70.30
1-5/8	19.30	20.40	21.50	22.50	23.50	1-5/8	27.50	111.20
2-1/8	40.00	42.20	44.40	46.50	48.60	2-1/8	47.80	230.50
2-5/8	70.50	74.50	78.30	82.10	85.60	2-5/8	73.70	407.30
3-1/8	112.30	118.60	124.80	130.70	136.40	3-1/8	105.20	649.60
3-5/8	166.60	176.00	185.10	193.90	202.30	3-5/8	142.30	965.00
4-1/8	234.70	247.80	260.70	273.10	284.90	4-1/8	185.00	1360.00
5-1/8	418.50	441.90	464.90	487.00	508.10	5-1/8	288.30	—
6-1/8	671.30	708.90	745.70	781.20	815.00	6-1/8	414.40	—

1. Table capacities are in tons of refrigeration.

Δp = Pressure drop due to line friction, psi per 100 feet equivalent length.

Δt = Change in saturation temperature corresponding to pressure drop,
°F per 100 feet.

2. Line capacity for other saturation temperatures Δt and equivalent lengths.

$$\text{Line capacity} = \text{Table capacity} \times \left(\frac{\text{Table } L_e}{\text{Actual } L_e} \right) \times \left(\frac{\text{Actual } \Delta t}{\text{Table } \Delta t} \right)^{0.55}$$

3. Saturation temperature Δt for other capacities and equivalent lengths L_e Δt

$$= \text{Table } \Delta t \left(\frac{\text{Actual } L_e}{\text{Table } L_e} \right) \times \left(\frac{\text{Actual Capacity}}{\text{Table Capacity}} \right)^{1.8}$$

The refrigerant cycle for determining capacity is based on saturated gas leaving the evaporator and no subcooling in the condenser. Discharge superheat is 105°F. The saturated suction temperature is 40°F for liquid line sizing.

Multiply table capacities by the following factors for condensing temperatures other than 105°F.

CONDENSING TEMPERATURE, °F	SUCTION LINE	DISCHARGE LINE
80	1.16	0.81
90	1.09	0.89
100	1.03	0.96
110	0.97	1.03
120	0.90	1.10
130	0.83	1.16
140	0.76	1.19

TABLE 27 - SUCTION LINE CAPACITIES IN TONS FOR REFRIGERANT R-410A

LINE SIZE	SATURATED SUCTION TEMPERATURE, °F											
	-60		-40		-20		0		20		40	
	t = 1°F	t = 0.5°F	t = 1°F	t = 0.5°F	t = 1°F	t = 0.5°F	t = 1°F	t = 0.5°F	t = 1°F	t = 0.5°F	t = 1°F	t = 0.5°F
TYPE L COPPER, O.D.	p = 0.42	p = 0.21	p = 0.635	p = 0.318	p = 0.925	p = 0.463	p = 1.285	p = 0.643	p = 1.73	p = 0.865	p = 2.25	p = 1.125
1/2	0.06	0.04	0.11	0.08	0.18	0.13	0.29	0.20	0.43	0.29	0.61	0.42
5/8	0.12	0.08	0.21	0.14	0.35	0.24	0.54	0.37	0.80	0.55	1.15	0.79
3/4	0.21	0.14	0.36	0.25	0.60	0.41	0.92	0.63	1.37	0.94	1.96	1.34
7/8	0.33	0.22	0.57	0.38	0.92	0.63	1.43	0.98	2.12	1.45	3.02	2.08
1-1/8	0.67	0.46	1.15	0.79	1.88	1.28	2.90	1.99	4.29	2.95	6.12	4.22
1-3/8	1.18	0.80	2.02	1.38	3.28	2.25	5.06	3.47	7.49	5.15	10.65	7.34
1-5/8	1.87	1.27	3.20	2.19	5.20	3.56	8.00	5.50	11.84	8.16	16.82	11.62
2-1/8	3.90	2.66	6.66	4.57	10.80	7.42	16.60	11.43	24.53	16.94	34.82	24.06
2-5/8	6.92	4.74	11.81	8.11	19.15	13.16	29.37	20.24	43.30	29.96	61.42	42.54
3-1/8	11.10	7.59	18.88	12.98	30.56	21.03	46.84	32.36	69.12	47.78	97.93	67.88
3-5/8	16.54	11.32	28.12	19.33	45.48	31.32	69.66	48.14	102.68	71.03	145.29	100.82
4-1/8	23.37	16.04	39.75	27.34	64.13	44.26	98.29	67.89	144.70	100.22	204.80	142.08
5-1/8	41.90	28.80	71.16	49.04	114.79	79.27	175.44	121.50	257.95	179.21	365.02	253.76
6-1/8	67.56	46.54	114.71	79.08	184.50	127.75	282.30	195.66	414.50	287.76	586.12	407.59

NOTES:

Capacities are in tons of refrigeration.

Dp = pressure drop due to line friction, psi per 100 feet equivalent length.

Dt = change in saturation temperature corresponding to pressure drop, °F per 100 feet.

TABLE 28 - DISCHARGE AND LIQUID LINE CAPACITIES IN TONS FOR REFRIGERANT R-410A

LINE SIZE	DISCHARGE LINES (delta t = 1°F, delta p = 4.75 PSI)						LINE SIZE	LIQUID LINES		
TYPE L COPPER, O.D.	SATURATED SUCTION TEMPERATURE, °F delta p = 4.75						TYPE L COPPER, O.D.	VEL. = 100 FPM	Δt = 1°F Δp = 4.75	Δt = 5°F Δp = 23.3
	-60	-40	-20	0	20	40				
1/2	1.13	1.17	1.22	1.26	1.30	1.33	0.50	2.00	4.60	10.81
5/8	2.11	2.20	2.29	2.36	2.43	2.49	0.63	3.20	8.60	20.24
3/4	3.59	3.74	3.88	4.02	4.14	4.23	0.75	4.70	14.30	33.53
7/8	5.53	5.76	5.99	6.19	6.38	6.52	0.88	6.70	22.60	52.92
1-1/8	11.16	11.64	12.09	12.50	12.88	13.17	1-1/8	11.40	45.80	106.59
1-3/8	19.39	20.21	21.00	21.72	22.37	22.88	1-3/8	17.40	79.70	185.04
1-5/8	30.63	31.92	33.16	34.30	35.33	36.14	1-5/8	24.60	125.90	291.48
2-1/8	63.20	65.88	68.44	70.78	72.90	74.57	2-1/8	42.80	260.70	601.13
2-5/8	111.20	115.90	120.41	124.53	128.25	131.20	2-5/8	66.00	459.70	1056.39
3-1/8	177.12	184.62	191.80	198.36	204.29	208.98	3-1/8	94.20	733.00	1680.52
3-5/8	262.44	273.54	284.19	293.90	302.70	309.64	3-5/8	127.40	1087.50	2491.00
4-1/8	369.45	385.08	400.07	413.75	426.13	435.90	4-1/8	165.70	1530.20	3500.91
5-1/8	658.32	686.18	712.88	737.26	759.31	776.72	5-1/8	258.20	2729.80	6228.40
6-1/8	1054.47	1099.10	1141.87	1180.91	1216.24	1244.13	6-1/8	371.10	4383.70	9980.43

1. Table capacities are in tons of refrigeration.

Δp = Pressure drop due to line friction, psi per 100 feet equivalent length.

Δt = Change in saturation temperature corresponding to pressure drop,
°F per 100 feet.

2. Line capacity for other saturation temperatures Δt and equivalent lengths.

$$\text{Line capacity} = \text{Table capacity} \times \left(\frac{\text{Table } L_e}{\text{Actual } L_e} \right) \times \left(\frac{\text{Actual } \Delta t}{\text{Table } \Delta t} \right)^{0.55}$$

3. Saturation temperature Δt for other capacities and equivalent lengths L_e Δt

$$= \text{Table } \Delta t \left(\frac{\text{Actual } L_e}{\text{Table } L_e} \right)^{1.8} \times \left(\frac{\text{Actual Capacity}}{\text{Table Capacity}} \right)$$

The refrigerant cycle for determining capacity is based on saturated gas leaving the evaporator and no subcooling in the condenser. Discharge superheat is 105°F. The saturated suction temperature is 40°F for liquid line sizing.

Multiply table capacities by the following factors for condensing temperatures other than 105°F.

CONDENSING TEMPERATURE, °F	SUCTION LINE	DISCHARGE LINE
80	1.16	0.81
90	1.09	0.89
100	1.03	0.96
110	0.97	1.03
120	0.90	1.10
130	0.83	1.16
140	0.76	1.19

**TABLE 29 - MINIMUM REFRIGERATION CAPACITY IN TONS FOR OIL ENTRAINMENT UP SUCTION RISERS
(TYPE L COPPER TUBING)**

REFRIGERANT	SATURATION SUCTION TEMP., °F	SUCTION GAS TEMP., °F	PIPE O.D., IN.											
			1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8	3-1/8	3-5/8	4-1/8
			AREA, IN ²											
			0.233	0.348	0.484	0.825	1.256	1.780	3.094	4.770	6.812	9.213	11.97	
R-22	-40	-30	0.07	0.12	0.20	0.30	0.59	0.99	1.53	3.05	5.25	8.19	11.95	16.57
		-10	0.07	0.12	0.20	0.30	0.58	0.97	1.51	3.00	5.16	8.06	11.75	16.30
		10	0.07	0.12	0.20	0.30	0.58	0.98	1.52	3.02	5.19	8.11	11.82	16.40
	-20	-10	0.09	0.16	0.26	0.39	0.76	1.28	1.97	3.94	6.77	10.57	15.41	21.38
		10	0.09	0.15	0.25	0.38	0.74	1.26	1.95	3.89	6.68	10.42	15.20	21.09
		30	0.09	0.15	0.26	0.39	0.75	1.27	1.96	3.92	6.73	10.51	15.33	21.26
	0	10	0.11	0.20	0.33	0.49	0.96	1.63	2.52	5.03	8.63	13.48	19.65	27.26
		30	0.11	0.19	0.32	0.49	0.94	1.60	2.47	4.93	8.47	13.22	19.29	26.75
		50	0.11	0.20	0.32	0.49	0.95	1.61	2.49	4.97	8.54	13.33	19.44	26.96
	20	30	0.14	0.25	0.41	0.62	1.20	2.03	3.15	6.28	10.78	16.84	24.56	34.06
		50	0.14	0.24	0.40	0.61	1.19	2.01	3.11	6.21	10.66	16.65	24.28	33.68
		70	0.14	0.24	0.40	0.61	1.19	2.01	3.11	6.20	10.65	16.63	24.25	33.64
	40	50	0.17	0.30	0.50	0.76	1.48	2.49	3.86	7.70	13.22	20.64	30.11	41.76
		70	0.17	0.30	0.49	0.74	1.45	2.45	3.78	7.55	12.96	20.24	29.52	40.94
		90	0.17	0.30	0.49	0.74	1.45	2.45	3.78	7.55	12.97	20.26	29.54	40.98
R-407C	-40	-30	0.06	0.10	0.17	0.25	0.49	0.84	1.29	2.58	4.44	6.92	10.10	14.01
		-10	0.06	0.10	0.17	0.26	0.51	0.86	1.33	2.65	4.55	7.10	10.35	14.36
		10	0.06	0.11	0.18	0.27	0.52	0.88	1.37	2.73	4.69	7.32	10.67	14.81
	-20	-10	0.08	0.14	0.23	0.34	0.67	1.13	1.75	3.49	6.00	9.36	13.65	18.93
		10	0.08	0.14	0.23	0.35	0.68	1.15	1.78	3.56	6.11	9.54	13.92	19.30
		30	0.08	0.14	0.24	0.36	0.70	1.18	1.83	3.65	6.28	9.80	14.29	19.82
	0	10	0.10	0.18	0.29	0.45	0.87	1.47	2.27	4.53	7.78	12.14	17.71	24.56
		0	0.10	0.18	0.30	0.46	0.89	1.51	2.33	4.65	7.98	12.46	18.17	25.20
		50	0.10	0.19	0.31	0.47	0.91	1.54	2.38	4.76	8.17	12.76	18.61	25.82
	20	30	0.13	0.23	0.38	0.58	1.12	1.90	2.94	5.86	10.06	15.71	22.92	31.79
		50	0.13	0.23	0.39	0.59	1.14	1.93	2.98	5.95	10.22	15.95	23.27	32.28
		70	0.13	0.24	0.39	0.60	1.16	1.96	3.03	6.05	10.40	16.24	23.68	32.85
	40	50	0.16	0.29	0.47	0.71	1.39	2.35	3.64	7.26	12.47	19.46	28.39	39.38
		70	0.16	0.29	0.48	0.73	1.41	2.39	3.70	7.38	12.68	19.79	28.87	40.05
		90	0.17	0.30	0.49	0.74	1.44	2.44	3.77	7.52	12.92	20.17	29.42	40.82
R-410A	-40	-30	0.09	0.16	0.26	0.39	0.76	1.29	2.00	3.98	6.84	10.68	15.58	21.61
		-10	0.09	0.16	0.26	0.40	0.78	1.32	2.04	4.07	6.99	10.90	15.90	22.06
		10	0.09	0.16	0.27	0.41	0.79	1.34	2.08	4.15	7.12	11.12	16.22	22.50
	-20	-10	0.11	0.20	0.33	0.50	0.98	1.66	2.56	5.12	8.79	13.72	20.01	27.76
		10	0.11	0.21	0.34	0.51	1.00	1.69	2.62	5.22	8.97	14.01	20.43	28.35
		30	0.12	0.21	0.35	0.52	1.02	1.73	2.67	5.33	9.15	14.29	20.84	28.91
	0	10	0.14	0.25	0.42	0.63	1.23	2.08	3.21	6.41	11.01	17.19	25.08	34.79
		30	0.14	0.26	0.43	0.64	1.26	2.12	3.28	6.55	11.25	17.57	25.62	35.54
		50	0.15	0.26	0.44	0.66	1.28	2.17	3.35	6.68	11.48	17.92	26.14	36.25
	20	30	0.19	0.34	0.56	0.85	1.65	2.79	4.32	8.61	14.80	23.10	33.69	46.74
		50	0.19	0.35	0.57	0.87	1.69	2.85	4.41	8.81	15.13	23.62	34.45	47.78
		70	0.20	0.35	0.58	0.88	1.72	2.91	4.50	8.97	15.42	24.07	35.11	48.70
	40	50	0.21	0.37	0.61	0.93	1.81	3.06	4.73	9.44	16.22	25.32	36.93	51.22
		70	0.21	0.38	0.63	0.95	1.85	3.13	4.84	9.65	16.58	25.88	37.75	52.36
		90	0.22	0.39	0.64	0.97	1.88	3.19	4.93	9.83	16.89	26.37	38.46	53.35

Refrigeration capacity in tons is based on 90°F liquid temperature and superheat as indicated by the temperature in the table. The saturated condensing and suction conditions are referenced to the dewpoint for R-407C. For other liquid line temperatures, use correction factors to the capacity given in the table below.

REFRIGERANT	LIQUID TEMPERATURE, °F								
	50	60	70	80	100	110	120	130	140
R-22	1.16	1.12	1.08	1.04	0.96	0.91	0.87	0.82	0.78
R-407C	1.21	1.16	1.11	1.05	0.94	0.89	0.83	0.77	0.70
R-410A	1.21	1.16	1.11	1.05	0.94	0.89	0.82	0.76	0.68

TABLE 30 - MINIMUM REFRIGERATION CAPACITY IN TONS FOR OIL ENTRAINMENT UP HOT GAS RISERS (TYPE L COPPER TUBING)

REFRIGERANT	SATURATION SUCTION TEMP., °F	SUCTION GAS TEMP., °F	PIPE O.D., IN.											
			1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8	3-1/8	3-5/8	4-1/8
			AREA, IN ²											
				0.233	0.348	0.484	0.825	1.256	1.780	3.094	4.770	6.812	9.213	11.97
R-22	80	110	0.23	0.42	0.69	1.04	2.02	3.42	5.29	10.56	18.15	28.33	41.32	57.31
		140	0.22	0.39	0.65	0.98	1.91	3.23	5.00	9.98	17.15	26.77	39.04	54.15
		170	0.21	0.38	0.62	0.94	1.84	3.11	4.80	9.58	16.46	25.70	37.49	52.00
	90	120	0.24	0.43	0.71	1.07	2.09	3.53	5.46	10.90	18.72	29.22	42.62	59.12
		150	0.23	0.40	0.67	1.01	1.96	3.32	5.13	10.25	17.60	27.48	40.08	55.60
		180	0.22	0.39	0.64	0.96	1.88	3.17	4.90	9.78	16.81	26.24	38.27	53.09
	100	130	0.25	0.44	0.73	1.11	2.16	3.65	5.64	11.26	19.34	30.20	44.05	61.10
		160	0.23	0.41	0.68	1.03	2.01	3.41	5.27	10.51	18.05	28.18	41.11	57.02
		190	0.22	0.40	0.65	0.99	1.92	3.25	5.02	10.02	17.21	26.86	39.18	54.34
	110	140	0.25	0.45	0.75	1.13	2.21	3.73	5.77	11.52	19.79	30.89	45.06	62.50
		170	0.24	0.42	0.70	1.06	2.06	3.48	5.38	10.73	18.44	28.79	41.99	58.24
		200	0.22	0.40	0.66	0.99	1.93	3.27	5.06	10.09	17.33	27.06	39.46	54.74
	120	150	0.26	0.46	0.76	1.15	2.25	3.80	5.87	11.72	20.14	31.44	45.85	63.60
		180	0.24	0.43	0.70	1.06	2.07	3.50	5.41	10.81	18.56	28.98	42.27	58.63
		210	0.23	0.41	0.67	1.01	1.97	3.34	5.16	10.30	17.70	27.63	40.30	55.90
R-407C	80	110		0.42	0.69	1.05	2.04	3.46	5.34	10.66	18.32	28.60	41.72	57.87
		140	0.22	0.40	0.66	0.99	1.93	3.27	5.05	10.08	17.31	27.02	39.42	54.67
		170	0.21	0.38	0.63	0.95	1.85	3.13	4.84	9.66	16.60	25.91	37.79	52.42
	90	120	0.24	0.43	0.71	1.07	2.07	3.51	5.42	10.83	18.60	29.03	42.35	58.74
		150	0.23	0.41	0.67	1.02	1.98	3.35	5.19	10.35	17.78	27.76	40.49	56.17
		180	0.22	0.39	0.65	0.98	1.90	3.22	4.97	9.93	17.06	26.63	38.83	53.87
	100	130	0.24	0.44	0.72	1.09	2.13	3.60	5.56	11.10	19.07	29.77	43.42	60.23
		160	0.23	0.42	0.69	1.05	2.04	3.44	5.32	10.62	18.25	28.49	41.55	57.63
		190	0.22	0.40	0.66	1.00	1.94	3.28	5.07	10.12	17.39	27.15	39.60	54.93
	110	140	0.25	0.45	0.73	1.11	2.16	3.66	5.65	11.28	19.38	30.25	44.12	61.21
		170	0.24	0.42	0.70	1.06	2.06	3.49	5.39	10.76	18.49	28.86	42.10	58.39
		200	0.23	0.41	0.67	1.01	1.98	3.34	5.17	10.31	17.71	27.65	40.32	55.93
	120	150	0.25	0.45	0.75	1.13	2.20	3.71	5.74	11.45	19.68	30.72	44.80	62.15
		180	0.24	0.43	0.71	1.07	2.09	3.53	5.46	10.91	18.73	29.25	42.66	59.17
		210	0.23	0.41	0.68	1.03	2.01	3.40	5.26	10.49	18.03	28.14	41.04	56.93
R-410A	80	110	0.30	0.54	0.88	1.33	2.60	4.40	6.80	13.56	23.30	36.38	53.06	73.60
		140	0.28	0.50	0.82	1.24	2.41	4.08	6.31	12.60	21.64	33.79	49.28	68.36
		170	0.25	0.45	0.74	1.11	2.17	3.67	5.67	11.32	19.44	30.35	44.27	61.41
	90	120	0.30	0.54	0.90	1.36	2.64	4.47	6.91	13.80	23.70	37.00	53.96	74.85
		150	0.28	0.50	0.83	1.25	2.43	4.11	6.36	12.69	21.79	34.02	49.62	68.83
		180	0.25	0.45	0.75	1.13	2.21	3.73	5.77	11.52	19.79	30.89	45.05	62.49
	100	130	0.31	0.55	0.91	1.37	2.67	4.51	6.98	13.93	23.93	37.36	54.49	75.59
		160	0.27	0.48	0.80	1.20	2.34	3.96	6.13	12.23	21.01	32.79	47.83	66.35
		190	0.26	0.46	0.76	1.15	2.23	3.77	5.84	11.65	20.01	31.24	45.56	63.19
	110	140	0.31	0.55	0.91	1.37	2.67	4.52	6.99	13.95	23.96	37.41	54.56	75.69
		170	0.27	0.49	0.80	1.21	2.36	3.99	6.16	12.30	21.13	32.98	48.11	66.73
		200	0.26	0.46	0.76	1.15	2.24	3.79	5.86	11.70	20.10	31.37	45.76	63.47
	120	150	0.30	0.54	0.90	1.36	2.64	4.47	6.91	13.80	23.70	37.00	53.97	74.86
		180	0.27	0.48	0.80	1.21	2.35	3.98	6.15	12.28	21.09	32.92	48.02	66.61
		210	0.26	0.46	0.76	1.15	2.23	3.78	5.84	11.66	20.03	31.27	45.61	63.27

Refrigeration capacity in tons is based on 90°F liquid temperature and superheat as indicated by the temperature in the table. The saturated condensing and suction conditions are referenced to the dewpoint for R-407C. For other liquid line temperatures, use correction factors to the capacity given in the table below.

REFRIGERANT	LIQUID TEMPERATURE, °F			
	-40	-20	0	40
R-22	0.91	0.94	0.97	1.03
R-407C	0.88	0.92	0.96	1.04
R-410A	0.91	0.94	0.97	1.02

TABLE 31 - FITTING LOSSES IN EQUIVALENT FEET OF PIPE (SCREWED, WELDED, FLANGED AND BRAZED CONNECTIONS)

NOMINAL PIPE OR TUBE SIZE, IN.	SMOOTH BEND ELBOWS							SMOOTH BEND TEES		
	90° STD. ^a	90° LONG RADIUS ^b	90° STREET ^a	45° STD. ^a	45° STD. ^a	180° STD. ^a	FLOW THROUGH BRANCH	STRAIGHT-THROUGH FLOW		
								NO REDUCTION	REDUCED 1/4	REDUCED 1/2
3/8	1.4	0.9	2.3	0.7	1.1	2.3	2.7	0.9	1.2	1.4
1/2	1.6	1.0	2.5	0.8	1.3	2.5	3.0	1.0	1.4	1.6
3/4	2.0	1.4	3.2	0.9	1.6	3.2	4.0	1.4	1.9	2.0
1	2.6	1.7	4.1	1.3	2.1	4.1	5.0	1.7	2.2	2.6
1-1/4	3.3	2.3	5.6	1.7	3.0	5.6	7.0	2.3	3.1	3.3
1-1/2	4.0	2.6	6.3	2.1	3.4	6.3	8.0	2.6	3.7	4.0
2	5.0	3.3	8.2	2.6	4.5	8.2	10.0	3.3	4.7	5.0
2-1/2	6.0	4.1	10.0	3.2	5.2	10.0	12.0	4.1	5.6	6.0
3	7.5	5.0	12.0	4.0	6.4	12.0	15.0	5.0	7.0	7.5
3-1/2	9.0	5.9	8.2	4.7	7.3	15.0	18.0	5.9	8.0	9.0
4	10.0	6.7	10.0	5.2	8.5	17.0	21.0	6.7	9.0	10.0
5	13.0	8.2	12.0	6.5	11.0	21.0	25.0	8.2	12.0	13.0
6	16.0	10.0	15.0	7.9	13.0	25.0	30.0	10.0	14.0	16.0

TABLE 32 - SPECIAL FITTING LOSSES IN EQUIVALENT FEET OF PIPE (ASHRAE)

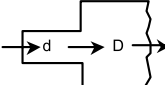
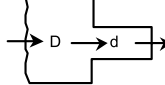
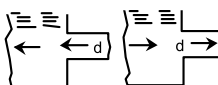
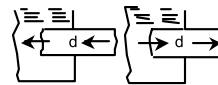
NOMINAL PIPE OR TUBE SIZE, IN.	SUDDEN ENLARGEMENT, D/D			SUDDEN CONTRACTION, D/D			SHARP EDGE		PIPE PROJECTION	
	1/4	1/2	3/4	1/4	1/2	3/4	ENTRANCE	EXIT	ENTRANCE	EXIT
										
3/8	1.4	0.8	0.3	0.7	0.5	0.3	1.5	0.8	1.5	1.1
1/2	1.8	1.1	0.4	0.9	0.7	0.4	1.8	1.0	1.8	1.5
3/4	2.5	1.5	0.5	1.2	1.0	0.5	2.8	1.4	2.8	2.2
1	3.2	2.0	0.7	1.6	1.2	0.7	3.7	1.8	3.7	2.7
1-1/4	4.7	3.0	1.0	2.3	1.8	1.0	5.3	2.6	5.3	4.2
1-1/2	5.8	3.6	1.2	2.9	2.2	1.2	6.6	3.3	6.6	5.0
2	8.0	4.8	1.6	4.0	3.0	1.6	9.0	4.4	9.0	6.8
2-1/2	10.0	6.1	2.0	5.0	3.8	2.0	12.0	5.6	12.0	8.7
3	13.0	8.0	2.6	6.5	4.9	2.6	14.0	7.2	14.0	11.0
3-1/2	15.0	9.2	3.0	7.7	6.0	3.0	17.0	8.5	17.0	13.0
4	17.0	11.0	3.8	9.0	6.8	3.8	20.0	10.0	20.0	16.0
5	24.0	15.0	5.0	12.0	9.0	5.0	27.0	14.0	27.0	20.0
6	29.0	22.0	6.0	15.0	11.0	6.0	33.0	19.0	33.0	25.0

TABLE 33 - VALVE LOSSES IN EQUIVALENT FEET OF PIPE (ASHRAE)

NOMINAL PIPE OR TUBE SIZE, IN.	GLOBE ^a	60° WYE	45° WYE	ANGLE ^a	GATE ^b	SWING CHECK ^c	LIFT CHECK
3/8	17	8	6	6	0.6	5	Globe and vertical lift same as globe valved
1/2	18	9	7	7	0.7	6	
3/4	22	11	9	9	0.9	8	
1	29	15	12	12	1.0	10	
1-1/4	38	20	15	15	1.5	14	
1-1/2	43	24	18	18	1.8	16	
2	55	30	24	24	2.3	20	
2-1/2	69	35	29	29	2.8	25	
3	84	43	35	35	3.2	30	
3-1/2	100	50	41	41	4.0	35	
4	12	58	47	47	4.5	40	Angle lift same as angle valve.
5	140	71	58	58	6.0	50	
6	170	88	70	70	7.0	60	

NOTE:

Losses are for valves in fully open position and with screwed, welded, flanged, or flared connections.

^a These losses do not apply to valves with needlepoint seats.^b Regular and short pattern plug cock valves, when fully open, have the same loss as gate valve.^c Losses also apply to the in-line, ball-type check valve.^d For Y pattern globe lift check valve with seat approximately equal to the nominal pipe diameter, use values of 60° Wye valves for loss.

TABLE 34 - REFRIGERANT CHARGE IN POUNDS PER 100 FEET OF SUCTION LINE

LINE SIZE, OD	SATURATED SUCTION TEMPERATURE, °F											
	R-22			R-134a			R-407C			R-410A		
	-40	0	40	0	20	40	-40	0	40	-40	0	40
1/2	0.03	0.07	0.15	0.05	0.07	0.11	0.02	0.06	0.14	0.05	0.11	0.23
5/8	0.05	0.12	0.25	0.08	0.12	0.17	0.04	0.10	0.22	0.07	0.17	0.36
3/4	0.07	0.18	0.37	0.11	0.17	0.26	0.06	0.15	0.33	0.11	0.25	0.53
7/8	0.10	0.24	0.51	0.16	0.24	0.36	0.08	0.21	0.46	0.15	0.35	0.74
1-1/8	0.17	0.42	0.87	0.27	0.41	0.61	0.14	0.36	0.79	0.25	0.60	1.26
1-3/8	0.26	0.64	1.33	0.41	0.62	0.92	0.21	0.55	1.20	0.38	0.92	1.92
1-5/8	0.37	0.90	1.88	0.58	0.88	1.31	0.30	0.78	1.70	0.54	1.30	2.72
2-1/8	0.65	1.57	3.27	1.00	1.54	2.27	0.53	1.35	2.95	0.95	2.25	4.74
2-5/8	1.01	2.42	5.04	1.55	2.37	3.50	0.81	2.09	4.55	1.46	3.47	7.30
3-1/8	1.44	3.45	7.19	2.21	3.38	5.00	1.16	2.98	6.50	2.08	4.96	10.42
3-5/8	1.94	4.66	9.73	2.99	4.57	6.77	1.57	4.03	8.79	2.82	6.71	14.10
4-1/8	2.52	6.06	12.65	3.88	5.94	8.79	2.04	5.24	11.42	3.66	8.72	18.32
5-1/8	3.93	9.45	19.71	6.05	9.26	13.70	3.17	8.17	17.80	5.71	13.59	28.56
6-1/8	5.65	13.58	28.34	8.69	13.31	19.70	4.56	11.74	25.59	8.20	19.53	41.05

TABLE 35 - REFRIGERANT CHARGE IN POUNDS PER 100 FEET OF DISCHARGE LINE

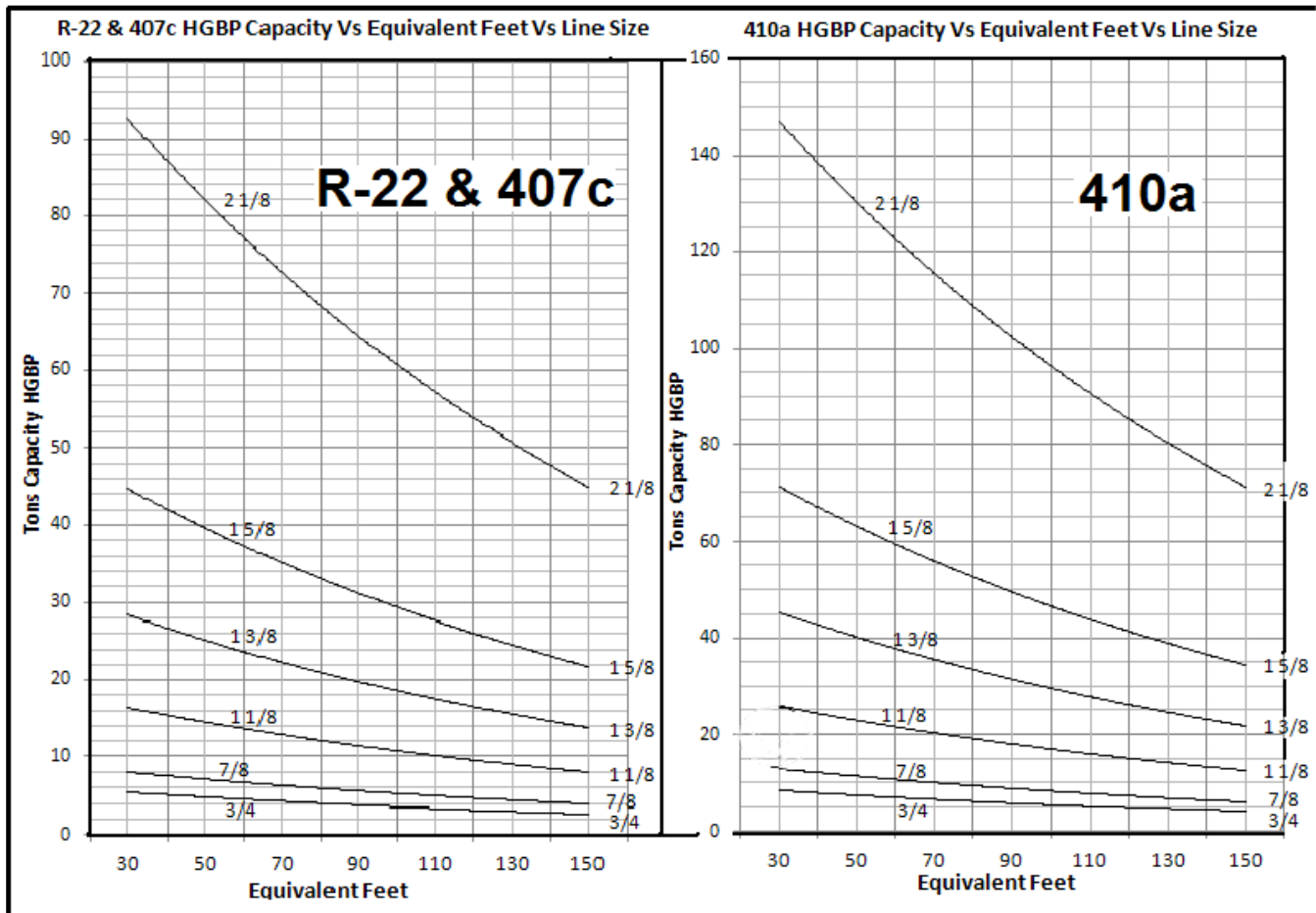
LINE SIZE, OD	SATURATED DISCHARGE TEMPERATURE, F											
	R-22			R-134A			R-407C			R-410A		
	80	110	140	80	110	140	80	110	140	80	110	140
1/2	0.22	0.33	0.48	0.17	0.27	0.40	0.21	0.33	0.50	0.37	0.56	0.85
5/8	0.35	0.53	0.77	0.27	0.43	0.65	0.34	0.53	0.80	0.58	0.89	1.35
3/4	0.53	0.79	1.15	0.41	0.64	0.97	0.50	0.78	1.19	0.86	1.34	2.02
7/8	0.73	1.10	1.60	0.57	0.89	1.34	0.70	1.09	1.65	1.20	1.85	2.81
1-1/8	1.25	1.87	2.72	0.97	1.52	2.29	1.19	1.86	2.81	2.05	3.16	4.79
1-3/8	1.90	2.85	4.14	1.48	2.31	3.49	1.81	2.83	4.28	3.12	4.82	7.29
1-5/8	2.69	4.04	5.86	2.09	3.28	4.94	2.57	4.01	6.06	4.42	6.82	10.31
2-1/8	4.67	7.02	10.20	3.63	5.70	8.59	4.47	6.97	10.55	7.68	11.86	17.94
2-5/8	7.20	10.83	15.72	5.60	8.79	13.25	6.89	10.74	16.27	11.85	18.29	27.66
3-1/8	10.28	15.45	22.45	8.00	12.54	18.92	9.83	15.34	23.22	16.91	26.10	39.48
3-5/8	13.91	20.90	30.36	10.82	16.96	25.59	13.30	20.74	31.40	22.88	35.32	53.42
4-1/8	18.08	27.17	39.46	14.06	22.05	33.26	17.29	26.96	40.82	29.72	45.89	69.41
5-1/8	28.17	42.34	61.50	21.91	34.37	51.84	26.94	42.02	63.62	46.34	71.54	108.20
6-1/8	40.50	60.87	88.41	31.50	49.40	74.52	38.73	60.41	91.46	66.60	102.82	155.52

TABLE 36 - REFRIGERANT CHARGE IN POUNDS PER 100 FEET OF LIQUID LINE

LINE SIZE, OD	SATURATED DISCHARGE TEMPERATURE, °F											
	R-22			R-134A			R-407C			R-410A		
	80	110	140	80	110	140	80	110	140	80	110	140
1/2	7.47	7.03	6.50	7.56	7.13	6.64	7.11	6.64	6.11	6.63	6.03	5.19
5/8	12.01	11.29	10.44	12.15	11.46	10.66	11.42	10.67	9.81	10.66	9.68	8.34
3/4	17.93	16.86	15.59	18.14	17.11	15.92	17.05	15.93	14.65	15.91	14.46	12.45
7/8	24.91	23.42	21.66	25.20	23.78	22.11	23.69	22.14	20.35	22.11	20.09	17.30
1-1/8	42.47	39.93	36.93	42.96	40.54	37.70	40.39	37.74	34.70	37.69	34.26	29.49
1-3/8	64.69	60.82	56.24	65.44	61.74	57.42	61.52	57.49	52.85	57.41	52.17	44.92
1-5/8	91.56	86.09	79.61	92.62	87.39	81.28	87.08	81.37	74.81	81.26	73.85	63.58
2-1/8	159.30	149.80	138.50	161.10	152.00	141.40	151.50	141.60	130.10	141.40	128.50	110.60
2-5/8	245.60	231.00	213.60	248.50	234.40	218.00	233.60	218.30	200.70	218.00	198.10	170.60
3-1/8	350.60	329.70	304.80	354.70	334.60	311.20	333.40	311.60	286.40	311.10	282.80	243.50
3-5/8	474.20	445.90	412.30	479.70	452.60	420.90	451.00	421.40	387.40	420.80	382.50	329.30
4-1/8	616.40	579.60	536.00	623.60	588.40	547.20	586.20	547.80	503.60	547.10	497.20	428.10
5-1/8	960.70	903.30	835.30	971.80	917.00	852.80	913.70	853.80	784.90	852.60	774.90	667.20
6-1/8	1381.00	1299.00	1201.00	1397.00	1318.00	1226.00	1313.00	1227.00	1128.00	1226.00	1114.00	959.10

TABLE 37 - HGBP QUICK LINE SELECTION

LINE SIZE (TYPE "L" REFRIG GRADE)	R-22 AND (R-407C) - MAX TONS, CAPACITY @ EQUIVALENT FT. (EF)		R-410A - MAX TONS, CAPACITY @ EQUIVALENT FT. (EF)	
	150 EF	50 EF	150 EF	50 EF
3/4"	2.6	4.7	4.0	7.4
7/8"	3.9	7.1	6.2	11.4
1-1/8"	7.9	14.4	12.6	23.0
1-3/8"	13.7	25.1	21.8	40.0
1-5/8"	21.7	39.6	34.5	63.1
2-1/8"	44.9	82.1	71.1	130.2

TABLE 38 - HGBP LINE SIZING FOR R-22, R-407C AND R-410A REFRIGERANTS

NOTE: When HGBP selections fall between two line sizes, always use the line size closest to the selection point.

NOTES



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Form 050.40-ES5 (212)
Issue Date: February 23, 2012
Supersedes: 050.40-ES5 (408)

800-861-1001
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