

INSTALLATION AND OPERATION

ADAPTA[®] *pak*[™]

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Due to our commitment to continuous improvement, all specifications shown in this manual are subject to change without notice.
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Thank You!

The Hillphoenix AdaptaPAK® refrigeration system provides customers with a compact refrigeration package designed to remove heat from both medium- and low-temperature loads. Such a system, as selected by the customer, is built to closely match the necessary heat removal capacity. It is a DX system with a refrigerant charge matched to the needs of the facility where it is installed. Each The fans and condensing units are sized to provide for sufficient heat rejection under the most demanding ambient conditions.

Each Unit utilizes a comprehensive controls system which monitors the refrigeration system to minimize energy and optimize performance.

The controls system allows field networking to the store's Building Management System. In addition, local networks may be installed to create coordinated case defrosts on a common schedule, similar to traditional refrigeration circuits of traditional remote systems.

Important Notices

Hillphoenix designates important information in all Hillphoenix installation and operations handbooks with alert symbols. These notices provide information about potential dangers to personal health and safety – as well as case damage – if these instructions are not carefully followed.



ATTENTION!

Indicates important information that is critical to proper system performance.



CAUTION!

Indicates the threat of potential injury if all instructions are not followed carefully.



DANGER!

Indicates an immediate threat of serious injury or death if all instructions are followed carefully.

Service Notes

To ensure optimum unit performance, we strongly recommend that Hillphoenix refrigeration units be installed and serviced by trained and qualified technicians who have experience working with commercial refrigerated systems, piping, display cases and storage cabinets. For a list of Hillphoenix-authorized installation and service contractors, visit hillphoenix.com/dealer-group.

General Information

This manual covers general installation and operational information for the Hillphoenix AdaptaPAK® refrigeration system. Hillphoenix recommends you retain a copy for future reference

Operating Environmental Conditions

The Hillphoenix AdaptaPAK® refrigeration system is designed to operate in external ambient environments. This system is housed in a pre-painted (pueblo tan), galvanized steel cabinet. An electrofin coated condenser coil is available to customers as an option.

Receiving Units

Inspect received units carefully. In the event of shipping damage and/or shortages, please contact the Hillphoenix Service parts Department at 1-844-HPX-PART (1-844-479-7278).

Unit Damage

Claims for damage must be: (1) noted on either the freight bill or the express receipt, and (2) signed by the carrier's agent. Otherwise, the carrier may refuse the claim. If damage becomes apparent after the unit has been unloaded/unpacked, retain all packing materials and submit a written request (along with photos of the damage) to the carrier for inspection within 14 days of receipt of the unit.

Missing Items

Hillphoenix refrigeration systems are inspected before shipping to ensure the highest level of quality. Any claim for missing items must be made to Hillphoenix within 48 hours of receipt of cases.

Technical Support

For technical support issues regarding this unit, contact the Hillphoenix Systems Division Technical Support at 1-770-285-3267.

Ordering Unit Parts

If you need to contact Hillphoenix regarding specific fixtures or parts, call 844-479-7278 and ask for a Service Parts

If the part you are interested in does not have a barcode affixed to it, please provide the following information:

- Model number and serial number of the unit for which the part is intended. The serial number may be found on the serial plate located on the unit.
- Length of the part, if applicable.
- Color of part (if painted) or color of polymer part.
- Whether the part is for a left-handed or a right-handed application.
- Quantity of parts
- Ship-to location.



If Hillphoenix Service Parts decides that a part must be returned instead of scrapped, you will be issued a Return Material Authorization number. Parts information also available at: <http://www.hpxparts.com/>

Section 1:

AdaptaPAK® Product Information

Hillphoenix offers the AdaptaPAK® range of parallel refrigeration systems to provide customers with an effective alternative to centralized parallel systems. The various versions of AdaptaPAK® are designed to meet a wide range of requirements.



AdaptaPAK® Features and Benefits

The Hillphoenix AdaptaPAK® parallel system works like any conventional DX refrigeration system, with the main difference being that there may be one or more individual systems required to serve the full range of refrigeration loads in a store. The arrangement is different than the installation of one, single, large centralized refrigeration system, the multiple condensers are an integral part of the unit.

It is also designed specifically to improve on the performance of low and/or medium temperature refrigeration installations in drug stores, convenience stores, and other smaller-footprint retail establishments.

An AdaptaPAK® parallel system shares suction, discharge, and an integrated condenser across several compressors. As a result, compressor capacity may be varied to match the required loads—a much more efficient design.

Multiple, single units with compressors running constantly at maximum output waste energy and reduce component life. Parallel installations, on the other hand, do just the opposite. Because compressor capacities are allowed to vary to match refrigeration loads, there is a marked savings of energy utilized—20% or more compared to single compressor unit—as well as positive benefits on the live of all system components.

There is also a savings in initial capital outlay with a parallel system. Shared suction, discharge, and an integrated condenser among compressors virtually guarantees cost savings versus the expense inherent in purchasing several, self-contained single units. Plus, the single point electrical connection along with a single roof curb and roof penetration add up to additional savings in installation costs.

Hillphoenix AdaptaPAK® parallel systems are available in a 2 fan unit, a 3 fan unit, and a 4 fan configuration. The compressors would be arranged in up to two suction groups, with one loop per suction group.



The AdaptaPAK® system will arrive fully designed for your load configuration, and ready for placement at the site in your designated pad or roof location. Placement would most commonly be performed with a cable/rope with proper rigging (refer to drawings for details). The remaining tasks would include charging with refrigerant, making electrical connections, and completing the connection of the AdaptaPAK® unit up to your refrigeration loads.

Dimensions of AdaptaPAK® Units

The 2 fan unit is 139 1/4 inches long by 50 1/2 inches wide by 51 1/4 inches high.

The 3 fan unit is 180 inches long by 50 1/2 inches wide by 51 1/4 inches high.

The 4 fan unit is 220 inches long by 50 1/2 inches wide by 51 1/4 inches high.

Clearances for AdaptaPAK® Units

Air Intake: 36 inches recommended

Air Exhaust: 36 inches recommended

Piping Clearance: 36 inches (minimum) recommended

Hinged Front Door: 36 inches (outward from door) by 50 inches (width)

NEC Electrical: 36 inches (outward from door) by 50 inches (width)

Weights of AdaptaPAK® Units (2 fan, 3 fan, and 4 fan)

Fans	Compressors	Estimated Weight
2	4	3,000 lbs
3	6	3,500 lbs
4	8	4,000 lbs

AdaptaPAK® Units' Standard Features

The following features are provided as standard equipment on AdaptaPAK® units (2 fan, 3 fan, and 4 fan):

- Pre-painted, galvanized steel cabinet (pueblo tan).
- Refrigerants available are R-407A and R-448A/R-449A
- Uncoated copper tube/aluminum fin condenser coil.
- Main power is 208V.
- Scroll compressors (only).
- Digital scroll compressor as the lead compressor per suction group
- Receiver includes analog liquid level indicator/alarm.
- Replaceable core filter/drier and sight glass.
- Fixed speed AC condenser fan motors.
- One low pressure control per suction group.
- One high pressure control per compressor.

- OMB electronic oil float per compressor.
- Through-the-door power disconnect for serviceability.
- Phase loss monitor with brownout protection.
- IEC contactors for all compressors.
- Convenient service control switches for compressors.
- Off cycle and electric defrost are available.
- Remote defrost panel (when required) will be shipped loose for field installation.
- Selection of various control systems may be installed in control panel.

Note that the AdaptaPAK® units are designed for outdoor placement, and thus are constructed with a painted steel finish for durability. Each unit has its own designated lifting points to facilitate easy lifting and site placement. Removable panels and hinged access doors provide for both equipment protection and serviceability.

In addition to the standard equipment detailed in the list above, customer-selectable options may have been included on the unit being installed. Please check the customer order or the Hillphoenix acknowledgement to determine which custom options have been provided for your specific unit. These options are detailed below.

Available AdaptaPAK® Unit Options

The following features are available as optional equipment on AdaptaPAK® units:

- Variable speed EC condenser fan motors.
- 460V main power.
- Electrofin coated condenser coil.
- Heat reclaim valve package (remote only).
- Cold Weather Package - split condenser and heated/insulated receiver
- Hail guard.
- Digital liquid level indicator/alarm.
- Low-pressure control per compressor.

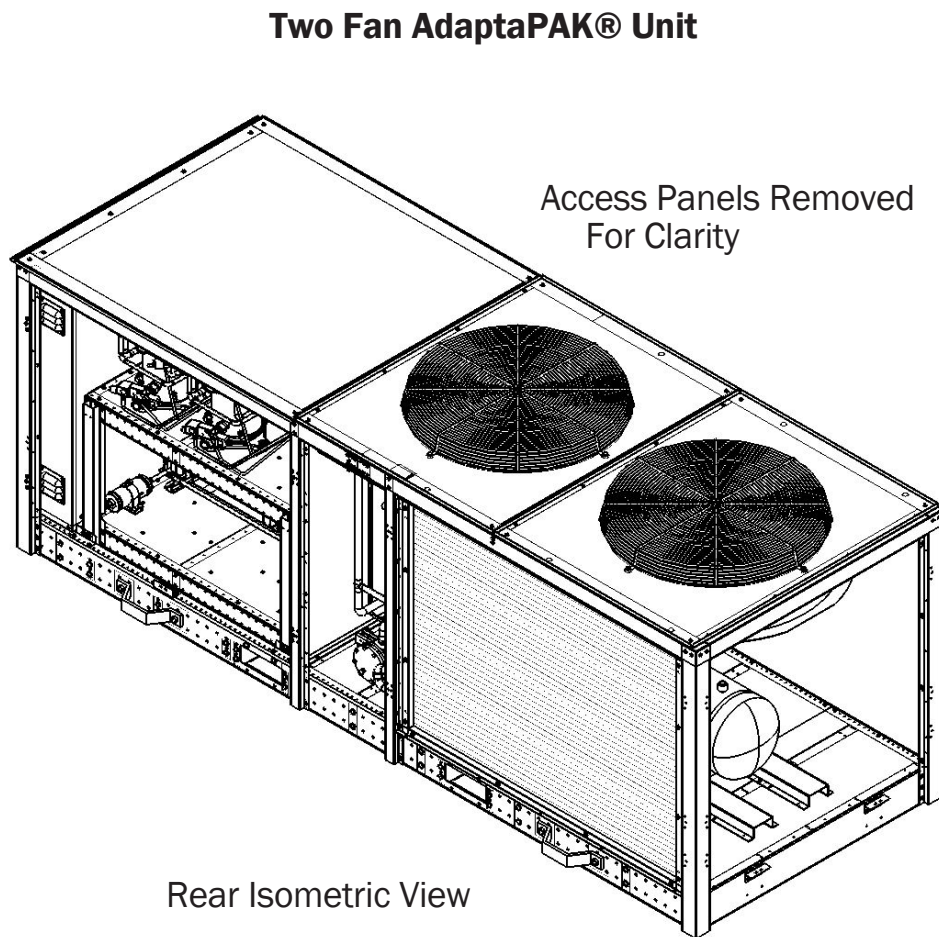
Two Fan AdaptaPAK® Unit

As noted earlier, this unit has two condenser fans and up to two condensers sized appropriately for the design-specified refrigeration heat removal loads.

The dimensions of the two fan unit, as well as the required clearances for operation and serviceability were provided earlier in this section.

Of course, the design-specified refrigeration heat removal load would be the determining the number/capacity of the compressors, the receiver size, and the details of the parallel system.

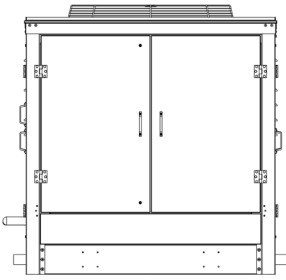
A rear, isometric view of the two fan AdaptaPAK® unit is shown below. Note that on this drawing the access panels and doors have been removed.



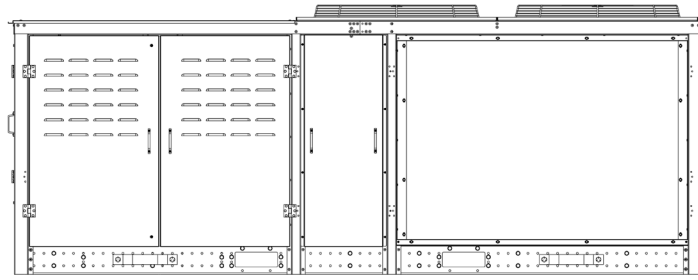
Note that the condenser coil(s) are located at the rear of the unit. The two fans on the top of the unit would draw ambient outdoor air in through the condenser coil(s) and exhaust that air through the fans on top. As noted previously, sufficient clearances are required for proper unit operation.

The layout drawing provided below shows the front view of the two fan unit, as well as the two end views.

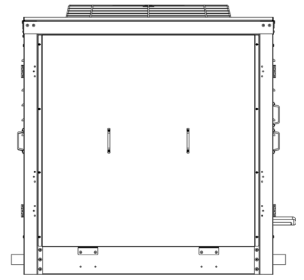
Two Fan AdaptaPAK® Unit



LEFT END VIEW



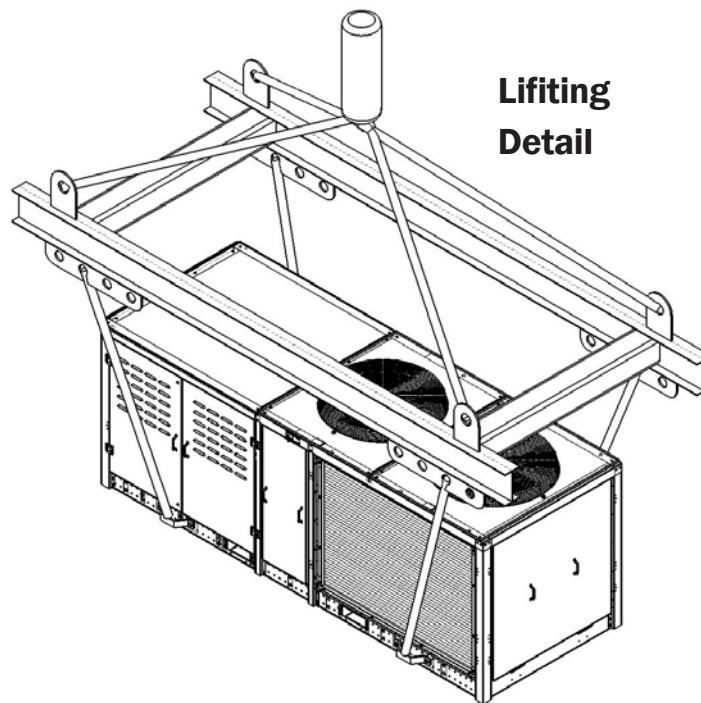
FRONT VIEW



RIGHT END VIEW

Also, as previously noted, a drawing is supplied which depicts the lifting points on the two fan AdaptaPAK® unit, and details an appropriate lifting jig and the necessary rigging for the cable/rope to perform a level lift and successful placement of this unit.

Two Fan AdaptaPAK® Unit



Lifting
Detail

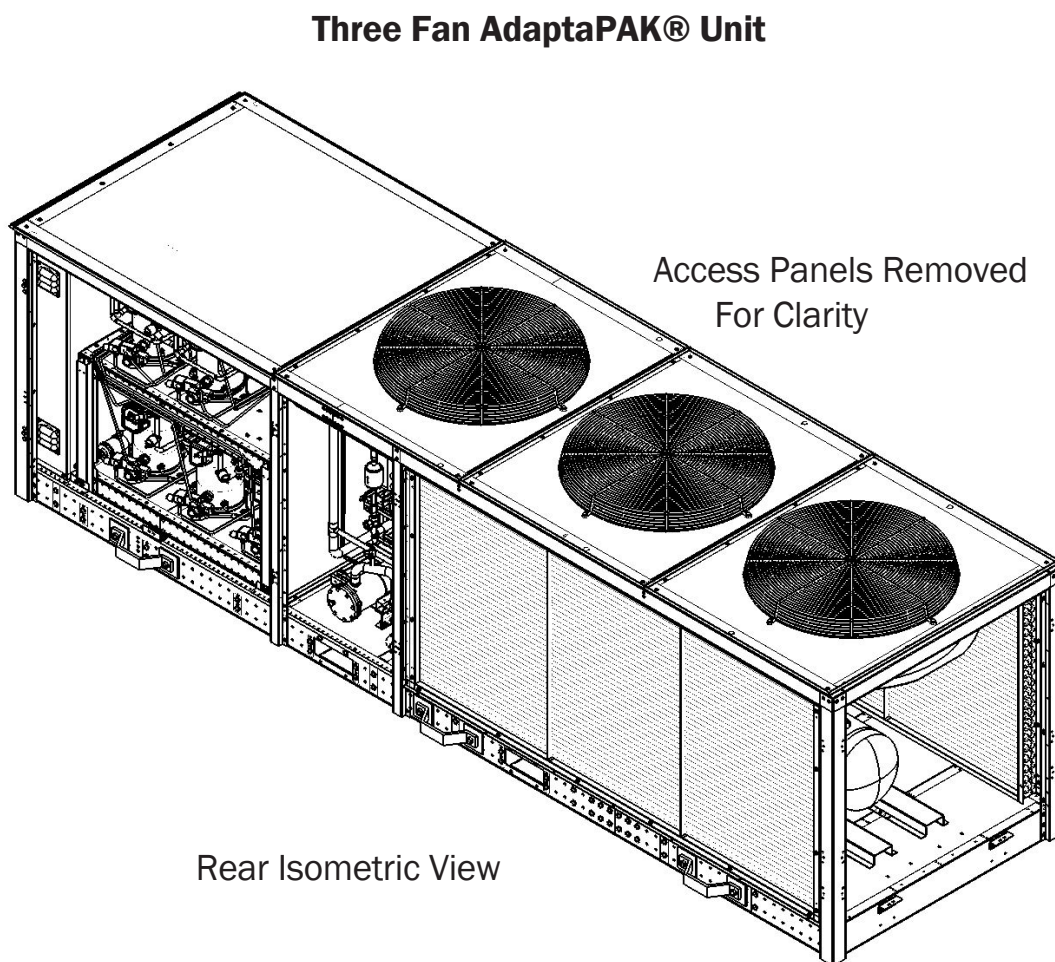
Three Fan AdaptaPAK® Unit

This unit has three condenser fans and two condensers sized appropriately for the design-specified refrigeration heat removal loads.

The dimensions of the three fan unit, as well as the required clearances for operation and serviceability were provided earlier on page two.

Of course, the design-specified refrigeration heat removal load would be used in determining the number/capacity of the compressors, the receiver size, and the details of the parallel system.

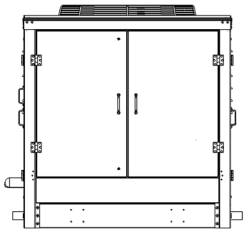
A rear, isometric view of the three fan AdaptaPAK® unit is shown below. Note that on this drawing the access panels and doors have been removed



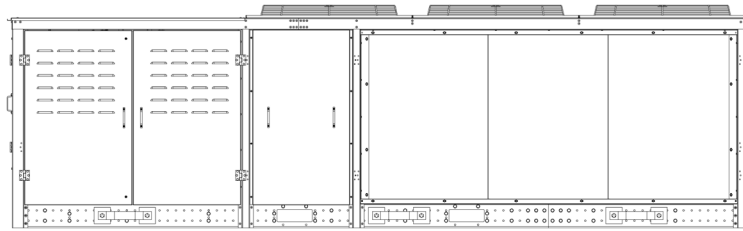
Note that the condenser coil(s) are located at the rear of the unit. The three fans on the top of the unit would draw ambient outdoor air in through the condenser coil(s) and exhaust that air through the fans on top. As noted previously, sufficient clearances are required for proper unit operation.

The layout drawing provided below shows the front view of the three fan unit, as well as the two end views.

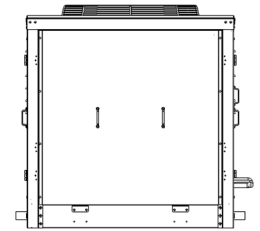
Three Fan AdaptaPAK® Unit



LEFT END VIEW



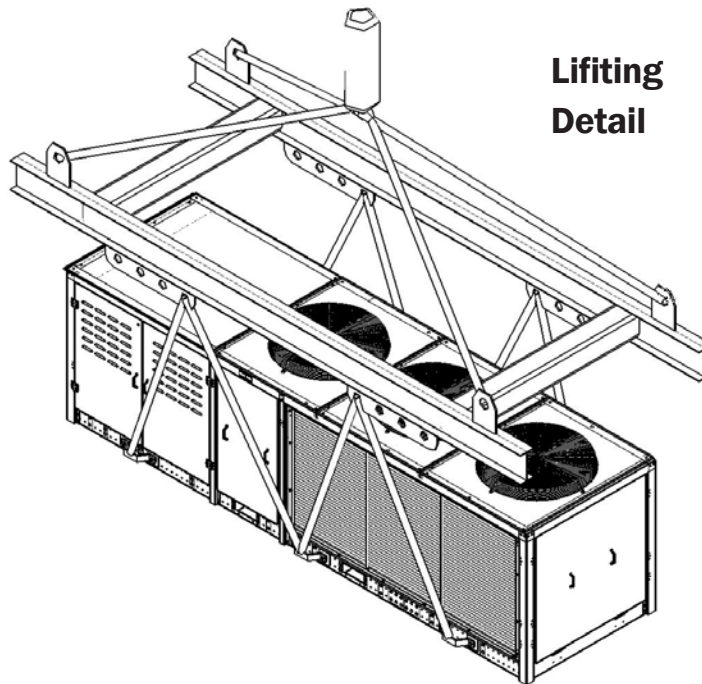
FRONT VIEW



RIGHT END VIEW

Also, as previously noted, a drawing is supplied which depicts the lifting points on the three fan AdaptaPAK® unit, and details an appropriate lifting jig and the necessary rigging for the cable/rope to perform a level lift and successful placement of this unit.

Three Fan AdaptaPAK® Unit



Lifting
Detail

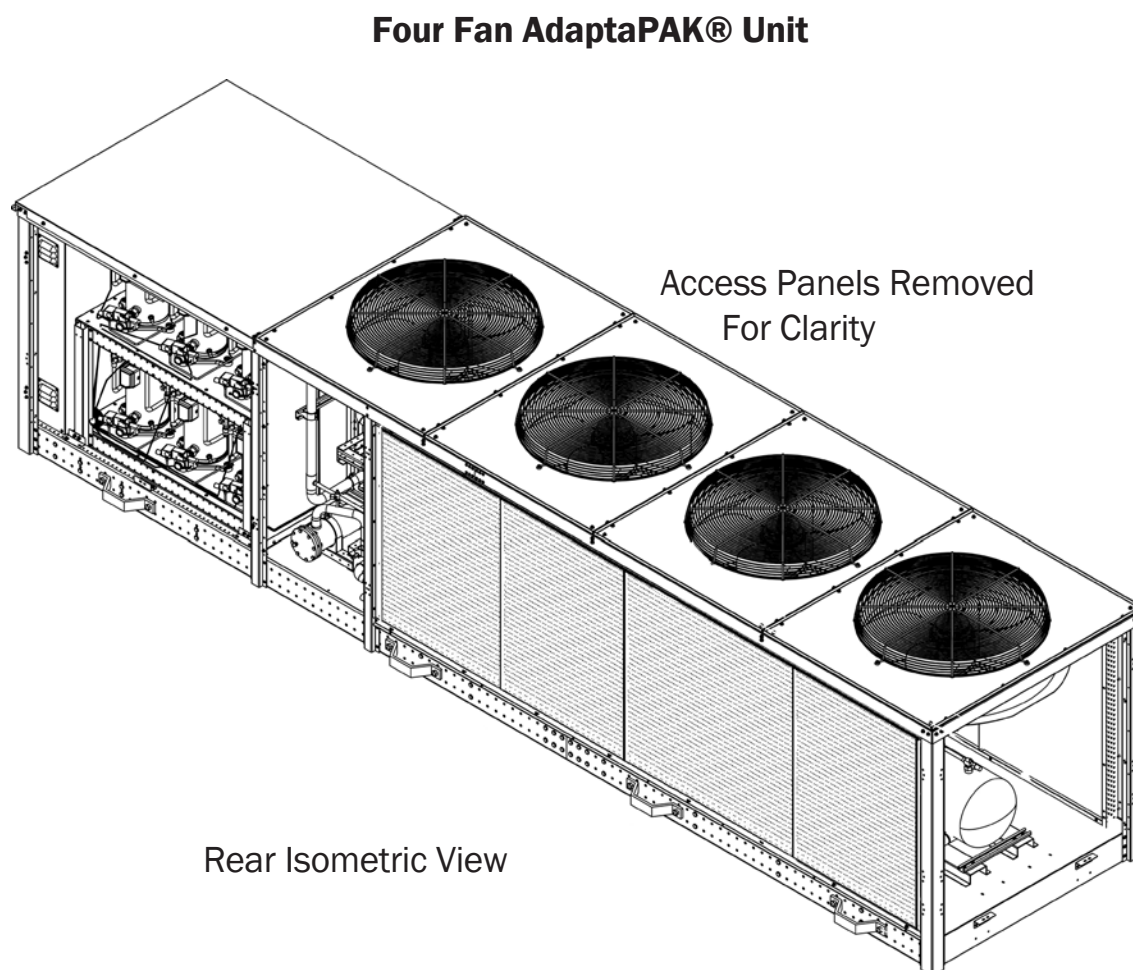
Four Fan AdaptaPAK® Unit

This unit has four condenser fans and two condensers sized appropriately for the design-specified refrigeration heat removal loads.

The dimensions of the four fan unit, as well as the required clearances for operation and serviceability were provided earlier on page two.

Of course, the design-specified refrigeration heat removal load would be used in determining the number/capacity of the compressors, the receiver size, and the details of the parallel system.

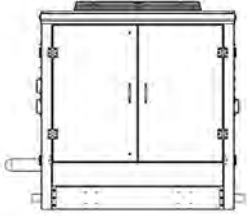
A rear, isometric view of the four fan AdaptaPAK® unit is shown below. Note that on this drawing the access panels and doors have been removed



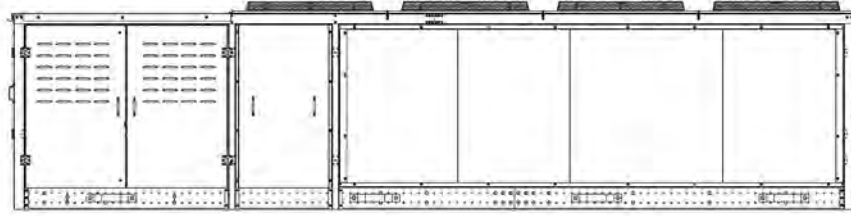
Note that the condenser coil(s) are located at the rear of the unit. The four fans on the top of the unit would draw ambient outdoor air in through the condenser coil(s) and exhaust that air through the fans on top. As noted previously, sufficient clearances are required for proper unit operation.

The layout drawing provided below shows the front view of the four fan unit, as well as the two end views.

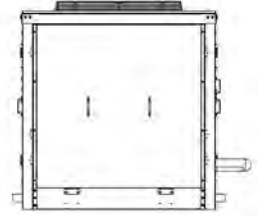
Four Fan AdaptaPAK® Unit



LEFT END VIEW



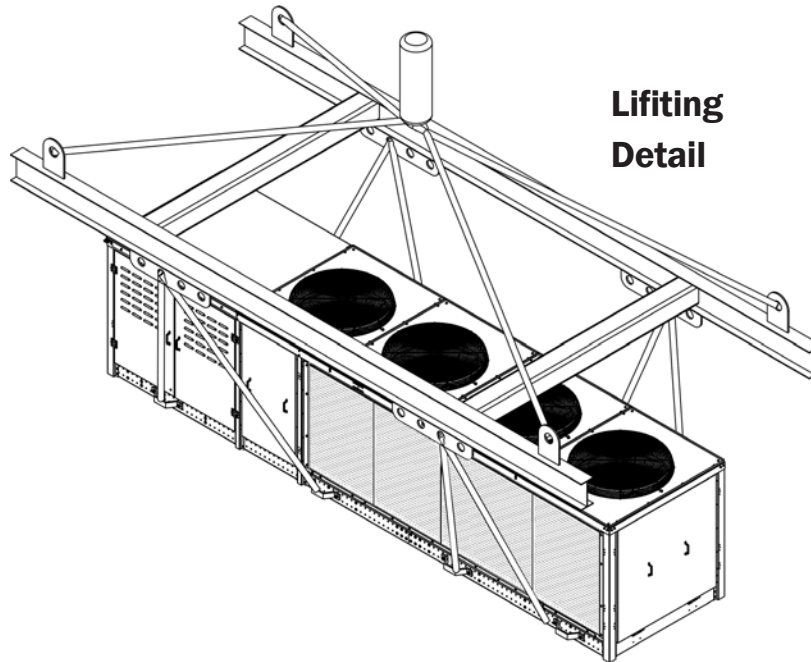
FRONT VIEW



RIGHT END VIEW

Also, as previously noted, a drawing is supplied which depicts the lifting points on the four fan AdaptaPAK® unit, and details an appropriate lifting jig and the necessary rigging for the cable/rope to perform a level lift and successful placement of this unit.

Four Fan AdaptaPAK® Unit



Lifiting
Detail

						Connections							
	Model	Number of Fans	# Coils	# Compressors	Unit Weight	LT Suction Connection	MT Suction Connection	LT Liquid Connection	MT Liquid Connection	Power Supply	MCA	MOPD	
Medium Temp Units	ADP-M0048-L0000*	2	1	2	2600		1-5/8		1-1/8	208.0	47.3	60.0	
	ADP-M0079-L0000*	2	1	2	2600		1-5/8		1-1/8	208.0	60.9	80.0	
	ADP-M0106-L0000	2	2	2	2600		1-5/8		1-1/8	208.0	85.7	110.0	
	ADP-M0152-L0000	2	2	3	2700		2-1/8		1-1/8	208.0	108.2	125.0	
	ADP-M0178-L0000	2	2	3	2700		2-1/8		1-1/8	208.0	134.2	150.0	
	ADP-M0198-L0000	2	2	4	2800		2-1/8		1-1/8	208.0	130.7	150.0	
	ADP-M0253-L0000	3	2	6	3400		2-1/8		1-1/8	208.0	185.5	200.0	
	ADP-M0299-L0000	3	2	6	3500		2-1/8		1-1/8	208.0	208.0	225.0	
	ADP-M0349-L0000	3	2	6	3200		3-1/8		1-1/8	208.0	194.0	225.0	
	ADP-M0403-L0000	4	2	6	4000		3-1/8		1-1/8	208.0	232.0	250.0	
Low Temp Units	ADP-M0442-L0000	4	2	6	4000		3-1/8		1-1/8	208.0	240.0	250.0	
	ADP-M0000-L0032*	2	1	2	2600	1-5/8		7/8		208.0	62.2	80.0	
	ADP-M0000-L0052*	2	1	2	2600	1-5/8		7/8		208.0	81.8	110.0	
	ADP-M0000-L0076*	2	1	3	2700	2-1/8		7/8		208.0	105.7	125.0	
	ADP-M0000-L0099	2	2	4	2800	2-1/8		7/8		208.0	129.6	150.0	
	ADP-M0000-L0122	2	2	5	2950	2-1/8		7/8		208.0	153.5	175.0	
	ADP-M0000-L0145	2	2	6	3100	2-1/8		7/8		208.0	177.4	200.0	
	ADP-M0000-L0161	3	2	6	3200	3-1/8		7/8		208.0	187.0	200.0	
	ADP-M0000-L0190	3	2	6	3250	3-1/8		7/8		208.0	213.0	225.0	
	ADP-M0048-L0012*^	2	1	4	2800	7/8	1-5/8	1/2	1-1/8	208.0	64.3	80.0	
Dual Temp Units	ADP-M0079-L0012*^	2	1	4	2800	7/8	1-5/8	1/2	1-1/8	208.0	77.9	100.0	
	ADP-M0106-L0012^	2	2	4	2800	7/8	1-5/8	1/2	1-1/8	208.0	97.9	125.0	
	ADP-M0152-L0012^	2	2	5	2950	7/8	2-1/8	1/2	1-1/8	208.0	120.2	150.0	
	ADP-M0178-L0012^	2	2	5	2950	7/8	2-1/8	1/2	1-1/8	208.0	146.2	175.0	
	ADP-M0048-L0032*	2	1	4	2800	1-5/8	1-5/8	7/8	1-1/8	208.0	86.8	100.0	
	ADP-M0079-L0032	2	2	4	2800	1-5/8	1-5/8	7/8	1-1/8	208.0	100.4	110.0	
	ADP-M0106-L0032	2	2	4	2800	1-5/8	1-5/8	7/8	1-1/8	208.0	120.2	150.0	
	ADP-M0152-L0032	2	2	4	2950	1-5/8	2-1/8	7/8	1-1/8	208.0	142.7	175.0	
	ADP-M0048-L0052	2	2	4	2800	1-5/8	1-5/8	7/8	1-1/8	208.0	106.4	125.0	
	ADP-M0079-L0052	2	2	4	2800	1-5/8	1-5/8	7/8	1-1/8	208.0	120.0	150.0	
	ADP-M0106-L0052	2	2	4	2800	1-5/8	1-5/8	7/8	1-1/8	208.0	139.8	175.0	
	ADP-M0048-L0076	2	2	5	2950	2-1/8	1-5/8	7/8	1-1/8	208.0	130.3	150.0	
	ADP-M0079-L0076	2	2	5	2950	2-1/8	1-5/8	7/8	1-1/8	208.0	143.9	175.0	
	ADP-M0106-L0076	2	2	5	2950	2-1/8	1-5/8	7/8	1-1/8	208.0	163.7	175.0	

*Not available with split condenser due to single coil design--available with heated and insulated receiver for low ambient applications
^ Uses fixed speed scroll in lieu of digital scroll on low temp due to compressor availability

Model Overview continued...



	Model	Number of Fans	# Coils	# Compressors	Unit Weight	Connections						
						LT Suction Connection	MT Suction Connection	LT Liquid Connection	MT Liquid Connection	Power Supply	MCA	MOPD
Dual Temp Units Continued	ADP-M0178-L0032	3	2	5	3400	1-5/8	2-1/8	7/8	1-1/8	208.0	175.6	200.0
	ADP-M0152-L0052	3	2	5	3400	1-5/8	2-1/8	7/8	1-1/8	208.0	169.2	200.0
	ADP-M0178-L0052	3	2	5	3400	1-5/8	2-1/8	7/8	1-1/8	208.0	195.2	225.0
	ADP-M0152-L0076	3	2	6	3500	2-1/8	2-1/8	7/8	1-1/8	208.0	193.1	225.0
	ADP-M0178-L0076	3	2	6	3500	2-1/8	2-1/8	7/8	1-1/8	208.0	219.1	250.0
	ADP-M0108-L0090	3	2	5	3200	2-5/8	2-1/8	7/8	5/8	208.0	169.0	175.0
	ADP-M0131-L0095	3	2	5	3200	2-5/8	2-1/8	7/8	5/8	208.0	182.0	200.0
	ADP-M0161-L0095	3	2	6	3300	2-5/8	2-1/8	7/8	5/8	208.0	196.0	225.0
	ADP-M0221-L0052	3	2	5	3250	2-1/8	2-5/8	5/8	7/8	208.0	184.0	200.0
	ADP-M0221-L0062	3	2	5	3250	2-1/8	2-5/8	5/8	7/8	208.0	193.0	225.0
	ADP-M0221-L0095	3	2	6	3400	2-1/8	2-5/8	7/8	7/8	208.0	223.0	250.0

*Not available with split condenser due to single coil design--available with heated and insulated receiver for low ambient applications

^ Uses fixed speed scroll in lieu of digital scroll on low temp due to compressor availability



Key to Codes in AdaptaPAK Model Numbers

ADP-MXXXX-LXXXX- _____

ADP = AdaptaPAK Platform

MXXXX = Medium Temperature Load in KBTUs

LXXXX = Low Temperature Load in KBTUs

SUFFIX - KEY TO OPTIONS					
SPLIT CONDENSER	EC MOTOR	COATED COIL	HAIL GUARD	HEAT RECLAIM	LP SWITCH/COMPR
S	E	C	H	R	P

Example: ADP-M0079-L0012-**ER**

ADAPTAPAK Model Breakdown			
(the number in parentheses indicates the number of condenser fans 2, 3, or 4)			
LOW TEMPERATURE SINGLE SUCTION (# fans)	MEDIUM TEMPERATURE SINGLE SUCTION (# fans)	MEDIUM TEMP AND LOW TEMP DUAL SUCTION (# of fans)	
ADP-M0000-L0032 (2)	ADP-M0048-L0000 (2)	ADP-M0048-L0012 (2)	ADP-M0178-L0032 (3)
ADP-M0000-L0052 (2)	ADP-M0079-L0000 (2)	ADP-M0079-L0012 (2)	ADP-M0152-L0052 (3)
ADP-M0000-L0076 (2)	ADP-M0106-L0000 (2)	ADP-M0106-L0012 (2)	ADP-M0178-L0052 (3)
ADP-M0000-L0099 (2)	ADP-M0152-L0000 (2)	ADP-M0152-L0012 (2)	ADP-M0152-L0076 (3)
ADP-M0000-L0122 (2)	ADP-M0178-L0000 (2)	ADP-M0178-L0012 (2)	ADP-M0178-L0076 (3)
ADP-M0000-L0145 (2)	ADP-M0198-L0000 (2)	ADP-M0048-L0032 (2)	ADP-M0221-L0052 (3)
ADP-M0000-L0161 (3)	ADP-M0253-L0000 (3)	ADP-M0079-L0032 (2)	ADP-M0221-L0062 (3)
ADP-M0000-L0190 (3)	ADP-M0299-L0000 (3)	ADP-M0106-L0032 (2)	ADP-M0221-L0095 (3)
	ADP-M0349-L0000 (3)	ADP-M0152-L0032 (2)	
	ADP-M0403-L0000 (4)	ADP-M0048-L0052 (2)	
	ADP-M0442-L0000 (4)	ADP-M0079-L0052 (2)	
		ADP-M0106-L0052 (2)	
		ADP-M0048-L0076 (2)	
		ADP-M0079-L0076 (2)	
		ADP-M0106-L0076 (2)	
		ADP-M0108-L0090 (4)	
		ADP-M0131-L0095 (4)	
		ADP-M0161-L0095 (4)	

Section 2:

DX Refrigeration Systems

Direct expansion (DX) refrigeration is one of the most common methods used for the removal of heat. Such a system takes heat from a place where it is unwanted and removes it to a place where it is unobjectionable. The Hillphoenix® AdaptaPAK® units utilize DX refrigeration to remove heat from store display cases and walk-in coolers/freezers, and transfer it to an outdoor location where it can be rejected.



Refrigeration Through Vapor Compression

Refrigeration is accomplished through application of various mechanical principles that occur as part of a continuous cycle, commonly known as the Vapor Compression Refrigeration Cycle.

In the vapor compression cycle, heat is absorbed as the liquid refrigerant in the evaporator changes to a vapor. The refrigerant boils at the new saturation point in the evaporator (located in the display case or cooler) where it changes to a superheated vapor. From the evaporator, the superheated refrigerant vapor enters the compressor and the refrigerant is compressed and changed from a low pressure superheated vapor to a high pressure superheated vapor (more on this later). It then flows to the condenser. In a simple refrigeration system, the ambient air outside of the condenser flows through the coils of the condenser where it absorbs heat from the vapor refrigerant causing it to change back to its liquid state before moving through the metering device where it crosses from the high pressure side of the system to the low pressure side. On the low pressure side, the refrigerant returns to the evaporator and the process (refrigeration cycle) is then repeated.

Refrigeration System Components

Knowing how the refrigeration process works helps in understanding where in the sequence of operation the major components of the mechanical system are, and the functions they perform. Almost any refrigeration system is built around four main components.

The four main components are:

- Compressor
- Condenser
- Metering Device (also known as an expansion valve)
- Evaporator

Beginning on the next page, these main components are individually presented and discussed.

Compressor

The compressor in a mechanical, vapor compression refrigeration system performs a basic function. It generates the pressure differential to move the refrigerant through the complete refrigeration cycle. It accomplishes its function in several simple steps. These steps are:

- The compressor draws in the low pressure refrigerant vapor from the evaporator (compressor suction side).
- Through mechanical means, the compressor compresses the refrigerant vapor to a high pressure.
- The high pressure refrigerant vapor is forced to exit the compressor through a discharge line.

The compressor performs work on the refrigerant by compressing it and raising its pressure and temperature. It thus adds energy to the refrigerant vapor.

Different types of compressors are used in different systems for various reasons. Some, called reciprocating compressors, draw the refrigerant into a cylinder, compress it, and then discharge it at a higher pressure. Other types compress the vapor between mating pairs of off-center scrolls (scroll compressors). Regardless of the method used, all types of compressors are designed to compress the refrigerant vapor, and thereby increase its pressure and move it through the refrigeration system.

Condenser

The condenser in a refrigeration system is designed to reject the heat energy that was picked up in the evaporator and the compressor, and reject it to the cooler outside ambient air. This process causes the high pressure refrigerant vapor to condense and become a high pressure liquid. The condenser operates as follows:

- The high pressure/temperature refrigerant vapor enters the condenser via the compressor discharge line.
- As the hot vapor enters the condenser and begins to flow through tubes of the condenser coil, lower temperature ambient air is drawn across the outside of the condenser's tubes/fins. An operating fan is often used as the motive force to move the air through the condenser coil.
- Due to the temperature difference, heat is transferred from the hot refrigerant to the cooler ambient air.
- As the hot refrigerant vapor gives up its heat, it changes state (condenses) and becomes a liquid.
- This liquid refrigerant then leaves the condenser via the "liquid line," and travels to the metering device.

All refrigeration systems utilize a condenser, with one of the most common types being air-cooled. The tubes of the condenser have copper or aluminum fins attached to them which act to dissipate the heat more effectively (other materials are used, but copper and aluminum are the most common).

Pressure is controlled in the condenser by a variety of means. On air-cooled condensers, a valve in the condenser's return line closes at a preset pressure in order to maintain pressure in the coil. As the pressure increases, the valve modulates so that a consistent pressure is maintained. The fans that force ambient air through the condenser are also cycled on and off to assist in the heat transfer process as needed.

Metering Device (Expansion Valve)

After the condenser, the high pressure liquid refrigerant reaches the metering device (expansion valve). The metering device meters, or controls, the flow of refrigerant from the high pressure, high temperature side of the system to the low pressure, low temperature evaporator. Important functions include:

- The metering device (expansion valve) regulates how much liquid refrigerant flows and enters the evaporator.
- The small opening for liquid refrigerant flow takes different forms. In some systems the metering device is a small thin copper tube known as a capillary tube; in others it is a small orifice that regulates flow; and in other refrigeration systems it is a thermostatic expansion valve (TEV or TXV).
- Control of the size of the opening for flow is crucial. It determines how much liquid refrigerant is allowed to pass. The size of this opening determines the temperature difference that exists between the saturated suction temperature (SST) and the temperature at the outlet of the evaporator. This temperature difference is so important that it has its own specific name—superheat.

One of the most common types of metering device is the thermostatic expansion valve (often referred to as a TXV or TEV). The opening/closing of these valves is controlled by the pressure and temperature at the exit of the evaporator.

Evaporator

Liquid refrigerant enters the evaporator from the metering device. The evaporator is located in the space that is being refrigerated. Several things happen in the evaporator:

- The liquid refrigerant entering the evaporator from the metering device (expansion valve) undergoes an instantaneous large pressure decrease (per the P-T chart, this is also a large temperature decrease).
- As it enters the evaporator, the liquid refrigerant immediately begins to absorb heat from the warm air flowing over the tubes and fins of the evaporator coil.
- With the absorption of heat, the liquid refrigerant also begins to change state (boil) to become a vapor.
- As the refrigerant continues to flow through the tubes of the evaporator, the continued absorption of heat results in more and more of the liquid refrigerant changing state to become a vapor.
- Prior to its exit from the evaporator, the refrigerant will have completely changed over to the superheated vapor state, and will then enter the suction line and head back to the compressor.

Inside the evaporator is where the refrigerant absorbs heat to carry it away from the refrigerated space. This could be the refrigerated space of a display case, a reach-in cooler, or walk-in freezer in which frozen foods are kept.

The basic principle at work here is that heat always moves from areas of higher temperature to areas of lower temperature. The refrigerant absorbs heat in the evaporator because it is at a lower temperature than the air moving across the evaporator. This temperature difference (TD) between the refrigerant and the air is approximately 8 to 10 °F.

Other components of refrigeration systems besides these basic ones are mainly just combinations of accessories and options that expand the capabilities of the system. Several of these are discussed later in this manual.

Section 3:

Controllers for the AdaptaPAK® Refrigeration System



The system controllers that Hillphoenix offers for installation in the AdaptaPAK® parallel refrigeration system include any of the following: Carel c.pCO Gateway, Emerson E2, Danfoss 800 series, the Micro Thermo MT Alliance™, and the Hillphoenix® multiMAX™. The choice is at the discretion of the customer and will be installed in the control panel of the AdaptaPAK in accordance with the individual manufacturer's requirements.

The Carel c.pCO programmable control system is designed to perform all of the necessary control functions flawlessly. It is a solid choice for the automatic control of all AdaptaPAK® parallel system control functions. It does a great job of controlling compressors and condensers, as well as other functions such as: oil management and heat reclaim. It includes standard alarming functions with and audible buzzer and a flashing red light. It also records system conditions and provides for alarm logging for easy troubleshooting and system documentation.

The Carel c.pCO programmable controller is able to perform a large number of different functions.

Carel c.pCO Gateway



Parallel Rack AdaptaPAK®

The following items apply to the control of the Hillphoenix AdaptaPAK® parallel rack refrigeration system.

Compressors:

- Two suction lines with control by pressure or temperature
- Compressors can be controlled with neutral zone band management
- Scroll compressor operational control; Copeland Coresense modules act as protective devices
- Maximum of 6 compressors
- Four different compressor rotation types: time, LIFO, FIFO, and custom (LIFO - last in, first out; FIFO - first in , first out)
- Standard compressor alarms featuring; high and low suction, inverter warning, superheat, oil, discharge, etc.

Condensers:

- Controlled by pressure or temperature
- Proportional band and neutral zone control
- Maximum control of 4, 3, or 2 fans
- Four different condenser fan rotation types: time, LIFO, FIFO, and custom
- Fans can be configured for modulation (pwm or 0 - 10 volts)
- Standard condenser fan alarms: high and low condensing psi and fan overload alarms; come with built-in Modbus slave ports that communication operational information to the Gateway Controller

Other Functions:

- Oil management, subcooling, liquid injection, and heat reclaim are available features for optimum compressor control
- Generic functions allow auxiliary functions to be configured for custom applications

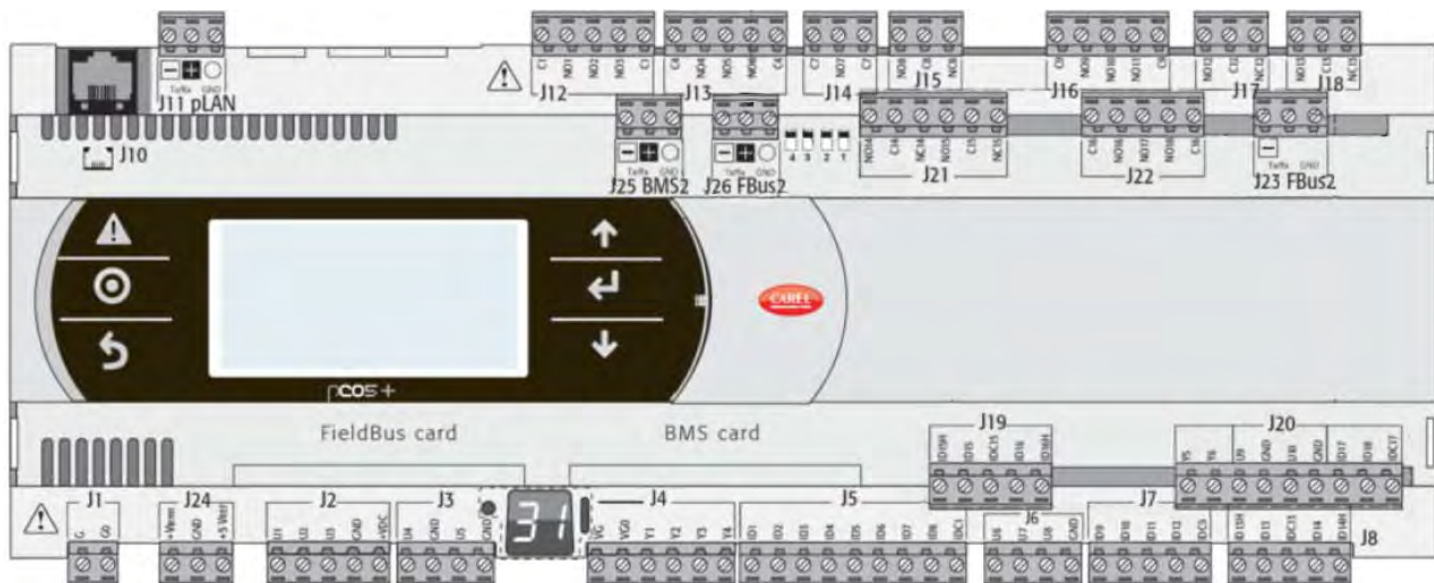
Alarms:

- Standard alarming with audible buzzer and flashing red light
- Alarm logging for easy troubleshooting and system documentation
- For some controls, a PGDx display is available with ethernet connectivity to permit alarm and screen monitoring, providing an HMI dashboard.

Inputs/Outputs

- All controller Inputs/Outputs are fully configurable (0-5v, 0-1v, 0-10v, and 4-20mA), (PT1000, NTC, HT-NTC, SPKP, PTC, PT500, and PT100)
- Controller has an I/O test mode for pre-testing of program

Carel c.pCO Gateway (showing input and output connections)



Definitions of Inputs and Outputs corresponding to the Carel pCO5+ Controller I/O.

J12 and J13 - Compressor Enable, Normally Open Relays

J12: Compressors 1, 2, 3 and J13: Compressors 4, 5, 6

Compressor Enable = a Normally Open (NO) relay that is used by the controller to energize one or more compressors in a given suction group. Energizing or de-energizing compressors is done in order to maintain the proper saturated suction pressure for the rack.

J16 - Condenser Fan Control, Normally Open Relay

J16: Condenser Fans 1, 2, 3

As required to meet system operational demands, condenser fans will be turned on or off. (Cycled to maintain drop leg pressure.)

J17 - Optional, Water Heat Reclaim, Normally Open Relay

J17: Water Heat Reclaim Valve

With this option, controller would close the relay and thus opening a valve to heat water in a heat exchanger.

J18 - Optional, Air Heat Reclaim, Normally Open Relay

J18: Air Heat Reclaim Valve

With this option, controller would close the relay and thus opening a valve to heat air in a heat exchanger.

J21 - Rack Alarm Output, Normally Open Relay

J21: Air Heat Reclaim Valve

If any rack alarm conditions are met, the controller will close the relay, activating rack alarms.

INPUTS

J1 - INPUT PWR, 24V AC/DC

J1: 24VAC Power to Controller

J2 -NTC/PRESS INPUTS

J2: Suction Pressure 1, Discharge Pressure, Drop Leg Pressure

J3 -TEMP INPUTS

J3: Suction Temperature 1, Ambient Temperature

J4 - 0-10VDC OUTPUTS

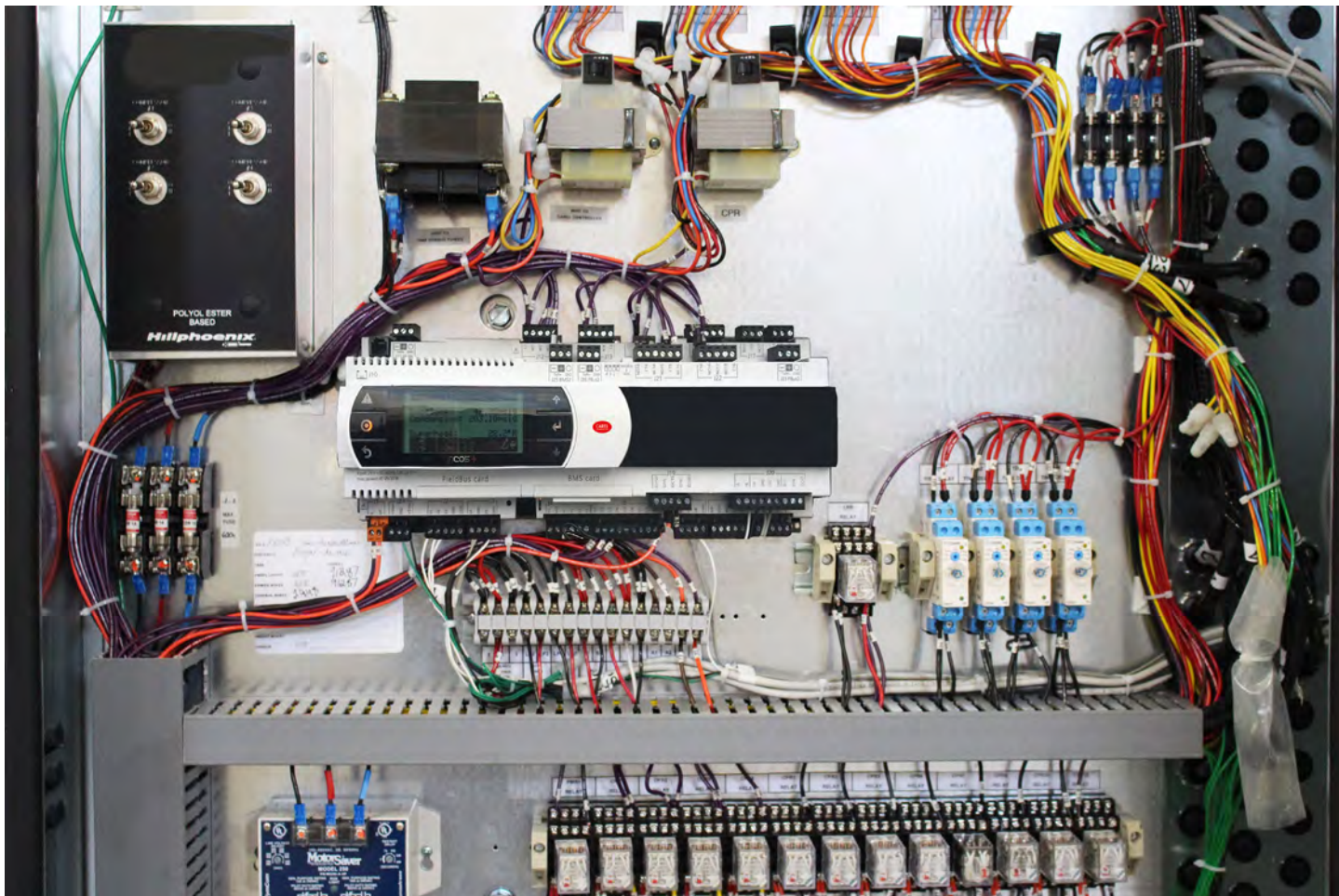
J4: 24 VAC Power, EC Fan Speed, Digital Compressor 1 Speed, Digital Compressor 2 Speed

J5 - 24V AC/DC DIGITAL INPUTS

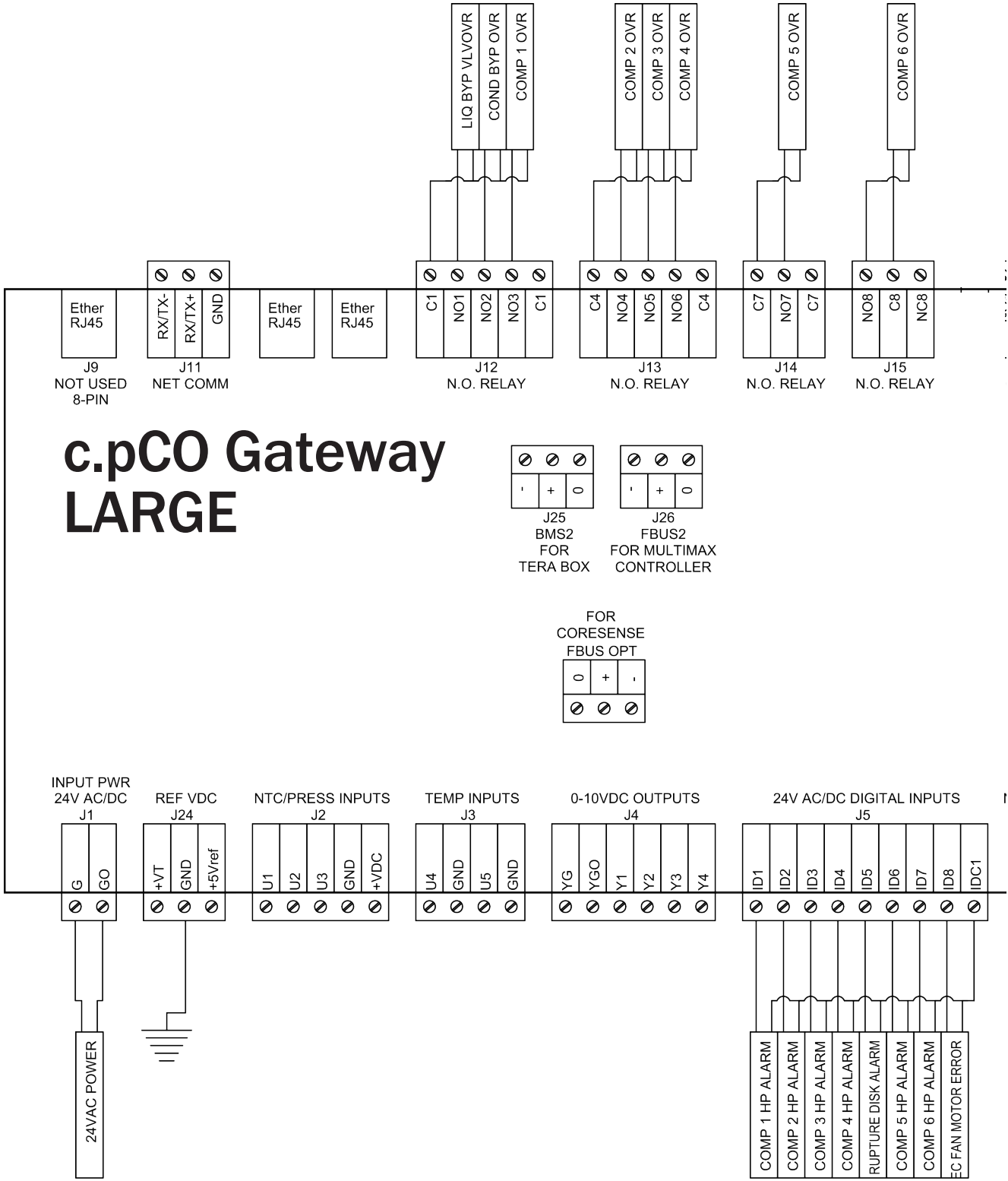
J5: Rack Oil Alarm, Phase Loss Alarm 1, Receiver Level SW, Water Heat Reclaim

J6 - NTC/PRESSURE INPUTS

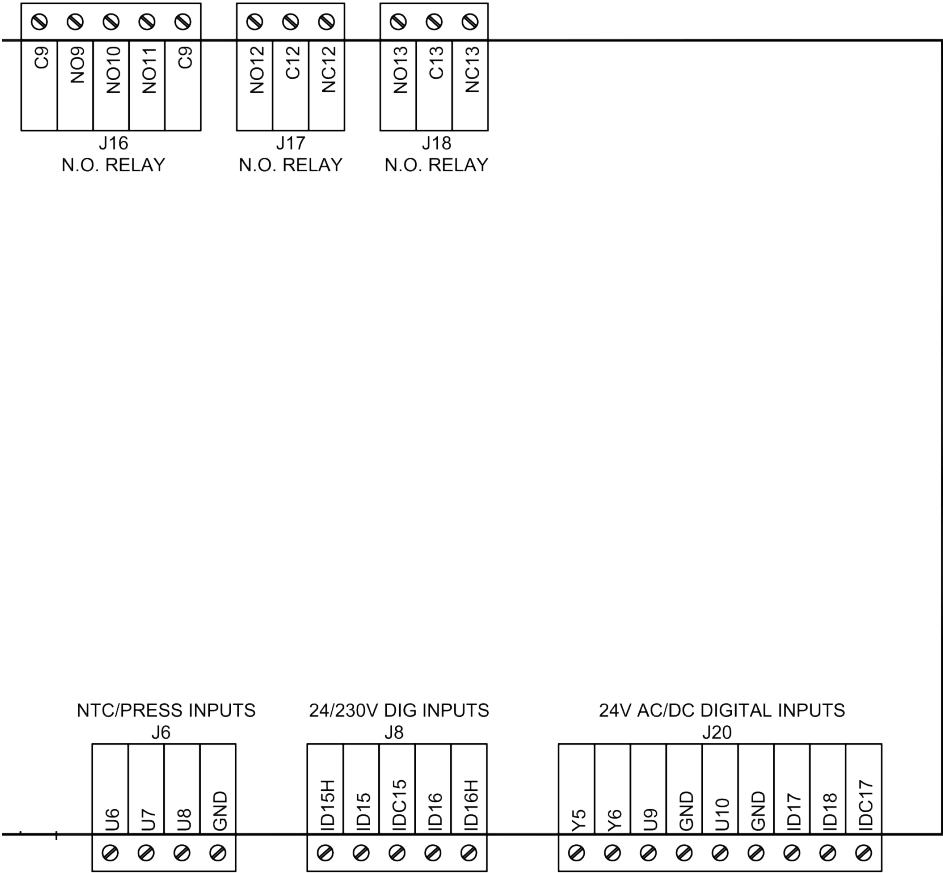
J6: Suction Temperature 2, Suction Pressure 2, Air Heat Reclaim

CAREL c.pCO GATEWAY WIRING INSTALLED IN AND ADAPATPAK CONTROL PANEL

SEE NEXT TWO PAGES FOR A FULL TWO-PAGE SPREAD OF CAREL c.pCO GATEWAY WIRING



Hillphoenix AdaptaPAK - Carel c.pCO Gateway Input-Output Schedule - left side



Hillphoenix AdaptaPAK - Carel c.pCO Gateway Input-Output Schedule - right side

Thus far, all of the discussion and presentation of inputs and outputs shown have been restricted to those required for the wiring of the Carel c.pCO Gateway programmable refrigeration controller.

However, it should be understood that the specific inputs and outputs required for control of the AdaptaPAK refrigeration system will remain pretty much the same no matter which manufacturer is chosen to control the system. The controller will have to monitor the same system pressures and temperatures via the use of transducers and sensors. Likewise, the same compressors, fans, valves, etc. will have to be controlled.

The additional Hillphoenix AdaptaPAK refrigeration controller options are as follows:

Emerson E2 Refrigeration Controller:

- Inputs - pressure and temperature monitoring
- Outputs - component control
- Control logic programmed for decision-making
- Alarms to notify of out of range values
- Requires appropriate I/O boards
- Capacity can vary by unit



Danfoss 800 Series of Refrigeration Controller:

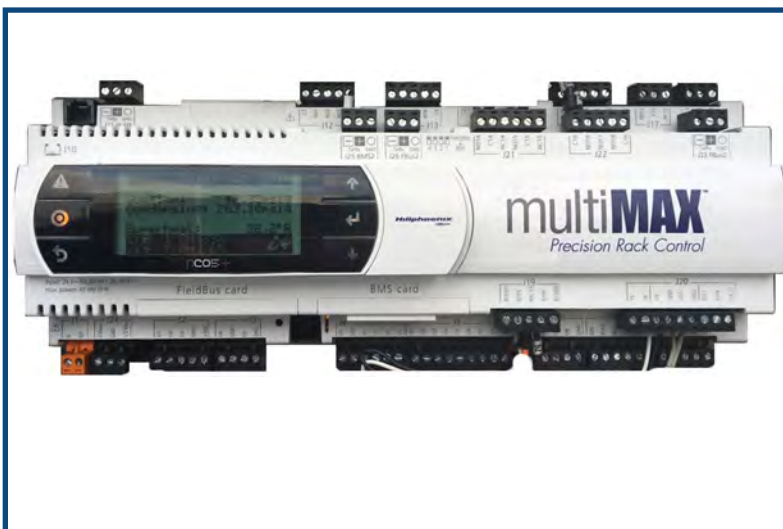
- AK-SM 820, 850, and 880
- Inputs - pressure and temperature monitoring
- Outputs - component control
- Control logic programmed for decision-making
- Alarms to notify of out of range values
- Requires appropriate I/O modules
- Capacity can vary by unit





Micro Thermo MT Alliance Refrigeration Controller:

- Inputs - pressure and temperature monitoring
- Outputs - component control
- Control logic programmed for decision-making
- Alarms to notify of out of range values
- Requires appropriate I/O modules
- Capacity can vary by unit



Hillphoenix multiMAX Refrigeration Controller:

- Similar to the Carel pCO5+ but with specific, custom programming features
- Inputs - pressure and temperature monitoring
- Outputs - component control
- Control logic programmed for decision-making
- Alarms to notify of out of range values
- Capacity can vary by unit

Section 4:

AdaptaPAK® Installation

Hillphoenix warrants all refrigeration systems and equipment it manufactures. In order for Hillphoenix to honor this warranty, it is essential that the systems and equipment be properly installed and started up by a qualified refrigeration technician. This section goes through the proper installation practices for AdaptaPAK® refrigeration systems and equipment.



Careful execution of the installation procedures for any refrigeration system is critical to the safe, effective, and efficient operation of the system. Every step must be followed in the exact order and the manner described, otherwise the equipment may not function properly. It is also critical that only the materials specified in the procedures be used.

Installation Materials

The process of installing AdaptaPAK® systems generally involves a variety of materials. In addition to the equipment itself, the items that are required to install a system often include:

- Valves (stop, pressure relief, solenoid, etc.)
- Refrigeration piping
- Insulation
- Filter dryers
- Assorted hardware and miscellaneous items
- Wiring
- Drain lines and traps
- Hangers, piping supports and other installation materials

Specifications for materials standards generally come from the customer but at a minimum always conform to published ASHRAE requirements.

Refrigeration Piping

Piping connects the components of a refrigeration system together. Refrigeration piping involves extremely complex relationships in the flow of, not only refrigerant, but also the oil that is required by the compressors for lubrication.

The three types of piping material commonly used in refrigeration systems are:

- Type K (Heavy Wall)
- Type L (Medium Wall)
- Type M (Light Wall)

The piping connects the refrigeration circuit together so that compressors are connected to cases or other types of refrigeration loads, and cases are connected to other cases. The type of piping material that is used to connect the circuits must have the capacity to perform one of three refrigeration system functions:

- Suction
- Liquid

Types K and L are used for most refrigeration applications. But the type of piping chosen for a particular function depends on a combination of factors. These include, for instance, the type of refrigerant and flow for which the piping will be used. And, when referring to flow, the diameter of the piping to be used also becomes important.

It is, therefore, useful to be able to estimate the weight of a refrigerant when sizing pipes and determining where piping supports are to be placed to ensure that the load is supported. The three types of refrigerant used in AdaptaPAK units are R-407A, R-448A, and R-449A. Note that the weight per lineal foot of copper refrigeration piping will depend not only on the pipe diameter, but will vary widely depending upon the state of the refrigerant (liquid or vapor). The table provided below does not specifically apply to the three AdaptaPAK refrigerants, but is being provided solely to give a general idea of the variation of weights based upon pipe diameter and the phase of the refrigerant.

REFRIGERANT.	Line Size	POUNDS PER 100 LINEAL FEET OF TYPE L COPPER TUBING						
		LIQUID	VAPOR	SUCTION GAS WITH NOMINAL SUPERHEAT				
				-40°F	-20°F	0°F	20°F	40°F
R-404A R-502 or R-507	3/8	3.6	0.29	0.02	0.04	0.06	0.08	0.11
	1/2	6.6	0.53	0.04	0.06	0.13	0.14	0.20
	5/8	10.8	0.86	0.07	0.10	0.17	0.23	0.33
	7/8	22.3	1.80	0.14	0.22	0.36	0.48	0.86
	1 1/8	38.0	3.10	0.24	0.37	0.61	0.83	1.16
	1 3/8	58.0	4.70	0.38	0.56	0.92	1.28	1.76
	1 5/8	82.0	6.60	0.64	0.80	1.31	1.81	2.49
	2 1/8	143.0	11.30	0.95	1.36	2.28	3.13	4.35
	2 5/8	220.0	17.60	1.46	2.14	3.51	4.85	6.69
	3 1/8	298	27.05-	2.09	3.06	5.02	6.93	9.54
	3 5/8	403-	36.50-	2.83	4.12	6.76	9.36	12.92
	4 1/8	526-	47.57-	3.68	5.38	8.82	12.20	16.81

Copper tube for air-conditioning and refrigeration field service (ACR) is designated by actual outside diameter.

“Temper” describes the strength and hardness of the tube. In the piping trades, drawn temper tube is often referred to as “hard” tube and annealed as “soft” tube. Tube in the hard temper condition is usually joined by soldering or brazing, using capillary fittings.

Tube in the soft temper can be joined by the same techniques and is also commonly joined by the use of flare-type and compression fittings. It is also possible to expand the end of one tube so that it can be joined to another by soldering or brazing without a capillary fitting—a procedure that can be efficient and economical in many installations. Tube in both the hard and soft tempers may also be joined by a variety of “mechanical” joints that may be assembled without the use of the heat source required for soldering and brazing.

Copper tube, Types K, L, M, ACR, DWV and Medical Gas, must be permanently marked (incised) in accordance with its governing specifications to show tube type, the name or trademark of the manufacturer, and the country of origin. In addition to incised markings, hard tube will have this information printed on it in a color which distinguishes its tube type.

When discussing refrigeration piping, it is appropriate to consider the type of joint that connects one section of piping to another. Installation specifications often call for brazing joints with “only a suitable silver solder alloy on suction and liquid lines.” (*Heatcraft Installation and Operation Manual*) The greatest concern with brazed joints is leaks. Leaks are caused by oxide and impurities (i.e., contamination) that enter the joint in the molten metal of an impure brazing alloy and impede the brazing alloy flow. Wherever there is contamination, the alloy flows around it, leaving pinholes in the joint. These pinholes are like tiny doors through which refrigerant gas can leak out.

Alloy	Silver%	Phos%	Melting Range		Fluidity Rating	Specifications				Recommended Joint Clearance
			Solidus °F/°C	Liquidus °F/°C		AWS A5.8	FED QB650C	DIN 8513	BS 1845	
Harris O	0	7.1	1310 / 710	1475 / 802	5	BCuP-2	BCuP-2	LCuP-7	—	.002 / .005"
Stay-Silv®2	2	7.0	1190 / 643	1450 / 788	4	BCuP-6	—	—	CP2	.002 / .005"
Stay-Silv 5	5	6.0	1190 / 643	1500 / 816	3	BCuP-3	BCuP-3	—	CP104	.002 / .006"
Stay-Silv 6	6	6.5	1190 / 643	1425 / 774	5	—	—	—	—	.002 / .005"
Dynaflow®	6	6.1	1190 / 643	1465 / 796	3	—	—	—	—	.002 / .006"
Stay-Silv 15	15	5.0	1190 / 643	1480 / 804	3	BCuP-5	BCuP-5	—	CP1	.002 / .006"
L-CuP6	0	6.5	1310 / 710	1545 / 841	4	—	—	—	CP6	.002 / .006"
L-Ag2P	2	6.5	1190 / 643	1515 / 824	3	—	—	L-Ag2P	CP2	.002 / .006"
L-Ag5P	5	6.3	1190 / 643	1465 / 796	4	—	—	L-Ag5P	CP4	.002 / .005"
L-Ag15P	15	5.4	1190 / 643	1435 / 779	4	—	—	L-Ag15P	CP1	.002 / .005"

*The higher the fluidity rating, the faster the alloy flows within the melting range.

Characteristics of Common Brazing Alloys.

Phosphorus/copper and silver/phosphorus/copper alloys are used to braze copper to copper and copper to brass. The phosphorus content in these alloys makes them self-fluxing on copper. The characteristics of certain alloys provided by one manufacturer are shown in the table on the previous page.

Pipe Fittings

Pipe fittings are used to route pipe runs in different directions. Two main types of fittings are short radius 90s (90 degrees) and long radius 90s. Long radius 90s are more often used than short radius 90s, the latter being primarily of use when space limitations are a factor.

Other types of fittings include T's, flares, and flare nuts. Although good piping practice calls for avoiding the use of the latter, flair nuts are sometimes found in certain applications, and if installed properly, can work well. However, sweat fittings should be used instead, whenever possible.

Besides the three general uses of piping mentioned earlier, other specific applications for refrigeration systems include:

- Circuit Piping -- compressor to cases
- Inside the store -- case to case

- Discharge
- Condensate
- Heat Reclaim

Insulation

Among the most common insulation material used for refrigeration piping is a type that goes by the brand name Armaflex®. This material uses a closed-cell, elastomeric foam with very low thermal conductivity properties – in other words, it has a high insulation value.

Other types of insulation that are used include:

- Rigid cellular phenolic foam
- Cellular glass closed-cell
- Polyisocyanurate closed-cell rigid

A number of considerations go into selecting the type of insulation to use for a particular application. These include:

- The application (fluid) temperature
- Ambient conditions such as:
 - dry-bulb temperature
 - relative humidity
 - surrounding air velocity
- Insulation Material
- Desired Performance

The application temperature is the temperature at which the refrigerant is intended to move through the piping. The ambient conditions are generally divided into three broad categories:

- Mild Conditions – maximum severity of 80°F dry bulb temperature, 50% relative humidity, and 0 ft/min air velocity
- Normal Conditions – maximum severity of 85°F dry bulb temperature, 70% relative humidity, and 0 ft/min air velocity
- Severe Conditions – maximum severity of 90°F dry bulb temperature, 80% relative humidity, and 0 ft/min air velocity

The mild design condition is typical of most indoor climate-conditioned environments in the U.S. A typical supermarket indoor design point of 75°F dry bulb temperature and 55% relative humidity can be considered equivalent to this mild condition for the purpose of sizing insulation. Although insulation thickness is usually based on the more demanding conditions of “normal” and “severe”, determining which of these to use ultimately depends on local ambient conditions and must be evaluated for each installation site. It is also important to realize that in some air-conditioned environments, air at, or near the ceiling or, roof can be warmer (sometimes considerably so) than elsewhere in the building; that consideration of these conditions is extremely important for systems containing overhead piping.

Two widely used types of insulation, polystyrene and urethane foam, have the following R-values::

- Polystyrene 3.5 to 5.0 per inch of thickness
- Urethane 5.5 to 6.0 per inch of thickness

In practice, insulation specifications will often be simply stated in terms such as:

“All medium temperature suction lines are to be insulated with ½-inch wall insulation, from the point of fixture penetration or walk in box coil, all the way to the compressor service valve or suction header and/or all liquid lines are to be insulated with 3/8-inch wall insulation.”

And/or:

“All low temp suction lines are to be insulated with ¾-inch wall insulation from the point of fixture penetration or walk in box coil all the way to the compressor service valve or suction header.”

Valves

Depending on the application, a number of different types of refrigeration valves are often field-installed. The most typical kinds are:

- Ball — typically used on larger pipes and where the valve is not intended to be readily adjusted without use of a wrench
- Hand — used most often in smaller spaces and where adjustment can be done by hand .
Both ball and hand valves generally serve the same function — shutting off flow for isolation
- Pressure relief — usually manufacturer-installed and used as check valves that open once pressure reaches a certain point, then releasing the pressure until it falls back into range and the valve closes
Typically mounted on receivers to protect the system from reaching dangerously high pressure level, pressure relief valves vent excess pressure and consequently release refrigerant
- Solenoid — either of a combination of two sets of functions; temperature control or isolation, and either normally open or normally closed
Another functional variation is that solenoids can be either one-way or two-way flow-permitting
Three-way — used for split condensers, heat reclaim, or in some applications for hot gas defrost
- Thermostatic expansion valves (TEV, referred to by some manufacturers as TXV) — all types work as metering devices regardless of whether mechanically or electrically operated
TEVs come in a wide variety of configurations, including SMS (Superheat Management System) used on Hillphoenix Coolgenix™ cases
- Check – (including pressure relief) allow flow in only one direction and prevent flow in the opposite direction, and are usually one of two configurations; differential or normal
Normal check valves prevent back flow, allowing free flow in only one direction

Other types of valves found in certain specific applications include:

- Inlet Pressure Regulator — controls inlet pressure at the valve
- EPR — Evaporative Pressure Regulating valves are usually located on the rack, but in some applications may be needed on the circuit
- Outlet Pressure Regulator — performs the opposite function of the inlet pressure regulator; controls pressure at the outlet of the valve

Filter and Filter/Driers

Filters are used to protect components in refrigeration systems from contaminants and other foreign material that accumulate in the system. A particular type of filter, called a filter/dryer, also removes moisture from the system.

Three main types of filters used for refrigeration systems are:

- Liquid Line Driers
- Suction Filters
- Oil Filters

Assorted Hardware and Other Installation Items

A number of various other types of hardware and other items are usually needed for any installation. These include, but are not limited to:

- Refrigerant and oil
- Pipe supports and fittings
- Strainers
- Flexible line
- Heating tape
- Pipe and conduit penetration covers
- Access fittings

Refrigerant and Oil

Every refrigeration system is designed to operate a specific refrigerant and type of oil. During installation, the proper refrigerant and oil must be added to the system. The refrigerants primarily used in commercial refrigeration are classified into three main groups:

- CFC – chlorofluorocarbons (R-11 and R-12)
- HCFC – hydrochlorofluorocarbons (HCFCs R-22 and R-124)
- HFC – hydrofluorocarbons (HFCs R-134a, R-404a and R-507, R-407A, R-448A/449A)

Because of their harmful effects on the environment, CFC refrigerants have been phased out and some HFC refrigerants are being phased out.

Most AdaptaPAK® units today use HFC type refrigerants, such as R-407A or R-448A/449A.

Refrigeration systems, like many other kinds of machinery with moving parts, use oil for lubrication. The movement of metal against metal generates friction (a form of heat), and friction in turn impedes the movement of those parts. By continuously coating the metal surfaces of the moving parts in the system, oil acts to reduce friction. Lubrication oil is essential to the operation of most compressors and other moving parts in refrigeration systems.

In refrigeration systems, the refrigerant and lubricating oil mix together. The oil dissolves in the refrigerant at most temperatures and pressures. Liquid refrigerant and oil are said to be completely miscible—that is, that they can be mixed in any proportions. When mixed, they exist in a single phase. The extent to which they are miscible depends on the type of oil and refrigerant that are mixing together.

The most commonly used lubricants in refrigeration systems are based on three different types of oils:

- Polyol Ester Oil (POE)
- Mineral Oil (MO)
- Alkyl Benzene Oil (AB)

The particular type of oil a refrigeration system uses is determined largely by the refrigerant it uses. A table showing which oil works (is compatible) with which refrigerant is provided in the table that appears below.

Refrigeration Oils HCFC-22		Traditional Refrigerants R401A R401B R402A (MP-39, MP-66, HP-80)	Interims R401A R401B R402A (MP-39, MP-66, HP-80)	HFC's HFC-134a R404A R507 R-407a, and R-448/449
POE's	Mobil EAL ARCTIC 22 CC	A	A	P
	ICI (Virginia KMP) EMKARATE RL 32CF	A	A	P
Mineral Oils	Suniso 3GS	P	A	NOT ACCEPTABLE
	Texaco WF32	P	PM	
	Calumet RO15 (Witco)	P	PM	
	Soltex 200-LT (White Oil)	(BR & Scroll Only)	PM	
	Witco LP-200	P		
AB	Zerol 200TD	AM	PM	NOT ACCEPTABLE
	Soltex Type AB-200		PM	

Key to Table: P=Preferred Lubricant Choice; A= Acceptable Alternative;

M=Mixture of Miner Oil and Alkyl Benzene (AB) with 50% AB.

(Information obtained from Heatcraft/Copeland)

It is important to use only the grade and type of oil that is specified by the manufacturer. Refrigerant and oil must only be handled by qualified personnel.

Pipe Supports and Fittings

Pipe supports and fittings are also referred to as mechanical fasteners. The material used for these purposes, of course, must be of sufficient strength to support the weight of the pipe.

Unistrut, a particular type of pipe support, is widely used for refrigeration piping. Angled steel, pipe clamps with plastic or rubber compound liner material that is held in place by an outer steel layer, along with wires and bands are also commonly used. These latter items are typically used in place of Unistrut. Bands used for pipe supports tend to be made of either metal or fiber. Fiber material, such as nylon, is preferred since it is unlikely to rip or tear insulation which can happen with metal. Painted or galvanized steel, however, generally works better than other types of unfinished metal. Plastic can also be used as long as it meets the criteria mentioned above, that it is strong enough to adequately support the weight of the pipe. In fact, even (nylon) cable ties are used in some cases.

Flexible Metal Line

Flexible metal line is sometimes used for discharge piping from the compressors. Because the compressors vibrate during operation, the lines connected to them are themselves subject to vibration. Flexible metal lines are sometimes referred to as vibration eliminators.

Vibration eliminators reduce line breakage that can otherwise result from the vibrating movement of the compressor.

This type of line is generally made of seamless bronze corrugated hose that is covered with a bronze wire braid. Standard copper tube fittings are attached at each end. Because of the way they are constructed, care must be taken when working with flexible line. For instance, flux must be immediately removed after brazing or soldering since the chlorides they contain are harmful to the material. During brazing or soldering, care must be taken not to heat the material either. When installed, lines subject to condensation, must be wrapped with a water-tight material to prevent ice from forming.

Vibration eliminators are most effective when installed perpendicular to the motion of the equipment to which they are attached. The fixed end of the equipment should be securely anchored as close as possible to the vibration eliminator. When major motion occurs in two directions, two lines should be installed.

Heating Tape

An electrical resistance tape is used to prevent freezing of drains in cold applications. Heating tape comes in a number of variations. Varieties of heating tape include self-regulating, adjustable, and continuously on.

Pipe and Conduit Penetration Covers

Exterior penetrations are used whenever any part of a system is located outside of the building. For instance, the piping that connects exterior-set mechanical houses, Weather Pac units (typically roof-mounted), and condensing units to the interior of the building must enter and exit through penetration covers. Properly designed and installed penetration covers keep the exterior elements out and the building's climate controlled conditions in. They create a solid barrier between the two environments and around the system's piping.

Installation plans usually include a penetration detail that indicates the type of penetration required.

Piping Practices

Hillphoenix refrigeration systems are always piped in accordance with ASHRAE refrigeration piping principles and practices. These can be found in, among other codes, ASHRAE 15, Safety Code for Mechanical Refrigeration.

AdaptaPAK® systems supplied by Hillphoenix are leak-checked, evacuated, and dehydrated at the factory. During installation, care must be taken to prevent foreign matter from entering the system.

Install all refrigeration system components in accordance with applicable local and national codes and in compliance with good practice required for the proper operation of the system. For instance, interconnecting pipe sizes are not necessarily the same size as the stub-out on the condensing unit or the evaporator. In any case, the refrigerant pipe size should be selected from an engineering table or from the manufacturer's legend or schedule. Wherever the information is provided, always find the correct size and never guess as to what size to use.

The basic principles for piping practices, listed below, spell out how piping for supermarket refrigeration systems should be installed. One overriding principle that applies to piping, as well as, all other aspects of refrigeration system installation is that verification should be documented during the entire process to ensure adherence to quality and performance standards.

Basic Piping Principles

Certain basic principles must be followed in piping refrigeration systems:

1. Verify components
2. Adhere to legend line sizes and use only clean dry piping
3. Properly size:
 - a. lines to reduce pressure drop to 1 to 2 pounds maximum to ensure correct velocities
 - b. line lengths that are subject to expansion and contraction
4. Provide proper support and clamping to refrigeration lines
5. Properly brazed joints
6. Insulate suction lines
7. Pressure test line sets
8. Properly evacuate system

Careful consideration of each step includes:

1. Verify components—positively confirm (as with all other aspects of the installation process) that all components match each other, i.e., all TEVs have the same refrigerant as the rack legend.
2. Adhere to legend line sizes and use only clean dry piping—only use those line sizes shown on the legend for the system; any discrepancies in the line size, as well as the refrigeration loads, must be brought to the attention of

the customer and Hillphoenix.

3. Properly size:

- a. Lines to reduce pressure drop to 1 to 2 pounds maximum to ensure correct velocities—lines should be sized to minimize pressure drop, while maintaining sufficient velocity to return the lubricating oil to the compressor crankcases—liquid lines should be of adequate size to provide proper refrigerant feed to the evaporators (restrictions in liquid lines, due to poor piping practices, increase pressure drop and promote flashing, further increasing the pressure drop due to turbulence).
- b. Line lengths that are subject to expansion and contraction—suction, liquid and remote condenser lines are subject to expansion and contraction and must be sized accordingly—depending on design considerations (typically long runs or hot gas), an expansion loop may need to be installed (may be indicated on the plan, but not always).

4. Provide proper support and clamping to refrigeration lines—line breakage must be avoided on all lines, particularly on long, straight runs of suction lines where expansion loops must be used with types of hangers that allow for longitudinal movement of piping and, as a result of closer placement, reduce sagging and vibration, discourage oil from collecting in fixture coils and piping through consistent sloping, and maintain proper lubrication in the compressors; all piping must be adequately supported with hangers that can withstand the combined weight of tubing, insulation, valves, and refrigerant in the tubing.
5. Properly brazed joints—all joints must be brazed according to the customer's specification after being thoroughly cleaned. Dry nitrogen at 1/2 psi must be flowing through the tubing while joints are brazed to avoid internal scale buildup. Limit the soldering paste or flux to the minimum required to prevent contamination of the solder joint internally. Flux only the male portion of the connection, never the female. After brazing, excess flux should be removed
6. Insulate suction lines—use only material listed in the customer specification. Insulation must be thick enough to keep heat from getting in, and moisture (sweating) getting out. Maintaining proper return gas temperatures cools compressor windings and prevents water damage and mold growth by keeping suction lines from sweating. When using subcooled liquid, the liquid line may also need to be insulated.
7. Pressure test line sets—use dry nitrogen to test for leaks in brazed joints to confirm they are able to hold pressure. Always take care to not over-pressurize any components.
8. Properly evacuate system—use a vacuum pump capable of 50 microns. Acceptable industry practice calls for a triple evacuation. A system that does not hold a vacuum has a leak. Never use a compressor.

Other Considerations

Several other important considerations should always be kept in mind about piping for any refrigeration system installation. For instance, all refrigeration piping must be sized in accordance with the capacity, and or size, recommended by the case, coil, and condensing unit manufacturers or engineering tables.

Tubing Material

Another important consideration is that all refrigeration tubing (unless otherwise noted, such as when soft drawn piping is specified for leading into coils) should be either type K or L hard drawn, cleaned and factory-sealed.

Tube Cutting

Any cutting of tubing should be done using a wheel type cutter, whenever possible. In order to keep out dirt and moisture, tubing should never be left open.

Pipe Turns

Turns in refrigeration piping should always be accomplished by the use of long radius 90 degree elbows. Short radius elbows and 45 degree elbows should be avoided due to higher pressure drops. 45 degree elbows have thinner walls due to the manufacturing process. On gas defrost systems, expansion loops (containing four 90's) or piping offsets (containing two 90's), should be installed.

Pipe Routing

When piping any copper-to-copper contact, heat transfer will occur. Generally copper lines should not touch one another even when it is necessary to cross pipes. Heat transfer will result from contact. Instead, they must be offset or insulated so as to insure that no copper to-copper contact occurs. There may, however, be times when heat transfer is beneficial. But careful consideration must be given to any possible trade-offs in efficiency when allowing contact.

Before starting, visually lay out piping to minimize 90 degree turns in order to reduce pressure drop.

Refrigerant piping should also not ever come into contact with electrical conduit or, certain dissimilar grounded metals, in order to avoid corrosion that can cause failure of the pipe.

Insulation

The Installation Contractor should always furnish and install adequate insulation to prevent condensation on all refrigeration suction piping in the sales area from the pits to the cases, at the point of piping entrance to the case, and insulate all refrigeration suction piping that is located in non-air conditioned areas. If ambient or mechanical sub-cooling is used, all liquid refrigerant lines should also be insulated. The more insulation that is used, the less heat gain the system absorbs. For instance, typical insulation for medium temperature suction lines is 3/4 inch, and on the same system for low temperature suction lines, 1 inch.

Regardless of the type of insulation, always follow the manufacturer's guidelines.

Oil Traps

Oil traps accumulate oil until pressure builds sufficiently to move oil up the riser. Oil traps should be installed before vertical risers and/or when recommended by the manufacturer. Vertical risers should also be sized in accordance with piping specifications shown on the refrigeration schedule.

Multiple coils should use inverted traps that prevent the oil from flowing from one evaporator to another.

Exterior Piping

Where refrigerant pipes penetrate building or cooler walls, the pipes should be insulated and the openings properly sealed by caulking with a suitable material. For refrigeration lines that pass through larger openings into the machine room or through the building roof, the lines should be insulated and the openings sealed. Lines that penetrate into walk-in boxes should also be sealed.

Evacuation

The system should be able to hold a vacuum for 24 hours with no micron increase and no vacuum pump attached. The vacuum should then be broken with refrigerant type used in the system from a factory filled cylinder. Always follow acceptable industry practices and customer specifications when evacuating systems.

It is important to recognize that the evacuation process does not remove liquid water, but reduces pressure to the point where liquid water boils into a vapor, which is then removed through evacuation.

Some things to consider when evacuating a system are:

- Make sure all system valves are open so that the entire system receives a vacuum, and that no part of the system is isolated from the vacuum.
- Copper line is generally considered best for connecting vacuum pumps to the system.
- Make multiple connections (depending on the size of the system, use more pumps) to the system so that both the high-side and low-side have vacuum.
- Always isolate the vacuum pump before shutting it off.
- Always read the micrometer at the furthestmost point of the system from the vacuum pump.
- Make sure to change the oil in the systems as necessary during evacuation.

Fittings and Connections

All fittings and connections for components should be sweat type unless otherwise specified. For instance, a safety relief valve of the proper pressure rating should be piped with a sweat (or in some cases, threaded) connection and vented to the outside a minimum of 30 feet from all intakes, or per local codes, if more stringent. In the event that a threaded connection is used, the proper thread sealant needs to be applied as determined by the type of refrigerant and oil used in the system.

Job Installation

In addition to piping, installation includes a number of other steps that must be performed. These include procedures to:

- Set and install racks
- Set and install condensers, cases, walk-ins and walk-in coils

- Choose and install lines for circuit piping
- Complete individual circuit piping inside cases, case-to-case, walk-ins and gas defrost
- Complete piping for condensers and heat reclaim
- Install drains for coils and cases
- Label equipment
- Install plan holders

Set and Install Unit

A basic part of the installation process is setting the unit for the system. As part of this process, an adequate number and type of vibration isolation units, or pads, should be installed to ensure that unit vibration is not transmitted to the rest of the store through the building's structure.

It is also quite important that the unit be installed such that it is level. Ensure that this occurs.

Set and Install Condensers, Cases, Walk-Ins and Walk-In Coils

Another basic part of the installation process is setting and installing condensers, cases, walk-ins and walk-in coils. Install these components according to the customer and manufacturer specifications. The exact steps necessary to complete the process may vary from manufacturer to manufacturer, so always make certain to follow the specific steps provided by the manufacturer.

Choose and Install Lines for Circuit Piping

Considerations for circuit piping include checking for:

- Pipe size
- Insulation
- Riser sizing
- Hangers and clamps
- Line slope and traps
- Heat reclaim
- Vibration elimination
- Building penetrations
- Condenser types (i.e., evaporative, air, plate-to-plate)
- Split condensers
- Opportunities to reduce piping through suction line sizing

Complete Individual Circuit Piping Inside Cases, Case-to-Case, Walk-Ins, and Gas Defrost

Keeping in mind that these considerations differ from those of general circuit piping considerations, as applied specifically to inside cases, case-to-case piping, walk-ins and gas defrost:

- Pipe size
- Insulation
- Ball valves
- Check valves

Along with these considerations, drains for coils and cases and heat tape and insulation for drains subject to freezing, must also be addressed.

On both the suction and liquid sides of the system, considerations for hot gas defrost (if part of the system) should include the use of return headers.

Complete Piping for Condensers and Heat Reclaim

Insulation, vibration eliminations, ball valves, check valves, hangers and clamps, risers, and building penetrations should be installed in accordance with customer and manufacturer specifications for condensers and heat reclaim systems.

Labeling Equipment

Every component of the system should be clearly labeled. All racks, control panels, and cases should be labeled with information that may include the following:

- System number
- Unit match (circuits matched to racks and vice-versa)
- Refrigerant type

Ensure that labels are attached to, or printed on, condensers, circuits, and cases, and that they match labels that appear elsewhere in the unit.

Install Plan Holders

A final step that is either sometimes specified by the customer, or should be part of the standard installation practice, is to install a plan holder. Usually these are placed near the refrigeration system (typically attached to the wall inside the unit) and contain a set of as-built plans for the system, as well as an updated refrigeration schedule and floor plan. These documents should be stored in such a way as to protect them from loss or damage.

Other Responsibilities

In addition to the installation steps listed above, the installation contractor in most situations has certain other responsibilities. These typically include, but are not always limited to:

1. Coordinating release of customer-furnished equipment to the customer's designated representative (usually their engineering staff or department).

2. Securing crane service, where needed, to hoist equipment to the mounting position.
3. Providing supervision and labor for setting customer-furnished equipment.
4. Providing labor to unload and set refrigeration equipment scheduled or shown on drawings.
5. Making final electrical connections to customer-furnished equipment.
6. Verifying controller operation and programming

Startup Procedures

As with other aspects of installing a system, following proper startup procedures is of critical importance to the eventual safe and effective operation of the system. Although unique characteristics of every installation may require some variation, the following procedures should be followed as closely as possible. All refrigeration startups should be performed by a qualified refrigeration technician.

Startup Checklists

An essential part of any startup is the careful and detailed verification of the necessary steps needed to get the system operating. Verification, therefore, should be documented during the process to ensure adherence to all quality and performance standards listed below, as well as, any that might be provided by the customer.

Typically the steps in the startup process include:

- Pressure testing
- Evacuating the piping
- Adding oil
- Adding refrigerant
- Installing liquid line driers and suction filters

Whether customers provide one or not, a startup checklist like the one included here (beginning on next page) should always be used. The checklist provides space for two types of entries, information to be filled in, and items to be checked off. Unless an item is not applicable to the installation, all items should be filled in or checked off.

SYSTEMS START-UP CHECK LIST

CUSTOMER NAME: _____ DATE: _____

UNIT MODEL #: _____

UNIT SERIAL #: _____

1. Verify that all electrical connects have been made and properly tightened. _____
2. Verify the Main Power Voltage readings and phasing of voltage against equipment requirements prior to turning on the power source:
L 1 > GD _____ A > B _____
L 2 > GD _____ A > C _____
L 3 > GD _____ B > C _____
3. Verify the Control Voltage. _____
4. On condensers check for proper operation and fan rotation including split valve operation and pump-out solenoids. _____
5. Check the oil pressure control on each compressor for proper operation by allowing each one to trip. Check the crankcase heater operation on each compressor. _____
6. Set the low pressure control according to the customer's specification. _____
7. Set the high pressure control to cut out at specified psi. _____
8. Turn on the circuit switches and verify that they are wired correctly. _____
9. Turn on the compressors and check the AMP draw of each phase. _____
10. Check and record oil pressure for compressors. _____
11. Check all evaporator fans for proper operation. _____
12. For electric defrost, check operation and load balancing. _____
13. If the system has EPR's, make sure they have been set before the rack is allowed to run unattended. _____
14. Check and set superheat on all condenser valves. _____
15. If the rack has heat reclaim, verify that it is operating correctly. _____
16. Check and record the suction temperature, suction pressure, and rack superheat. _____
17. Check and record the drop leg temperature and pressure. _____
18. Check and record the discharge pressure. _____

19. Check and record the ambient temperature.
20. Check low pressure and high pressure switch operation. _____
21. Verify all controller set points match manufacturer's specifications and case alarms are cleared from controller.

Checklist Completion

When all the steps have been completed, review the list to verify that they all have been performed properly and that no issues have arisen. If issues do remain, however, carefully assess the procedures to make sure no steps were omitted, or were not properly performed. If problems continue, despite whatever immediate action is taken to address them, the troubleshooting steps described in the next lesson should be followed to address the situation. Contact Hillphoenix concerning any problems that persist.

Section 5:

AdaptaPAK® Maintenance and Troubleshooting Procedures

Supermarket refrigeration systems like the AdaptaPAK® system are complex arrangements of equipment and machinery involving numerous components spread among a variety of subsystems that provide refrigeration to the store's different circuits and loops. In order to keep all that equipment and machinery running safely and efficiently, regularly scheduled maintenance must be performed. However, regardless of how well maintained the equipment is, problems will occur from time to time. Like any other kind of machinery, and especially like other complex systems, something will eventually fail to work as designed. In those cases, there are troubleshooting procedures that aid in determining the causes of various problems. This section presents the maintenance and troubleshooting procedures for Hillphoenix AdaptaPAK® refrigeration systems.



Maintenance Procedures

Refrigeration equipment has been noted to account for approximately 50% of the total electrical power consumption of the typical supermarket. In DX systems the compressors generally consume the greatest portion. As such, there is considerable potential for conservation measures to have a huge impact on the store's operating costs through the application of proper maintenance procedures.

Foremost among the maintenance procedures for DX systems is checking the system's safety and operating controls. The checks to be performed also include verification that the original settings are maintained.

Operating Strategies — Maintaining Compressor Efficiency

One means of reducing a compressor's electrical consumption (and a store's resulting operating costs) is to lower the discharge (head) pressure. The head pressure will be at its highest during the heat of summer, when the ambient temperature is close to design conditions. This is also when the compressor motor amperage will be at its highest. Because more work is required to compress a vapor to a higher pressure, it logically follows that more electrical energy is required to accomplish this. There is a proportional relationship between head pressure and compressor motor current draw. When head pressure is either raised or lowered, the motor current draw will increase or decrease in proportion. For example, one manufacturer's 20 HP compressor, using R-404A, and operating at -25°F SST (13 psig) and 110°F SCT (272 psig), with 5°F liquid subcooling, and a 50°F return gas temperature, will deliver 61,389 Btu/h. Under these conditions the compressor motor's current draw is 40 amps. A 30°F reduction in condensing temperature (110°F to 80°F) will reduce the current draw to 37.3 amps. While a 6.75% reduction is significant, it is only part of the story.

Typical supermarket compressor racks run reasonably constant suction pressure, regardless of head pressure. The suction pressure is determined by the saturated suction temperature requirement of the lowest operating system connected to the rack, and maintained by the energy management system. Unless the suction pressure requires readjustment, the **ONLY** reduction in compression ratio (ratio of absolute discharge pressure/absolute suction pressure) will come from lowering the head pressure. In this case, lowering the condensing temperature to 80°F (175 psig) will yield a significantly lower compression ratio (10.35:1 vs. 6.87:1). Using the same compressor data, the net result of this lower compression ratio is a 31% increase in compressor capacity.

So, in addition to a 6.75% reduction in current draw, the 31% increase in compressor capacity means that **FEWER** compressors will be required to operate to achieve the same pumping capacity. This is where the real savings come from: *INCREASED COMPRESSOR VOLUMETRIC EFFICIENCY*.

Safety and Operating Controls

As should be clear by now, the safe and efficient operation of Hillphoenix refrigeration systems is of the utmost importance to the company. Therefore it is essential that the safety and operation controls installed on each system are functioning correctly. As part of regular maintenance, these should be checked at specific intervals.

Refrigeration systems include operating controls that cycle on and off in order to maintain certain temperatures. They also require safety controls to stop operation if unsafe conditions occur. There are many varieties of controls. Different types work in response to temperature, pressure, humidity, liquid levels, and other inputs.

The basic controls on a refrigeration system govern the operation of three essential components:

- Compressor
- Condenser fan motor
- Evaporator fan motor

The basic controls that are necessary for these components to safely operate are the:

- Thermostatic control
- Low pressure control
- High pressure control
- Oil failure switch

Thermostatic Control

In a basic system, such as a single unit cooler, a thermostatic control switch, called a T-Stat for short, opens and closes to call for refrigeration whenever the temperature of the cooler rises beyond a certain, or set, point. When the T-Stat closes, the compressor goes On-Cycle and provides refrigerant to the evaporator thereby lowering the temperature of the cooler below the set point and causing the T-Stat to open. The compressor at that point then goes Off-Cycle.

The T-Stat senses the changes in temperature that cause the control to open and close through a device called a sensing bulb. The sensing bulb is mounted so that it reacts to the evaporator inlet air. Due to the continuous operation of the evaporator fan, the temperature of the recirculating air in the cooler is an average of the product temperature, the wall temperature, and any infiltrated air and any other loads such as those caused by a person entering the cooler. When the air temperature reaches the cut-in point of the control it calls for refrigeration.

In most medium temperature applications, the on-cycle set point at which the system calls for refrigeration is 40 °F. This set point is usually referred to as the cut-in point. In most medium temperature applications, the system will continue running until the lower, or cut-out, set point is reached; 37 °F is typically used for the cut-out point. The difference between the set points allows the compressor to cycle on and off without short cycling. Each compressor start causes wear. Too much starting and stopping (short cycling) shortens the life of the compressor and increases the maintenance required to keep it running. The best way to avoid short cycling is to spread the set points wide enough apart that the system is not continuously calling for refrigeration.

The upper set point, the Cut-in, in this example is 40 °F. Above 40 °F, bacterial growth rates increase dramatically, and below 40 °F, they decline. So a basic product safety check for any system should always be that the Cut-out and Cut-in points are properly set.

In addition to temperature controls, refrigeration systems also commonly rely on pressure control schemes. These work in basically the same manner as the temperature differential controls except that the set points are determined in psig instead of degrees F. To imagine how such a system would work, in the example described above, substitute pressure in psig for temperature in °F, and 68 psig and 64 psig, respectively, for the Cut-in and Cut-out points (on R-22 systems).

Low Pressure Control

A device called a Low Pressure Control (LPC) monitors the pressure in the system.

Besides controlling the set points in the system, pressure controls also almost always work as safety controls. In some systems, both T-Stats and LPCs are used.

In these cases, the LPCs protect the system from a loss of refrigerant charge by being set to cut-out at a pressure that is lower than anticipated low-side operating pressure.

Any time the compressor operates with an undercharge, the windings on the motor are apt to overheat and significant damage can then occur. As long as the system operates above the minimum pressure, the LPC remains in what is called the normally closed (NC) position. Small leaks that cause a gradual loss of refrigerant, and minute drops in pressure, initially trip the LPC to the open position which briefly stops the compressor. As the leak increases, the LPC trips more and more frequently until it eventually gets to the point where the system only runs for a few seconds before cutting out. At that point the high and low side pressures will equalize and the system will try starting once again. This again results in short cycling. As already noted, short cycling is not good, but destroying the compressor by operating indefinitely with an undercharge is worse.

High Pressure Control

Another control commonly found on most systems is for high pressure. High Pressure Controls work exactly opposite of LPCs. Often the two kinds of controls are combined into a single unit called a dual pressure control. The two sections of the control can be easily recognized due to fact that the low pressure side requires a larger bellows assembly since it must react to a lesser amount of force than the high pressure side.

Oil Failure Switches

The final safety system to consider is the one that controls against a loss of oil. Oil failure switches are used primarily on reciprocating compressors. These switches work by monitoring the refrigerant oil pressure of the oil pump discharge. The refrigerant oil pressure *MUST* be higher than the suction pressure. If the refrigerant oil pressure is lower than the suction pressure of the compressor, an oil leak is occurring. Oil leaks could be due to:

- An oil pump failing
- Refrigerant leaking and loss of oil
- Liquid refrigerant flooding back to compressor and “washing” the oil out of the crankcase

When a loss of pressure is detected, an alarm indicator light turns on to indicate that an oil failure has occurred. The oil failure switch should never be reset without determining and fixing the cause of the problem. Otherwise, the compressor will undoubtedly fail.

The safe and efficient operation of the system depends on the regular inspection of these controls as part of standard maintenance procedures. Each one should always be carefully checked and the appropriate action taken if any problem is indicated.

Visual Inspection

In addition to the safety checks to be performed on the system, it is also necessary to further examine its operation for any other problems that might occur. Some of the checks listed below should be performed regularly and other less frequently, but at consistent intervals.

The areas of the system on which inspections should be focused are the:

- Electrical and mechanical components of the system
- Case coils
- Condensers

Regular Inspections

The following checks should be routinely performed on AdaptaPAC systems:

1. Check compressor discharge and suction pressures—if not within system design limits, determine why and take corrective action

2. Check liquid line sight glass and expansion valve operation—if there are indications that more refrigerant is required, leak test all connections and system components (including cases) and repair any leaks before adding refrigerant
3. Using suitable instruments, carefully check line voltage and amperage at the compressor terminals; voltage must be within +/- 10% of that indicated on the compressor nameplate—if high or low voltage is indicated, notify the power company; If amperage draw is excessive, immediately determine the cause and take corrective action (on 3 phase motor compressors, check to see that a balanced load is drawn by each phase)
4. Check that the maximum approved settings for high pressure controls on air cooled condensing equipment are not exceeded
5. On air-cooled systems, also check as follows:
 - a. Make sure all condenser fans come on and run
 - b. Check the amp draw of all condenser fan motors
 - c. Disconnect the fan motors or block the condenser inlet air
 - e. Watch high pressure gauge for cutout point
6. Check head pressure controls for pressure settings
7. Check crankcase heater operation (if used)
8. Re-check all safety & operating controls for proper operation and adjust if necessary

Monthly Inspections

Approximately once a month the following inspections should be performed:

1. Clean drain pan interior. Dirt and other impurities, which have washed into the drain pan, should be hosed from the drain pan area. Shut off water to the float valve and open the drain connection for flushing.
2. Clean suction strainer, if equipped.
3. Check water operating level. Adjust float arm as required.
(DO NOT BEND FLOAT ARM)
4. Check, and adjust as needed, belt tensioning on open-drive compressors and condensers, if equipped.
5. Inspect the fan motor(s), water and water circulation and lubricate per the lubrication nameplate or manufacturer's recommendations.
6. Inspect fan wheels, housing and inlet screens removing any debris, which may have accumulated during operation.
7. Inspect the water distribution system to insure that nozzles and spray orifices are functioning correctly. The inspection should be done with the circulation pump on and fans off.

Other Checks

All electrical connections (including those at the compressor terminals) should be periodically checked for tightness. Loose connections contribute to low-voltage conditions that may cause motor failure.

Refrigerant connections should be inspected to insure that they have not loosened. Whenever it is necessary to add refrigerant, a careful leak check of all refrigerant connections should be made.

The oil level in the compressor crankcase should be at the specified level in the sight glass at all times. If the oil level is low, more oil should not be added until the cause of the oil migration is corrected. Check the expansion valve adjustment, the size of the risers and traps and the head pressure control valve settings.

If the oil level continues to remain low, pump the system down a few times to see if it will bring the oil back. On hot gas systems, put a few cases in defrost. Check the evaporator coils and make sure none are iced up. Check the oil in the oil reservoir, and if there is plenty of oil in the reservoir but a compressor that is low, adjust the oil float on that compressor. Make sure oil is not pumping out of the compressor through a bad valve plate or bad cylinder.

Dirty, discolored oil may indicate one of two things:

- Contaminants such as moisture, air, etc., trapped in the system. If the discoloration is not severe, a new liquid line filter-drier and 1 or 2 oil filters are usually enough to remove contamination and clean the oil. If the discoloration is severe and caused by contamination alone, the oil should be replaced and a new liquid line filter-drier and oil filter installed as many times as necessary to eliminate the contamination.
- Excessive system pressure drop or improper control settings. Compressors that operate in a vacuum result in oil discoloration due to motor overheating. The resulting inadequate suction cooling causes overheating of the motors.

Preventive Maintenance

Preventive maintenance, as the name suggests, is intended to stop problems before they happen. Preventive maintenance, when performed at the intervals specified below, reduces problems and keeps the system running smoothly.

Preventive maintenance should, in particular, be performed on unit coolers, air-cooled condensers, and fluid coolers that are connected to the AdaptaPAK® systems.

Unit Coolers

At every six month interval, or sooner if local conditions cause clogging or fouling of air passages through the finned surface, the following items should be checked:

1. Visually inspect unit
 - a. Look for signs of corrosion on fins, cabinet, copper tubing and solder joints.
 - b. Look for excessive or unusual vibration for fan blades or sheet metal panels when in operation. Identify fans causing vibration and carefully check motor and blade.

c. Look for oil stains on headers, return bends, and coil fins. Check any suspect areas with an electronic leak detector.

d. Check drain pan to ensure that drain is clear of debris, obstructions or ice buildup, and is freely draining.

2. Clean evaporator coil and blades

a. Periodic cleaning can be accomplished by using a brush, pressurized water or a commercially available evaporator coil cleaner or mild detergent. Never use an acid based cleaner. Follow label directions for appropriate use. Be sure the product you use is approved for use in your particular application.

b. Flush and rinse coil until no residue remains.

c. Pay close attention to drain pan, drain line and trap.

3. Check the operation of all fans and ensure airflow is unobstructed

a. Check that each fan rotates freely and quietly. Replace any fan motor that does not rotate smoothly, or makes an unusual noise.

b. Check all fan blade set screws and tighten, if needed.

c. Check all fan blades for signs of stress or wear. Replace any blades that are worn, cracked or bent.

d. Verify that all fan motors are securely fastened to the motor rail.

e. Lubricate motors if applicable.

4. Inspect electrical wiring and components

a. Visually inspect all wiring for wear, kinks, bare areas and discoloration. Replace any wiring found to be damaged.

b. Verify that all electrical and ground connections are secure, and tighten if necessary.

c. Check operation/calibration of all fan cycle and defrost controls, when used.

d. Look for abnormal accumulation of ice patterns and adjust defrost cycles accordingly.

e. Compare actual defrost heater amp draw against unit data plate.

f. Visually inspect heaters to ensure even surface contact with the coil. If heaters have crept, decrease defrost termination temperature and be sure you have even coil frost patterns. Realign heaters as needed.

g. Check drain line heat tape for proper operation (supplied and installed by others).

5. Refrigeration Cycle

a. Check unit cooler superheat and compare reading for your specific application.

b. Visually inspect coil for even distribution.

Air-Cooled Condensing Units

A number of checks should be performed at the intervals listed below.

Quarterly

On a quarterly basis visually inspect the unit to:

1. Look for signs of oil stains on interconnection piping and condenser coil. Pay close attention to areas around solder joints, building penetrations and pipe clamps. Check any suspect areas with an electronic leak detector. Repair any leaks found and add refrigerant as needed.
2. Check condition of moisture indicator/sightglass in the sight glass, if so equipped. Replace liquid line drier if there is indication of slight presence of moisture.
3. Check moisture indicator/sightglass for flash gas. If found, check entire system for refrigerant leaks and add refrigerant as needed after repairing any leaks.
4. Check compressor sightglass (if equipped) for proper oil level.
5. Check condition of condenser. Look for accumulation of dirt and debris (clean as required).
6. Check for unusual noise or vibration. Take corrective action as required.
7. Inspect wiring for signs of wear or discoloration and repair, if needed.
8. Check and tighten flare connections, if necessary.

Semi-Annually

On a semi-annual basis, the following checks should be performed:

1. Repeat all quarterly inspection items.
2. Clean condenser coil and blades
 - a. Periodic cleaning can be accomplished by using pressurized water and a commercially available foam coil cleaner. If foam cleaner is used, it should not be an acid based cleaner. Follow label directions for appropriate use.
 - b. Rinse until no residue remains.
3. Check operation of condenser fans.
 - a. Check that each fan rotates freely and quietly. Replace any fan motor that does not rotate smoothly or makes excessive noise.
 - b. Check all fan blade set screws and tighten, as required. Check all fan blades for signs of cracks, wear or stress. Pay close attention to the hub and spider. Replace blades, as required.

- c. Verify that all motors are mounted securely.
- d. Lubricate motors, if applicable. Do not lubricate permanently sealed, ball bearing motors.

4. Inspect electrical wiring and components

- a. Verify that all electrical and ground connections are secure; tighten as required.
- b. Check condition of compressor and heater contacts. Look for discoloration and pitting. Replace, as required.
- c. Check operation and calibration of all timers, relays, pressure controls and safety controls.
- d. Clean electrical cabinet. Look for signs of moisture, dirt, debris, insects and wildlife. Take corrective action as required.
- e. Verify operation of crankcase heater by measuring amp draw.

5. Check refrigeration cycle.

- a. Check suction, discharge and net oil pressure readings. If abnormal, take appropriate action.
- b. Check pressure drop across all filters and driers. Replace, as required.
- c. Verify that superheat at the compressor conforms to specification (i.e., 30°F to 45°F).
- d. Check pressure and safety control settings and verify proper operation.

Annually

Finally, once a year, perform the following checks:

1. In addition to quarterly and semi-annual maintenance checks, submit an oil sample for analysis.

- a. Look for high concentrations of acid or moisture. Change oil and driers until test results read normal.
- b. Investigate source of high metal concentrations, which normally are due to abnormal bearing wear. Look for liquid refrigerant in the crankcase, low oil pressure or low superheat as a possible source.

2. Inspect suction accumulator (if equipped).

- a. If the accumulator is insulated, remove insulation and inspect for leaks and corrosion.
- b. Pay close attention to all copper to steel-brazed connections.
- c. Wire brush all corroded areas and peeling paint.
- d. Apply an anticorrosion primer and paint, as required.
Re-insulate, if applicable.

Air-Cooled Condensers

At every six month interval, or sooner if local conditions cause clogging of air passages through the finned surface, the following items should be checked.

1. Visually inspect unit.
 - a. Look for signs of corrosion on fins, cabinet, copper tubing and solder joints.
 - b. Look for excessive or unusual vibration for fan blades or sheet metal panels when in operation. Identify fan cell(s) causing vibration and check motor and blade carefully.
 - c. Look for oil stains on headers, return bends, and coil fins. Check any suspect areas with an electronic leak detector.
2. Clean condenser coil and blades.
 - a. Periodic cleaning can be accomplished by using brush, pressurized water or a commercially available coil cleaning foam. If a foam cleaner is used, it should not be an acid based cleaner. Follow label directions for appropriate use.
 - b. Clear unnecessary trash and debris away from condenser.
3. Check the operation of all fans.
 - a. Check that each fan rotates freely and quietly. Replace any fan motor that does not rotate smoothly or makes an unusual noise.
 - b. Check all fan set screws and tighten, if needed.
 - c. Check all fan blades for signs of stress or wear. Replace any blades that are worn, cracked or bent.
 - d. Verify that all fan motors are securely fastened to the motor rail.
 - e. Lubricate motors, if applicable (most Heatcraft condenser motors are permanently sealed, ball bearing type and do not require lubrication).
4. Inspect electrical wiring and components.
 - a. Visually inspect all wiring for wear, kinks, bare areas and discoloration. Replace any wiring found to be damaged.
 - b. Verify that all electrical and ground connections are secure, tighten, if necessary.
 - c. Check operation/calibration of all fan cycle controls, when used.

Fixture Cleaning

The evaporator coils in most refrigeration cases are, by design, located at the bottom of the case. This arrangement keeps the piping, valves and fans needed to operate the cases out of sight and places the product closer to

the customer. From a merchandising perspective, this approach makes for sound design. From a maintenance perspective, however, it's somewhat problematic.

Refrigeration case evaporator coils, because of their placement, are subject to fouling from product and packaging debris that settles to the bottom of the case. Dust and other airborne material that settles on the coils between defrost cycles may also accumulate. This material must be removed and the cases kept clean in order for the coils to operate efficiently.

Cleaning Procedures

A periodic cleaning schedule should be established to maintain proper sanitation, insure maximum operating efficiency, and avoid the corrosive action of food fluids on metal parts that are left on for long periods of time. Hillphoenix recommends cleaning once a week by performing the following procedures:

1. To avoid shock hazard, be sure all electrical power to the case (or other type of refrigeration unit) is turned off before cleaning. In some installations, more than one disconnect switch may have to be turned off to completely de-energize the case.
2. Check the waste outlet to insure that it is not clogged before starting to clean and avoid introducing water faster than the case drip pipe can carry it away.
3. Avoid spraying cleaning solutions directly on fans or electrical connections.
4. Place a temporary separator between the cases being cleaned and ones adjacent to it.
5. Keep cases turned off long enough to clean any frost or ice from coil and flue areas.
6. Remove and clean the honeycomb discharge grill. It may be necessary to use spray detergent and a soft, long bristle brush.
7. Use mild detergent and warm water to clean with. When necessary, water and baking soda solution will help remove case odors. Avoid abrasive scouring powders or pads.
8. Use the following specialty cleaning products for difficult stains that may appear on polymer exterior bumper parts:
 - 3M brand® Stainless Steel Cleaner and Polish
 - 3M brand® Troubleshooter Cleaner
 - 3M brand® Sharpshooter, Extra Strength No Rinse Cleaner
 - Revere® aluminum powder for tank liner
 - Armor All® for polymer parts

Troubleshooting Procedures

Supermarket refrigeration systems are complex configurations of equipment. Like any other types of complex machinery, regardless of the care and attention given to their installation and startup, refrigeration systems will occasionally run into problems. In most cases, the safety and operating controls with which the system is equipped will give some indication of the problem. In other cases, however, the causes will not be so clear. For those situations, various troubleshooting procedures have been developed so that the causes of problems in the system can be identified and the appropriate actions taken to get the system up and running.

Sometimes when problems occur they can be determined rather quickly to involve a certain part of the system. At other times, it may be necessary to check the entire system in order to isolate the cause of a problem. The following charts provide guidelines for both general and specific indications of trouble in the system.

General System Troubleshooting

Specific aspects of system troubleshooting focus on the following areas:

- Compressors
- Discharge pressure
- Suction pressure
- Oil pressure

Problems observed with the operation of the compressors in the refrigeration system can often lead to root causes in one or more of these areas (Tables 1 through 8). Table 1: Compressor Will Not Run; Table 2: Compressor Noisy/Vibrating; Table 3: Compressor High Discharge Pressure; Table 4: Compressor Low Discharge Pressure; Table 5: Compressor High Suction Pressure; Table 6: Compressor Low Suction Pressure; Table 7: Compressor Loses Oil; Table 8: Compressor Protector Switch Open.

1 - TROUBLESHOOTING - COMPRESSOR WILL NOT RUN		
SYMPTOMS	SYMPTOMS	POSSIBLE ACTIONS
Compressor will not run	1. Main switch open	1. Close switch
	2. Blown Fuses	2. Check electrical circuits and motor winding for shorts or grounds Investigate for possible overloading Replace fuses after fault has been corrected
	3. Thermal overloads tripped	3. Overloads are automatically reset Check unit closely when it comes back online
	4. Defective contactor or coil	4. Repair or replace defective component
	5. System shut down by safety devices	5. Determine type and cause of shutdown and correct it before resetting safety switch
	6. No cooling required	6. None; wait until system calls for cooling
	7. Liquid line solenoid will not open	7. Repair or replace coil
	8. Motor electrical trouble	8. Check motor for open windings, short circuit, or burnout

1 - TROUBLESHOOTING - COMPRESSOR WILL NOT RUN (continued)		
SYMPTOMS	SYMPTOMS	POSSIBLE ACTIONS
Compressor will not run	9. Loose wiring	9. Check all wire junctions and tighten all terminal screws.
	10. Phase loss monitor inoperative	10. Turn power off at disconnect switch Swap any two of the three power input wires Turn power on, indicator light should glow and compressor should start Observe motor for correct rotation

2 - TROUBLESHOOTING - COMPRESSOR NOISY/VIBRATING		
SYMPTOMS	SYMPTOMS	POSSIBLE ACTIONS
Compressor is noisy or vibrating	1. Flooding of refrigerant into crankcase	1. Remove the noncondensables
	2. Improper piping support on suction or liquid line	2. Remove excess
	3. Worn compressor	3. Open valve
	4. Scroll compressor rotation reversed	4.. Rewire for phase change

3 - TROUBLESHOOTING - COMPRESSOR HIGH DISCHARGE PRESSURE		
SYMPTOMS	SYMPTOMS	POSSIBLE ACTIONS
High compressor discharge pressure	1. Non-condensables in the system 2. System is overcharged with refrigerant 3. Discharge shutoff valve partially closed 4. Fan not running 5. Head pressure control setting 6. Dirty condenser coil	1. Remove the non-condensables 2. Remove excess 3. Open valve 4. Check electrical circuit 5. Adjust 6. Clean it

4 - TROUBLESHOOTING - COMPRESSOR LOW DISCHARGE PRESSURE		
SYMPTOMS	SYMPTOMS	POSSIBLE ACTIONS
Low compressor discharge pressure	1. Faulty condenser temperature regulation. 2. Suction shutoff valve partially closed 3. Insufficient refrigerant in system 4. Low suction pressure 5. Variable head pressure valve	1. Check condenser control operation 2. Open valve 3. Check for leaks; repair and add charge 4. See corrective steps for low suction pressure 5. Check valve setting

5 - TROUBLESHOOTING - COMPRESSOR HIGH SUCTION PRESSURE		
SYMPTOMS	SYMPTOMS	POSSIBLE ACTIONS
High compressor suction pressure	1. Excessive load 2. Expansion valve is overfeeding	1. Reduce load or add additional equipment 2. Check Remote bulb; regulate superheat

6 - TROUBLESHOOTING - COMPRESSOR LOW SUCTION PRESSURE		
SYMPTOMS	SYMPTOMS	POSSIBLE ACTIONS
Low compressor suction pressure	1. Lack of refrigerant	1. Check for leaks; repair and add charge
	2. Evaporator dirty or iced	2. Clean/Check Remote
	3. Clogged liquid line filter drier	3. Replace cartridge(s)
	4. Clogged suction line or compressor suction gas strainers	4. Clean strainers
	5. Expansion valve malfunctioning	5. Check and reset for proper superheat
	6. Condensing temperature is too low	6. Check means for regulating condensing temperature
	7. Broken internal compressor part	7. Fix component; repair or replace compressor

7 - TROUBLESHOOTING - COMPRESSOR LOSES OIL		
SYMPTOMS	SYMPTOMS	POSSIBLE ACTIONS
Compressor loses oil	1. Lack of refrigerant	1. Check for leaks, and repair; add refrigerant
	2. Excessive compression ring blow-by	2. Replace compressor
	3. Refrigerant “flood back”	3. Maintain proper superheat at compressor
	4. Improper piping or traps	4. Correct piping

8 - TROUBLESHOOTING - COMPRESSOR THERMAL PROTECTOR OPEN		
SYMPTOMS	SYMPTOMS	POSSIBLE ACTIONS
Compressor thermal protector switch open	1. Operating beyond design limits.	1. Add components to bring conditions within acceptable limits (i.e., CPR/EPR valves, additional condenser surface, liquid injection, etc.)
	2. Discharge valve partially shut	2. Open valve
	3. Blown valve plate and/or gasket	3. Replace valve plate or and/or gasket
	4. Dirty condenser coil	4. Clean coil
	5. Overcharged system	5. Reduce charge

If, after performing the steps above, problems persist and you are not able to determine their cause, you may need to contact Hillphoenix Field Service for assistance.

Evaporator Troubleshooting

Evaporators, because of where they are located in the cases (or walk-ins), may experience problems that affect the performance of the case. Many of these problems can be addressed at the source—the evaporator.

EVAPORATOR TROUBLESHOOTING CHART		
SYMPTOMS	SYMPTOMS	POSSIBLE ACTIONS
Fan(s) will not operate	1. Main switch open 2. Blown Fuses 3. Defective motor 4. Defective timer or defrost thermostat 5. Unit in defrost cycle 6. Coil does not get cold enough to reset thermostat	1. Close switch 2. Replace fuses, check for short circuits or overload conditions 3. Replace motor 4. Replace defective component 5. Wait for completion of cycle 6. Adjust fan delay setting of thermostat, check defrost thermostat
Case or Walk-In temperature is too high	1. Thermostat set too high 2. Superheat too high 3. System low on refrigerant 4. Coil iced up 5. Unit cooler located too close to doors 6. Heavy air infiltration	1. Adjust thermostat 2. Adjust thermal expansion valve 3. Add refrigerant 4. Manually defrost coil, check defrost controls for malfunction 5. Relocate unit cooler or add strip curtain to door opening 6. Seal all unwanted openings
Ice accumulating around the evaporator or accumulating near the fan(s)	1. Defrost duration is too long 2. Fan delay not delaying fans after defrost period 3. Defective defrost thermostat or timer 4. Too many defrosts	1. Adjust defrost termination thermostat 2. Defective thermostat or not adjusted properly 3. Replace defective component 4. Reduce no. of defrosts

EVAPORATOR TROUBLESHOOTING CHART		
Coil not clearing of frost during defrost cycle	<ol style="list-style-type: none"> 1. Coil temperature not getting above freezing point during defrost 2. Not enough defrost cycles per day 3. Defrost cycle too short 4. Defective timer or defrost thermostat 	<ol style="list-style-type: none"> 1. Check heater operation 2. Adjust timer for more defrost cycles overload conditions 3. Adjust defrost thermostat or timer for longer cycle 4. Replace defective component
Ice accumulating in drain pan	<ol style="list-style-type: none"> 1. Defective heater 2. Unit or pan not pitched properly 3. Drain line plugged 4. Defective drain line heater 5. Defective timer or thermostat 	<ol style="list-style-type: none"> 1. Replace heater 2. Check and adjust if necessary 3. Clean drain line 4. Replace heater 5. Replace defective component
Uneven coil frosting	<ol style="list-style-type: none"> 1. Defective heater 2. Location is too close to door or opening 3. Defrost termination set too low 4. Incorrect or missing distributor nozzle 	<ol style="list-style-type: none"> 1. Replace heater 2. Check and adjust if necessary 3. Adjust defrost termination setting to be higher 4. Add or replace nozzle with appropriately sized orifice for conditions

Defrost Troubleshooting

Although the defrost system is relatively simple and trouble-free in operation, there are certain basic components that may cause problems. For systems with electric defrost, the components to check when problems occur include the following:

- Timer
- Fan motor
- Fan delay and defrost termination control
- Defrost heater
- Drain pan

Timer

If the system does not go through its proper sequence:

1. Check timer operation through a defrost cycle.
2. Check for loose wires or terminals.
3. Check other components before replacing the timer.

Other steps can be taken for systems equipped with certain types of timers that are commonly installed.

Fan Motor

If the motor does not operate, or it cycles on thermal overload, remove the motor leads from the terminal block and test it by applying the correct voltage across the leads. If the motor still does not operate satisfactorily, it must be replaced. Before starting the unit, rotate the fan blades to make sure they turn freely and have sufficient clearance.

Fan Delay & Defrost Termination Control

These controls generally use a single-pole, double-throw switch. Usually the red lead wire is wired to common. The black wire is then wired in series with the fan motors. A brown wire is often wired in series with the defrost termination. When controls are wired this way, the brown and red contacts close and the black and red contacts open when the temperature is above the *ON* set-point (e.g., 55°F). The black and red contacts close and the brown and red contacts open when the temperature is below the *OFF* set-point (e.g., 35°F).

On the initial call for refrigeration, or pull-down, the fan will not start until the coil temperature reaches approximately 35°F (in this example). If the case is still comparatively warm (e.g., 60°F) when the fan starts, then blowing this warm air over the coil may cause it to warm up to 55°F and thus cause the fan to stop. Therefore, the fan may recycle on initial pull down. This cycling of the fan is normal and will cease as the case gets down to temperature. This control cannot be adjusted.

If the fan motor fails to start when the control is below the set-point, disconnect the fan motor leads and check the motor as described above for fan motors. Also check whether current is being supplied at the “N” and the “4” terminals from the timer. The fan delay control must be below 35°F when checking for a closed circuit.

Defrost Heater

If a defrost heater unit shows little or no evidence of defrosting, and does not heat, disconnect the heater and check to see if it is burned out. To test, apply the correct voltage across the heater or use a continuity flashlight battery tester.

Drain Pan

If a drain pan has a build-up of ice, the drain line may be frozen. The drain line should be pitched sharply, and exit the cabinet as quickly as possible. Sometimes the location of the drain and the ambient air temperature at the drain outside of the case may cause the drain pan to freeze-up. A drain line heater may be required to correct the freeze-up condition. To avoid this condition, any traps in the drain line must be located in a warm ambient temperature location (often the case for case drains).

Finally, after correcting any faulty condition, it is essential that the coil and case be free of ice before placing the case back into the automatic mode of operation.

If you should have questions about the steps or procedures listed in this manual, be sure to contact your Hillphoenix Field Service Representative.

