Residential Heat Pump Systems

Field Reference Guide

Updated October 2023

Johnson Controls

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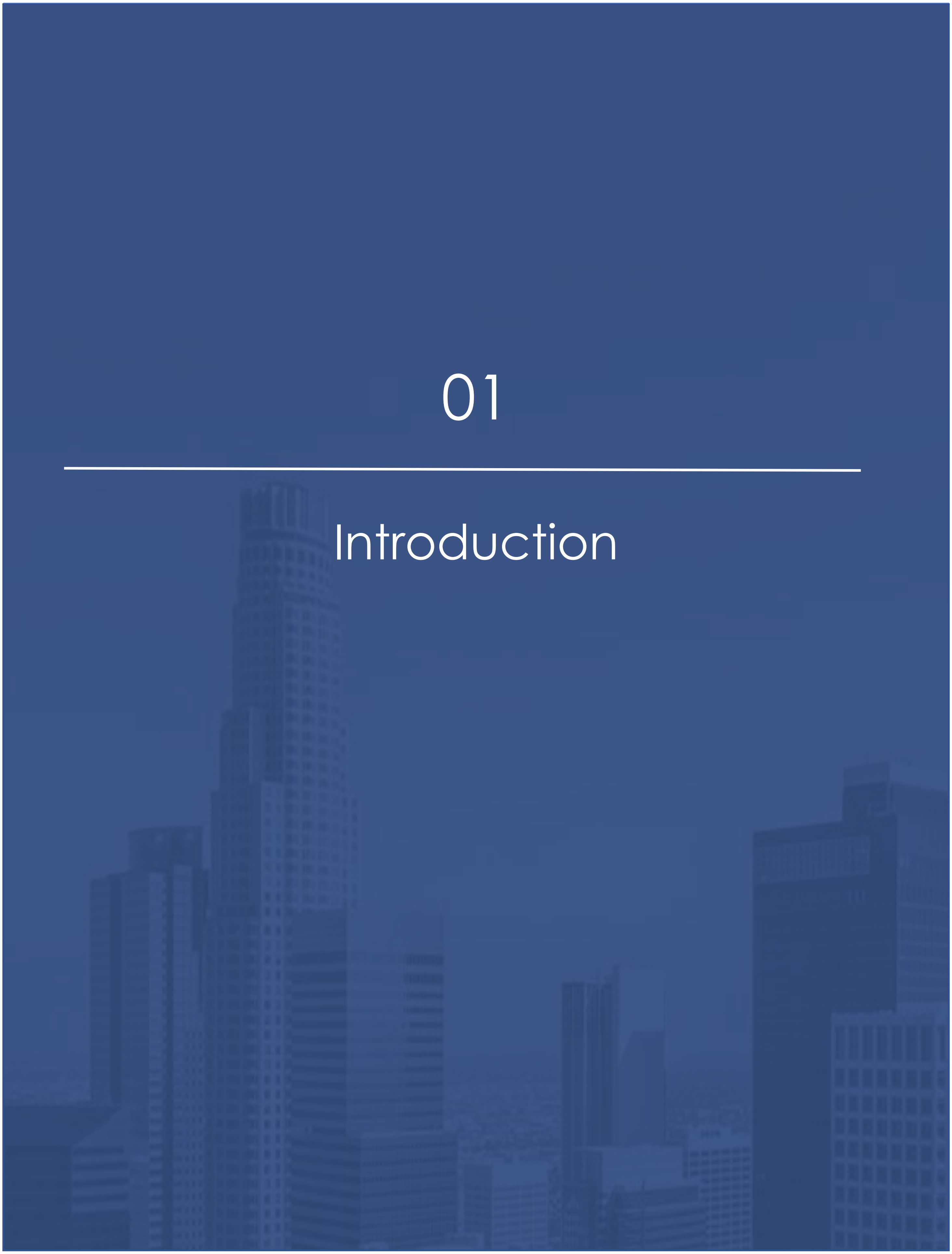
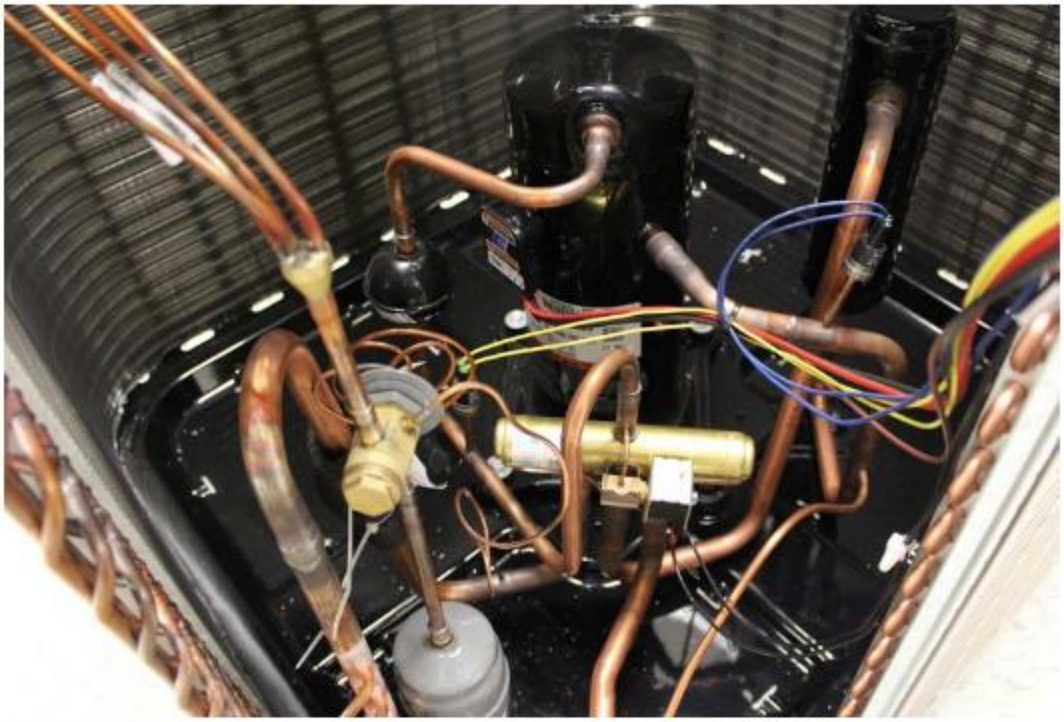


01

Introduction

Available Models



Heap Pump Unit Interior

This Guide covers residential heat pump systems, detailing the operation of the refrigeration cycle and individual components. This guide is not designed to replace the documentation provided with the equipment. The technician should always refer to the Installation Manual and Tech Guide during installation and service of any heat pump equipment. Follow all local, state, and federal laws, codes, rules, and regulations when performing work on any of the equipment described in this guide.

Safety is always a concern when working on HVAC (Heating Ventilation and Air Conditioning) equipment. In Section 2 (Safety), many factors regarding workplace safety are reviewed. This is not an all-inclusive safety document. Rather, it is the responsibility of the employer and the technician to identify potential safety hazards that may change from one job site to the next. The procedures in this guide will provide technicians with additional basic safety awareness tips when installing and servicing heat pump units. Only qualified technicians with proper safety training should install, service or maintain the equipment described in this guide.

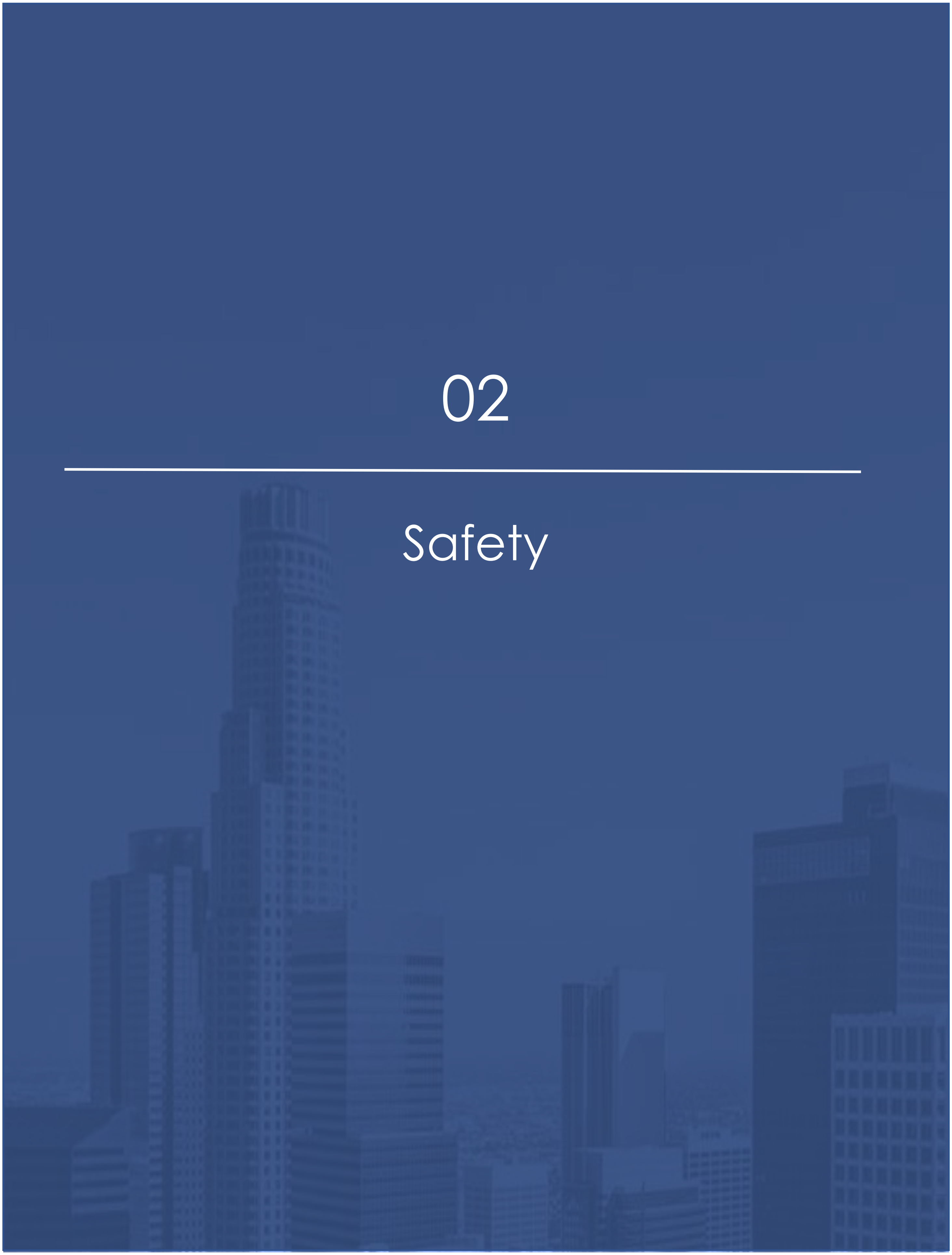
Proper installation and service of heat pump systems requires a thorough understanding of electrical and mechanical components and system operation. In Section 3 (Component Familiarization), the heat pump cycle, electrical components, and field-installed accessories are reviewed.

In Section 4 (Installation) and Section 5 (Start Up), basic installation and start up procedures (including residential and light commercial equipment) will be discussed.

Advanced microprocessor-based control systems offer more features, better system performance and diagnostic information. Section 6 (Sequence of Operation) covers the electrical advancements provided on the heat pump systems.

Section 7 (Troubleshooting) provides common techniques to help identify problems within the refrigeration cycle, electrical components, airflow problems, and diagnostic flash codes.

Section 8 (Maintenance) overviews maintenance procedures for the various components within the heat pump.

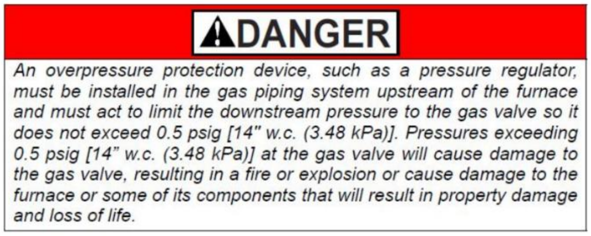


02

Safety

Safety Symbols

Reminder – use this manual in conjunction with the technical literature for each product. This manual Does Not Supersede the Installation Manual and Technical Guide provided with the equipment. Always read and follow all instructions before installing equipment. Understand and pay particular attention to the signal words **DANGER**, **WARNING** or **CAUTION**.

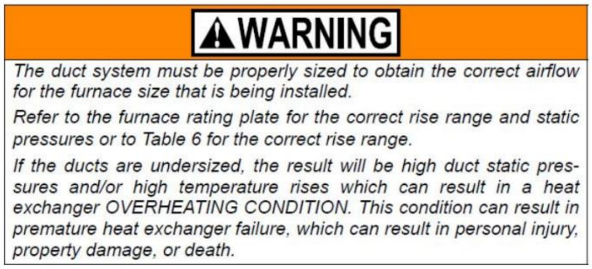


DANGER

An overpressure protection device, such as a pressure regulator, must be installed in the gas piping system upstream of the furnace and must act to limit the downstream pressure to the gas valve so it does not exceed 0.5 psig [14" w.c. (3.48 kPa)]. Pressures exceeding 0.5 psig [14" w.c. (3.48 kPa)] at the gas valve will cause damage to the gas valve, resulting in a fire or explosion or cause damage to the furnace or some of its components that will result in property damage and loss of life.

Sample Danger Label

DANGER indicates an imminently hazardous situation which could result in death or serious injury.



WARNING

The duct system must be properly sized to obtain the correct airflow for the furnace size that is being installed.

Refer to the furnace rating plate for the correct rise range and static pressures or to Table 6 for the correct rise range.

If the ducts are undersized, the result will be high duct static pressures and/or high temperature rises which can result in a heat exchanger OVERHEATING CONDITION. This condition can result in premature heat exchanger failure, which can result in personal injury, property damage, or death.

Sample Warning Label

WARNING indicates a potentially hazardous situation which could result in death or serious injury.

CAUTION

The indoor coil must be installed in the supply air duct, downstream of the furnace. Cooled air may not be passed over the heat exchanger.

Sample Caution Label

CAUTION indicates a potentially hazardous situation, which, if not avoided, may result in minor or moderate injury. It is also used to alert against unsafe practices and hazards involving only property damage.

Safety Specific Rules

Follow these specific safety rules for a safe application:

- Air conditioning systems utilizing gas heating can only use natural gas or propane (LP) gasses as an approved fuel. LP applications require installation of the appropriate LP conversion kit. Refer to the unit rating plate or Installation Manual for information on proper inlet and manifold pressures.
- Install air conditioning systems only in locations and positions as specified in the Installation Manual.
- Provide adequate clearances for service, combustion, and ventilation air to the unit. The recommended clearances are specified in the Installation Manual.
- Test for gas leaks as specified in the Installation Manual.
- Only connect the equipment to a duct system which has an external static pressure within the allowable range as specified in the Installation Manual.
- These unites are not to be used for temporary heating or cooling of buildings or structures under construction. Improper installation will shorten equipment life, reduce product efficiency, and void the warranty.
- Always install the systems to operate within the equipment’s intended temperature and operating ranges.
- The size of the unit should be based on an acceptable and approved heat load calculation for the structure being conditioned.

Safety Requirements

Follow these safety requirements for a safe application:

- All equipment should be installed in accordance with all national and local building/safety codes and requirements, local plumbing or wastewater codes, and other applicable codes. In the absence of local codes, install in accordance with the most recent National Electrical Code, National Fuel Gas Code and/or Natural Gas and Propane Installation Code (latest editions). Furnaces have been certified to the latest edition of standard ANSI and CSA standards.
- Only approved heat accessories shall be installed on these air conditioning units local.
- Refer to the unit rating plate for the equipment model number, and refer to the Installation Manual for proper air plenum dimensions.
- Provide clearances from combustible materials as listed under Clearances to Combustibles in the Installation Manual and the equipment rating plate.
- Provide clearances for servicing ensuring that service access is allowed for both the burners and indoor fan motor.
- Provides clearances for servicing.
- Failure to carefully read and follow all instructions in this manual and the equipment Installation Manual can result in equipment malfunction, death, personal injury and/or property damage.
- Check the rating plate and power supply to be sure that the electrical characteristics match. All commercial 15 through 25-ton units distributed in North America use nominal 208/230 volts AC, nominal 460 volts AC, or nominal 575 volts AC 3 Phase, 60-Hertz power supply. DO NOT CONNECT THIS APPLIANCE TO A POWER SUPPLY OR A VOLTAGE OTHER THAN THE RANGE SPECIFIED ON THE UNIT DATA TAG.
- The equipment shall be installed so the access panels are readily available, and the electrical components are protected from water infiltration.
- Installing and servicing HVAC equipment can be hazardous due to the electrical and mechanical components. Only trained and qualified personnel should install, repair, or service HVAC equipment. When working on equipment, observe precautions in the manuals and on the labels attached to the unit and other safety precautions that may apply.
- The Installation manual covers minimum requirements needed to conform to existing national standards and safety codes. In some instances, these instructions exceed certain local codes and ordinances. These instructions are required as a minimum for safe installation and operation.

General Awareness

Safety is ALWAYS the primary concern for everyone. On the job injuries can be significantly reduced when proper guidelines are followed. Always be aware of all company, local, state and/or OSHA (Occupational Safety and Health Administration) regulations.

Jobsite Safety

Keeping the job site clean of trash, extra tools and equipment will significantly reduce the chance for injuries. Since each job is unique and has its own hazards, all new workers to the area should be made aware of the location of hire and first-aid equipment, fire escape routes, and other dangers.

Hazardous Materials

Many different chemicals and compounds are used in the service and installation of HVAC systems. Please read the directions and use caution along with PPDs whenever handling these materials. Read and understand the MSDS for all materials used.

Confined Spaces

Never enter or work in a confined space without taking the appropriate precautions. Have someone available outside the space ready to assist or summon help if necessary. Even spaces that seem relatively safe can quickly become hazardous if a pipe were to break and fill the space with refrigerant, steam, poisonous fumes or other gasses. Welding or brazing in a confined space is especially hazardous.

Pressure

High pressures have always been part of the HVAC profession. Wear the proper personal protective devices including safety glasses and gloves. Proper hose ratings and manifolds are required for high-pressure refrigerants.

Electrical Safety

Jewelry should be removed prior to any electrical work being performed. Ensure that the equipment disconnect switch removes the primary power source prior to taking resistance readings or disconnecting any wires or connections. Removal of system power should be verified with the voltage function of a multimeter. All electrical safety guidelines should be always followed. Only trained, qualified technicians should perform electrical maintenance, installation, inspections and troubleshooting of electrical equipment.

Electrocution occurs when a current as low as 6 to 200mA flows through the heart, disrupting its normal operation and causing death. Electrical shock is an injury that occurs because of exposure to an electrical current. Inspect all extension cords and power tools regularly. Fuses and circuit breakers are designed to protect equipment, not people. For personal electrical protection, GFCI or Ground Fault Circuit Interrupters are highly recommended.

Lock-Out Tag-Out

OSHA Standards cover the servicing and maintenance of machines and equipment, in which unexpected energizing or startup of the machines or equipment, or release of stored energy, could cause injury to employees.

These standards establish minimum requirements for the control of such hazardous energy. To ensure safety, put a lock that is tagged with the technician’s name on the electrical disconnect or breaker of the equipment or circuit which is being serviced.

Be aware of others who may be working on the same circuit or other circuits served by the same electrical panel. The technician should also be aware that other technicians may not have used the proper Lock-Out, Tag-Out procedures.

Fire Safety & Burns

While brazing, keep the area clear of combustible material or use a heat shield to help reduce risk of fire.

Check equipment regularly and never try to modify or repair regulators.

While servicing the refrigeration circuit, improper use of equipment and tools can result in serious burns that are associated with refrigerants. This may include frostbite, which is a deep tissue injury. Proper personal protection devices must be in use when servicing the refrigeration system.

Personal Safety

Personal safety always includes remaining aware of the surroundings, using properly maintained tools, and correct use of items designed for personal protection.

Personal Protection Devices (PPD)

- Hard Hat: Hard hats must be worn when there is a danger of head injury.
- Safety Glasses: Eye protection should be worn at all times while on a job site.
- Gloves: Assist in the prevention of serious injury to the hands from serious cuts as well as injuries from high-pressure gasses such as refrigerants. Rubber gloves can protect the technician’s hands from chemicals when inspected and worn properly.
- Safety Shoes: Work shoes with steel toes for foot protection. There are also electrical safety shoes that can aid in protecting the technician against electrical shock and/or electrocution. At a minimum, leather work shoes with rubber soles are required.
- Respirator: Used in a confined space where the air can be dissipated by refrigerant which can cause asphyxiation.
- Safety Harness: Used when working above grade level. Ladders must be tied down. Ensure that PPDs provide the intended protection. They should be inspected regularly, used properly and never altered or modified in any way.

Clothing

Rotating and moving components pose a serious risk. Loose fitting clothing and ties should not be worn when servicing rotating equipment. If any clothing becomes entangled in moving parts, serious injury or death is a likely result.

Jewelry

Serious injury or death can result if jewelry contacts an energized circuit or is caught in moving parts. Leave jewelry at home or in your service bag or service vehicle.

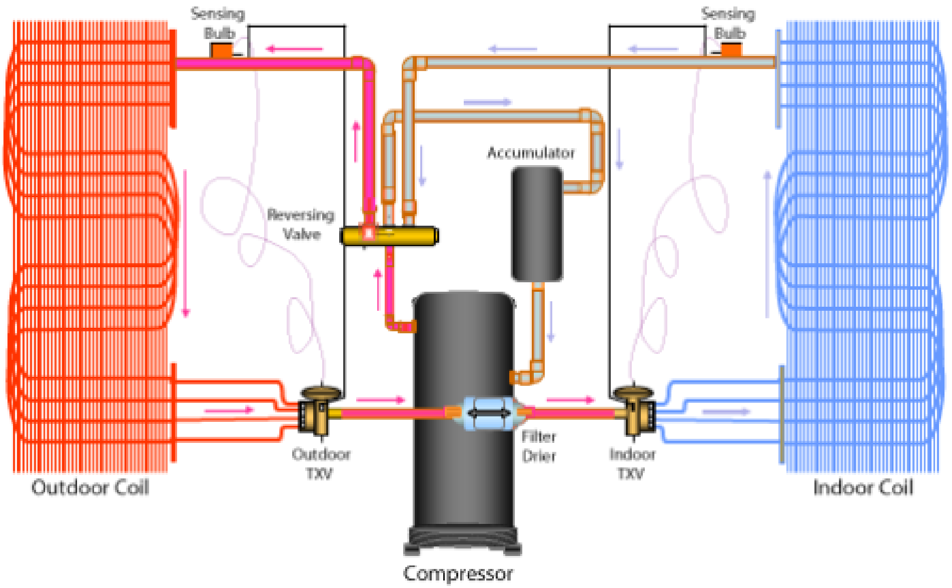
Lifting

To avoid back injuries, always adhere to proper lifting techniques. Be aware of personal limitations and seek help with items that are too heavy to safely lift. A back support belt may provide additional protection.

03

Component Familiarization

Heat Pump Cycle



Heat Pump Cooling Cycle

Overview

This section discusses the general heat pump cycle operations. Every heat pump has

- Outdoor Coil
- Indoor Coil
- Reversing Valve
- Compressor
- Outdoor Metering Device
- Indoor Metering Device
- Liquid Drier
- Accumulator

Cooling Mode

The heat pump cooling mode is like a conventional system cooling operation. Heat pumps operating in cooling mode utilize the outdoor coil as a condenser, which rejects heat to the outdoor air. Hot high-pressure refrigerant is discharged from the compressor into the reversing valve. The refrigerant is then routed to the outdoor coil. Since heat transfer is from hot to cold, the cooler ambient air passing over the outdoor coil absorbs heat from the refrigerant.

As the air passes through the outdoor coil, the ambient air begins to cool the hot discharge gas down to the refrigerant's saturation temperature. This is known as de- superheating the refrigerant. After the refrigerant has been de-superheated, the refrigerant will begin to condense into a liquid.

After the refrigerant has condensed to a liquid and the outdoor fan motor continues to move air across the coil, the condensed liquid refrigerant will cool below the saturation temperature. This is known as "subcooling".

The ability of the coil to sub-cool the refrigerant is important to make sure that 100% liquid refrigerant is delivered to the indoor metering device during cooling. As the liquid refrigerant leaves the outdoor coil, the refrigerant is carried to the metering device in the liquid line.

Heating Mode

Throughout this guide, the concentration will be on the heat pump cycle, necessary components to operate a heat pump, and how each component functions in the heat pump cycle. These include:

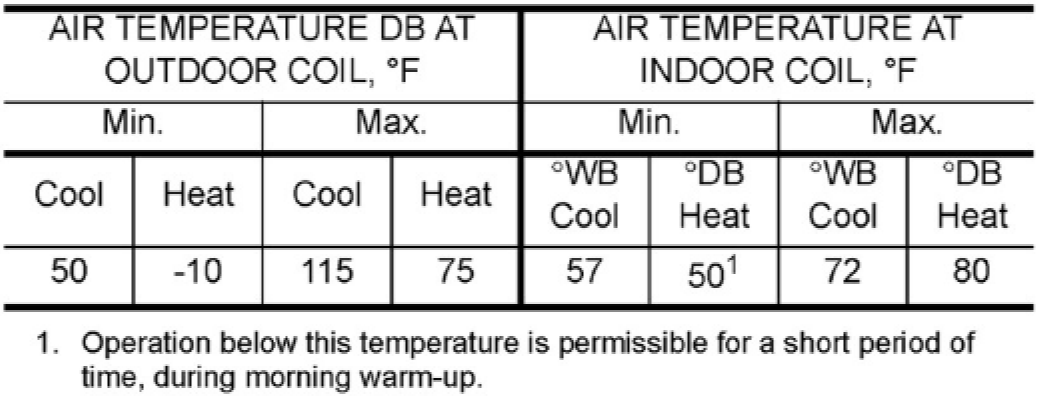
- Reversing valve ("four-way valve")
- Accumulator
- Defrost control board.
- Coil (Liquid Line) temperature sensor
- Ambient (Outdoor Air) temperature sensor

Since the heat pump is used during heating and cooling operation, the terms "evaporator" and "condenser" are called the "indoor coil" and "outdoor coil".

Note

Heat pumps have minimum and maximum operating temperatures for heating and cooling operation that must be followed. Various models of the 1.5-to-5-ton heat pump units are not designed to operate with any kind of low ambient hit unless specifically noted in the Installation Manual. The heat pump units must not be modified to use a low ambient kit.

Evaluate the “Application Limitations” table in the Installation Manual, to verify the designed operating conditions for proper equipment operation.

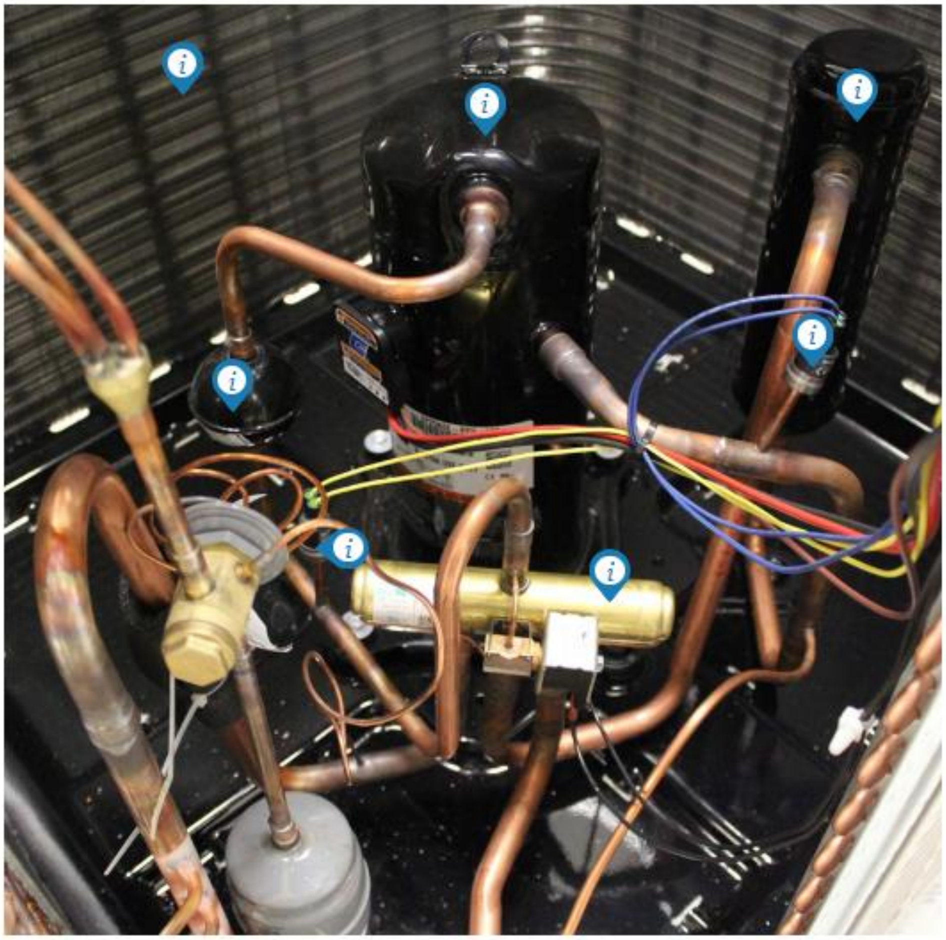


AIR TEMPERATURE DB AT OUTDOOR COIL, °F				AIR TEMPERATURE AT INDOOR COIL, °F			
Min.		Max.		Min.		Max.	
Cool	Heat	Cool	Heat	°WB Cool	°DB Heat	°WB Cool	°DB Heat
50	-10	115	75	57	50[1]	72	80

[1] Operation below this temperature is permissible for a short period of time, during morning warm-up.

Example of Minimum & Maximum Operating Temperature Table

Along with the additional refrigeration components, there will be an additional controls, piping configurations, and sequences of operation that will be discussed throughout this guide. This will include the defrost control board, supplemental/auxiliary heat, and how the defrost cycle is utilized.



Heat Pump Interior

Compressors

The compressor creates a pressure difference, moves refrigerant through the system, and transforms refrigerant from a low-pressure vapor to a high-pressure vapor. The pressure of the refrigerant entering the inlet ("suction") side of the compressor is the low side pressure or suction pressure.

A compressor is a vapor pump only. It is important to use proper charging methods to ensure that there is no liquid refrigerant returning to the compressor. This is known as liquid flood back or "slugging" which can destroy the compressor.

The compressor increases the pressure of the cool vapor returning to the compressor and creates a pressure difference within the system. As the cool vapor enters the compressor, it is transformed from a low-pressure vapor to a high-pressure vapor. This increases the pressure and temperature of the refrigerant.

The compressor raises the temperature of the refrigerant above the ambient temperature of the outdoor coil during cooling, and above the ambient air moving across the indoor coil during the heating mode of operation. This allows the heat to be rejected to the surrounding air. The vapor refrigerant is compressed and discharged from the compressor. The refrigerant leaving the compressor has been compressed to a hot discharge gas.

Hot discharge vapor is a combination of heat absorbed in the coil, heat from compression, and heat from the compressor itself. The hot discharge gas is pumped from the compressor through the discharge line to the appropriate coil which is dependent on whether the mode of operation is "Heating", "Cooling", or "Defrost".

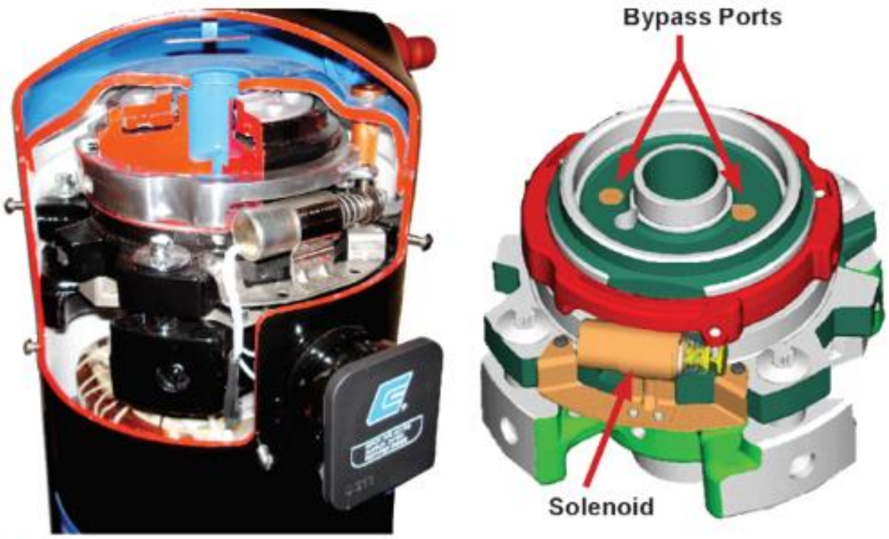
Scroll Compressor

Scroll Compressor & Internal Scroll Components

In a scroll compressor, an orbiting scroll moves in a circular motion within a second, fixed scroll. The low-pressure refrigerant vapor entering the suction inlet is pressurized into continuously smaller areas until the refrigerant exits through the discharge line as a high-pressure vapor.

Two-Stage Scroll Compressor

The Copeland two stage scroll compressor has two internal bypass ports. When the bypass ports are open, the compressor operates at 67% capacity. A call for 1st stage operation energizes the contactor which starts the compressor at 67% capacity. A call for 2nd stage operation energizes an internal solenoid, which closes the bypass ports for 100% capacity.



Two-stage Compressor

Reciprocating Compressor

Some models in the product line contain a reciprocating compressor. Reciprocating compressors use pistons that travel up and down (reciprocate) within cylinders to compress refrigerant vapor. On the “down stroke”, a suction inlet valve is opened, and low-pressure vapor refrigerant is drawn into the cylinder. When the piston begins its “up stroke”, the suction inlet valve is closed. The piston compresses low pressure vapor into high pressure vapor and the high-pressure vapor exits through the discharge port.

Reciprocating Compressor

Outdoor Coil

Cooling Mode

Heat pumps operating in cooling mode utilize the outdoor coil as a condenser, which rejects heat to the outdoor air. Hot discharge vapor is pumped from the compressor into the outdoor coil. The cooler outdoor air begins to remove heat from the refrigerant and rejects the heat to the outdoor air. The heat within the vapor can only move in one direction, from warmer to cooler, and is rejected from the refrigerant through the coil surface to the outdoor air.

As the air passes through the outdoor coil, the ambient air begins to cool the hot discharge gas down to the refrigerant's saturation temperature. This is known as de- superheating the refrigerant. After the refrigerant has been de-superheated, the refrigerant will begin to condense into a liquid.

After the refrigerant has condensed to a liquid and the outdoor fan motor continues to move air across the coil, the condensed liquid refrigerant will cool below the saturation temperature. This is known as "subcooling".

The ability of the coil to sub cools the refrigerant is important to make sure that 100% liquid refrigerant is delivered to the indoor metering device during cooling. As the liquid refrigerant leaves the outdoor coil, the refrigerant is carried to the metering device in the liquid line.

Heating Mode

Heat pumps operating in heating mode utilize the outdoor coil to absorb heat from the ambient air. Although the outdoor air is significantly cooler than the space being conditioned, there is a great quantity of BTUs that can be absorbed from the air and transferred into the refrigerant. The heat absorbed into the refrigerant from the outdoor air is then compressed and directed to the indoor coil with the reversing valve. The hot discharge vapor is pumped into the indoor coil and is used to heat the air being supplied to the structure.

A clean, unobstructed coil is critical to its heat transfer capabilities and overall system efficiency. During installation, follow all recommendations regarding minimum spacing and clearances from surrounding structures and other equipment.

Metering Devices

Although only one metering device is controlling the flow of refrigerant at any one time, heat pumps have two metering devices within the piping system: one at the inlet of the outdoor coil for heating operation and one at the inlet of the indoor coil for cooling operation. The metering devices allow unrestricted refrigerant flow in one direction and will regulate refrigerant flow in the opposite direction. This eliminates the use of check valves and additional piping within the system, allowing the refrigerant to flow in either direction through the liquid line.

On the inlet or upstream side of the metering device is a high-pressure liquid refrigerant being supplied to the appropriate metering device for the thermostat's mode of operation. The liquid refrigerant enters the metering device. As the refrigerant passes through the metering device, it is introduced into the low side of the system and drops in pressure.

TXV (Thermostatic Expansion Valve)

The TXV is a common metering device used in heat pump systems. The TXVS installed in these units should be charged by weight or field adjusted by the subcooling methods that are identified in this guide, on the unit, or in the Installation Manual accompanying the equipment. The TXV is designed to maintain a constant superheat within the coil.

The factory-installed metering device on the outdoor unit controls the flow of refrigerant to the outdoor coil during the heating cycle.

The metering device on the indoor unit controls the flow of refrigerant to the indoor coil during the cooling cycle.

Indoor Coil

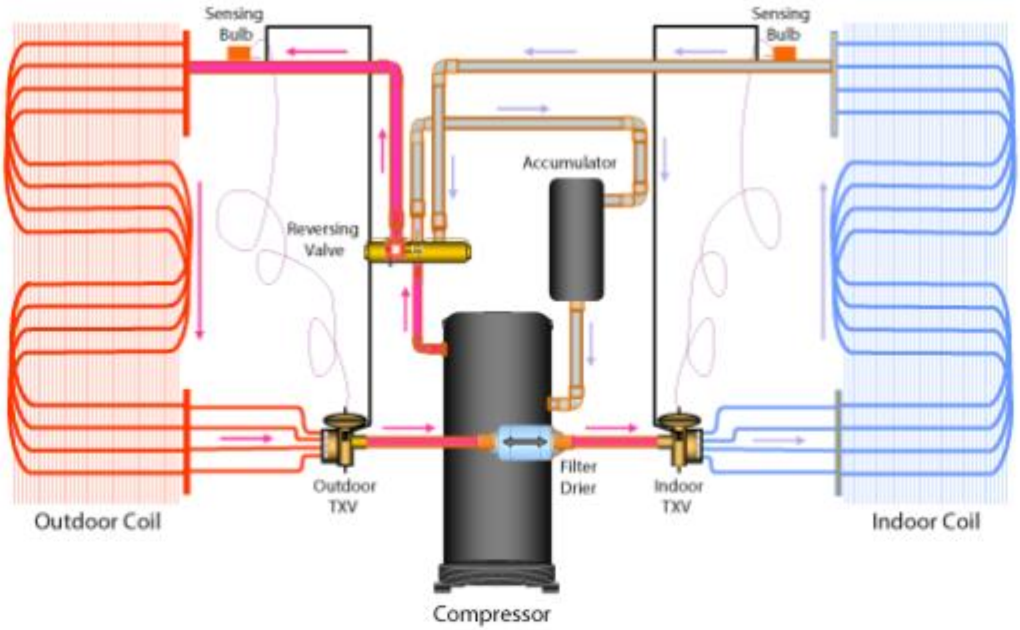
In the cooling mode, heat pumps use the indoor coil as an evaporator. The purpose of the evaporator is to absorb heat from the conditioned space and to change the state of the refrigerant from a liquid to 100% vapor. The return air from inside the structure is moved across the indoor coil with the indoor fan motor. As the heat from the warm return air is passed through the coil, the refrigerant starts to absorb heat from the air and begins to boil the refrigerant into a vapor. The indoor fan continues to move the return air across the coil and the vapor refrigerant is heated above the boiling point or saturation temperature. This is known as “superheat”.

The proper amount of superheated vapor ensures that 100% vapor returns to the compressor, preventing liquid flood back (slugging) of the compressor. The low temperature, superheated vapor will also help cool and maintain the compressor's designed operating temperature.

In the heating mode, heat pumps use the indoor coil as a condenser. The indoor coil is heated by the hot discharge gas leaving the compressor. As the return air is moved across the indoor coil, the return air absorbs heat from the refrigerant within the coil to heat the conditioned space. As the heat is absorbed out of the refrigerant, the refrigerant is changed from a hot gas to a liquid and is pumped to the metering device in the outdoor unit.

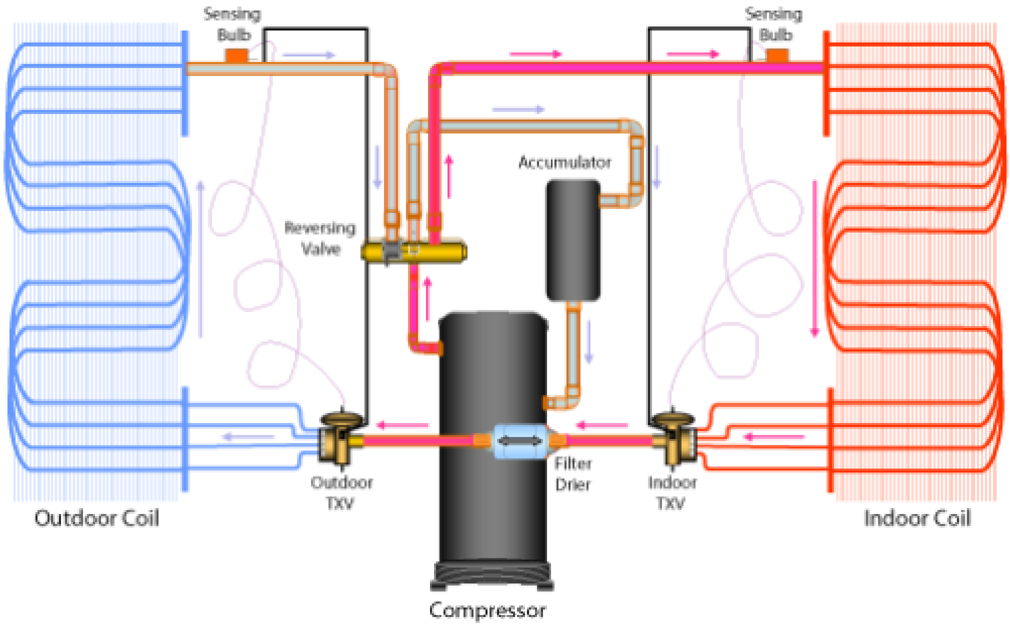
Indoor Coil

Quick Overview of Cooling & Heating Cycles



Heat Pump Cooling Cycle

During the cooling cycle, warm return air is moved across the indoor coil with the indoor fan motor. The refrigerant in the indoor coil begins to absorb heat from the air and starts to boil off to a vapor. The vapor refrigerant continues to absorb heat from the return air, super-hating the vapor and sending the low temperature superheated vapor to the compressor. The compressor compresses the vapor refrigerant increasing the pressure and temperature of the refrigerant. The refrigerant's temperature is increased above ambient temperature to allow the outdoor unit to reject heat from it. As the outdoor fan motor moves ambient air across the coil, the refrigerant is de-super-heated, condensed, and sub-cooled. The sub-cooled refrigerant is pumped to the metering device feeding refrigerant to the indoor coil. The refrigerant enters the metering device as 100% liquid. As the refrigerant passes through the metering device, the refrigerant drops in pressure and flash gas are produced. The flash gas removes heat from the refrigerant and drops the temperature of the refrigerant, changing the refrigerant to approximately 80% liquid and 20% vapor. This cool refrigerant is pumped through the 80/20 line and into the indoor coil as the cycle starts again.



Heat Pump Heating Cycle

During the heating cycle, cool return air is moved across the indoor coil with the indoor fan motor. The hot discharge vapor refrigerant entering the indoor coil begins to de-super-heat, condense, and sub-cool as the return air absorbs heat from the refrigerant. The refrigerant leaving the indoor coil should be in a liquid state. The liquid refrigerant is pumped through the liquid line to the metering device feeding the outdoor coil.

The refrigerant enters the metering device as 100% liquid. As the refrigerant passes through the metering device, the refrigerant drops in pressure and flash gas are produced. The flash gas removes heat from the refrigerant and drops the temperature of the refrigerant below the ambient temperature surrounding the outdoor coil. As the refrigerant enters the outdoor coil, the refrigerant is approximately 80% liquid and 20% vapor. As the outdoor fan motor moves the ambient air across the coil, the refrigerant absorbs heat from the air and begins to boil off into 100% vapor. The vapor continues to absorb heat from the outdoor air and is heated above the boiling point. The vapor is now super-heated.

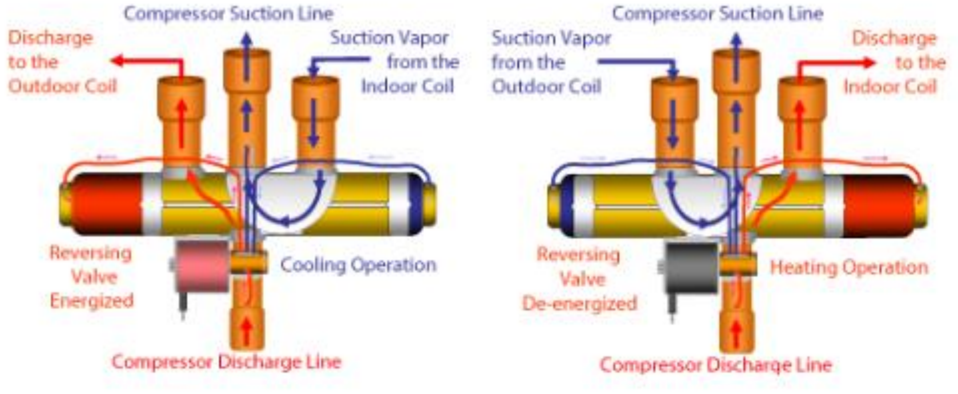
The super-heated vapor is then pumped to the compressor. The compressor compresses the vapor refrigerant increasing the pressure and temperature of the refrigerant. The hot discharge vapor is pumped to the indoor coil and the cycle starts again.

Reversing Valve

The reversing valve, or "four-way valve", changes the direction of the refrigerant flow through the system based on system mode.

The reversing valve is energized during cooling and defrost operation and is de- energized during the heating mode. The reversing valve is controlled by a 24-volt AC signal sent from the defrost control board.

During the cooling cycle, the heat pump operates like an ordinary air conditioning system. The reversing valve is energized, hot discharge gas is directed to the outdoor coil, and the cool suction vapor is pulled from the indoor coil. During the heating cycle, the reversing valve is de-energized. The suction vapor is pulled from the outdoor coil which has absorbed heat from the outdoor air. The hot gas is discharged to the indoor coil to provide heat for the conditioned space.



Reversing Valve in Cooling & Heating Operation

When the solenoid on the reversing valve is energized or de-energized, a small valve on the front changes position. This directs high discharge pressure from the discharge line entering the reversing valve to one end of the internal slide.

The opposite end of the internal slide is connected to a small capillary tube. The capillary tube relieves pressure to the suction line leaving the reversing valve. This pressure difference across the slide moves the slide to the opposite end of the reversing valve. This action redirects the hot discharge gas and the suction gas through the appropriate coils. When the reversing valve is de-energized, the internal slide is shifted back to the original position. When the slide is shifted, the hot discharge gas and the suction gas are redirected between the indoor and outdoor coils.

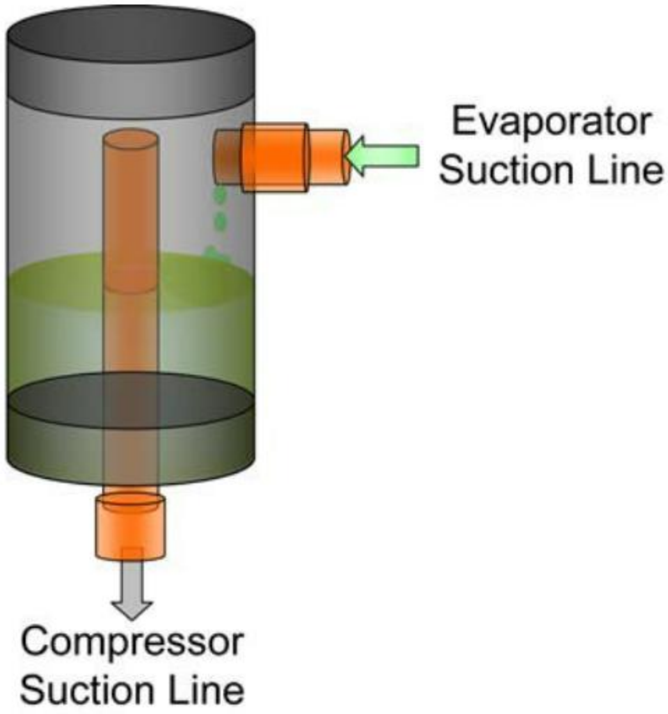
Accumulator

In a heat pump application, the accumulator is installed between the reversing valve and the compressor. The accumulator ensures that any liquid refrigerant that exits the coil, such as can occur during defrost, has a holding location. The refrigerant boils back into a vapor before entering the compressor. This prevents liquid refrigerant slugging of the compressor.

The accumulator is constructed to allow the liquid refrigerant to drop to the bottom of the cylinder.

The suction line is then attached to the
outlet of the accumulator and is designed to pull vapor from the top of the cylinder. This provides additional protection against liquid flood-back or slugging of the compressor.

Accumulator



Standpipe Suction Line

Control Panel

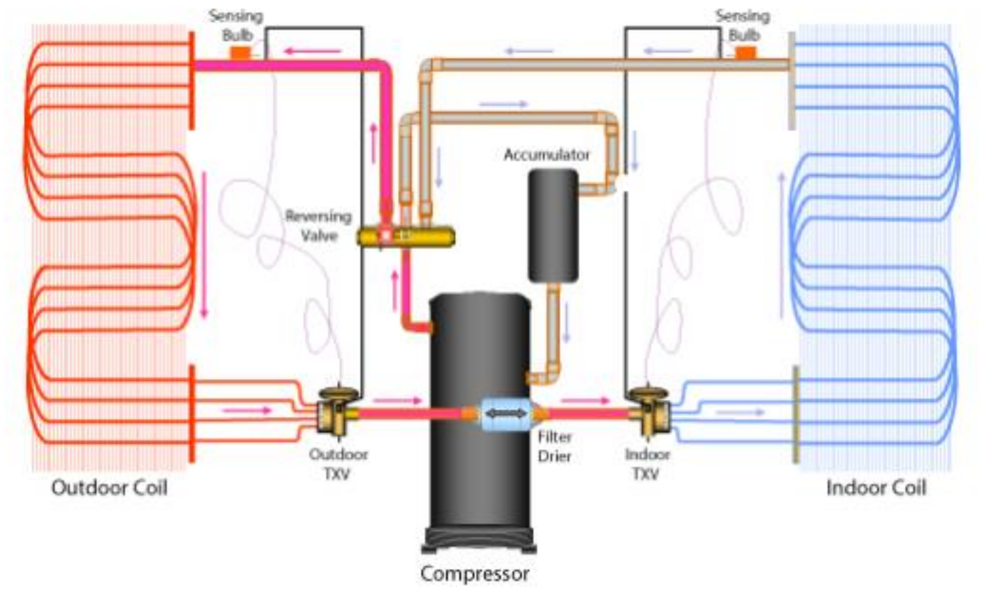
The control panel contains the defrost control board, contactor, capacitors and start components (when used) and access to the outdoor air thermistor. Line voltage and low voltage connections are made here, with wiring entering the cabinet through the supplied knockouts.

Control Panel

Defrost Control Board

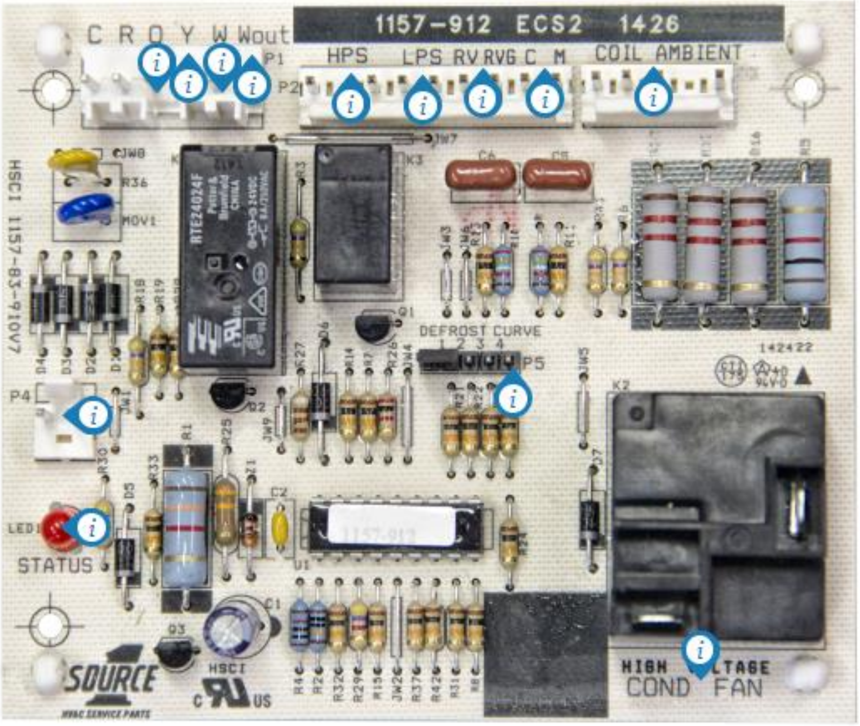
In the heating mode, the defrost control board receives inputs from an ambient (outdoor) temperature sensor and a coil (liquid line) temperature sensor. When the senor temperature indicates that frost or ice as accumulated on the outdoor coil, and the ambient temperature is within the defrost curve parameters programmed into the control board, a defrost cycle is initiated to remove the ice from the coil.

When a defrost cycle is initiated, the control board energizes the reversing valve, routing hot discharge gas to the outdoor coil to melt the frost or ice. At the same time, the outdoor fan is de-energized, which increases the effect of the hot discharge gas and decreases the amount of time the system has to remain in defrost.



Heat Pump Defrost Cycle

Heat Pump Control Board Connection Points



Defrost Control Board

Defrost Curves Characteristics

Split System Demand Defrost				
Jumper position	**1**	**2**	**3**	**4**
Coupling Assumed	----	----	----	----
Initiate 1	33.5° @ 50°F amb	37.2° @ 50°F amb	40.7° @ 50°F amb	36.5° @ 50°F amb
Initiate 2	-3.3° @ 0°F amb	-5.6° @ 0°F amb	-10.4° @ 0°F amb	-8.2° @ 0°F amb
Initiate Curve Equation	DefT = (0.737*AmbT) - 3.316	DefT = (0.856*AmbT) - 5.593	DefT = (1.022*AmbT) - 10.378	DefT = (0.894* AmbT) - 8.206
Defrost Inhibit Temp	40°F (Coil)	40°F (Coil)	40°F (Coil)	40°F (Coil)
Defrost Inhibit Time Limit	40 min.	40 min.	40 min.	40 min.
Defrost Terminate Temp	55°F	55°F	55°F	80°F
Maximum Defrost Cycle Time	14 Min	14 Min	14 Min	14 Min
Compressor Delay Time	N/A	N/A	N/A	N/A

Thermistor Inputs – General

All thermistor inputs are provided by a thermistor with nominal resistance as shown.

Nominal Resistance (K ohms)	Temperature (C)
10.0	25
32.65	0
85.52	-17.8

The control detects the state of the thermistor based on the values shown.

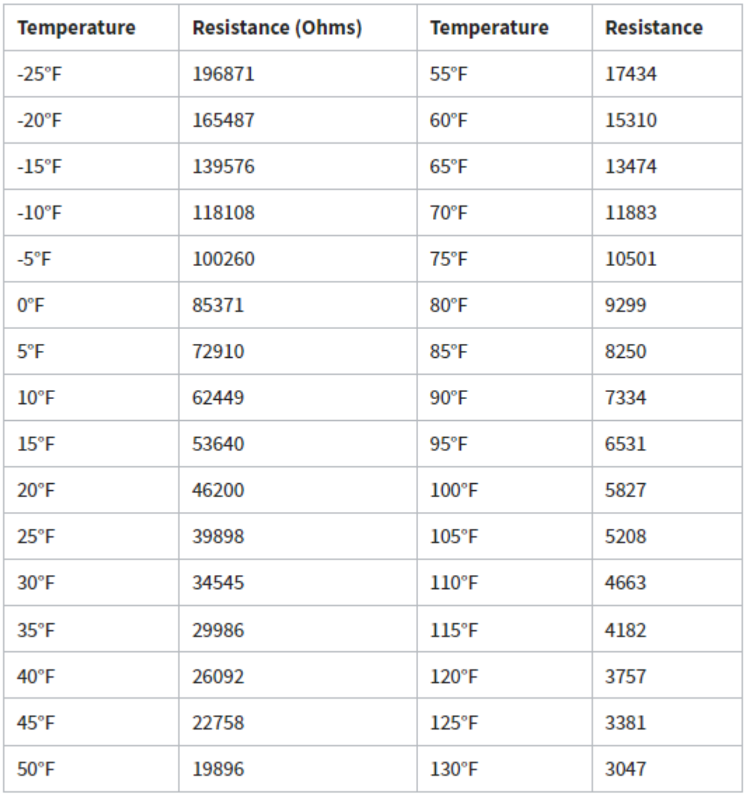
Thermistor Input	Shorted Thermistor Definition (Resistance in Ohms)	Open Thermistor Definition (Resistance in Ohms)
Liquid Line	<1000	>350,000
Outdoor Ambient	<1000	>350,000

Thermistor Input	Primary Operational Range (F)	Accuracy over Primary Operational Range (+/- F)
Liquid Line	- 25 to 90	1
Outdoor Ambient	- 10 to 110	1

Liquid Line Thermistor Temperature/ Resistance/ Voltage Conversion

Temperature	Resistance (Ohms)	Temperature	Resistance
-25°F	196871	45°F	22758
-20°F	165487	50°F	19896
-15°F	139576	55°F	17434
-10°F	118108	60°F	15310
-5°F	100260	65°F	13474
0°F	85371	70°F	11883
5°F	72910	75°F	10501
10°F	62449	80°F	9299
15°F	53640	85°F	8250
20°F	46200	90°F	7334
25°F	39898	95°F	6531
30°F	34545	100°F	5827
35°F	29986	105°F	5208
40°F	26092	110°F	4663

Outdoor Ambient Thermistor Temperature/ Resistance/ Voltage Conversion



Temperature	Resistance (Ohms)	Temperature	Resistance
-25°F	196871	55°F	17434
-20°F	165487	60°F	15310
-15°F	139576	65°F	13474
-10°F	118108	70°F	11883
-5°F	100260	75°F	10501
0°F	85371	80°F	9299
5°F	72910	85°F	8250
10°F	62449	90°F	7334
15°F	53640	95°F	6531
20°F	46200	100°F	5827
25°F	39898	105°F	5208
30°F	34545	110°F	4663
35°F	29986	115°F	4182
40°F	26092	120°F	3757
45°F	22758	125°F	3381
50°F	19896	130°F	3047

Timers & Delays

The control accumulates compressor run time whenever the M relay contacts are closed. All defrost timers are based on accumulated compressor run time. The control resets all timers when power (24VAC) is removed from the control.
The timings specified throughout this guide are based on the control being supplied 60Hz. If the control is installed where it is being supplied 50Hz all timings will be 20% longer than specified in this document.

Power Interruption

If the power to the control is interrupted for less than 20 milliseconds, the control resumes operation at the same point in the timing cycle. The control will not change modes of operation due to a power interruption of less than 20 milliseconds. Relays may temporarily drop out during the power interruption.

Power interruptions over 20 but less than 50 milliseconds are to reset the short cycle timer. If the compressor was energized, it de-energizes for the short cycle time to prevent the compressor contactor from chattering. Defrost timing is not to be affected below 100 ms. Power interruptions greater than 100 milliseconds may reset the control as a power-up sequence. Power interruptions of any duration are not to cause lockout.

Anti-Short Cycle Delay (ASCD) Timer

The ASCD timer prevents the compressor from starting within the timer duration after power loss or the completion of a compressor cycle. The duration of the timer is 5 minutes.

Low Voltage Sensing

The control can sense a low voltage condition. If the average voltage drops below 19.2VAC (+/- 1.0V) for longer than 125ms, the control will not energize any relay outputs. If a relay is already energized, it remains energized unless the average voltage drops below 16VAC (+/- 1.0V) for longer than 125mS. If the average voltage drops below 16VAC (+/- 1.0V) for longer than 125mS, the relays open and de-energize any relay outputs.

The ASCD period is initiated. The control will not re-energize the outputs until the average voltage is above 19.2VAC (+/- 1.0V) for longer than 125mS and the ASCD expires for the compressor outputs. Note that the specified voltages are for room temperature conditions. Voltages may vary more than +/- 1.0 VAC at temperature extremes. If the average voltage is between 16 VAC and 19.2 VAC and the control needs to change the outputs based on thermostat inputs or any condition changes, the control de-energizes the relay outputs as if the voltage dropped to below 16 VAC.

Coil (Liquid Line) Temperature Sensor

The coil temperature sensor, sometimes called a liquid temperature sensor, is a 10K thermistor installed on the bottom section of the outdoor coil. The distance from the base pan to the coil temperature sensor can vary depending on the model and tonnage of the unit.

Coil Temperature Sensor

High-Pressure Switch (HPS)

The high-pressure switch is in the control circuit and designed to protect the system against excessive high side or discharge pressures. There are multiple conditions which could cause this switch to open and de-energize the compressor.

The high-pressure switch is piped into the discharge line between the compressor and the reversing valve. This will allow the “HPS” to monitor the high side pressure during both heating and cooling operation.

Excessive head pressure is commonly caused by poor airflow across the outdoor coil during cooling and across the indoor coil during heating operation.
During cooling operation excessive discharge pressure may be caused by:

- Dirty outdoor coil
- Failed outdoor fan motor.
- Improper outdoor fan speed

During heating operation excessive discharge pressure may be caused by:

- Dirty return air filter
- Dirty indoor coil
- Improper duct sizing
- Restriction in the supply or return air duct.
- Inoperative or too low indoor fan speed

It is also possible for the excessive discharge pressure to be caused by overcharging the system and/ or having non-condensable such as air or nitrogen in the system. The high-pressure switch opens at specific pressures that are dependent on the type of refrigerant the system uses. The technician should refer to the specific equipment model when ordering a replacement switch.

Low-Pressure Switch (HPS)

The low-pressure switch in the liquid line is designed to open if there is a loss of refrigerant charge.

The defrost control board will ignore the low-pressure switch input during any of the following conditions:

- During the first two minutes of compressor operation
- During defrost mode
- During the first two minutes after the defrost is terminated
- During the “TEST” mode with a “Y1” input from the thermostat

The low-pressure switches open at 30+/- 5 psig and reset at 60+/- 5 psig. If the refrigerant pressure drops below 30 psig for more than 5 seconds, the control enters a soft lockout. When a soft lockout is initiated, the control will display the appropriate fault code using the onboard LEDs (Light Emitting Diodes).

Low Pressure Switch

Crankcase Heater (CCH)

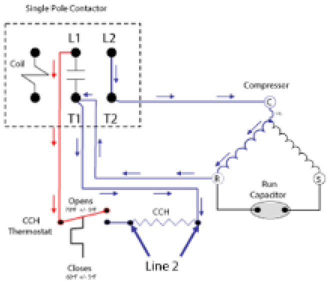
The crankcase heater (CCH) is provided on some models as a factory option. It is also available as a field-installed accessory. By default, refrigerant migrates to the coldest area of the refrigeration system during the units off cycle. During the colder times of the season, refrigerant will migrate to the outdoor unit and condense in the oil within the compressor’s crankcase. The sole purpose of the CCH is to add heat to the compressor’s crankcase and warm the oil during the off cycle. When the risk of refrigerant migration exists, the technician should consider adding a CCH to the system.

If the compressor is energized when refrigerant is mixed with the oil, the compressor can fail from inadequate lubrication. The CCH will warm the oil enough to vaporize any refrigerant that may be present within the crankcase. There are two additional methods of wiring the crankcase heater determined by the compressor contactor and the circuit design. If the contactor is a single pole contactor, the CCH is energized during the compressors off cycle and de-energized during the run cycle.

Crankcase Heater Thermostat

A crankcase heater thermostat is sometimes provided to cycle the crankcase heater during low ambient temperature conditions.

The CCH thermostat is designed to open when the ambient temperature reaches 70 degrees F +/- 5 degrees F. This will keep the crankcase heater de-energize when ambient temperatures are warm enough to prevent refrigerant migration to the compressor's crankcase.



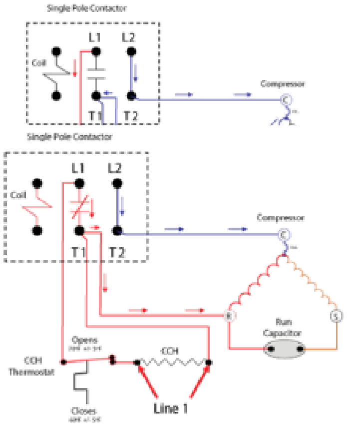
Example 1 of Crankcase Heater Thermostat

When the ambient temperature drops to 60 degrees F +/- 5 degrees F, the thermostat will close as can be seen in Example 2.

Although the CCH thermostat may close during low ambient conditions, the contactor must be de-energized and the contacts between terminals "L1" and "T1" must be open for the crankcase heater to be energized.

As can be seen in Example 2, when the ambient temperature drops to 60 degrees F +/- 5 degrees F and the CCH thermostat closes, power from "L1" is sent through the thermostat to one side of the crankcase heater.

The second line of power is provided to the crankcase heater from the "L2" terminal of the contactor, out of the "T2" terminal and through the run winding of the compressor.



Example 3 of Crankcase Heater Thermostat

In Example 3, the crankcase heater is energized by the current taking the path of least resistance. The crankcase heater has greater resistance than the run winding of the compressor. This allows the lower resistance run winding to be used as a conductor providing power to one side of the crankcase heater.

The crank case heater is de-energized as the electrical current takes the path of least resistance through the contacts between terminals "L1" and "T1", bypassing the crankcase heater and energizing the compressor.

As can be seen in Example 3, the crankcase heater has "Line 1" on both sides of the heater and will not be energized even if the CCH thermostat is closed.

Thermostat

The heat pump thermostat controls system operation in the following modes:

Mode	24-volt AC Output
Heating	Y
Cooling	Y, O
Emergency Heat	W
Continuous Fan	G

Note the energization of the “O” terminal in cooling mode. This energizes the reversing valve. The de-energized reversing valve defaults to the heating mode.

Heat Pump Thermostat

Contactor

The contactors are energized on a call for heating or cooling by 24 volts AC signal coming from the defrost control board. When 24 volts AC is applied to the contactor coil, the contacts close ("pull in"). This allows line voltage to energize the compressor and outdoor fan motor circuits.

If 24 volts AC is present at the contactor coil and the contactor does not pull in, further troubleshooting of the contactor coil should be completed.

The unit should be locked out at the equipment disconnect before any resistance readings are taken. Depending on the model of indoor unit and the thermostat settings, it is possible for 24 volts AC to be present at the contactor coil. Proper Lock- Out Tag-out procedures for both the indoor unit and outdoor units is essential to provide a safe work environment when attempting to use an ohm meter to troubleshoot a system.

At least one of the control wires feeding the contactor coil should be disconnected prior to taking a resistance reading. An ohmmeter may be used to measure the resistance reading across the contactor coil. An infinite reading indicates the coil is open and a reading of zero ohms indicates a shorted coil.

If it has been determined that the coil is open or shorted, the contactor must be replaced. The line voltage on the load side of the contactor should match the line voltage on the line side of the contactor. If it does not, evaluate the contacts for pitting, dirt, or corrosion.

Capacitors (Single Phase Motors Only)

Capacitors are rated in microfarads and also have a voltage rating on the case of the capacitor. Microfarads are usually identified on the capacitor with a number value, the Greek symbol "u" for micro, and an "F" for farad.

Example: 370 volts AC / 45 µF

When a run capacitor is tested with a capacitor analyzer, the run capacitors should test to within the µF % rating on the capacitor. Start capacitors should test equal to or up to 20% greater than the µF rating on the capacitor. If the test indicates that a start capacitor has less than the rated uF, the capacitor should be replaced.

The voltage rating on the capacitor does not represent the line voltage applied to the equipment. Instead, this voltage rating is the maximum amount of back electromotive force (BEMF) the capacitor can have applied to it during normal operation without damage occurring. In some instances, the motor data plate will provide a different voltage that is acceptable during normal operation. A capacitor should only have a replacement rated equal to or greater than the existing capacitor's voltage rating.

For Example:

If a run capacitor is rated at 10 µF +/-10% and 370 volts AC, it is possible to replace the capacitor with a capacitor rated at 9 µF and 440 volts AC. This is within +/-10% of the µF rating and the new capacitor is rated for a voltage greater than or equal to the rating of the existing capacitor.

Note
Capacitors may have stored energy even though the electrical disconnect has been locked out and line voltage has been removed from the system. Use a resistor to bleed the stored voltage from the capacitor. A 20,000 ohm 2-watt resistor is recommended. Do not use a screwdriver to bleed the capacitor. Improper bleeding of the capacitor can cause damage to the capacitor and to the motor itself.

Run Capacitor (Single Phase Motors Only)

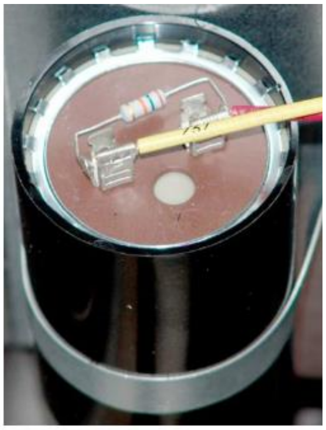
The run capacitor provides enhanced running torque to the motor. Run capacitors are installed on single phase compressors and PSC (Permanent Split Capacitor) fan motors. The run capacitor is in the circuit 100% of the time; thus, the case of the run capacitor is impregnated with oil, which assists in cooling the capacitor and allows the capacitor to remain in operation for the entire run cycle.

Run Capacitor

Note
Run capacitors are often marked with an identified terminal on the top of the capacitor. If the capacitor is marked for polarity, the identified terminal must be wired to the "run" terminal of the motor.

Start Capacitor (Reciprocating Compressors Only)

The start capacitor adds additional torque to the compressor when starting up. The start capacitor is only in the circuit on compressor start- up; therefore, the start capacitor must have a relay to remove the capacitor from the circuit. A start capacitor and start relay are collectively referred to as a "hard start kit".

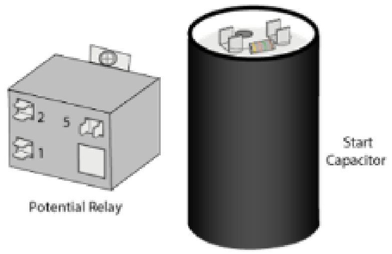


Start Capacitor

Hard Start Kit (Single Phase Compressors Only)

Outdoor unit model numbers ending with an "H" have a factory installed hard start kit which is required when a TXV is installed on the indoor unit.

Outdoor unit model numbers with no "H" ending do not require a hard start kit unless a TXV is being installed on the indoor unit or unless local regulations dictate it.



Hard Start Kit

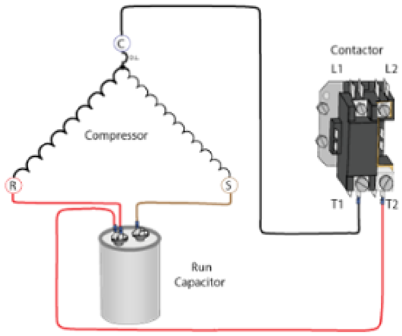
The Tabular Data Sheet which comes with the unit specifies whether a hard start kit is required. When a TXV Kit is needed, it should be ordered from Source 1.

When the motor is energized, supply voltage is applied to the start capacitor. The start capacitor increases the starting torque of the motor, and the rotor begins to turn. Once the rotor has reached 75% of running speed, the potential relay coil is energized by the counter electromotive force produced from the start winding. When enough counter electromotive force is produced from the start winding, the normally closed set of contacts open. When the normally closed contact on the potential relay opens, the start capacitor is electrically removed from the circuit. The start capacitor must be removed from the circuit after startup or damage to the start winding and/or start capacitor will occur.

Motor Types

PSC (Permanent Split Capacitance) Motor (Single Phase Only)

The PSC motor contains a start winding and a run winding. The PSC motor has a run capacitor wired between the run and start winding as shown in the diagram.



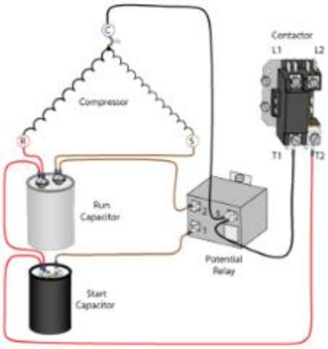
Electrical Diagram of PSC Motor

CSR (Capacitor Start Capacitor Run) Motor (Single Phase Compressors Only)

The CSR motor is electrically wired the same as a PSC motor with the addition of a start capacitor and a relay wired in the circuit as seen in the diagram.

The potential relay is designed to remove the start capacitor from the circuit at approximately 75% of motor start up. Note the proper electrical wiring of each of the motors installed on the equipment. Improper wiring can result in equipment failure and can be very costly.

All connections should be checked and corrected prior to energizing the system.



Electrical Diagram of CSR Motor

Liquid Line & Suction Line Service Valves

Heat pumps are made with liquid line and suction line service valves on the corner section of the outdoor unit. These provide access to both the high and low side of the system during installation and service. The outdoor coil is shipped with the service valves in the fully front seated (clockwise) position. The service valves isolate and hold the refrigerant charge in the outdoor unit. The technician must install and braze all lineset and indoor coil connections. Secondly, the lineset and indoor coil should be leak tested and a proper evacuation performed down to 500 microns. After evacuation, the service valves should be fully back seated (counterclockwise). This will release the refrigerant into the lineset and indoor coil.

Liquid Line & Suction Line Service Valves

The outdoor unit is shipped pre-charged with enough refrigerant for the outdoor coil, 15 feet of lineset, and the smallest matched indoor coil. If a longer lineset or larger indoor coil is required, additional refrigerant will have to be added as indicated in the Tabular Data Sheet. The heat pump must be matched with the proper indoor unit and coil if the system is to achieve system performance ratings. If the lineset is shorter than 15 feet, it may be necessary to recover refrigerant to meet the proper charge for the system.

When servicing the equipment, it is important to identify which mode of operation the equipment is in when installing the manifold gauge set. A measurement can be taken of the low side pressure at the suction service valve when the unit is operating in the cooling mode, but not in the heating mode. The suction service valve is downstream of the reversing valve, and if the system is in the heating cycle, the pressure measured will be of the compressor discharge pressure, instead of the suction pressure. There is a Schrader valve located directly above the service valves. The Schrader valve is attached to the suction line between the accumulator and the compressor and is used to measure the suction pressure in both heating and cooling operation.

Identify the type of refrigerant the equipment uses. Then use the corresponding manifold gauges and correct refrigerant when servicing the equipment. This will provide proper operation and prevent equipment damage.

Liquid Line Filter Drier

The purpose of the liquid line filter drier is to trap moisture, acid, and small particles within the drier; effectively stopping the contaminants from traveling through the system and causing damage.

A solid core, bi-flow filter/drier located in the liquid line in the outdoor unit, mounted between the liquid line service valve and the outdoor coil metering device.

The filter driers are designed for specific refrigerants and pressures. Only filter driers that are designed for sue on the system being serviced should be installed. Replacement driers must match the filter drier originally installed by the manufacturer.

A restricted liquid line filter drier can be diagnosed by taking a temperature measurement. Allow the system to operate for at least ten minutes and then take a temperature measurement on both sides of the drier. If the temperature has dropped more than two degrees Fahrenheit, the drier should be replaced.

Note
Caution must be taken when installing a liquid line filter drier in the system. Use an approved heat sink to protect the metering device, filter drier, and service valves when brazing.

Discharge Line Muffler

The discharge line muffler reduces line vibration related ot refrigerant compression.

Discharge Line Muffler

Electrical Wiring

All field wiring must be installed using copper conductors only and must be grounded with a separate ground wire in accordance with all local and national fire, safety, and electrical codes. The electrical supply must meet the values specified on the unit nameplate and wiring labels. All conductors for power wiring, control wiring, the electrical disconnect, and over protection must be provided by the installer and be sized in accordance with the most current National Electrical Code (NEC).

Power Wiring

All equipment must have a properly rated and sized weatherproof disconnect switch located outdoors and within sight of the unit. Some municipalities may require a licensed electrical contractor to provide the line voltage electrical connections to the outdoor unit from the electrical disconnect. All equipment must be protected either by properly sized time-delay fuses or circuit breakers rated in accordance with the NEC.

Control Wiring

All control wiring must be installed in accordance with the National Electrical Code and/or local city or state codes, whichever is more stringent. The complete electrical wiring diagram and schematics are located on the unit in the service access panel for reference.

Snow Risers/Outdoor Unit

A snow riser kit provides additional clearance for an outdoor unit where snow levels could reach a height that restricts airflow across the coil. Depending on the average snow fall, some municipalities require that snow risers be installed.

If snow or ice restricts the airflow across the coil, it is possible that the heat pump will not be capable of properly defrosting the coil. This can result in:

- Efficiency loss
- Excessive defrost cycles.
- Improper heating of the structure
- Liquid flood back
- Compressor failure

R-410A

R-410A pressures are approximately 60% higher than a comparable R-22 system. All components in the system must be rated to handle higher pressure. This includes a manifold gauge set and refrigerant recovery machine designed to handle the higher pressures of R-410A.

Due to the higher pressures, all field connections should be made with brazing rod that has a minimum of 5% silver content. Soft solder must not be used to connections in R-410A systems.

Components designed for use with R-410A are usually tagged with a rose-pink label that is the same color as a cylinder of R-410A.

R-410A Cylinder

R-410A is not compatible with the mineral based refrigerant oil used in R-22 systems. R-410A systems use synthetic oil called polyol Ester (POE). POE is not compatible with mineral oil as used in R-22 systems; therefore, service tools that touch the refrigerant side of the system, such as the manifold gauge set, recovery cylinders, and recovery machines should be dedicated to a single refrigerant only. Do not risk mixing the oils as it may compromise the system. POE oil is very hygroscopic, which means that it has a great affinity for water. Any moisture in the system will cause system problems. This is where good service techniques really become important; especially regarding proper evacuation of the lineset and indoor coil prior to system start up. A liquid line filter drier must be installed with every R-410A system installation.

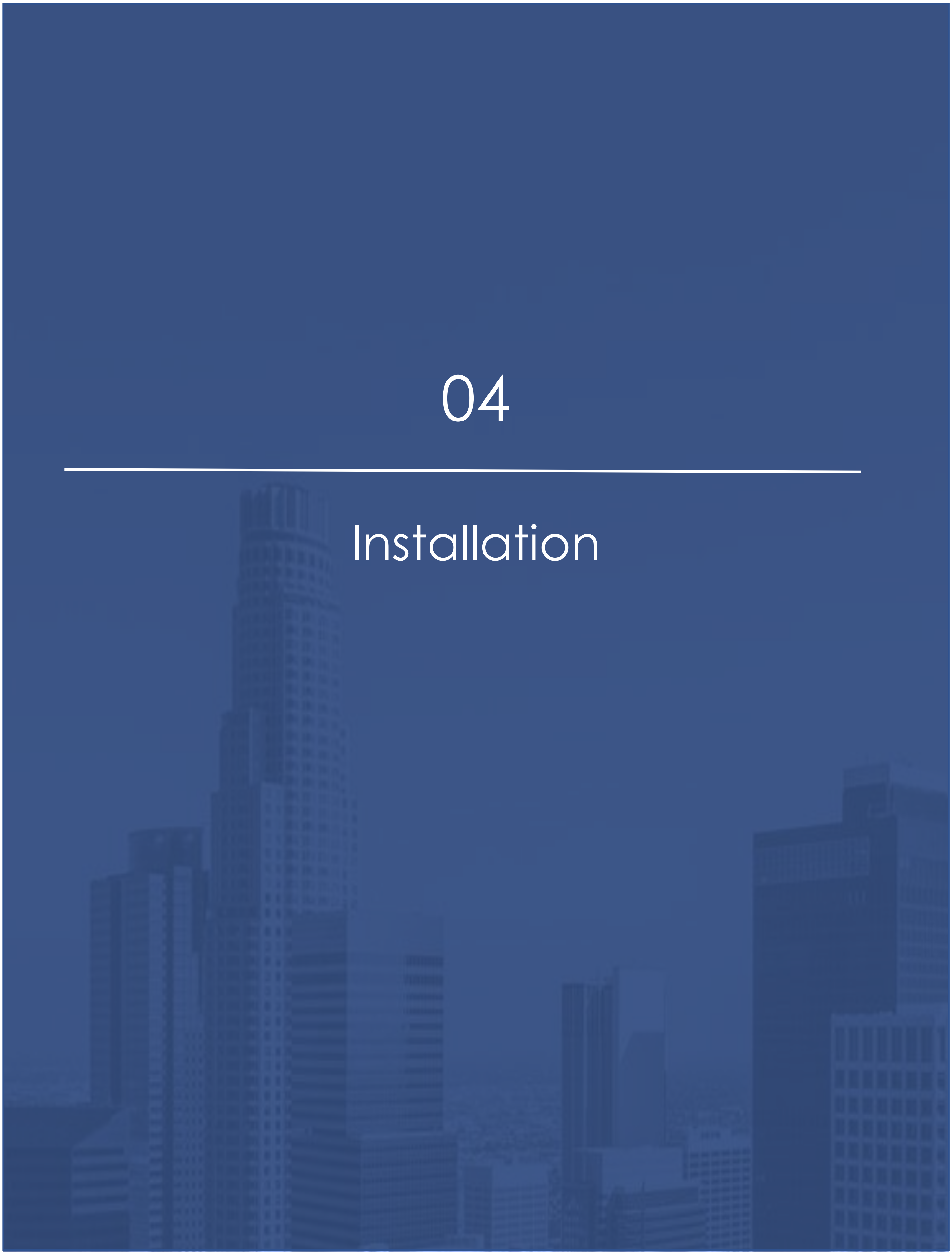
Most of the heat pumps are shipped with a liquid line filter drier and do not require a field installed drier. The technician must evaluate the piping to verify that the drier was factory installed prior to completing the installation. Anytime the system is opened to the atmosphere during a repair, the old drier must be removed and replaced with an approved filter drier.

Note
Caution should be exercised when retrofitting an existing system to prevent mixing mineral and POE refrigerant oils. If possible, a new lineset and indoor coil should be installed with the new heat pump. This ensures there is no residual mineral oil that could affect system operation.

Expansion valves that are compatible with R-410A must be used with these systems. Do not use a non-approved metering device.

When adding refrigerant to an R-410A system, the refrigerant must be taken out of the cylinder in liquid form. This eliminates any possibility for the refrigerant to fractionate (separate into its individual components). A quick-charge adapter will flash the liquid R-410A into vapor before it enters the suction line. Alternately, the liquid line may be “throttled” into the suction line. Use caution when letting the liquid refrigerant enter the suction line while throttling the low side manifold valve. Throttling the valve properly allows the refrigerant to flash to vapor before entering the suction side of the compressor.

With the R-410A systems requiring a fixed orifice metering device, the system should be charged using the recommended superheat values outlined in the Installation Manual that accompanied the equipment.

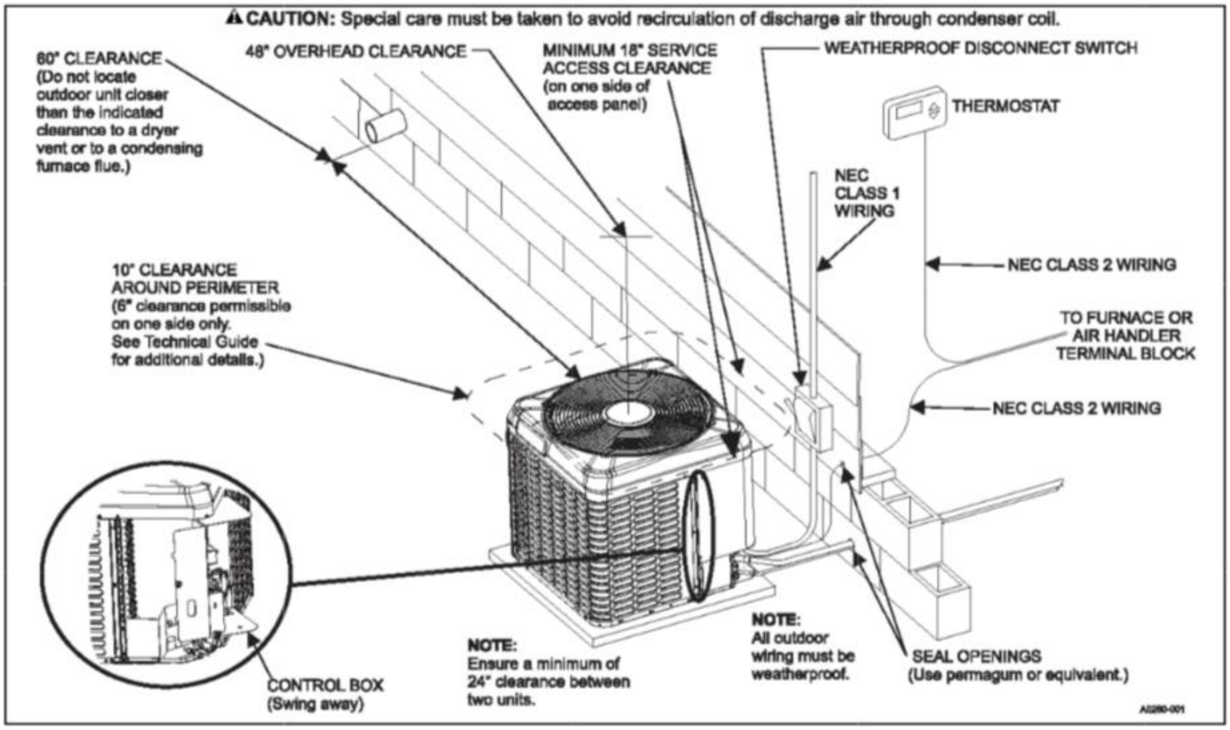


04

Installation

Introduction

The heat pump units shall be installed in accordance with all current local, city, state, and national laws or code requirements. If the equipment is installed outside of the United States, all laws, and codes within the country of origin shall be adhered to.



Typical Installation

The technician must follow the installation procedures specified in the Installation Manual. If the specifications are exceeded by code, or if code is exceeded by the specifications, adhere to the most restrictive code requirements.

Thermostat

If the thermostat is not selected to match the equipment's operating requirements or if the thermostat is not installed properly, the system cannot provide adequate comfort within the structure.

Thermostats should be level and mounted on an interior wall. Thermostats mounted on walls around the perimeter of a structure will not sense accurate temperatures and the length of the run cycles will increase. This will cause overshooting of the thermostat settings, decreased comfort levels, and inefficient system operation.

The thermostat should be mounted on the wall at eye level and away from the supply air registers. A thermostat that is in the supply air stream will short cycle the equipment and result in uncomfortable space temperatures and / or equipment failure. The heat anticipator must be set to the requirements provided in the Installation Manual for the model installed.

Some electronic thermostats do not have adjustable heat anticipators. They may have cycle rate adjustment settings rather than anticipator settings. The cycle rate adjustment setting should be set to the recommended cycle rating for the unit installed.

Some electronic thermostats do not have adjustable heat anticipators. They may have cycle rate adjustment settings rather than anticipator settings. The cycle rate adjustment setting should be set to the recommended cycle rating for the unit installed.

Electrical Wiring

All electrical connections and components shall be installed in accordance with current national electrical code requirements within the United States, or current national codes within the country of origin where the equipment is being installed.

The power supply should be a dedicated circuit with the proper equipment grounding and circuit protection. Failure to provide adequate wire sizing, circuit protection and equipment grounding will result in improper system operation, property damage, personal injury, and/ or loss of life.

When installing an electric air handler or furnace as the supplemental heat source, the power supply should be upgraded to provide adequate conductor sizing and circuit protection for the equipment.

All electrical conduits entering the controls section of the indoor unit and the outdoor unit should be sealed with an approved, non-conducting electrical sealant. This will prevent moisture from being pulled through the conduit and corroding electrical components within the controls section.

Prior to connecting the main power supply to the unit, the primary voltage taps to the transformer must be wired properly for the voltage being applied. If the transformer is not wired properly, electrical component failure will occur.

Control Wiring

A qualified installation technician should install the field supplied thermostat by following the installation instructions that accompany the thermostat and the electrical wiring diagrams shipped with the equipment. As has been discussed throughout this guide, thermostats should be selected with all the system's modes of operation taken into consideration.

With the thermostat and the electrical disconnect set to the "OFF" position and locked- out, connect the thermostat wiring from the wiring connections on the thermostat to the terminal strip as indicated in the Installation Manual. It is important to read the equipment Installation Manuals and provide control wiring to the appropriate control boards and terminal strips as indicated on the electrical wiring diagrams for the equipment being installed.

Electronic thermostats may require the common wire from the transformer's 24 volts AC secondary side to be connected to the "C" terminal. The digital display and electronics in the thermostat are powered by the transformer at the "R" and "C" terminals of the thermostat. All control wiring should have a minimum of 18-gauge wire.

Ductwork Installation

To properly design the ductwork for the structure, refer to the ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) Fundamentals Handbook chapter on "Duct Design", or Air Conditioning Contractors of America (ACCA) "Manual D".

Sizing, installing, and insulating the duct work shall also be in accordance with industry recognized procedures identified by the equipment specifications and duct manufacturer specifications.

The duct system must be designed properly per approved methods and matched to the equipment being installed. Improperly sized duct systems will result in loss of efficiency, equipment damage, structural damage, and indoor air quality problems.

Location & Clearances

The outdoor heat pump unit must be installed with proper clearances for airflow, servicing and defrost operation. Proper clearances shall be provided according to the Installation Manual that accompanies the unit.

All outdoor units installed at ground level shall be on a level pad or slab. The pad or slab location and dimensions shall also meet local code requirements.

Some heat pump installations may require risers to provide additional clearances from ground or roof level to the bottom of the unit.

The indoor unit has minimum clearances for proper operation, service, and safety. Follow all installation instructions shipped with the indoor unit. All local city, state, and national codes must be followed. Each of these units can have different clearances depending on whether the installer is using an electric air handler or furnace for supplemental heat. Additional clearances may also depend on whether the system is installed in a crawl space, attic, garage, or closet application.

Lineset

The lineset must be refrigerant rated copper that has been cleaned and dehydrated. Refrigeration or ACR copper has been manufactured to meet the requirements for installing heat pumps and air conditioners. The tubing has been cleaned internally, dehydrated, and capped at each end. The copper tubing should never be left uncapped for a long time. If the copper is open to the atmosphere, moisture can accumulate within the tubing and cause oxidation, extended evacuation, and cleanup time, and damage the system by producing acid.

Heat pumps have more internal moving parts than a typical air conditioning system. The reversing valve is susceptible to being damaged when the oxidation is moving through the valve during operation. This can damage the valve, causing it to stick and can damage the compressor.

Installing the lineset with as few bends or elbows as possible will help to ensure that the refrigerant and oil will flow without being restricted below the design of the equipment.

The lineset must be installed where it will not obstruct the technician's access to any portion of the equipment that may require future service or repair.

Insulate the suction/ vapor line with closed cell foam rubber. Insulation of the liquid line may also be required if the line is exposed to direct sunlight or extreme temperatures, which may cause the refrigerant to flash before entering the metering device.

Proper bending techniques must be used when installing soft drawn copper. Any copper tubing that has been distorted or kinked must be cut out and replaced.

The proper sizing of the lineset must be in accordance with the Installation Manual. Use of the Application Guidelines or the Comfort Cooling Piping Software located on Solution Navigator can assist in properly sizing copper tubing for various applications.

The heat pump will not be capable of operating to capacity if the lineset is undersized or oversized. In addition to reducing system capacity, improper line sizing will cause refrigerant and oil circulation problems resulting in reduced operating efficiency and shorten the equipment's life.

Special Considerations

The use of approved conduit, such as PVC (POLYVINYL CHORIDE), must be used for all underground piping installations. The length of buried lineset must be kept to a minimum. The vapor in the suction line can condense during shutdown and cause liquid to flood back on startup.

Proper suspension of copper tubing with approved hangers is required to isolate and reduce vibration. If the lineset is installed through a wall, an approved protective sleeve and sealing compound must be used to seal the penetration and protect the lineset.

Brazing

All indoor and outdoor coil connections are copper-to-copper and should be brazed with a phosphorous copper alloy material such as Silfos-5 or an equivalent brazing alloy with at least 5% silver content. Do not use soft solder.

The outdoor units have both liquid and vapor service valves located on the corner post. The service valves are provided with 1/4" flare fittings to install a service manifold set.


Silfos-5

Without Nitrogen

The system must be purged with dry nitrogen when brazing. Brazing reaches temperatures exceeding 800 degrees Fahrenheit. At these temperatures, oxidation will form inside of the copper tubing if dry nitrogen is not used, Oxidation Caused by Brazing Without Nitrogen Purge oxidation will form inside of the copper tubing as seen in the image.

The oxidation will be released from the copper tubing when the refrigerant is flowing through the system during normal operation. The oxidation will flow to the filter drier, metering device, and reversing valve causing improper operation and component failure.


Oxidation Caused by Brazing Without Nitrogen Purge

Heat sinks must be used to prevent heat damage to the equipment service valves, metering devices, filter driers, compressors, and reversing valve while brazing. A wet rag can be used to wrap around each of these devices to provide protection during installation.
Heat shields should be used to protect property and equipment including the structure, painted panels, wiring diagrams, data plates, and aluminum fins.
When connecting the lineset, use the following procedures:

- Remove the Schrader valve cap and core from the liquid and vapor service valves at the new outdoor unit.
- Low-pressure nitrogen should be connected to the liquid line service port and bleed through the lineset out of the vapor service port while brazing. A pressure regulator and safety valve must always be used on the nitrogen tank to ensure that only low pressure is applied to the system. Nitrogen should be flowing continually while the technician is brazing.
- The liquid line should be brazed to the liquid line service valve at the outdoor unit. The valve body must be wrapped with a wet rag to minimize the amount of heat the valve is exposed to.
- The plugs/caps should be carefully removed from the indoor coil connections and the pressure carefully bled off.
- The liquid line should be brazed to the indoor coil liquid line connection. Dry Nitrogen should be flowing through the indoor coil.
- The Installation Manual should be referred to for detailed instructions regarding the installation of an indoor TXV.
- The grommet must be pulled away from the vapor connection at the indoor coil. The vapor line is then brazed to the indoor coil vapor connection. After the brazed connection has cooled gradually, the grommet would be moved back into the original position.
- The vapor valve must be protected with a wet rag and the vapor line connection brazed to the outdoor unit. The flow of dry nitrogen should be exiting the system from the vapor service port connection.
- After the connections have been brazed and the joints have cooled gradually, the nitrogen can be valved off and removed from the liquid line service port.
- The Schrader valve cores should be replaced in the liquid and vapor valves.
- A leak test must be performed on all refrigerant piping connections including the service port flare caps to ensure they are leak tight. The caps should not be overtightened.

Pressure Testing

The lineset and indoor coil can be pressurized up to 250 psig with dry nitrogen and leak tested with a bubble type leak detector. Do not use refrigerant to purge or leak test the system. Do not exceed the rated test pressure located on the indoor coil data plate when pressure testing the system. The nitrogen charge can be released into the atmosphere.

Evacuation

The vapor line, indoor coil, and liquid line should be evacuated to 500 microns or less. This will allow the moisture and non-condensable time to be evacuated from the system.

- The service valves are opened by removing the top plunger cap and inserting a hex wrench into the stem while backing out counterclockwise until the valve stem just touches the retaining wall or ring. The vapor line should be opened first until the pressure is equalized. Once the pressure is equalized, the liquid line service valve can be backed out fully counterclockwise.
- The plunger cap should be finger tight and then tightened an additional 1/12th of a turn. The cap must be replaced to prevent leaks.

Note

If there is any chance that liquid refrigerant is present in the compressor's crankcase, the crankcase heater should be powered up to 24 hours prior to operating the compressor.

The caps should be replaced on the service ports. The flare caps must not be removed from the service ports and gauges connected except during start-up checks or when necessary for servicing the system. Approximately 3/4 ounce of refrigerant is lost each time they are connected. Over a long time, the system could become grossly undercharged due to installing and removing gauges when it may not be necessary.

If the refrigerant tubing, indoor coil, or outdoor coil develops a leak or is opened to the atmosphere during service, evacuate the system down to at least 500 microns to eliminate contamination and moisture in the system.
R-410A having POE (Polyol Ester) oil with much greater hygroscopic properties, utilizing all necessary tools and following installation procedures to ensure proper equipment operation is necessary.

Proper installation procedures include, but are not limited to:

- Brazing (with nitrogen purge)
- Pressure testing (with nitrogen up to 250 psig)
- Evacuation (500 microns)
- Purging manifold gauge set (with refrigerant)
- Charging methods
  - Weight (TXV or Fixed Orifice)
  - Subcooling (TXV)
  - Superheat (Fixed Orifice)

Condensate Drain (Indoor Coil)

The heat pump applications should be installed with a condensate drain plumbed from the indoor coil to an open drain. The condensate drain should have a condensate trap in the line. If an open drain is not available, contact the local authority having jurisdiction and identify local requirements for the condensate drain. The condensate drain should be sized properly, and all fittings and connections sealed with an approved sealing compound. After installation, the trap should be primed with water. Evaluate local building codes as to proper drainage for units installed in areas where a plugged drain could potentially cause property damage.

In many municipalities, it is required to have an auxiliary drain pan and/or float switch installed to provide additional protection to property. When the coil is installed in an attic or above a finished ceiling, install an auxiliary drain pan under the coil. The indoor coil should be installed level or slightly pitched toward the drain end of the pan no more than 1/4" per foot of slope.

When a secondary drain pan is utilized, the drain must be piped to a location that will provide a visual warning to the occupant if the primary drain becomes restricted. If a float switch is installed, the switch must be electrically wired to de-energize the compressor if a restriction occurs preventing the condensate from draining properly.

Outdoor Unit Drainage

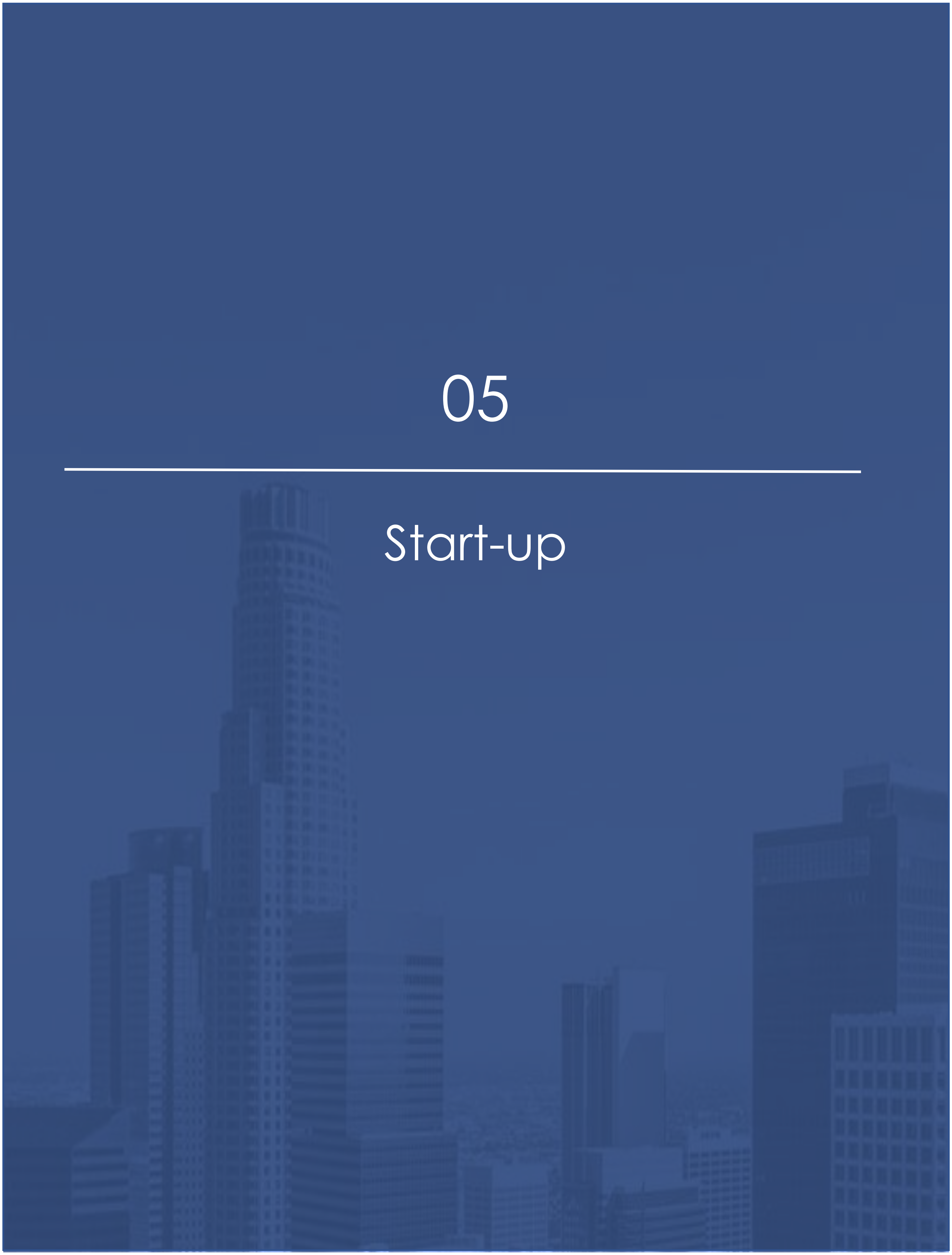
When installing a heat pump, the drainage for the heat pump during defrost operation must also be considered. Proper drainage should not allow moisture from defrost to drain toward walkways or areas that may produce slip hazards or damage to property.

Filters

The filters used with these units must be installed with an approved filter kit properly sized for the system. The filter sizes should be entered on the start-up sheet when the system is installed. Never operate the unit without a suitable air filter system.

Equipment Sizing

Equipment sizing should be based on heat loss/ heat gain calculations and completed in accordance with industry-recognized procedures identified by the Air Conditioning Contractors of America (ACCA).



05

Start-up

Airflow Setup

Airflow in all modes of operation MUST be established upon installation in all instances. Do not assume anything is "factory set." **Each job varies and as such, blower speed selections must be properly established in the field for each mode of system operation without exception.**

Speed Selection

The required airflow must be established PRIOR TO evaluating the system refrigerant charge.

Proper airflow establishment involves measurement of external static pressure (ESP) in cooling mode and selection of appropriate blower speed taps that provide 350-450 CFM per ton of cooling in the cooling mode, and provide a temperature rise within the range listed on the unit data plate in the heating mode. Refer to the airflow tables in the Installation Instructions that correspond with the duct configuration (side or down discharge).

External Static Pressure (ESP)

As with most all residential equipment, residential gas electric package systems are designed to provide their rated airflow at up to .5" w.c. total external static pressure. External static pressures greater than .5" w.c. will cause a reduction in indoor airflow volume and may lead to comfort and operational issues. Be sure to locate and correct the source(s) of airflow restriction before trying to start the system.

Understanding airflow configuration and limitations is a critical element of HVAC (Heating Ventilation and Air Conditioning) service work. This knowledge must be at the forefront of service and installation activities.

All systems, including those that utilize the ECM (Electronically Commutated Motors) indoor fan motors, have airflow limitations. If a system does not have the proper ductwork, the unit will not meet the designed seasonal energy efficiency ratings, system operational sound will be greater than expected, and the system may also experience component failures.

The measurement of external static pressure (ESP) and proper adjustment is of the utmost importance if the system is going to operate to design conditions.

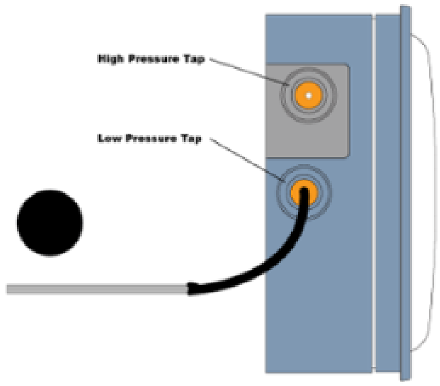
Restrictions in the duct system, such as undersized ducts, dirty filters, dirty indoor coil and closed or blocked registers, will cause the external static pressure to increase. As the external static pressure increases, the unit's ability to move air decreases. Most residential heat pumps are designed to deliver a maximum airflow up to .5" w.c. of total, external static pressure.

Using the Magnehelic

A common tool of choice for measuring ESP is the Magnehelic© gauge or an incline manometer. The example below illustrates the use of the Magnehelic© gauge. Keep in mind that the measurement procedure and probe placement will be identical with an incline manometer.

The Magnehelic© gauge has two ports, labeled "high" and "low". The "high" port causes the value shown by the needle to increase if pressure is being put into the port. This port is connected to the supply side of the system, as will be discussed.

The port marked "low" causes the value shown by the needle to increase if there is a negative pressure on the port. This port is connected to the return side of the system as close to the unit as possible.



Magnehelic© Gauge Side View

Supply Static Pressure Measurement

To measure the supply static pressure, the Magnehelic© gauge probe is connected to the port marked "high". The probe is inserted immediately off the supply duct connection or as close to the takeoff as possible.

Return Static Pressure Measurement

To measure the return static pressure, the Magnehelic© probe is connected to the port marked "low". The probe should be inserted in the return air duct as close to the unit as possible between the return air filter and the indoor unit.

Total External Static Pressure (ESP) Measurement

To measure the total external static pressure, the supply air static pressure and the return air static pressure measurements should be added together.

Example:

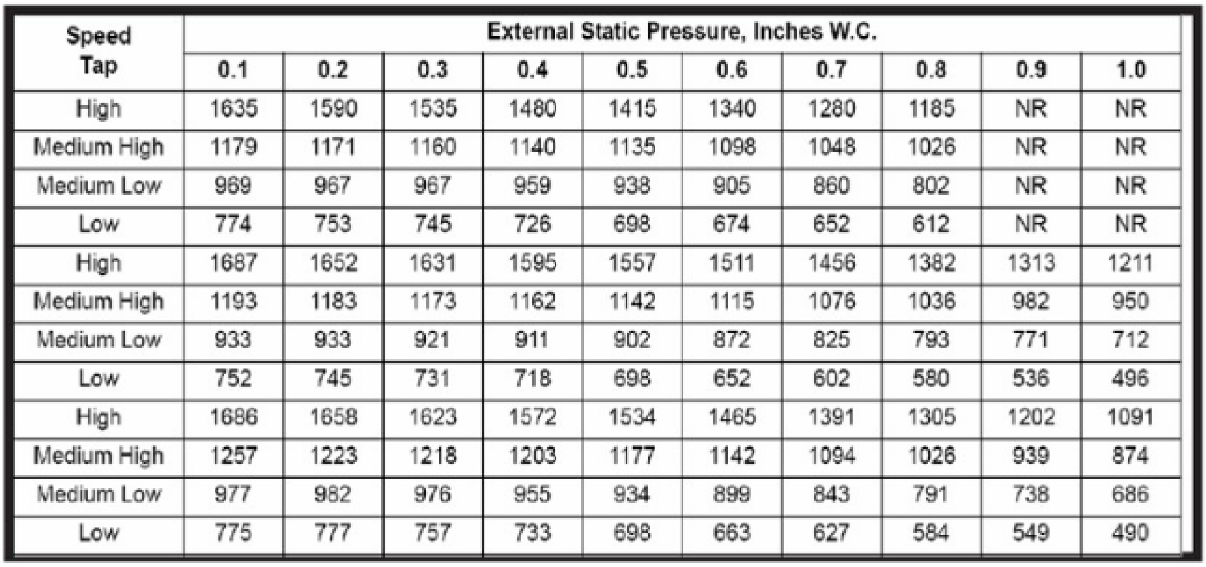
Supply Air Static: .3" W.c.
Return Air Static: + -.2" W.c.
____
= Total ESP = .5" W.c.

If the total pressure exceeds the designed maximum allowable ESP on the equipment data plate, the duct system must be evaluated to ensure that it is sized properly.

Standard ECM & PSC (Permanent Split Capacitance) Indoor Fan Motors

Speed tap adjustments are made at the terminal block for PSC or Standard ECM motors. Units with ECM motors are adjusted using the CFM selector board on the indoor unit. Use the blower performance data in the Installation Manual or the Technical Guide to set up proper air flow. The chart below is an example of a blower performance chart that should be used to identify the proper fan selection for approximately 400 CFM per ton of cooling and heat pump operation.

To achieve the desired indoor air flow, connect the motor wires to the corresponding motor speed tap receptacle located on the motor housing. Motor wiring details are located on the unit wiring label.



Speed Tap	External Static Pressure, Inches W.C.									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
High	1635	1590	1535	1480	1415	1340	1280	1185	NR	NR
Medium High	1179	1171	1160	1140	1135	1098	1048	1026	NR	NR
Medium Low	969	967	967	959	938	905	860	802	NR	NR
Low	774	753	745	726	698	674	652	612	NR	NR
High	1687	1652	1631	1595	1557	1511	1456	1382	1313	1211
Medium High	1193	1183	1173	1162	1142	1115	1076	1036	982	950
Medium Low	933	933	921	911	902	872	825	793	771	712
Low	752	745	731	718	698	652	602	580	536	496
High	1686	1658	1623	1572	1534	1465	1391	1305	1202	1091
Medium High	1257	1223	1218	1203	1177	1142	1094	1026	939	874
Medium Low	977	982	976	955	934	899	843	791	738	686
Low	775	777	757	733	698	663	627	584	549	490

Example of Blower Performance CFM Chart

ECM Indoor Fan Motors

The airflow and comfort setting selection must be set properly at the time of installation and start-up for proper system operation. The jumpers must be placed in the proper location based on the information shown in the installation Manual.

Note
Incorrect airflow and comfort settings may result in decreased system efficiency and performance.

The furnaces and air handlers used for supplemental heating will have four tap selections and four jumper sets on the indoor unit control board if an ECM indoor fan is utilized. Use the Installation Manual to identify the proper jumper selection for the specific model being serviced or installed. The "ECM Indoor Fan Motor" chart below is an example and should only be used for training purposes. The tap selections are labeled "cooling", "heating", "adjust", and "delay". Each of these tap selections has four jumper positions labeled "A", "B", "C", or "D". Both the "cool" and the "adjust" tap selections must be set for the cooling airflow (CFM). The set up for cooling air flow is the same as was discussed in the Standard ECM and PSC section. For the system to operate at design efficiency, nominal cooling air flow must be set at 400 CFM with a maximum of 0.5" water column (w.c.).

ECM fan motors are designed to deliver a constant airflow (CFM) even when external static pressure (ESP) in the duct system exceeds the recommended 0.5" w.c. value. Therefore, if too many supply registers are closed, a filter becomes clogged, or if there is a restriction in the duct work, the motor will automatically operate at a higher speed and torque to compensate for the higher ESP. This will result in a higher operating sound level and reduced electrical efficiency.

All airflow (CFM) is shown at 0.5" w.c. external static pressure. Variable speed ECMs automatically adjust to provide constant CFM from 0.0" to 0.6" w.c. static pressure. From 0.6" to 1.0" w.c. static pressure, CFM is reduced by 2% per 0.1" w.c. increase in external static pressure. Operation of duct systems with greater than 1.0" w.c. external static pressure is not recommended.

Cooling & Heat Pump Indoor Blower Set-Up

The outdoor unit Technical Guide must be referenced for the recommended airflow with the matching evaporator coil. Refer to the Installation Manual for cooling and heat pump airflow settings like the ECM Indoor Fan Motor table above. The "cool" and "adjust" jumpers should be set on the control as indicated in the table to match the desired air flow. The heat pump airflow setting is the same as the cooling airflow setting; however, the "mode" jumper on the indoor unit to the heat pump should be set to the "YES" position for proper operation.

Supplemental Heat Indoor Blower Set-Up

The blower speed required for supplemental heating is different than the settings for cooling. Tables located in the furnace or air handler Installation Manual must be referenced for the possible CFM selections.

After adjusting the jumper selection, verify that the equipment is providing the required airflow by performing an air temperature rise (ATR) calculation and an external static pressure measurement (ESP). The ATR and ESP measurements and calculations will be discussed in greater detail later in this chapter.

The tables within the Installation Manual are like the examples in the tables below. The tables in the Installation Manual must be referenced to identify the required heat jumper selection by the BTU input or by the model number of the indoor unit being installed.

The "adjust" tap selection does not affect the supplemental heat setting. The cooling and heat pump airflow settings are directly affected when the "cool" and "adjust" jumpers are moved.

Comfort Delay Profiles

DELAY Tap Selection:

The "delay" tap provides four profiles. Each of the four profiles have unique fan cycling characteristics that will allow the fan to maximize comfort levels in various climates for cooling and heat pump operation. "Delay" tap selection does not apply and is not to be adjusted for gas heating mode.

Delay Tap	Comfort Setting
A	Normal
B	Humid
C	Dry
D	Temperate

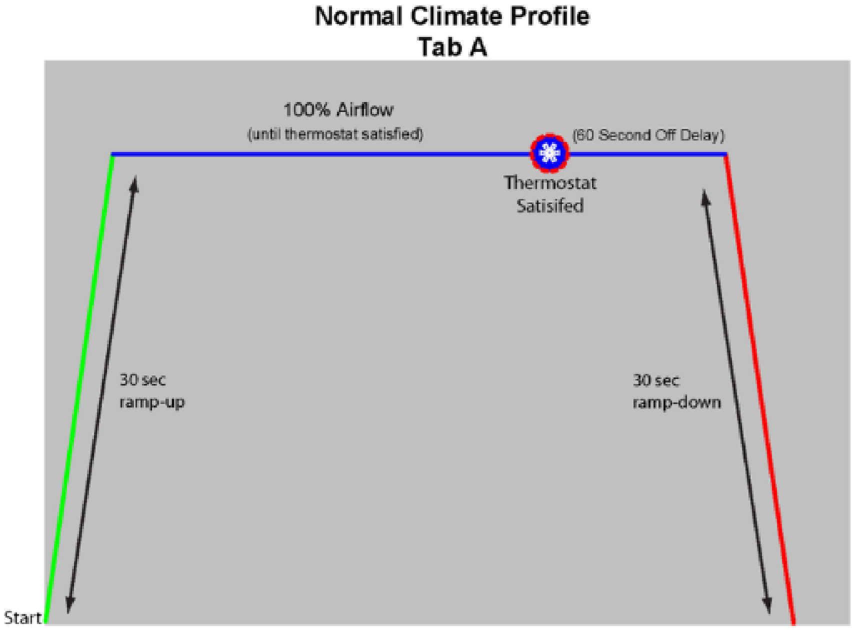
Throughout this section, the text references the “ramp-up” and “ramp-down” times to be 15 to 30 seconds or 30 to 60 seconds. The time variation is dependent on the model of the equipment and control board on the unit.

Normal

A - Factory Standard Default Profile:

Thermostat call: 15 to 30-second ramp-up to 100% CFM

Thermostat satisfies: 60-second off delay and then a 15 to 30-second ramp-down to zero CFM.



Normal / Default Climate Profile

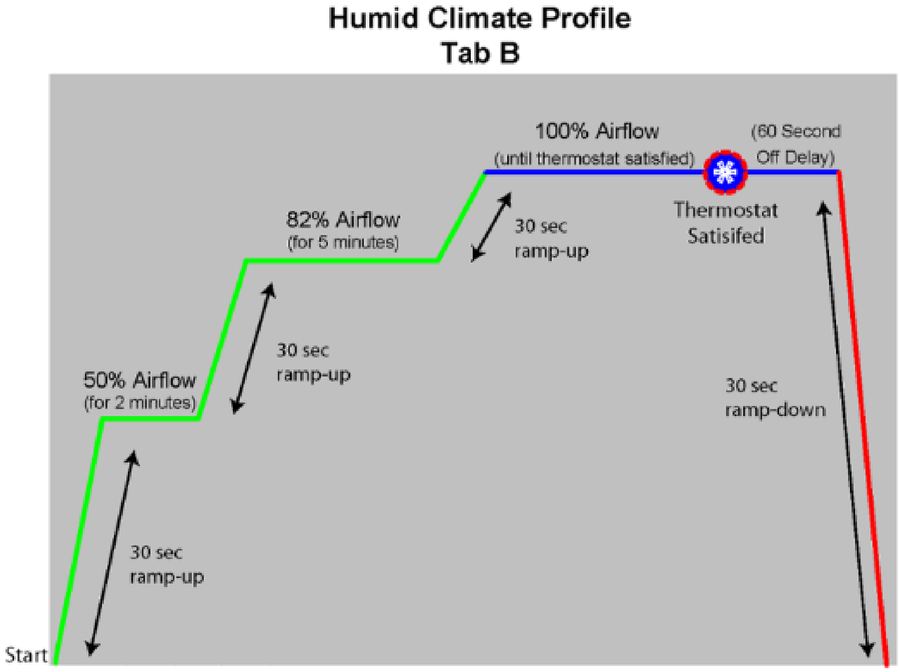
The "normal" setting provides a 15 to 30-second ramp-up from zero airflow to full capacity and a 15 to 30 second ramp-down from full capacity back to zero airflow. Whenever there is a change in airflow mode, such as a call for cooling or a change from low heat to high heat, the motor will take 15 to 30 seconds to ramp from one speed to the other. After reaching cut-off, the motor will have a 60-second off delay and then will ramp down to zero airflow.

Humid

B-Humid Profile:

Thermostat call: 15 to 30-second ramp-up to 50% of CFM for 2 minutes. After 2 minutes: 15 to 30-second ramp-up to 82% of CFM for 5 minutes.

After 5 minutes: 15 to 30-second ramp-up to 100% of CFM until thermostat satisfies. Thermostat satisfies: 60-second off delay and a 15 to 30 second ramp down to zero CFM.



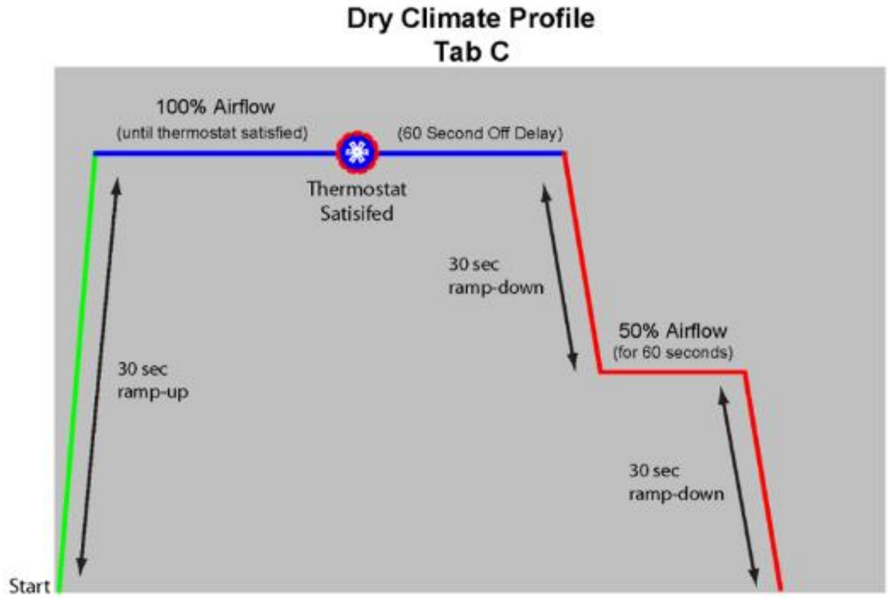
Humid Climate Profile

The "humid" setting is best suited for installations where the humidity is frequently extremely high during the cooling season. On a call for cooling, the blower will ramp up to 50% of full capacity and will stay there for 60 seconds, then will ramp-up to 82% of full capacity and will stay there for five minutes, and then it will ramp-up to full capacity, where it will stay until the wall thermostat is satisfied. The motor will have a 60-second off delay. In every case, it will take the motor 15 to 30 seconds to ramp-down from full capacity back to zero airflow.

Dry

C - Dry Profile:

Thermostat call: 30-second ramp-up to 100% CFM.
Thermostat satisfies: 60-second off delay and a 30 to 60 second ramp-down to 50% CFM for 60 seconds.
After 60 seconds: 30 to 60-second ramp down to zero CFM.



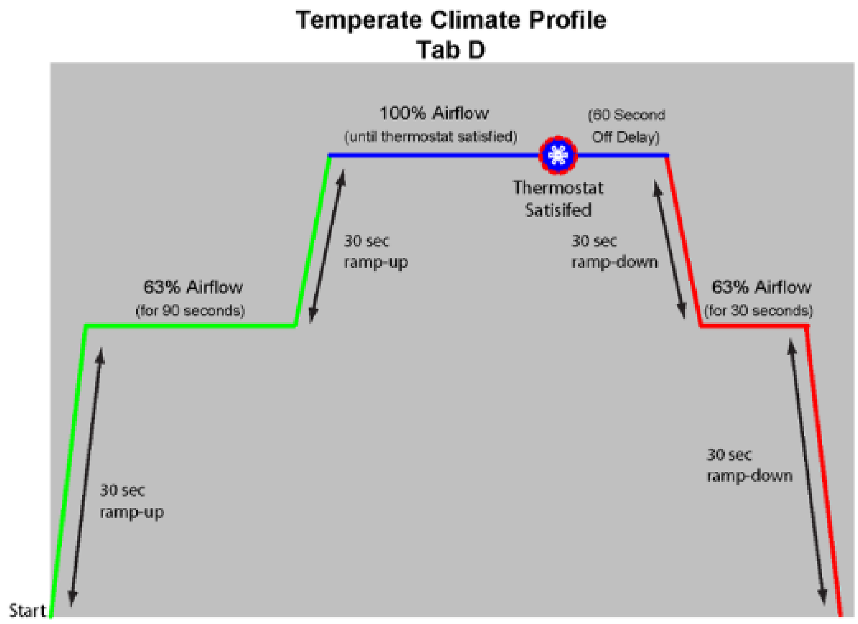
Arid / Dry Climate Profile

The "dry" setting is best suited to areas where excessive humidity is not a problem, where the summer months are usually dry. On a call for cooling, the motor will ramp-up to full capacity and will stay there until the thermostat is satisfied. At the end of the cooling cycle, the motor will have a 60-second off delay; the blower will ramp-down to 50% of full capacity where it will stay for 60 seconds, and then it will ramp down to zero. In every case, it will take the motor 30 seconds to ramp-up from one capacity to another and will take 60 seconds to ramp-down to a lower speed or down to zero.

Temperate

D - Temperate Profile:

Thermostat call: 15 to 30-second ramp-up to 63% CFM for 90 seconds.
After 90 seconds: 15 to 30 second ramp-up to 100% CFM.
Thermostat satisfies: 60-second off delay, and then a 15 to 30 second ramp-down to 63% CFM for 30 seconds.
After 30 seconds: 15 to 30-second ramp down to zero CFM.



Temperate Climate Profile

The "temperate" setting is best suited for many parts of North America, where neither excessive humidity nor extremely dry conditions are normal. On a cooling call, the motor will ramp-up to 63% of full capacity and will stay there for 90 seconds, then will ramp-up to full capacity. At the end of the cooling cycle, the motor will have a 60-second off delay, motor will ramp-down to 63% of full capacity and will stay there for 30 seconds, and then will ramp down to zero. In every case, it will take the motor 15 to 30 seconds to ramp from one capacity to another.

Air Temperature Rise (ATR)

The temperature rise depends on whether the system is operating in gas heat, electric heat, or heat pump operation. Temperature rise is measured by subtracting the return air dry bulb temperature from the supply air dry bulb temperature as seen in the following example. Supply and return air temperatures should be measured as close to the indoor unit as possible without being in direct view of the heat exchanger or electric heating elements. If the readings are taken in direct line of sight to the elements, the temperature will be of the radiant heat generated, rather than the air temperature entering, or leaving the unit.

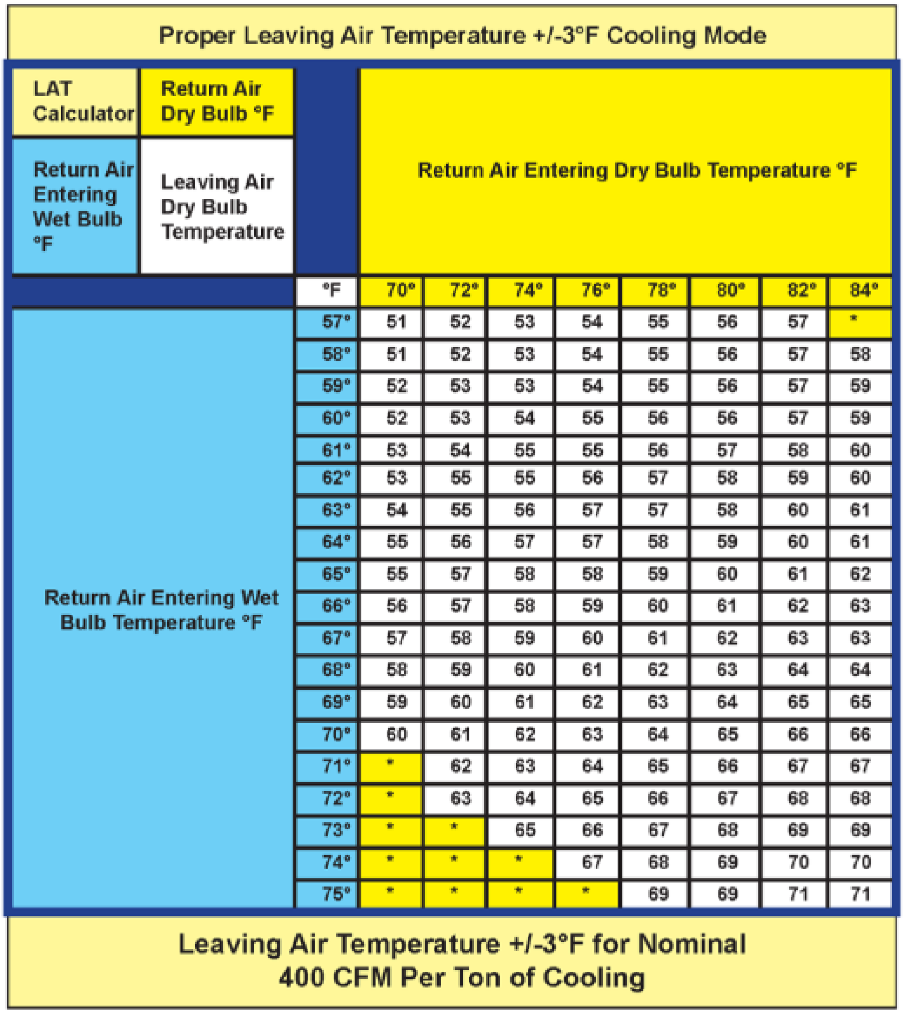
Example: Supply air dry bulb 115°F
Return air dry bulb -70°F
____
=Temperature Rise = 45°F ΔT - Rise

Calculating the heating temperature rise is a means of measuring the CFM of air flow being provided by the unit during the heating mode. This is demonstrated in the "Air Flow Calculation" section.

Temperature Drop

A heat pump, that is within normal operating temperatures, will have an 18-degree F to 20-degree F temperature drop across the indoor coil during cooling. The temperature drop is measured by subtracting the supply air dry bulb temperature from the return air dry bulb temperature.

Example: Return air dry bulb 75°F
Supply air dry bulb -55°F
____
=Temperature Rise = 20°F ΔT - Drop



Proper Leaving Air Temperature +/-3°F Cooling Mode

LAT Calculator	Return Air Dry Bulb °F
Return Air Entering Wet Bulb °F	Leaving Air Dry Bulb Temperature

Return Air Entering Wet Bulb Temperature °F		Return Air Entering Dry Bulb Temperature °F							
	°F	70°	72°	74°	76°	78°	80°	82°	84°
	57°	51	52	53	54	55	56	57	*
	58°	51	52	53	54	55	56	57	58
	59°	52	53	53	54	55	56	57	59
	60°	52	53	54	55	56	56	57	59
	61°	53	54	55	55	56	57	58	60
	62°	53	55	55	56	57	58	59	60
	63°	54	55	56	57	57	58	60	61
	64°	55	56	57	57	58	59	60	61
	65°	55	57	58	58	59	60	61	62
	66°	56	57	58	59	60	61	62	63
	67°	57	58	59	60	61	62	63	63
	68°	58	59	60	61	62	63	64	64
	69°	59	60	61	62	63	64	65	65
	70°	60	61	62	63	64	65	66	66
	71°	*	62	63	64	65	66	67	67
	72°	*	63	64	65	66	67	68	68
	73°	*	*	65	66	67	68	69	69
	74°	*	*	*	67	68	69	70	70
	75°	*	*	*	*	69	69	71	71

Leaving Air Temperature +/-3°F for Nominal 400 CFM Per Ton of Cooling

During certain conditions, the temperature drop may be increased or decreased depending on the return air wet bulb temperatures. To increase accuracy when evaluating if the system is absorbing the proper amount of heat, the information in the table above can be referenced.

This chart can be used to identify whether the air leaving the indoor coil is correct for a system that should be moving a nominal 400 CFM of supply air per ton of cooling. If the technician records the return air wet bulb temperature and the return air dry bulb temperature and cross references the temperatures on the chart, the chart will indicate the dry bulb temperature within +/- 3 degrees F that should be leaving the coil if the system is operating within design specifications.

Airflow Calculation

This formula will give a means of evaluating the CFM produced during heating operation. The CFM formula requires measuring the BTU output from the heating unit and calculating temperature rise across the heating section.

Electric Heat (Single Phase):

Formula:

$$\frac{\text{BTU Output}}{1.08 \text{ X Temp Rise}} = \text{CFM}$$

To calculate CFM with supplemental electric heat, the unit should be operating with all heating elements energized. Note the formula to calculate the BTU/H output of a heating element with different voltages applied.

A heating element rated at 5KW with a 240 volts AC power supply will provide:

Example 1:
5000 watts / 240 volts AC = 20.83 amps
240 volts AC / 20.83 = 11.52Ω of resistance
5000 watts X 3.413 BTU/H = 17,065 BTU/H
3 strips X 17,065 BTU/H = 51,195 BTU/H Output

In example 1, if the BTU/H output is 51,195 and the unit has a 35 °F ΔT (Temperature Rise), the formula would indicate an air flow of 1354.36 CFM.

$$3 \text{ X } 17{,}065 \text{ BTU/H} = \frac{51{,}195 \text{ BTU/H Output}}{1.08 \text{ X } 35^{\circ}\text{F}\Delta\text{T}} = 1354.36 \text{ CFM}$$

The same heating element will produce less heat if the voltage is decreased. A 5KW heating element, rated at 240 volts AC, has a resistance of 11.52 ohms. If a heating element has a resistance of 11.52 ohms and a voltage of 208 volts is applied, the wattage is now 3755 Watts instead of 5000 Watts.

Example 2:
208 volts AC / 11.52Ω of resistance = 18.05 amps
208 volts AC X 18.05 amps = 3755 watts
3755 watts X 3.413 BTU/H = 12,816 BTU/H
3 Strips X 12,816 BTU/H = 38,448 BTU/H Output

In example 2, if the BTU/H output is 38,448 and the unit has a 35°F ΔT (Temperature Rise) the formula would indicate an air flow of 1017.14 CFM.

$$3 \text{ X } 12{,}816 \text{ BTU/H} = \frac{38{,}448 \text{ BTU/H Output}}{1.08 \text{ X } 35^{\circ}\text{F}\Delta\text{T}} = 1017.14 \text{ CFM}$$

There is a significant difference in the BTU/H output and CFM air flow from example 1 to example 2. This difference is produced when the voltage input changes. Proper voltage readings must be used to calculate the CFM.

Calculating Gas Heat Input & Output (Clocking the Meter)

One method to clock the gas meter and confirm the input to the furnace is to perform the following:

- All other gas appliances must be in the "OFF" position to calculate the exact input to the furnace.
- The furnace must be firing at full capacity.
- Log the cubic feet of gas utilized in 6 minutes of operation. Keep in mind, 6 minutes is 1/10th of one hour.
- Multiply the cubic feet of gas by 10.

If the unit uses 5 cubic feet of gas in 1/10th of one hour, the 5 cubic feet is multiplied by 10. This would indicate an input of 50 cubic feet of gas in one hour.

10 x 5 = 50 cubic feet per hour input

Multiply the BTU content of the fuel by cubic feet per hour.

If the BTU content were verified to be 1030 BTU per cubic foot, the 1030 BTU per cubic foot would be multiplied by the 50 cubic feet input per hour.

1030 x 50 = 51,500 BTU/H input

This would indicate a 51,500 BTU/H input to the unit.

Multiply the BTU/H input by the AFUE (Annual Fuel Utilization Efficiency) rating.
If this furnace had an AFUE rating of 80%, the output would be approximately 41,200 BTU/H.

51,500 x .80 = 41,200 BTU/H Output

Refrigerant Charge Adjustment

The outdoor unit is precharged with refrigerant. The instructions below provide guidance on initial charge adjustment.

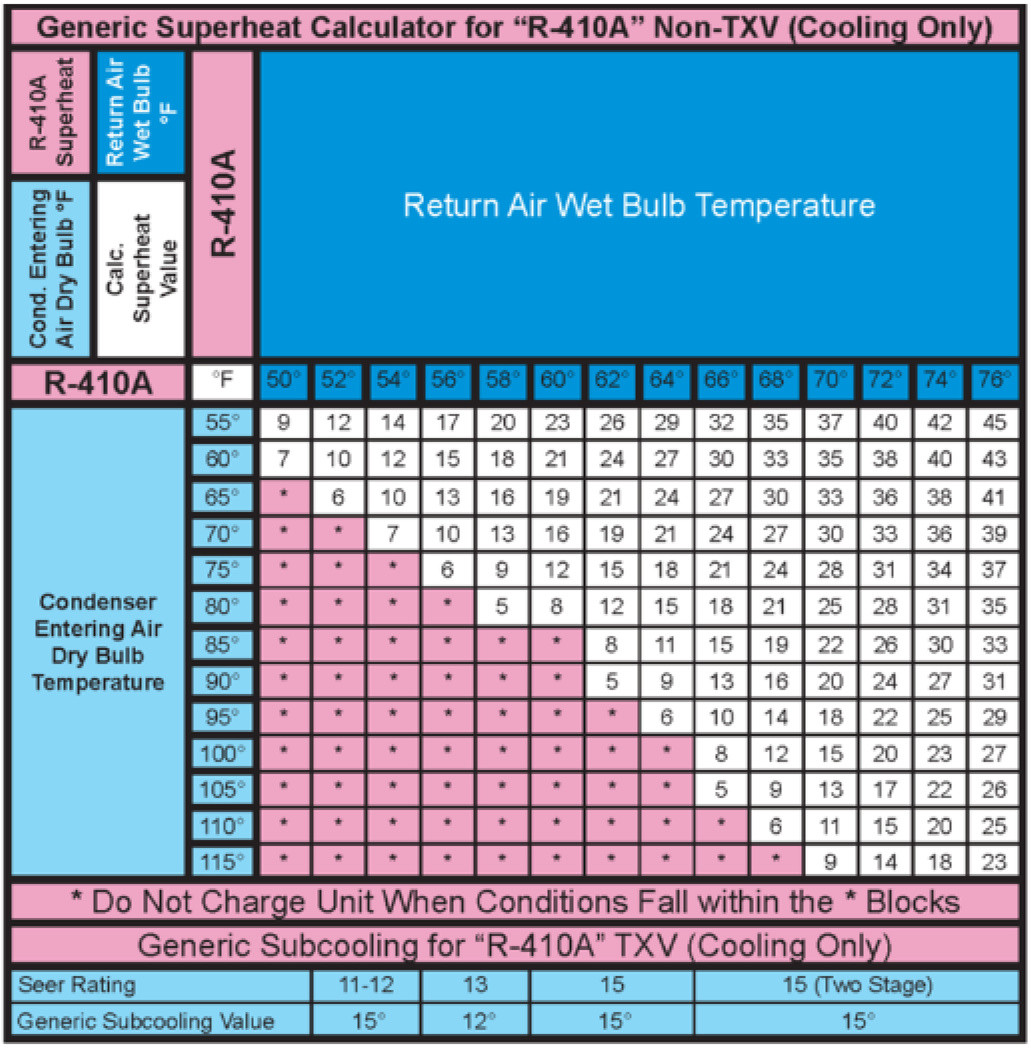
1. Check the Factory Unit Charge listed on the unit data plate to verify the refrigerant charge for the outdoor unit, the smallest matched indoor unit, and the 15 feet of interconnecting lineset.
2. Verify the indoor metering device and additional charge required for the specific matched indoor unit in the system using the above table.
3. Add additional charge for the amount of interconnecting lineset greater than 15 feet at the rate specified in the Physical and Electrical Data Table.
4. For installations requiring additional charge, weigh in refrigerant for the specific matching indoor unit and actual lineset length.
5. Once the charge adders for matched indoor unit and for lineset have been weighed in, verify the system operation against the temperatures and pressures in the Charging Chart for the outdoor unit. Locate Charging Charts on the outdoor unit and in the Service Data Application Guide on Solution Navigator.
6. Follow the Subcool or the Superheat charging procedure in the Installation Manual according to the type of indoor metering device in the system and allow ten minutes after each charge adjustment for the system operation to stabilize. Record the charge adjustment made to match the Charging Chart.
7. Permanently stamp the unit data plate with the TOTAL SYSTEM CHARGE defined as follows: TOTAL SYSTEM CHARGE = Base Charge (as shipped) + charge adder for matched indoor unit (+ or -) charge adder for actual lineset length + charge adjustments to match the Charging Chart.

The two alternatives to charging a system by weight are the superheat and subcooling methods. The charging method is determined by the type of metering device matched with the system.

Prior to refrigerant charge verification, proper system airflow must be established (400 cfm/ton). Do NOT attempt to validate system charge without first establishing proper airflow.

Fixed orifice metering devices are charged using the superheat charging charts provided with the equipment. Thermostatic expansion valve (TXV) metering devices can be charged using the subcooling values listed on the equipment or in the Installation Manual. Do not charge the TXV system by the superheat method. If a system using a TXV metering device has the wrong amount of superheat, the system must be evaluated to verify that it is properly charged.

When evaluating a system for acceptable refrigerant charge, refer to the published superheat and subcooling values. If the required values do not exist, the following generic charging values may be used. These values should only be used if there are no other charging methods available for the unit.



Generic Superheat Calculator for “R-410A” Non-TXV (Cooling Only)

R-410A Superheat

Return Air Wet Bulb °F

Cond. Entering Air Dry Bulb °F

Calc. Superheat Value

R-410A

Return Air Wet Bulb Temperature

R-410A	°F	50°	52°	54°	56°	58°	60°	62°	64°	66°	68°	70°	72°	74°	76°
Condenser Entering Air Dry Bulb Temperature	55°	9	12	14	17	20	23	26	29	32	35	37	40	42	45
	60°	7	10	12	15	18	21	24	27	30	33	35	38	40	43
	65°	*	6	10	13	16	19	21	24	27	30	33	36	38	41
	70°	*	*	7	10	13	16	19	21	24	27	30	33	36	39
	75°	*	*	*	6	9	12	15	18	21	24	28	31	34	37
	80°	*	*	*	*	5	8	12	15	18	21	25	28	31	35
	85°	*	*	*	*	*	*	8	11	15	19	22	26	30	33
	90°	*	*	*	*	*	*	5	9	13	16	20	24	27	31
	95°	*	*	*	*	*	*	*	6	10	14	18	22	25	29
	100°	*	*	*	*	*	*	*	*	8	12	15	20	23	27
	105°	*	*	*	*	*	*	*	*	5	9	13	17	22	26
	110°	*	*	*	*	*	*	*	*	*	6	11	15	20	25
	115°	*	*	*	*	*	*	*	*	*	*	9	14	18	23

* Do Not Charge Unit When Conditions Fall within the * Blocks

Generic Subcooling for “R-410A” TXV (Cooling Only)

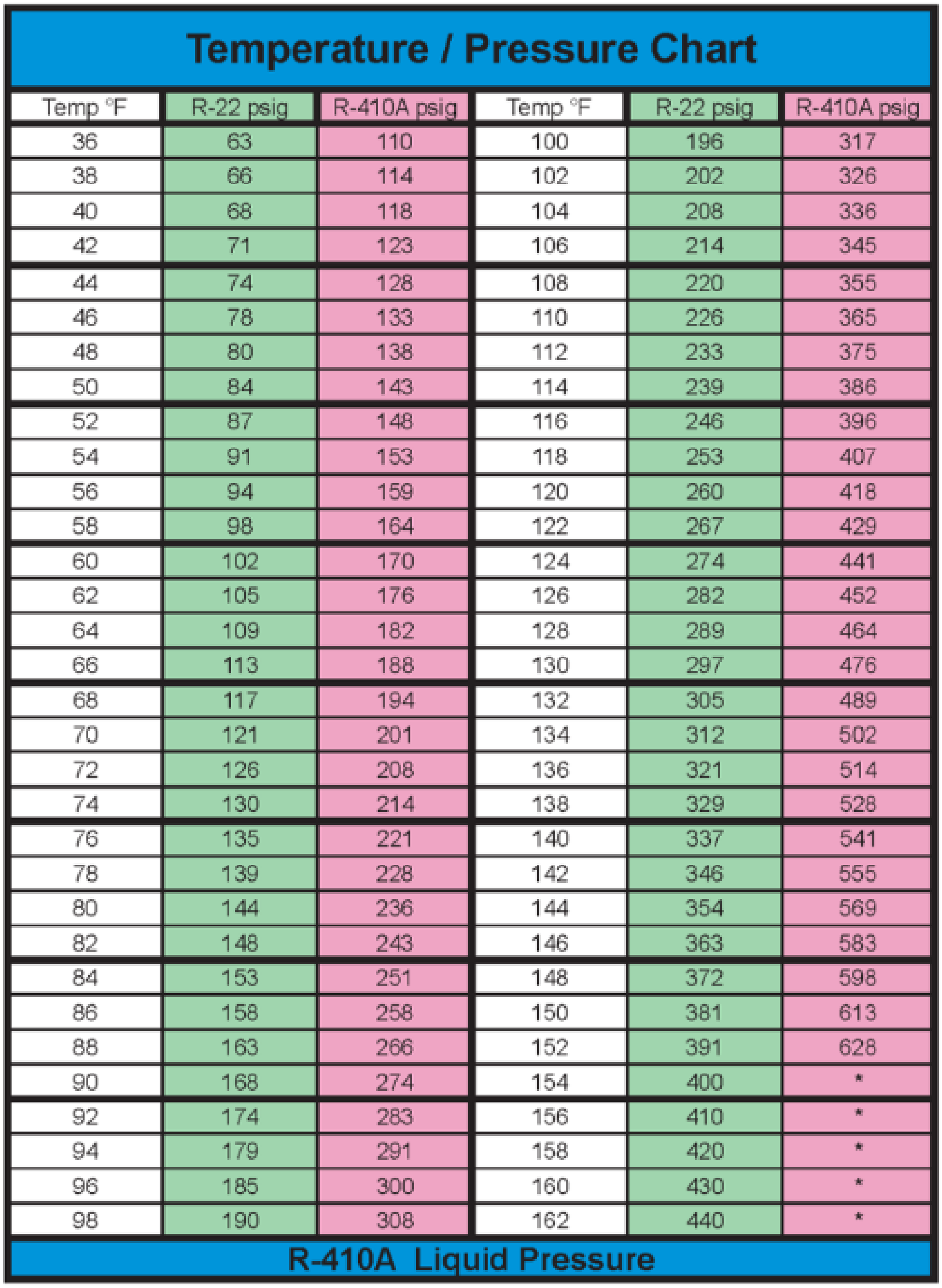
Seer Rating	11-12	13	15	15 (Two Stage)
Generic Subcooling Value	15°	12°	15°	15°

Superheat Verification

The required superheat values on a fixed orifice metering device can vary, depending on the heat load of the evaporator and ambient conditions. Often, it is necessary to measure the indoor wet bulb and the outdoor dry bulb temperatures.

The "target" superheat value must be known for the conditions present during service or initial setup. To verify superheat, proceed as follows:

1. Operate the system until conditions stabilize, usually 10 to 15 minutes.
2. Measure the suction pressure by attaching the low side of the manifold gauge set to the low side valve port.
3. Convert the suction pressure to temperature using a temperature/pressure chart like the chart below. This chart shows the boiling point or saturation temperature in the "Temp "F" columns, and the pressure (psig) under the refrigerant column.
4. Measure the suction temperature by attaching an electronic thermometer to the suction line approximately 6 inches from the suction service valve. To obtain an accurate measurement, the thermometer must be insulated and in solid contact with the suction line.
5. Subtract the converted temperature from the suction line temperature. If superheat is too, the unit may be overcharged. If it is too high, the unit may be undercharged.
6. After adding or removing charge, allow the system to operate 10 to 15 minutes prior to rechecking the superheat value.



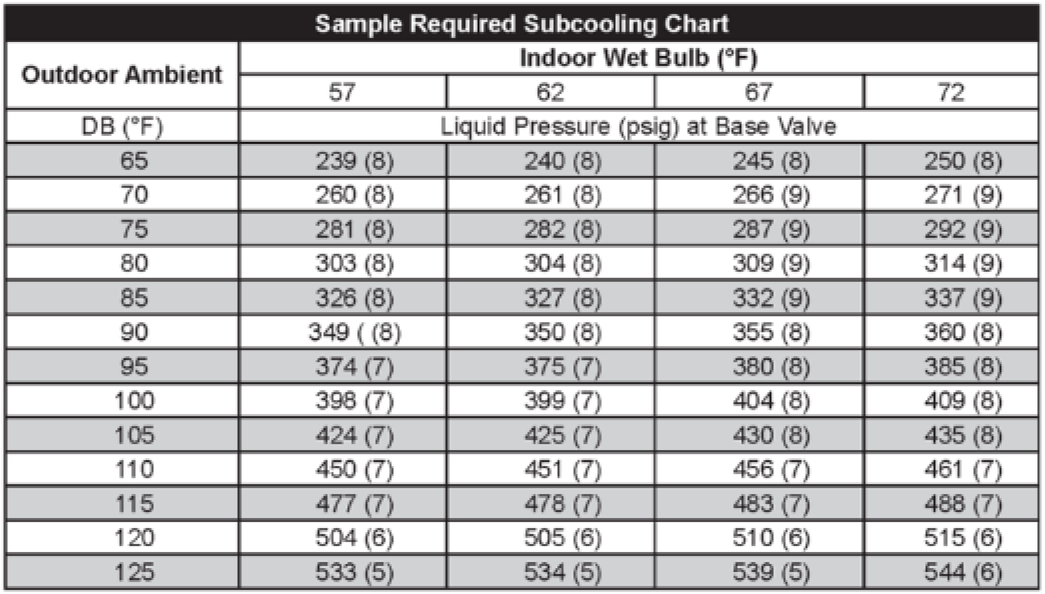
Temperature / Pressure Chart

Temp °F	R-22 psig	R-410A psig	Temp °F	R-22 psig	R-410A psig
36	63	110	100	196	317
38	66	114	102	202	326
40	68	118	104	208	336
42	71	123	106	214	345
44	74	128	108	220	355
46	78	133	110	226	365
48	80	138	112	233	375
50	84	143	114	239	386
52	87	148	116	246	396
54	91	153	118	253	407
56	94	159	120	260	418
58	98	164	122	267	429
60	102	170	124	274	441
62	105	176	126	282	452
64	109	182	128	289	464
66	113	188	130	297	476
68	117	194	132	305	489
70	121	201	134	312	502
72	126	208	136	321	514
74	130	214	138	329	528
76	135	221	140	337	541
78	139	228	142	346	555
80	144	236	144	354	569
82	148	243	146	363	583
84	153	251	148	372	598
86	158	258	150	381	613
88	163	266	152	391	628
90	168	274	154	400	*
92	174	283	156	410	*
94	179	291	158	420	*
96	185	300	160	430	*
98	190	308	162	440	*

R-410A Liquid Pressure

Subcooling Verification

The "subcooling method" is used to verify refrigerant charge on systems with a TXV metering device. The subcooling charging charts are in the Installation Manual and are often on a corner post of the condensing unit.



Sample Required Subcooling Chart

Outdoor Ambient	Indoor Wet Bulb (°F)			
	57	62	67	72
DB (°F)	Liquid Pressure (psig) at Base Valve			
65	239 (8)	240 (8)	245 (8)	250 (8)
70	260 (8)	261 (8)	266 (9)	271 (9)
75	281 (8)	282 (8)	287 (9)	292 (9)
80	303 (8)	304 (8)	309 (9)	314 (9)
85	326 (8)	327 (8)	332 (9)	337 (9)
90	349 ((8)	350 (8)	355 (8)	360 (8)
95	374 (7)	375 (7)	380 (8)	385 (8)
100	398 (7)	399 (7)	404 (8)	409 (8)
105	424 (7)	425 (7)	430 (8)	435 (8)
110	450 (7)	451 (7)	456 (7)	461 (7)
115	477 (7)	478 (7)	483 (7)	488 (7)
120	504 (6)	505 (6)	510 (6)	515 (6)
125	533 (5)	534 (5)	539 (5)	544 (6)

In the subcooling charging chart above, if the outdoor ambient temperature is 100°F and the indoor wet bulb temperature is 67°F, the required subcooling value is 8°F.

To measure the subcooling on the unit, proceed as follows:
Allow the system to operate in the cooling mode until equipment temperatures and pressures stabilize. Two-stage systems must have both stages ("Y1" and "Y/Y2") energized.

Measure liquid line temperature by attaching an electronic thermometer to the liquid line about 6 inches from the service valve. To obtain an accurate measurement, the thermometer must be insulated and in solid contact with the liquid line.

While using a temperature pressure chart, find the saturation point of the refrigerant by locating the system high side pressure under the column for the system refrigerant. Follow that value across to the corresponding temperature to find the saturation point.

Subtract the liquid line temperature from the saturation point, and the result is the subcooling value.

Example R-410A Subcooling:
High side pressure = 407 psig
High side pressure converted to saturation temperature or boiling point using the temperature/pressure chart = 118°F
Liquid line temperature at the outlet of the condenser coil = 110°F
High side saturation temperature minus liquid line temperature equals subcooling.

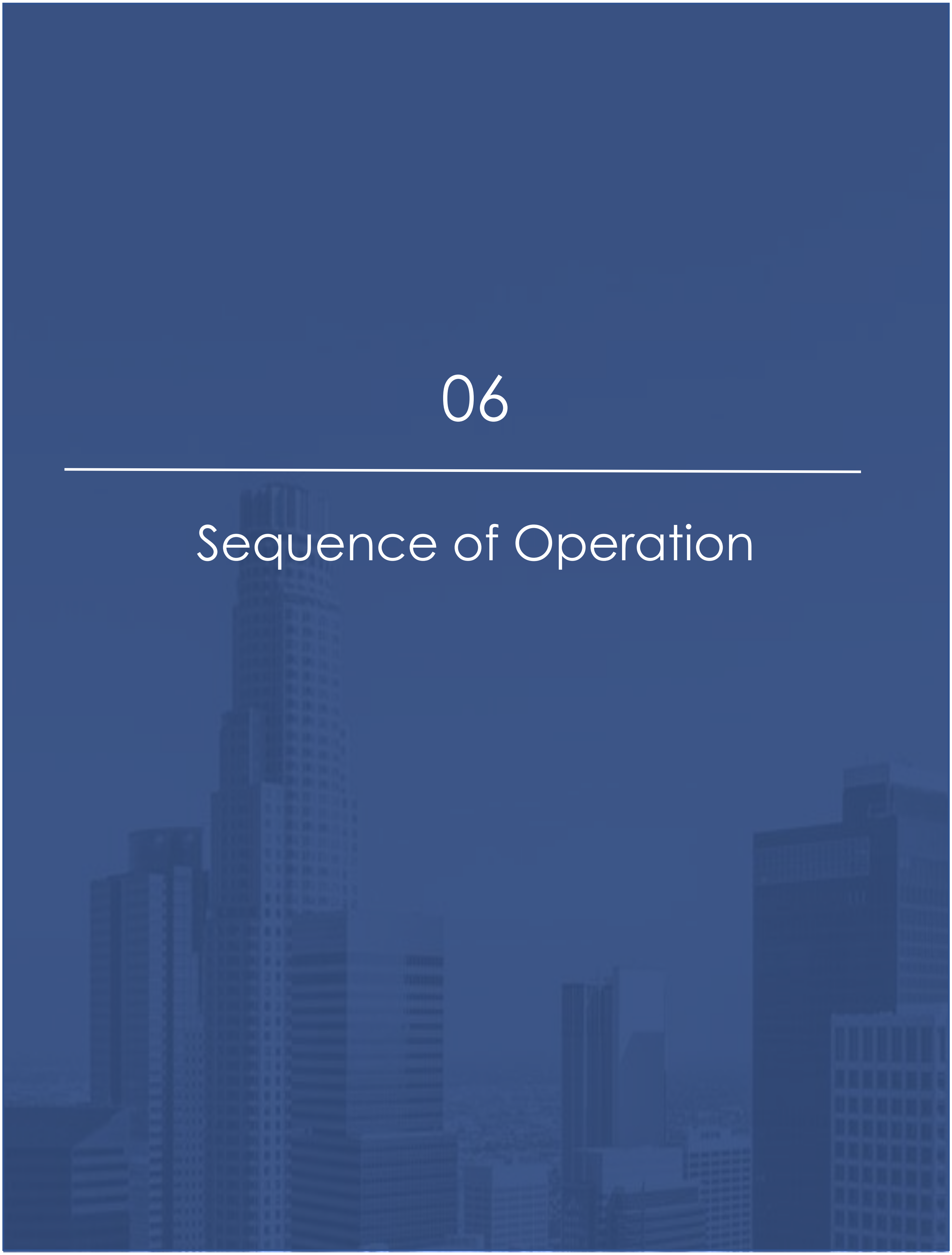
Subcooling calculation:

High Side Saturation Temperature	118°F
- Liquid Line Temperature	-110°F
= Subcooling	= 8°F

If the measured subcooling is higher than the target subcooling value, a refrigerant overcharge is indicated, and refrigerant must be removed using approved refrigerant recovery techniques. If the measured system subcooling is lower than the target subcooling value, a refrigerant undercharge is indicated, and additional refrigerant should be added to the system.

For optimum performance, R-410A should be removed from the cylinder as a liquid and charged into the suction line during equipment operation. This can be done with a liquid charging adapter, which causes the liquid refrigerant to flash to a vapor prior to entering the system.

After adding or removing charge, allow the system to operate for 10 to 15 minutes prior to rechecking the subcooling value.



06

Sequence of Operation

General Operation Description

The control controls the defrost operation based on accumulated compressor run time, outdoor coil temperature, and outdoor ambient temperature. The control allows the unit to operate in the normal heating mode until the control determines that a defrost cycle is needed. The demand for defrost will exist when the coil temperature falls below the initial set point at a given ambient temperature based on an initial curve.

Thermostat Signal Assumptions

- A call for compressor cooling is defined as a Y and an O signal.
- A call for compressor heating is defined as a Y signal only.
- A call for aux heating is defined as a Y and a W signal.
- A call for emergency heating is defined as a W only signal.

Compressor Heating Mode

During normal compressor heating mode, the control causes all the following to occur.

- Outdoor fan motor is energized (except in defrost)
- Compressor contactor outputs is energized.
- Reversing valve is de-energized.

Compressor Cooling Mode

During normal cooling mode for a heat pump, the control causes all the following to occur:

- Outdoor fan motor is energized.
- Compressor contactor outputs is energized.
- Reversing valve is energized.

Additionally:

- If the control receives an O input without a Y input, it energizes the reversing valve only.
- If the control receives a W input and an O input, it energizes the reversing valve and WOUT. This is technically an error condition for heat pumps and air conditioners since O and W should never be energized at the same time.

Emergency Heat

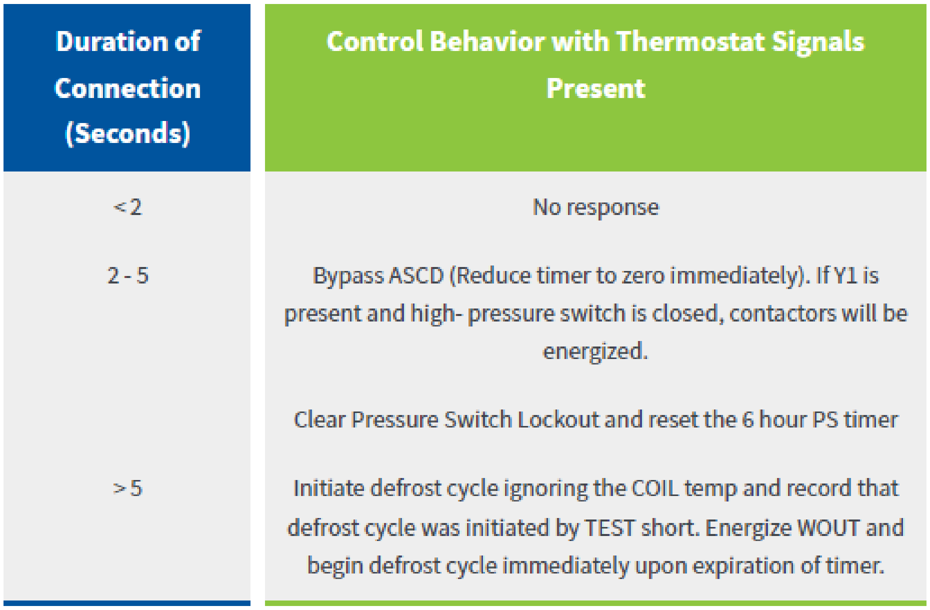
A call for emergency heat is defined as a W signal without a Y signal. The control energizes WOUT immediately when an emergency heat signal (W) is received.

Auxiliary Heat

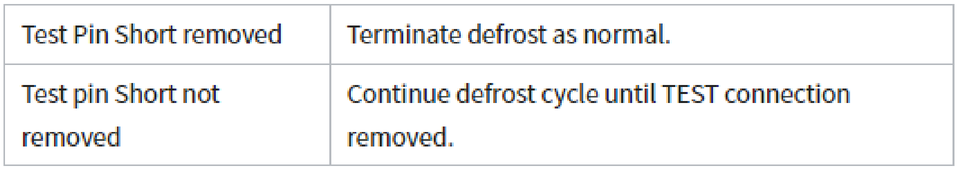
During auxiliary heating mode, the control causes all the following to occur.

- Outdoor fan motor is energized.
- Compressor contactor outputs is energized.
- Reversing valve is de-energized.
- WOUT output is energized.

Test Input Operation with Thermostat Signals Present



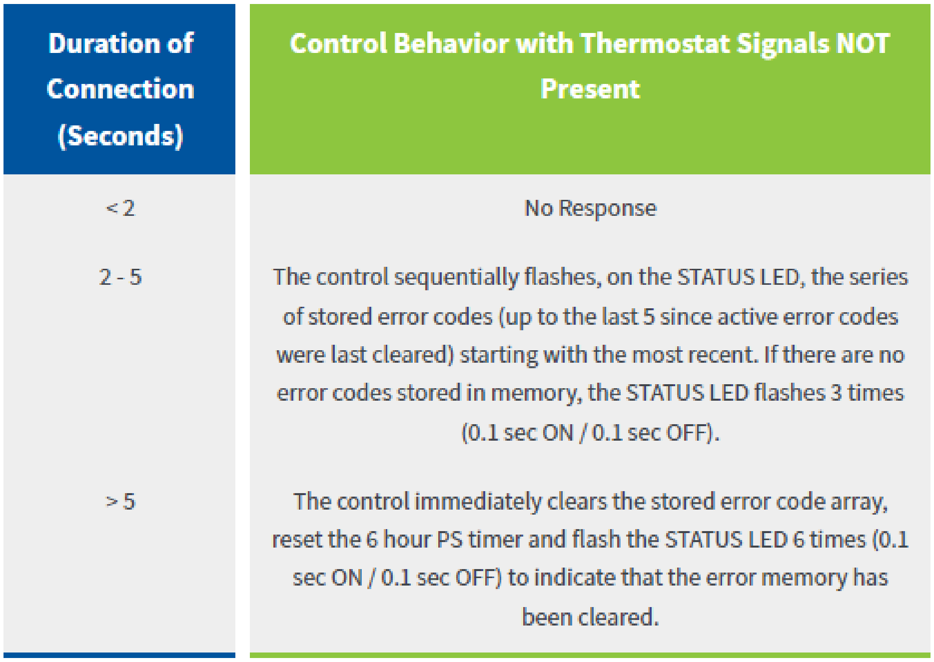
Duration of Connection (Seconds)	Control Behavior with Thermostat Signals Present
< 2	No response
2 - 5	Bypass ASCD (Reduce timer to zero immediately). If Y1 is present and high- pressure switch is closed, contactors will be energized.
	Clear Pressure Switch Lockout and reset the 6 hour PS timer
> 5	Initiate defrost cycle ignoring the COIL temp and record that defrost cycle was initiated by TEST short. Energize WOUT and begin defrost cycle immediately upon expiration of timer.



Test Pin Short removed	Terminate defrost as normal.
Test pin Short not removed	Continue defrost cycle until TEST connection removed.

When the TEST input is shorted for over five seconds, the control will activate a defrost and remain in defrost if it remains shorted. This will occur if the Y signal is present, and the control is in forced defrost mode and if no other thermostat signals are present. Other sections of this document describe the details of this feature.

Test Input Operation with Thermostat Signals NOT Present



Duration of Connection (Seconds)	Control Behavior with Thermostat Signals NOT Present
< 2	No Response
2 - 5	The control sequentially flashes, on the STATUS LED, the series of stored error codes (up to the last 5 since active error codes were last cleared) starting with the most recent. If there are no error codes stored in memory, the STATUS LED flashes 3 times (0.1 sec ON / 0.1 sec OFF).
> 5	The control immediately clears the stored error code array, reset the 6 hour PS timer and flash the STATUS LED 6 times (0.1 sec ON / 0.1 sec OFF) to indicate that the error memory has been cleared.

Anti-Short Cycle Delay

The ASCD (Anti Short Cycle Delay) prevents the compressor from starting within the timer duration after power loss or the completion of a compressor cycle. The duration of the ASCD timer is 5 minutes. The control accumulates compressor off time whenever the compressor contactor output is not energized. The ASCD timer delay is present when the control is powered up and immediately following the completion of a compressor cycle.

The outdoor fan will not be energized during the ASCD timer delay. The outdoor fan should be energized when the compressor is energized.

When the TEST terminals are shorted with a Y input energized and the pressure switch closed, the ASCD will be bypassed, and the compressor contactor outputs will be energized within two seconds based on the input signals present.

Demand Defrost Curve Selection

The defrost operation parameters of the control are defined as data sets or "curves" that will be assigned to specific heat pump model numbers.

The control stores four unique, selectable curves.

The control has jumper pins that allow the installer to select the active demand defrost curve to be used by the control. If no jumper is present the control operates as defrost curve 1.

Defrost Mode

The parameters for the defrost are based on requirements of individual heat pump models. These requirements are referred to as defrost curves. All defrost timings referenced are based on accumulated compressor run time.

The defrost mode is equivalent to the cooling mode except that the outdoor fan motor is de-energized. The control provides the following action initiates a defrost cycle.

- De-energize the outdoor fan.
- Energize the reversing valve.
- Energize the WOUT output as described in another section of this document.
- Begin the maximum defrost cycle length timer.

If the call for heating is removed from the control during the defrost cycle, the control terminates the defrost cycle and stops compressor operation. The control stops the defrost cycle length timer but does not reset it. When the control receives another call for heating, it restarts the defrost cycle and the timer at the point at which the call for heating was removed if the liquid line temperature conditions allow defrost to occur.

Defrost Initiation

The control allows the heat pump to operate in the heating mode until the combination of outdoor ambient and outdoor coil temperatures indicate that a defrost cycle is necessary, unless the previous defrost was terminated based on the Maximum Defrost Cycle Time allowed for the selected curve.

The control initiates a defrost cycle when the Defrost Inhibit Time Limit has elapsed if the previous defrost cycle was terminated based on the Maximum Defrost Cycle Time. This occurs regardless of the liquid line (coil) temperature reading. The coil does not have to be cold for the unit to be forced into defrost. Once the defrost cycle begins the control follows the normal defrost cycle routine.

The control initiates a defrost cycle when the liquid line (coil) temperature is below the initiate point for the measured ambient temperature continuously for 4-1/2 minutes. The liquid line temperature used to initiate the defrost cycle may be filtered to improve the performance of the heat pump during TXV hunting conditions. The 4- 1/2-minute delay eliminates unnecessary defrost cycles caused by refrigeration surges such as those that occur at the start of a heating cycle.

The control initiates a defrost cycle every 6 hours and 4 minutes of accumulated compressor run time to recirculate refrigerant lubricants. This forced defrost timer will be reset and restarted following the completion or termination of a defrost cycle. If this defrosts cycle continues through the maximum defrost cycle time, it will re- enter another defrost cycle based on the minimum inhibit timer.

The control also initiates a defrost cycle when the TEST terminals are shorted. This feature allows an installer or service technician to start a defrost cycle immediately as required. When the TEST terminals are shorted with a Y input energized and the pressure switch closed, the ASCD will be bypassed, and the compressor contactor outputs will be energized after two seconds. When the control is forced into defrost cycle with the TEST terminals, the control records this mode so that it can distinguish between a forced defrost cycle and a defrost cycle that occurs based on conditions present. The control will use this information to behave differently in a forced or regular defrost condition.

When the TEST terminals are shorted for more than five seconds with a Y input energized, the control will begin a defrost cycle. When the defrost, cycle is forced using the TEST input, the control energizes WOUT immediately when it begins the defrost cycle. This will allow faster run test cycles. When the TEST inputs are used to force a defrost cycle, the state of the liquid line temperature input will be ignored. The coil does not have to be cold for the unit to be forced into defrost. After the TEST input is removed (remove short), the defrost mode will be terminated as normal. The defrost cycle length timer will not be started until the TEST input is removed. If the TEST terminals remain shorted, the control keeps the unit in defrost mode.

Defrost Inhibition

The control will not initiate a defrost cycle if the liquid line temperature is above the inhibit curve. However, the control begins a defrost cycle regardless of liquid line temperature when a defrost cycle is forced using the TEST pins or if the previous defrost cycle was terminated based on the Maximum Defrost Cycle Time.

The inhibit curve will be a flat line (one temperature) but that temperature unique for each defrost curve selection. The control includes a timed inhibit feature that prevents a defrost cycle from being initiated too soon after the termination of the previous defrost cycle. After the inhibit time has expired, the control applies the 4- 1/2-minute timer described above and initiates a defrost cycle if the appropriate conditions still exist. The duration of the timer is specified for each part number in the defrost curve data section of this document. This timer is applied when power is applied to the control and after the completion or termination of each defrost cycle. The timer is based on accumulated compressor run time.

Defrost Termination

The control terminates the defrost cycle immediately after the liquid line temperature goes above the defrost termination curve. The liquid line temperature used to terminate the defrost cycle may be filtered to improve the performance of the system.

The terminate curve will be a flat line (one temperature) but the temperature may be unique for each defrost curve selection. The terminate curve required for each defrost curve is shown in the defrost curve data section of this document. The control terminates the defrost cycle when the maximum defrost cycle length timer expires.

This timer duration is specified in the defrost curve data sections of this document. If the defrost was initiated by shorting the test pins, the defrost cycle is terminated normally when the short is removed.
The control will not terminate a normal defrost cycle if it receives an O signal during the defrost cycle.

The control terminates a defrost cycle as follows:

- Energize the outdoor fan.
- De-energize the reversing valve.
- De-energize the auxiliary heat outputs (unless required by heating call present)
- Reset and restart defrost inhibit timer.

Defrost Curve Data Sets

The control behaves according to the defrost initiate curve when the liquid line temperature is within the specified temperature range for the curve. The control will not enter a defrost cycle (inhibit defrost) when the outdoor ambient temperature is outside of the specified operating range shown in the tables below.

07

Troubleshooting

Introduction

This section provides the most common diagnostic techniques used in the industry. It is the technician's responsibility to become familiar with the equipment being serviced and utilize the appropriate techniques.

Flash Codes

The table below lists the various flash codes and their possible causes.

Single Stage Heat Pump Flash Codes

Flashes	Status/Problem
OFF	No Power to Control
Solid On	Active Compressor Operation
2s On / 2s Off	Standby - No Faults
0.1s On/0.1s Off	Compressor Call ASCD Timer Active
2 Flashes	High Pressure Switch Open (no lockout)
3 Flashes	High Pressure Switch Lockout (last mode was normal operation)
4 Flashes	High Pressure Switch Lockout (last mode was defrost)
5 Flashes	Low Pressure Switch Lockout (last mode was normal operation)
6 Flashes	Low Voltage (<19.2 VAC)
7 Flashes	Low Voltage (<16.0 VAC)
8 Flashes	Liquid Line (Coil) Sensor Failure (open or shorted)
9 Flashes	Outdoor Ambient Sensor Failure (open or shorted)
10 Flashes	Control Failure

Troubleshooting Older-Standard ECM Motors

Troubleshooting the ECM motor is not just an “ON” or “OFF” solution. The following are four problems that will not allow the motor to run:

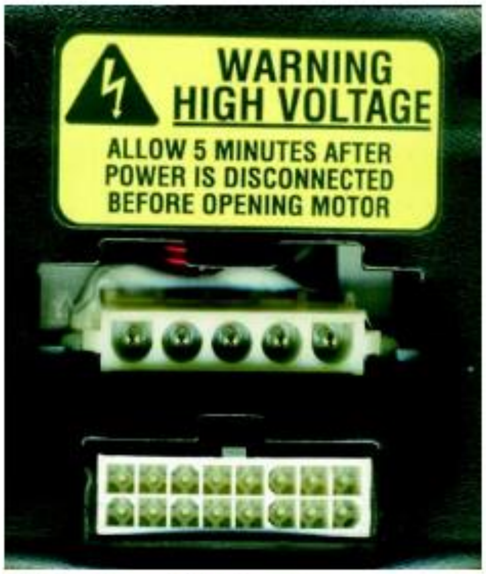
- There is no input power to the motor controller (high voltage inputs)
- There is improper or no communication to the motor controller (low voltage inputs). This problem could be in the interface board or the low voltage connector.
- The motor controller has failed.
- The motor module has failed.

40% of ECM field returns are "No Problem Found". Do not simply assume the motor has failed because it is not running! Measure the input power (High Voltage) to the motor controller by following these steps:

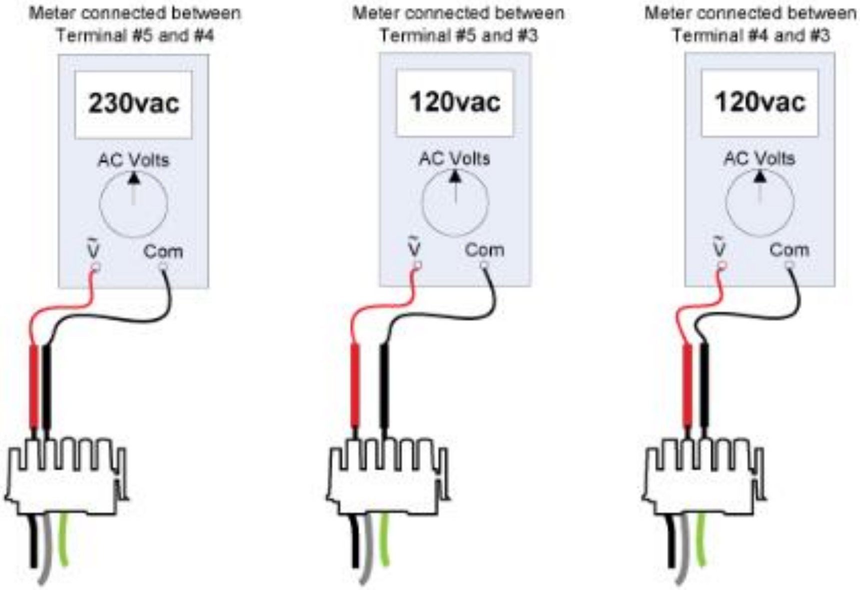
1. Disconnect the power to the system.
2. Disconnect the 5-pin (high voltage) connector.
3. Restore the power to the system.
4. Check for proper input power.

When the main power is restored, a measurement of the power should be taken at the 5-pin connector as shown in the diagram below.

5 Pin Connector



Checking Power on 5 Pin Connector



Motor Test 230 vac &120 vac

Reconnecting the Plug

After all the input high voltage power connections are confirmed or corrected, turn the power off and reconnect the plug to the motor control. When reconnecting the plug, the connector is keyed and must be connected properly. The connector must not be forced in the wrong way.

The plug must be connected fully to prevent arcing. If it is not fully connected, vibration may cause the connection to be broken. When the plug is fully inserted, the latches should click on both sides.

If the plug is inserted with the correct orientation, it should slide gently, all the way in until both clicks are heard. Forcing the plug in the wrong direction or manner can permanently damage the motor.

Motor Grounding

To ensure proper operation and safety, the motor must have a properly grounded connection from the connector to the main ground.

Continuity between the two connections should be evaluated with an ohm meter. The power must be disconnected to the system before checking the resistance. The resistance reading measured should be zero between the two connections. If any other readings are indicated, the problem should be corrected immediately.

Although the motor may run, despite not being properly grounded, this is a safety concern that must be immediately corrected.

ECM Indoor Fan Motor

On motor models 2.0 and 2.3, using Thermostat Mode, the motor control can be checked with the TECMateTM Service Tool from GE ECM. This tool makes short work of the big question, is it the motor or the communication?
The TECMateTM has been manufactured in two versions. The TECMate XLTM is a 4- switch version (discontinued but may still be available through some distributors). The TECMate PROTM is a single switch version. Both perform the same basic function of sending artificial communication to the motor controller, telling it to run.

TECMate Pro

Connecting the TECMateTM

The following procedures below may be used to connect both TECMate models:

1. Disconnect the AC power from the system and wait for the motor to come to a complete stop.
2. Remove the 16-pin connector from the motor and connect the 16-pin connector from the TECMateTM to the motor. Removing the 5-pin AC connector will make it easier to access the 16-pin connector latch, but it must be reconnected prior to testing. Reconnect the 5-pin connector once the TECMateTM is connected.

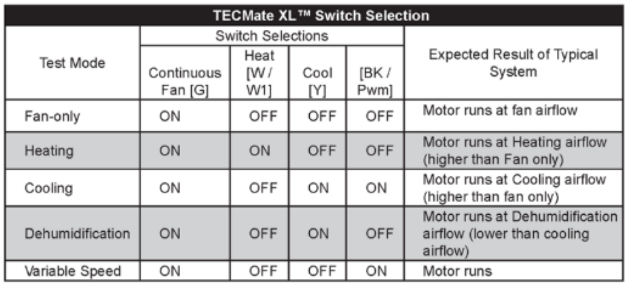
3. Connect the two alligator clips from the TECMateTM to a 24 volts AC power source. (Terminals "R" and "C" on most units represent 24 volts AC power and 24 volts AC common respectively). These two wires are not polarity sensitive. If these wires are connected to any voltage greater than 24 volts AC +/- 10%, permanent damage may be done to the motor control and the TECMateTM
4. The switch(s) on the TECMateTM must be in the "OFF" position.
5. Reconnect the AC power to the system.

Although the ECM motor can be evaluated while the blower housing is in or out of the unit, it is preferred that the blower be left in the unit when possible. The motor should never be operationally checked without the blower wheel attached or the motor will oscillate up and down. If the motor is checked with the blower out of the unit, the technician must take precautions to provide a safe and secure operating surface and work area to test the motor.

TECMate XL™

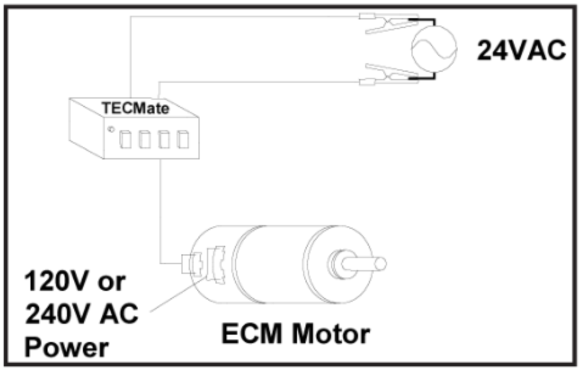
When the power is turned on to the system, the TECMate XLTM power LED (Light Emitting Diodes) light should illuminate.

The correct switches should be placed in the "ON" position and the motor observed for 15 seconds. The table on the back of the TECMate XLT displays switch selections of the various test mode settings.



TECMate XL™ Switch Selection

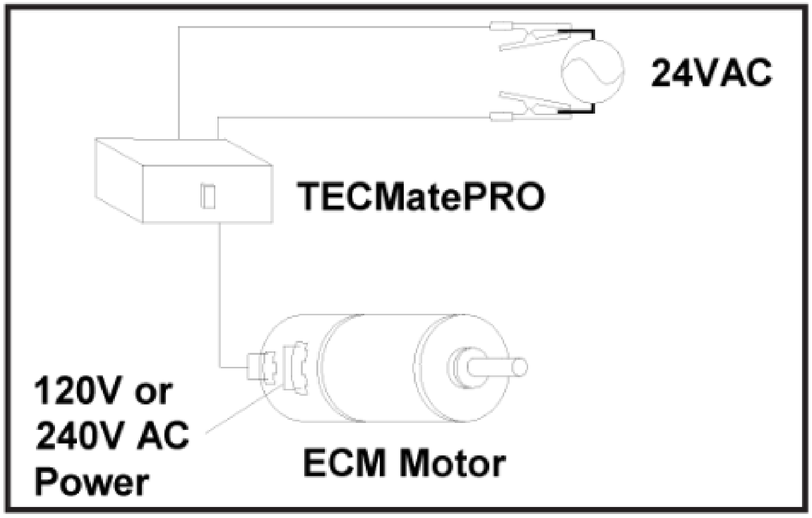
Test Mode	Switch Selections				Expected Result of Typical System
	Continuous Fan [G]	Heat [W / W1]	Cool [Y]	[BK / Pwm]	
Fan-only	ON	OFF	OFF	OFF	Motor runs at fan airflow
Heating	ON	ON	OFF	OFF	Motor runs at Heating airflow (higher than Fan only)
Cooling	ON	OFF	ON	ON	Motor runs at Cooling airflow (higher than fan only)
Dehumidification	ON	OFF	ON	OFF	Motor runs at Dehumidification airflow (lower than cooling airflow)
Variable Speed	ON	OFF	OFF	ON	Motor runs



TECMate XL Connection Diagram

TECMate PRO™

The switch should be placed in the "ON" position and the LED light on the switch should illuminate when connected properly to 24 volts AC. The motor should be observed for 15 seconds. The Table on the back of the TECMate PROTM can be referred to for operation guidelines.



TECMate PRO 24VAC Connection

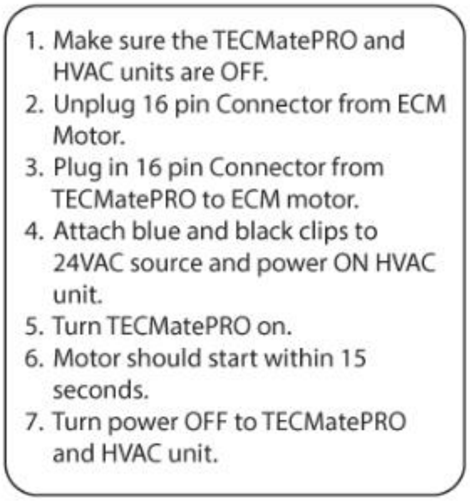
If the motor starts with the TECMate:

The system malfunction is not caused by an ECM control or motor problem.

1. When finished testing with either TECMate, place the switch(s) in the "OFF" position on the TECMate and wait for the motor to completely stop. Depending on the program, sometimes the motor will not shut off immediately after a test; this is normal.
2. Once the motor comes to a complete stop, turn the system power off before removing the TECMate. The 16-pin connector must be reconnected to the system before proceeding with the diagnosis. The connector is keyed and has one clip that should click when the connector is inserted properly.

The next step is to check the low voltage communication on the 16-pin connector. If the control voltage is not present, the problem is the communication from the control board or the communication through the 16-pin connector. The connections at both ends of the 16-pin connector and the wires to the connector should be evaluated for damage. The sockets must not be distorted, bent, or pushed out of the connector.

If the motor does not start with the TECMate, the electronic control (motor control) should be replaced. Before replacing the electronic control module, test the motor module to ensure it is not also damaged. Procedures for testing the motor module are included in "Replacing the ECM Module".


1. Make sure the TECMatePRO and HVAC units are OFF.
2. Unplug 16 pin Connector from ECM Motor.
3. Plug in 16 pin Connector from TECMatePRO to ECM motor.
4. Attach blue and black clips to 24VAC source and power ON HVAC unit.
5. Turn TECMatePRO on.
6. Motor should start within 15 seconds.
7. Turn power OFF to TECMatePRO and HVAC unit.

TECMate Pro™ Table

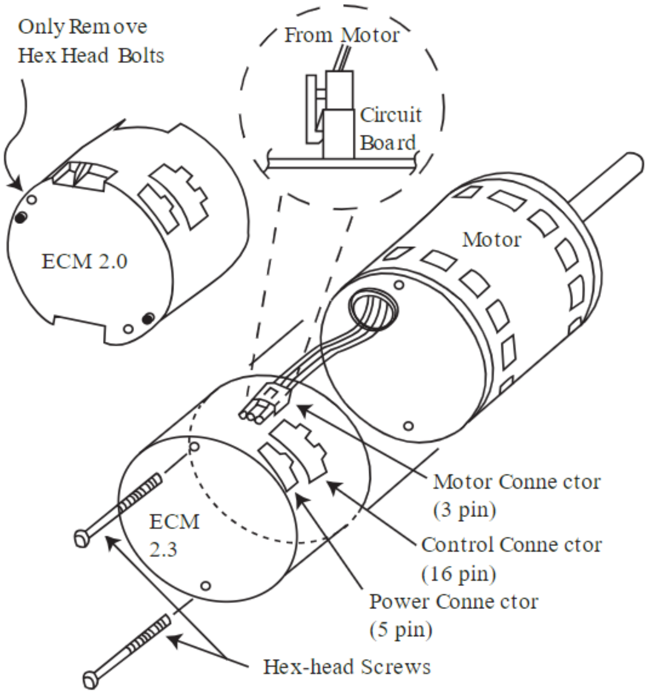
Replacing the ECM Control Module

1. Lock-out and Tag-out the electrical disconnect.
2. Unplug the 5-pin connector and the 16-pin connector from the motor control.
3. Remove the blower assembly from the HVAC (Heating Ventilation and Air Conditioning) system.
4. Remove the two (2) hex-head screws from the back of the control.
5. Unplug the 3-pin connector from inside of the control module by squeezing the latch and gently pulling on the connector.
6. Ensure the motor module is not damaged by performing the two module tests.

ECM Motor Control Disassembly Review

Step 1: Unplug the 16-pin connector and the 5-pin connector from the motor control.
Step 2: Remove the blower assembly from the HVAC system.
Step 3: Remove the two (2) hex-head screws from the back of the control.
Step 4: Unplug the 3-pin connector from inside the control by squeezing the latch and gently pulling on the connector.

Control Disassembly



Control Disassembly

Motor Module Tests

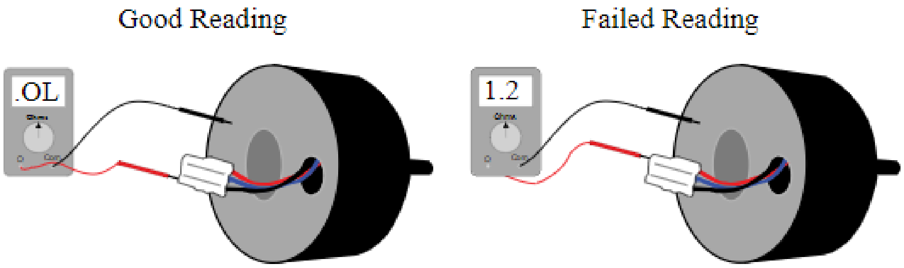
These tests are no different from taking resistance readings on a 3-phase compressor motor. Confirm that the windings are not shorted to ground, and that the resistance is equal when tested phase to phase.

Test A:

Measure the resistance between each of the 3 motor leads to the unpainted part of the end shield (Winding to Ground Resistance). Typically, a good motor will read infinite ohms to the ground on all leads. A grounded motor will read a measurable resistance from any one of the motors that leads to ground. For this test, the meter should be set to the highest ohms scale unless it is auto-ranging. Mega- ohm meters should not be used for this test.

If the motor has a resistance of less than 100k ohms between any one motor lead to ground, the motor should be replaced with an exact replacement.

If the resistance is greater than 100k ohms, then perform Test B.



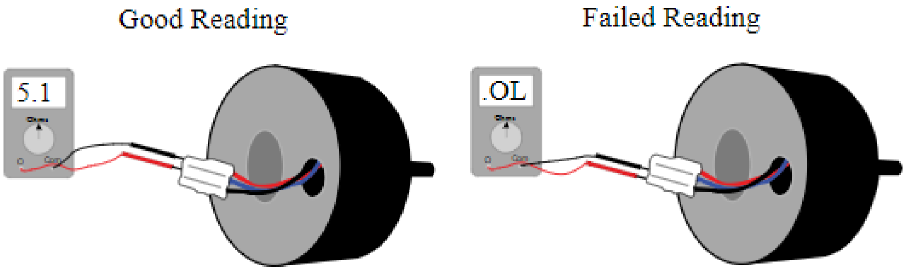
Sample Good Motor Readings and Failed Motor Readings (Test A)

Test B:
Measure the motor phase-to-phase resistance by checking these combinations of the 3-pin motor connector with an ohmmeter. For this test, either end of the connector may be used as Lead 1, the center Lead may be used as Lead 2, and the opposite end as Lead 3.

- Resistance between Lead 1 and Lead 2
- Resistance between Lead 1 and Lead 3
- Resistance between Lead 2 and Lead 3

The values for each lead-to-lead resistance reading should be measured with the meter set to the highest ohms scale unless it is auto-ranging.

The resistance across any two leads should be less than 20 ohms. All resistance readings measured between any two of the three leads should be no greater than +/-10% of each other. If any of the three resistance measurements are greater than 10% from the other readings, the motor module should be replaced with an exact replacement.
The motor must pass both tests to be good. If the motor passes both tests, the motor control should be replaced (control module) only. If the motor fails either test, it must be replaced.



Sample Good Motor Readings and Failed Motor Readings (Test B)

When replacing a failed motor or reinstalling the existing motor, caution must be taken to ensure that the belly band is not covering any vents and is not installed on the motor control. The motor module does not have a specific orientation, however, the motor control does. The three-wire plug must be oriented properly, allowing the plug to reach the motor control. This must be aligned properly prior to tightening the belly band.

Always make sure to tighten the wheel key on the flat side of the motor shaft with the blower wheel centered in the housing.

If the wheel sits too close to the motor when centered or cannot be centered because it hits the motor, the motor must be adjusted in the belly band.

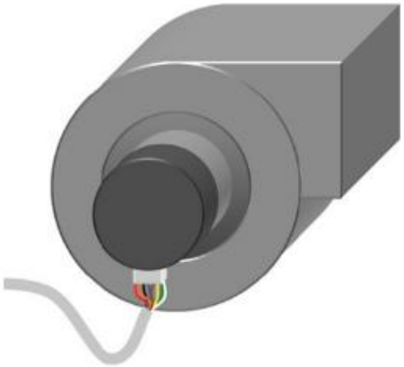
Attaching the New Control Module

The 3-pin connector should be inserted into the new control module. A slight click should be heard when inserted properly.

If the ECM 2.3 control module is replaced, the new control should be oriented to the motor's end shield with the connectors facing down, and with the bolts inserted and tightened.

The 16-pin connector and the 5-pin connector should be plugged back into the motor. The keyed connectors must be inserted properly and securely until they click.

The blower/ motor assembly should be re-installed into the HVAC system.
A drip-loop must be formed so that water cannot enter the motor by draining down the cables. Condensate or droplets can accumulate in the harness and may eventually travel into the motor.



Drip Loop Cable

ECM Motor Failure Footnotes

All repair parts for ECM motors must be obtained as a specific match to the existing motor or control module. Even if the new part looks like a direct replacement, all literature that comes with the new part must be read. There may be a small but very important change in mounting, programming, or wiring that could make the difference between a long-term repair and a short-term call back.

Models 2.0/2.3 - If these motors are suspect, instructions on the TECMateTM and in the ECM Service Guide must be followed to determine if the motor, the motor control, or both have failed and should be replaced as needed. The 2.0 motor control is no longer in production. The replacement motor control will be the 2.3. The motor modules are electrically wired the same and should not require any wiring modifications.

If this motor is suspected, the OEM (Other Equipment Manufacturers) literature will be required for troubleshooting and replacement. The TECMateTM is not set up to test this motor and the use of a multi- meter may be required.

Standard ECM Motor - Connections & Communications

There is one connection block on the Standard ECM motor with two rows of terminals and two different size terminals used.

The power inputs (High Voltage) to the motor connect through the 3/16" terminals on the following terminals:

(L) - Line 1
(G) - Ground
(N) - Neutral or Line 2

The line voltage is present at these terminals whenever the system is powered regardless of thermostat demand.
The control inputs (Low Voltage Inputs) to the motor connect through the 1/4" terminals. Terminal "C" is common and terminals 1-5 are used to select airflow settings programmed into the motor.

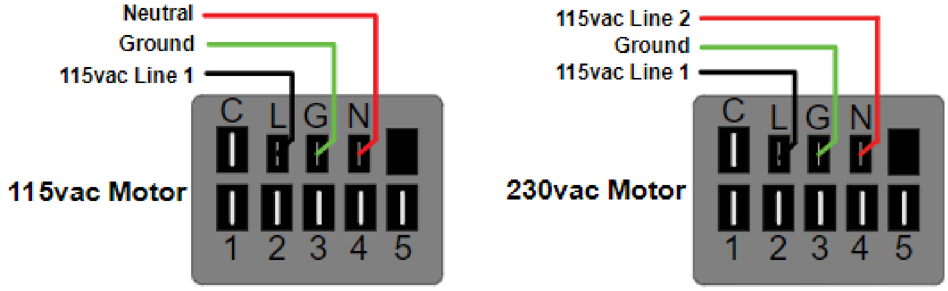
Communication to the Standard ECM motor is the low-voltage 24 volts AC provided to taps 1 through 5. The purpose of this voltage is to communicate with the motor only, not to operate it. The 24 volts AC provided to each tap is only a communication signal used to select up to five different torque values. The motor's control board uses this signal to determine which torque value it should deliver and then uses the line voltage (high voltage that is continuously connected) to operate the motor according to that program.

Each motor has a unique program. Changing taps on one motor will have different results than any other. It is not necessary to program all the taps. The number of taps used on the ECM motor is program selected. However, all Standard ECM motors will physically have 5 taps.

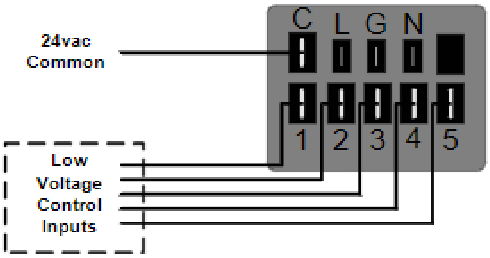
The tap settings must never be changed to adjust airflow without checking the air flow charts for the system installed. These examples do not show a tap specifically programmed for continuous fan selection. Depending on the application, the heating or cooling selection may be used as continuous fan blower speed. The percentage used for continuous fan operation can be found in the Installation Manual for each unit.

Standard ECM Connections

Connectors: The high voltage connections contain three terminals labeled "L", "G", and "N" and the low voltage connections contain one terminal labeled "C" for the 24 volts AC common and the five torque settings labeled "1" through "5".



115vac / 230vac Inputs



Low Voltage Control Inputs

The high voltage plug is used when troubleshooting the low voltage input to the motor, since the 24 volts AC common terminal "C" is in this plug.

The plugs are designed to prevent an improper connection. The high voltage plug has a full blank tab on the opposite end from the "C" terminal. This prevents it from being installed on the low voltage terminals.

Both the high and low voltage plugs have tabs on the bottom of them. When the high voltage plug is installed properly, the low voltage plug can only be installed with its tab down, or opposite from the high voltage plug. This will properly orient the low voltage terminals 1-5.

Servicing the Standard ECM Motor

Service Basics

The Standard ECM motor can be operated by 115- or 230-volt AC. However, these are two different motor models. Unlike the ECM motor, the Standard ECM is not a dual voltage motor. Applying incorrect line voltage to the Standard ECM motor may prevent the motor from operating, or even damage the motor.

The Installation Manual, diagrams and wiring schematics must be consulted for proper set up, wiring, operation, and all troubleshooting. Checking all system limits, rollouts, and safeties before troubleshooting the motor is important.

Troubleshooting this motor will be simple if the following information is known:

1. Which tap(s) have programs and what are their purposes (heating airflow, cooling airflow, continuous fan airflow)?
2. Where on the controls or circuit board do the line voltage and control voltage come from?
3. What is the sequence of operation of the controls or circuit boards (when the control voltage is sent to the motor from each thermostat demand and if there are any delays).

Troubleshooting the voltage at the Standard ECM motor comes down to two simple factors:
1. Line voltage (115- or 230-volts AC), which should be present with or without a demand for heating, cooling, or a continuous fan. Make sure proper line voltage is present between the "L" and "N" terminals as shown for the specific model being serviced.

- If there is no high voltage present at the motor, the voltage loss must be traced back towards the wiring and controls.

Line voltage should be present at the motor with or without a demand from the thermostat. The allowable voltage variance can be between:

- 98-132 volts AC on the 115 volts AC models
- 196-264 volts AC on the 230 volts AC models

1.24 volts AC low (control) voltage at the appropriate tap, with the appropriate thermostat demand call. Control voltage should be present between terminals 1- 5 and the "C" terminal as shown in the above diagram, depending on which terminal is receiving control voltage.

- If there is no low (control) voltage present at the motor, the voltage loss must be traced back towards the wiring and controls. It may be necessary to confirm that there is a proper demand from the thermostat.

The allowable voltage variance can be as much as +/-10% of the nominal 24 volts AC. If this voltage is present below this range, confirm that the control voltage is present at the unit transformer, and at the thermostat low voltage connections on the unit control board.

- If high voltage is present at the motor, the low (control) voltage is present on a programmed tap, and the motor is operating, then any airflow issues, such as high or low temperature rise, tripping main limit, freezing coils, or compressor overload tripping, should be addressed as an airflow issue first.

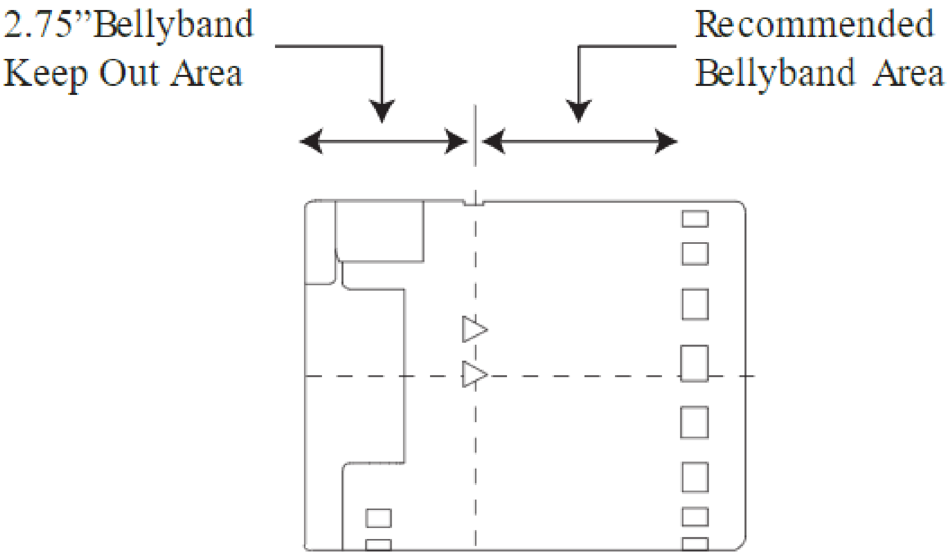
The Standard ECM is not a constant CFM motor. Airflow will decrease if static pressure rises too high in the system.
The Installation Manual can be utilized to confirm that the low (control) voltage connections are applied to the proper tap per thermostat demand.
All obvious airflow restrictions such as closed or blocked registers, grilles, dampers, blower wheel and dirty filters or indoor coils must be corrected. The external static pressure (ESP) should be evaluated, and any airflow restrictions corrected.
Probable causes of high static pressure are:

- Blocked, crushed, or dented ductwork.
- Undersized ductwork

If the high voltage and the low (control) voltage are present at the appropriate electrical connections and the motor will not operate, the motor must be replaced. A direct replacement motor from the manufacturer for the same model and size unit is required.

Replacing the Standard ECM Motor

The Standard ECM motor is a one-piece motor that is replaced as a whole and is not field repairable.
The Standard ECM motor must have a direct replacement for the specific model unit it came from.
When using a bellyband for mounting, the band should not be in the area identified in the diagram below as the "Keep Out Area".



Bellyband Keep Out Area

The wheel key must be tightened on the flat side of the motor shaft with the blower wheel centered in the housing.
If the wheel sits too close to the motor when centered or if the wheel cannot be centered because it hits the motor, the motor must be adjusted in the belly band. The blower/ motor assembly should be reinstalled into the HVAC system.
All wires and plugs should be reconnected to the motor confirming connection to proper terminals per demand.
A drip-loop should be formed so water cannot enter the motor by draining down the cables. Condensate or droplets can accumulate in the harness and may find their way into the motor.

Final Installation Checks – ECM & Standard ECM Motors

A visual inspection of all wiring and connections, especially those removed while servicing should be completed. The system should be setup as follows:

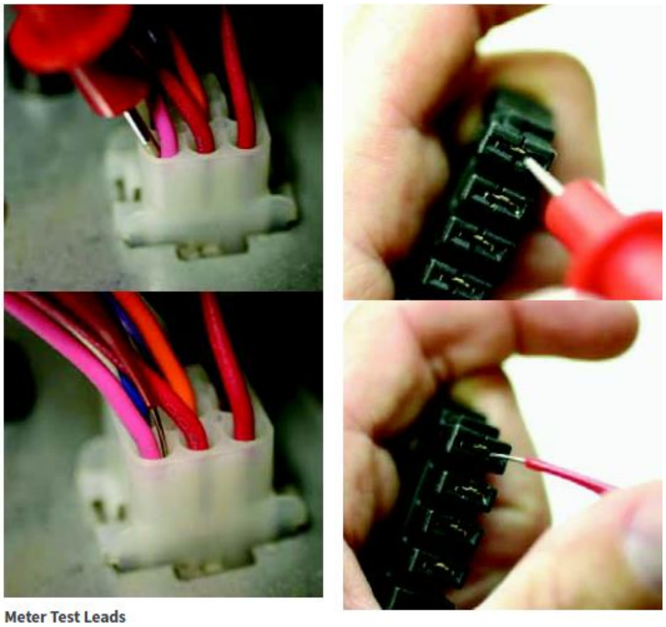
- The AC power should be reconnected to the HVAC system and verification that the new motor control module is working properly should be completed.
- All leaks in return ducts and equipment cabinet should be plugged and sealed by approved methods.
- Verify that the system is running quietly and smoothly, in all modes (heating, cooling, and continuous fan) and all stages (if applicable)
- The thermostat settings should be returned to the customer's preference.

If this is a repeat failure, check the following:

- Any evidence of moisture requires correcting the issue.
- If the area is subject to excessive amounts of lightning strikes, the use of additional transient protection may be helpful.

Tech Tips

- The input power can be within +/-10% of the nominal 115- or 230-volts AC. Any voltage outside of this range should be corrected.
- A True-RMS meter is not required to check input voltage to this motor. Any standard AC voltmeter analog or digital will work if it can read voltage up to at least 500 volts AC.
- If the polarity is reversed on the 115 volts AC connection the motor may still run, but this should be corrected.
- The 115 volts AC applications requires a jumper on the ECM motor, and the 230 volts AC applications must have this jumper removed. This is not applicable on the Standard ECM motor.
- Standard meter leads test pins are typically larger than the terminals or sockets from the plug connections being checked for voltage. Using thinner test pins will assist in preventing terminals from being damaged. Pictured below is an example of a standard meter lead test pin (above) and a thinner one (below). These test pins are also available bent at a 90-degree angle for tight areas. These types of leads can be purchased from most meter manufacturers.



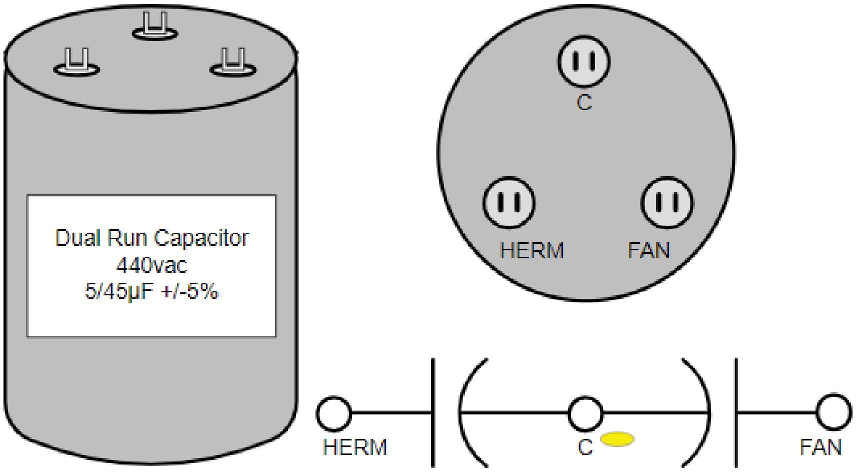
Meter Test Leads

Capacitors

Heat pumps are available with many different wiring configurations. The three phase units can be manufactured with PSC (Permanent Split Capacitance) or ECM fan motors depending upon the required application. The single-phase units can be manufactured with both PSC fan motors and compressors and may have a CSR (Capacitor Start Capacitor Run) (Capacitor Start Capacitor Run) compressor. These motors were covered in Section 3 (Component Familiarization). Gain a thorough understanding of troubleshooting capacitors when servicing single phase motors. Improper troubleshooting of these motors and capacitors has resulted in condemning the motor when the capacitor itself was the faulty component.

Three Terminal Capacitors

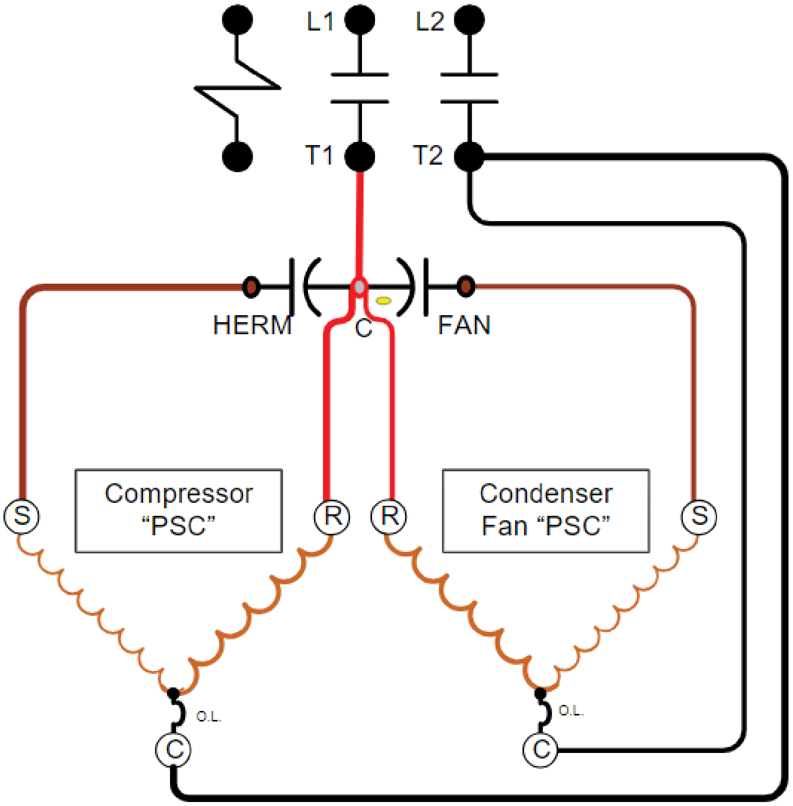
The technician should understand the three terminal capacitors. The three terminal capacitors are two capacitors built in one housing. This is one capacitor for the compressor and one capacitor for the outdoor fan motor. Each of the three terminals on the capacitors are labeled with "HERM", "FAN" and "C" as indicated in the following illustration. Some manufacturers of capacitors will label them as "H", "F" and "C" or "HERM", "FAN" and "COM". The "C" or "COM" terminal is the common point between the two capacitors and should be utilized as the identified terminal for both capacitors. This would be the terminal that is wired to the Run leg of power. The "HERM" terminal stands for Hermetic and is wired to the "S" or start terminal of the compressor. The "Fan" terminal stands for the outdoor fan motor and is wired to the start terminal of the outdoor fan motor as indicated in the diagram below.



Three Terminal Capacitor

Three Terminal Capacitor Connections

Before using a multi-meter or capacitor analyzer to evaluate a run or start capacitor, the capacitor must be discharged using a bleed resistor. The bleed resistor should be a 20,000-ohm 2-watt resistor. Do not use a screwdriver to bleed the capacitor. Using a screwdriver can damage the capacitor.



Example Electrical Wiring for Three Terminal Run Capacitor

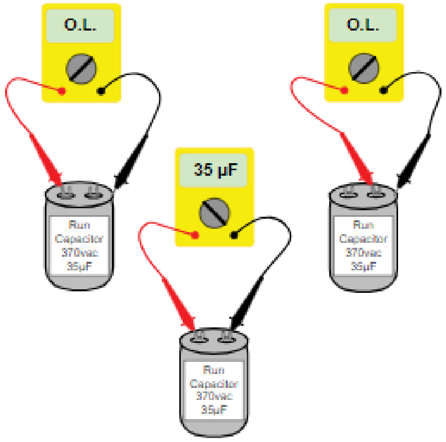
Capacitor Testing & Troubleshooting

The use of a capacitor analyzer or multi-meter has become quite common when troubleshooting single phase motors. The three main faults to test for are: open, shorted, or grounded capacitors.

Functional Capacitors

Will have an infinite reading between all the terminals to the shell of the capacitor and a measured microfarad reading between terminals within the capacitor data label's percentage rating.

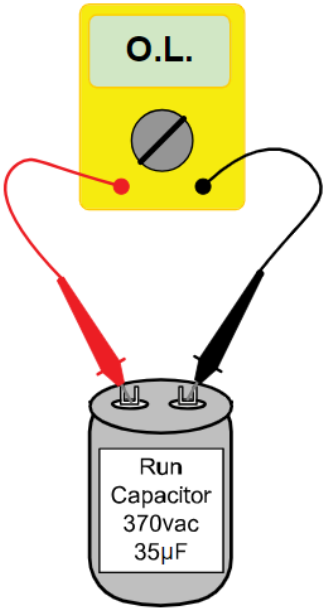
The technician can identify if the capacitor is charging and discharging with a standard ohm meter, but to read microfarads, a capacitor analyzer should be used. Some multi-meters have this capability. If the readings are outside of the rating on the capacitor data plate, the capacitor should be replaced. The diagram is an example of a potentially good capacitor.



Example Good Capacitor Readings

Open Capacitors

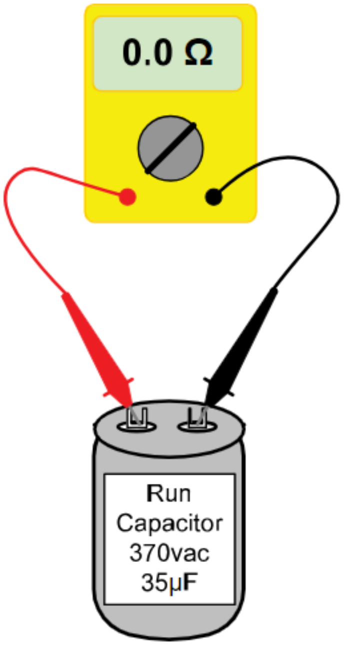
Open capacitors will have an infinite reading between the terminals on the capacitor when using an ohm meter to troubleshoot the capacitor. This is represented by an infinite reading or O.L. on the multi-meter as indicated in the image. If a capacitor analyzer is used the instructions with the meter should be followed.



Example of an Open Capacitor

Details

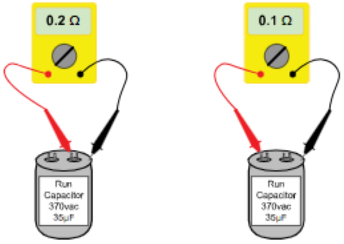
Shorted capacitors will have a reading of Zero ohms of resistance between the terminals of the capacitor as indicated in the image. If a capacitor is shorted, the readings between terminals will not fluctuate. Instead, the readings between the terminals will stay steady, and in most situations, will read less than 1 ohm of resistance. The readings can be verified by reversing the meter leads to the capacitor terminals. If the resistance begins to increase or decrease, the capacitor is not shorted.



Example of a Shorted Capacitor

Grounded Capacitor

Grounded capacitors will have a measurable resistance from any of the capacitor terminals to the shell as shown in the diagram.
If the capacitor has become grounded, it must be replaced, and the motor must be evaluated thoroughly.



Example of Grounded Capacitors

Refrigerant Charge Verification

The outdoor section for the split system heat pump units should be charged from the factory with enough refrigerant to accommodate the following:

- The outdoor coil
- Fifteen feet of lineset
- The smallest matched indoor coil

If a larger indoor coil is matched or if the lineset is longer or shorter than 15 feet, the Tabular Data Sheet or the Technical Guide must be used to identify the amount of refrigerant that must be added or removed from the system to achieve the systems design efficiency.

These documents also have the additional charge required if a Thermostatic Expansion Valve (TXV) is installed in the system.

One of these two documents must be used to evaluate the listed factory charge. The factory charge should be adjusted by the amount of refrigerant that was added or subtracted for the interconnecting lineset. The charge should also be adjusted by the amount of refrigerant added for the indoor coil (if required) and for the TXV (if required). The total amount of refrigerant in the system after all adjustments have been made should be permanently marked on the unit nameplate. If a technician has made a repair and the refrigerant has been recovered, the equipment should be charged by weight using the values on the equipment nameplate.

If the system is being evaluated for a "no cooling" or a "poor cooling" call, the system refrigerant charge can be verified using the superheat or subcooling charging methods.

When charging a system using superheat or subcooling charging methods, the system should be operating in cooling mode only. If the system is operating in the heating season, the only accurate charging method would be to recover the refrigerant and charge the system by weight.

As indicated, properly installed systems should have the required amount of refrigerant permanently marked on the nameplate and should be charged by weight when possible.

Alternatives to charging a system by weight include:

- **Fixed Orifice** metering devices can also be charged using the superheat charging charts provided with the equipment.
- **Thermostatic Expansion Valve** metering devices can also be charged using the subcooling values sometimes listed on the equipment or in some Installation Manuals

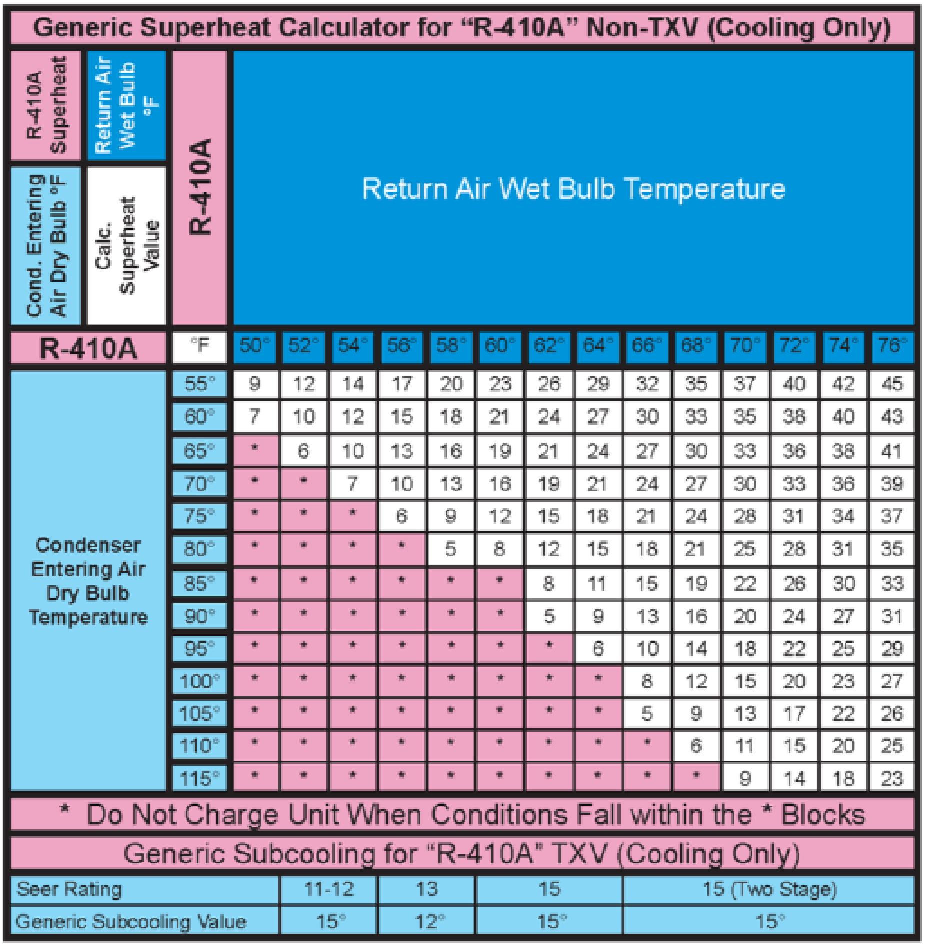
Do not charge the TXV system by the superheat method. If a system using a TXV metering device is identified as having the wrong amount of superheat, the system must be evaluated to verify that it is properly charged by weight or charged to the manufacturer's required subcooling values.

Identify the following conditions prior to evaluating the system for proper refrigerant charge:

- Proper air flow has been established and does not exceed the total external static pressure listed on the unit data plate
- All major components are operating including the compressor, outdoor fan motor, and indoor fan motor
- The indoor and outdoor coils are clean and free of debris
- Return air filter is clean
- Supply air vents are in the open position
- Temperature probes are installed and insulated on the appropriate refrigerant lines
- The appropriate refrigerant gauge manifold set is properly purged and installed
- The system has operated in the cooling mode for a minimum of 15 to 20 minutes The system's metering device was located to verify which of the charging methods will be used
- The proper superheat or subcooling refrigerant charge was identified on the equipment data plate or in the equipment Installation Manual

If there is not a published superheat or subcooling value and the technician is evaluating a system for acceptable refrigerant charge, the following generic charging values may be used.

These values should only be used if there are no other charging methods available for the unit.
The values in the "Generic Superheat Calculator for R-410A" chart below should be within +/-3 degrees of the measured refrigerant charge.



Generic Superheat Calculator for "R-410A" Non-TXV (Cooling Only)

R-410A Superheat: Return Air Wet Bulb °F

Cond. Entering Air Dry Bulb °F: Calc. Superheat Value

R-410A: Return Air Wet Bulb Temperature

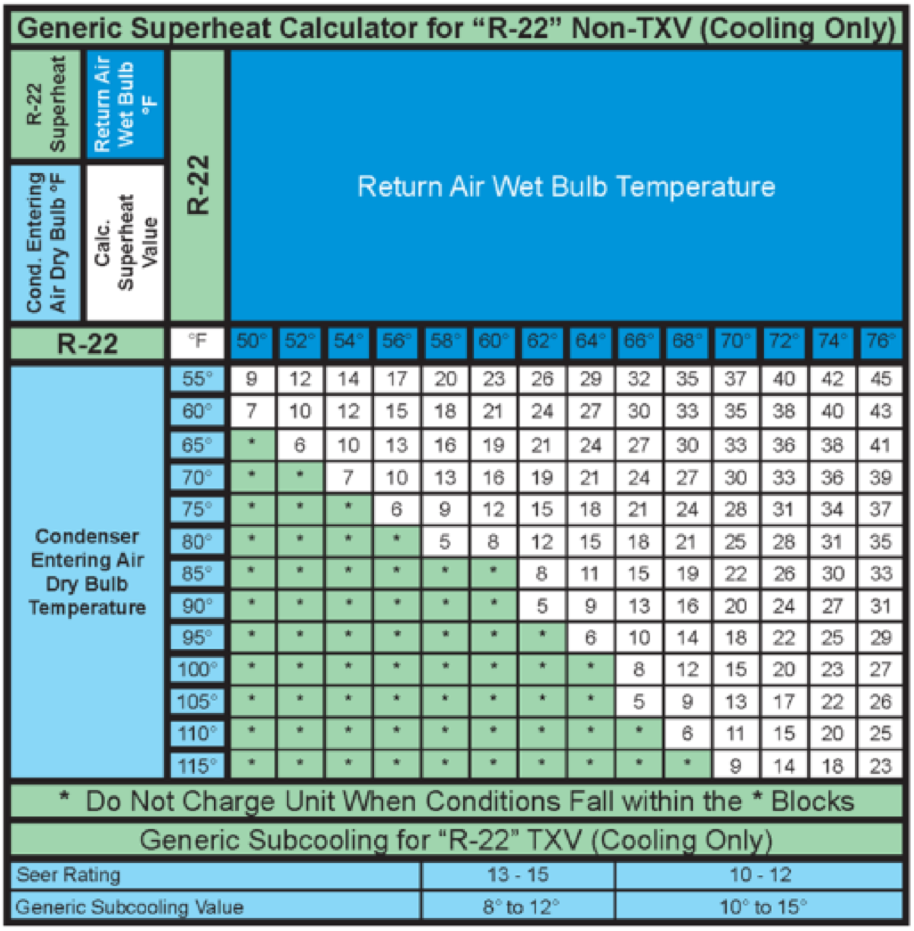
R-410A	°F	50°	52°	54°	56°	58°	60°	62°	64°	66°	68°	70°	72°	74°	76°
Condenser Entering Air Dry Bulb Temperature	55°	9	12	14	17	20	23	26	29	32	35	37	40	42	45
	60°	7	10	12	15	18	21	24	27	30	33	35	38	40	43
	65°	*	6	10	13	16	19	21	24	27	30	33	36	38	41
	70°	*	*	7	10	13	16	19	21	24	27	30	33	36	39
	75°	*	*	*	6	9	12	15	18	21	24	28	31	34	37
	80°	*	*	*	*	5	8	12	15	18	21	25	28	31	35
	85°	*	*	*	*	*	*	8	11	15	19	22	26	30	33
	90°	*	*	*	*	*	*	5	9	13	16	20	24	27	31
	95°	*	*	*	*	*	*	*	6	10	14	18	22	25	29
	100°	*	*	*	*	*	*	*	*	8	12	15	20	23	27
	105°	*	*	*	*	*	*	*	*	5	9	13	17	22	26
	110°	*	*	*	*	*	*	*	*	*	6	11	15	20	25
	115°	*	*	*	*	*	*	*	*	*	*	9	14	18	23

* Do Not Charge Unit When Conditions Fall within the * Blocks

Generic Subcooling for "R-410A" TXV (Cooling Only)

Seer Rating	11-12	13	15	15 (Two Stage)
Generic Subcooling Value	15°	12°	15°	15°

The values in the "Generic Superheat Calculator for R-22" chart below should be within +/-3 degrees of the measured refrigerant charge.



Generic Superheat Calculator for “R-22” Non-TXV (Cooling Only)

R-22 Superheat | Return Air Wet Bulb °F

Cond. Entering Air Dry Bulb °F | Calc. Superheat Value

R-22

Return Air Wet Bulb Temperature

R-22	°F	50°	52°	54°	56°	58°	60°	62°	64°	66°	68°	70°	72°	74°	76°
Condenser Entering Air Dry Bulb Temperature	55°	9	12	14	17	20	23	26	29	32	35	37	40	42	45
	60°	7	10	12	15	18	21	24	27	30	33	35	38	40	43
	65°	*	6	10	13	16	19	21	24	27	30	33	36	38	41
	70°	*	*	7	10	13	16	19	21	24	27	30	33	36	39
	75°	*	*	*	6	9	12	15	18	21	24	28	31	34	37
	80°	*	*	*	*	5	8	12	15	18	21	25	28	31	35
	85°	*	*	*	*	*	*	8	11	15	19	22	26	30	33
	90°	*	*	*	*	*	*	5	9	13	16	20	24	27	31
	95°	*	*	*	*	*	*	*	6	10	14	18	22	25	29
	100°	*	*	*	*	*	*	*	*	8	12	15	20	23	27
	105°	*	*	*	*	*	*	*	*	5	9	13	17	22	26
	110°	*	*	*	*	*	*	*	*	*	6	11	15	20	25
	115°	*	*	*	*	*	*	*	*	*	*	9	14	18	23

* Do Not Charge Unit When Conditions Fall within the * Blocks

Generic Subcooling for “R-22” TXV (Cooling Only)

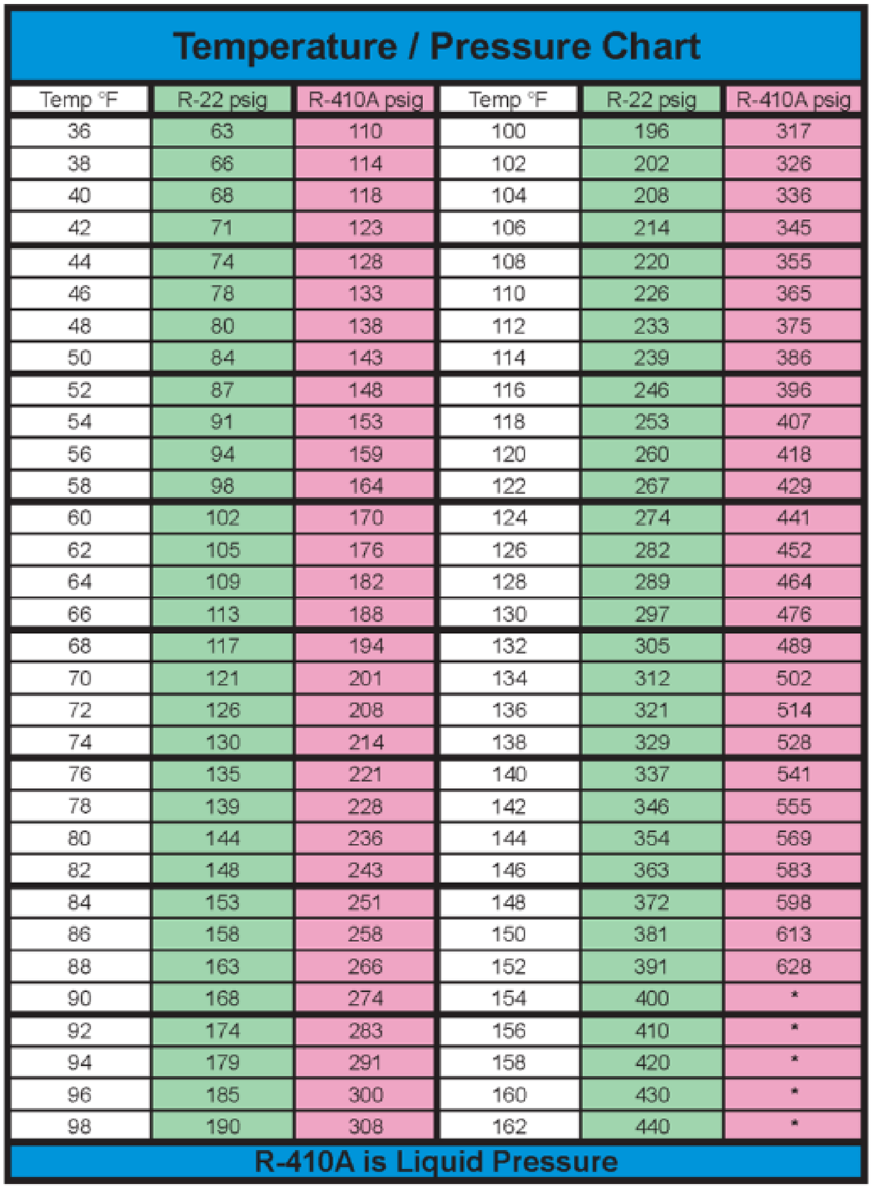
Seer Rating	13 - 15	10 - 12
Generic Subcooling Value	8° to 12°	10° to 15°

Superheat Verification

The required superheat values on a fixed orifice metering device can vary depending upon the ambient conditions. Often, it is necessary to measure the indoor wet and dry bulb temperatures as well as the outdoor dry bulb temperature. The "target" superheat value must be known for the conditions present during service. A tolerance of +/- three degrees is allowed from the target value.

To verify superheat:

- Operate the unit until conditions stabilize. Two stage systems should have both stages ("Y1", "Y2" and "O") energized
- Measure the suction pressure by attaching the low side of the manifold gauge set to the low side valve port
- Convert this pressure to temperature using the Temperature - Pressure Chart" below. This chart indicates the temperature (Boiling Point or Saturation Temperature) in the left-hand column and the pressure (PSIG) under the refrigerant column



Temperature / Pressure Chart

Temp °F	R-22 psig	R-410A psig	Temp °F	R-22 psig	R-410A psig
36	63	110	100	196	317
38	66	114	102	202	326
40	68	118	104	208	336
42	71	123	106	214	345
44	74	128	108	220	355
46	78	133	110	226	365
48	80	138	112	233	375
50	84	143	114	239	386
52	87	148	116	246	396
54	91	153	118	253	407
56	94	159	120	260	418
58	98	164	122	267	429
60	102	170	124	274	441
62	105	176	126	282	452
64	109	182	128	289	464
66	113	188	130	297	476
68	117	194	132	305	489
70	121	201	134	312	502
72	126	208	136	321	514
74	130	214	138	329	528
76	135	221	140	337	541
78	139	228	142	346	555
80	144	236	144	354	569
82	148	243	146	363	583
84	153	251	148	372	598
86	158	258	150	381	613
88	163	266	152	391	628
90	168	274	154	400	*
92	174	283	156	410	*
94	179	291	158	420	*
96	185	300	160	430	*
98	190	308	162	440	*

R-410A is Liquid Pressure

- Measure the suction temperature by attaching an electronic type of thermometer to the suction line at the compressor inlet or suction service valve. To obtain an accurate measurement, the thermometer must be insulated and in solid contact with the suction line
- Subtract the converted temperature from the suction line temperature. If superheat is too low, the unit may be overcharged. If it is too high, the unit may be undercharged
- After adding or removing charge, allow the system to operate 10-15 minutes prior to rechecking the superheat value

Subcooling Verification

Systems with TXV metering devices cannot be charged using the superheat method because TXVs will attempt to maintain a constant superheat regardless of refrigerant charge or load conditions. For this reason, TXV systems are charged by weight or using the subcooling method.

To verify subcooling, begin by obtaining the target subcooling value from the Installation Manual and proceed with the following:

- Operate the unit until conditions are stable. Two stage systems should have both stages ("Y1" and "Y2") energized

- Measure the head pressure by attaching the high side of the manifold gauge set to the high side valve port
- Measure the liquid line temperature by attaching an electronic type of thermometer to the liquid line at the liquid line service valve. To obtain an accurate measurement, the thermometer must be insulated and in solid contact with the liquid line
- While using a temperature pressure chart, find the saturation point of the refrigerant by locating the system high side pressure under the column for the refrigerant that is in the system. Follow that value across to the corresponding temperature to find the saturation point
- Subtract the liquid line temperature from the saturation point, and the result is the subcooling value
- There is a tolerance of +/- three degrees allowable from the target value

In the following example, if the subcooling is 8°F and the required subcooling is 6°F, it is not advisable to adjust the charge. The only time a charge should be adjusted is when the subcooling value is more than 3°F outside of the manufacturer's target subcooling value.
High Side Pressure R-410A = 418 psig

High side pressure converted to saturation temperature or boiling point using the pressure/temperature chart = 120°F
Liquid Line Temperature at the outlet of the condenser coil = 112°F

High Side Saturation Temperature minus Liquid Line Temperature equals subcooling.

Subcooling Calculation

High Side Saturation Temperature	120°F
- Liquid Line Temperature	- 112°F
=Subcooling	= 8°F

If the measured subcooling is more than three degrees higher than the recommended subcooling value for the heat pump being serviced, refrigerant is removed to decrease subcooling. Use proper refrigerant recovery techniques.

If the measured subcooling is more than three degrees lower than the recommended subcooling value for the heat pump being serviced, refrigerant must be added to increase subcooling. If refrigerant must be added, the refrigerant should be added in a vapor state into the suction line, while the unit is running.

R-410A systems will require some type of charge master to flash the refrigerant from a liquid to a vapor when charging refrigerant into the suction line. This is because R- 410A is a near azeotrope and exits the charging drum as a liquid. After adding or removing charge, the system should be allowed to operate 10-15 minutes prior to rechecking the subcooling value.

Frozen Indoor Coil

Many "no cooling" calls come from a neglected air filter or other causes of restricted airflow. As airflow is reduced, the temperature of the indoor coil during cooling operation decreases below the freezing point of water and the moisture in the return air will freeze on the coil surface.

If left running long enough in this condition, the indoor coil will become a block of ice. As a result, minimal heat transfer will occur between the return air and the refrigerant within the coil. The liquid refrigerant entering the indoor coil will not be able to boil off to a vapor and will pass into the suction side of the compressor. If liquid refrigerant flows back into the compressor, the compressor may fail.

To prevent such an occurrence, customers must be advised to replace air filters on a regular basis and refrain from closing off rooms that are not in use. Closing off registers or rooms does not save operational costs. Rather, it increases static pressure in the system and the possibility of liquid refrigerant flooding back. The technician should take the time to explain to the customer that the equipment will continue to run until the thermostat is satisfied, regardless of if the unused bedrooms are open or closed.

Although airflow is properly set up and the customer is educated about his/her role in system upkeep, "no cooling" calls due to airflow restrictions can be avoided. The appearance of frost can also indicate a low system refrigerant charge or a restriction. If frost appears on or immediately downstream of a specific component in the refrigeration system, (such as the filter drier or metering device), there is a restriction within that component. A low system refrigerant charge can cause the indoor coil temperatures to drop below 32°F during cooling operation. This causes the moisture in the return air to freeze on the surface of the coil.

If a frozen indoor coil is encountered during cooling operation, allow the coil to completely defrost. When the coil has defrosted, proper airflow must be verified using the methods discussed earlier. Then, the refrigerant charge may be verified. If the system has a low system refrigerant charge, the system should be leak checked. Any leaks present should be repaired prior to attempting to adjust the system refrigerant charge.

If the heat pump is operating in the heating mode and the indoor coil is accumulating ice or frost, evaluate the system operation. The coil of the reversing valve should receive 24 volts AC only during cooling and defrost operation. If the reversing valve is stuck in the cooling or defrost position when the system should be operating in the heat mode, evaluate the thermostat and defrost control board outputs.

A voltage measurement can be taken at the "RV" and "RVG" terminals of the YORK GUARD VI defrost control board or the "REV VALVE" terminals of the Demand Defrost and Time Temperature defrost control boards.

If 24 volts AC is not present and the reversing valve is in the cooling position, the reversing valve is defective and should be replaced. If 24 volts AC is present, verify the inputs to the defrost control board. Ensure that all jumpers are removed from the "TEST" pins on the control board and that the system is not in a forced defrost mode. If the "TEST" pins are shorted together, the control board will maintain operation in the defrost mode until the jumper is removed. A thorough evaluation of the thermostat wiring must also be completed to ensure proper operation.

High Discharge Pressures

Many "no cooling" calls are identified with high discharge pressures. High discharge pressures can result in:

- Inefficient operation
- Internal overload tripping
- High discharge line temperature trips (YorkGuard VI)
- High Amperes
- Lubrication failure
- Compressor failure

If the internal overload continues to trip, the overload will be permanently damaged and could require compressor replacement. Excessive discharge pressures can reduce the life of the oil and lubrication failure can occur.
There are three common problems associated with high discharge pressures:

1. Poor airflow across the outdoor coil during cooling operation and across the indoor coil during heating operation
2. System overcharge
3. Non-condensable in the system

The most common of these problems is poor airflow across the coils.
If the coil is dirty, the equipment cannot reject the heat from the refrigerant properly and high discharge pressures will be present.

To save valuable time when troubleshooting a system, the condition of the indoor and outdoor coils should be evaluated. If the coil is dirty, it should be cleaned prior to installing the manifold gauge set. This will help eliminate poor airflow across the coil as the cause of poor system operation and high discharge pressures.

If the coils have proper airflow and the manifold gauge readings indicate the high side pressure to be excessive, the next step would be to evaluate the system to identify if the unit is properly charged.

A grossly overcharged system will produce high discharge pressures and should be corrected immediately. Proper charging methods were covered earlier in this section.

If the unit continues to operate with high discharge pressures, despite proper airflow across the coils and a proper charge in the system, then it is possible that non-condensable are present in the system.

Non-condensable are gases that will not condense into a liquid state. This is usually air allowed to enter the system, or dry nitrogen used to pressure test or purge the refrigeration system while brazing copper tubing.

Non-condensable are pumped to the outdoor coil during cooling and to the indoor coil during heating operation. The non-condensable are trapped at the top of the coil. This reduces the capacity of the unit and increases high side discharge pressure.

Non-condensables are usually introduced in the system by improper manifold gauge installation. They can also be introduced by improper evacuation of the unit after a major repair or component replacement within the refrigeration cycle.

It is rare that non-condensables are introduced in the system during normal operation. It is possible that the non-condensables are pulled into the low side of the system when the unit has a leak on the low side and has been allowed to operate with negative pressure.

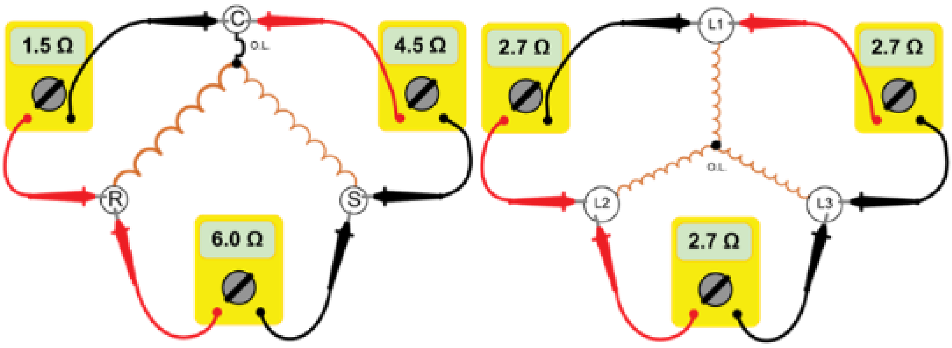
To properly remove non-condensables from the unit, first perform a leak test on the system. After identifying any leaks that may be present, recover the system's entire refrigerant charge and perform an acid test to determine if the refrigerant oil is contaminated. If acid is detected, the system must be cleaned using approved methods. This may include flushing the system, replacing contaminated copper, methods. This may include flushing the system, replacing contaminated copper, adding a suction line filter drier to protect the compressor, or performing a triple evacuation prior to charging. All leaks should be repaired, and new filter driers installed.

Once the filter driers have been installed, the system should be evacuated to approximately 500 microns and then charged to the recommended weight, superheat, or subcooling methods provided on the unit or in the Installation Manual.

If a severe burnout is detected with the acid test kit, a suction line filter drier should be installed to help clean up the system. The accumulator will have a small amount of refrigerant oil in the bottom of the reservoir that could return to the compressor and cause damage. When possible, the suction line filter drier should be installed between the accumulator and the compressor. It is also recommended that a suction line filter drier be removed after no more than 50 hours of compressor operation.

Compressor Electrical Troubleshooting

A good understanding of the electrical layout of the compressor is extremely important when diagnosing compressor faults. This section will cover the single phase and three phase compressors utilized in heat pump units.



Example of Electrical Layout of Single Phase & Three Phase Compressors

Single Phase Compressor

The single-phase compressors described in this guide have been manufactured with a run winding, a start winding, and an internal overload wired to the common terminal of the compressor. Single phase compressors may be installed in systems which require the compressor to start under high pressures. The greater the pressure, the greater the starting torque required to start the motor. The start and run windings are wound a few electrical degrees out of phase and provide minimal starting torque. The system may require a starting relay and capacitor to provide greater starting torque because of these characteristics. The starting components for single phase motors were discussed in Section 3 (Component Familiarization).

In single phase heat pumps, the compressors have a "run winding" and a "start winding", which are indicated by "R" and "S" on the compressor terminal block. In addition to the "R" and "S" terminals, the compressor has a "C" terminal. The "C" terminal represents a "common" point between the start and run windings.

Notice the internal thermal overload wired in series between the "C" terminal and the run and start windings. The internal thermal overload is installed to provide additional protection for the compressor's windings when the motor is subjected to overheating.

When troubleshooting electrical equipment, there are a few checks that should be made and many safety guidelines to follow.

Taking a voltage reading to verify that the compressor is receiving the required voltage +/- 10% of the voltage rating on the equipment data plate is important when troubleshooting the compressor.

After the supply voltage to the compressor has been verified and the compressor is not operating, the following procedures should be followed:

- Lock-out and tag-out the electrical supply voltage at the equipment disconnect. The electrical disconnect is usually within 6 feet of the equipment and should be installed according to the local authority having jurisdiction, the National Electrical Code and all applicable city, state, and federal regulations
- Verify that the voltage has been disconnected with a voltage meter
- Bleed the capacitors as described in the capacitor topic of this section
- Evaluate the compressor windings using an ohm meter

Compressor Resistance Readings

Single Phase

The resistance readings in the examples for this section are used as a reference point to assist the technician in understanding the internal configuration of the compressor. Resistance readings in the field will vary from one compressor to the next; however, the relationship between the start, run, and common terminals will remain the same.

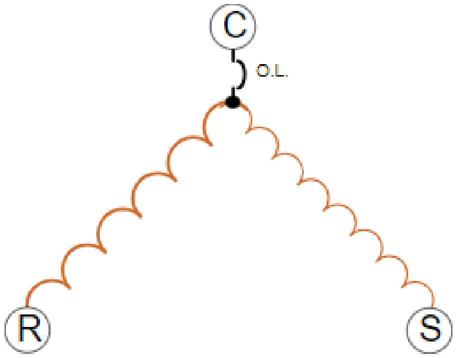
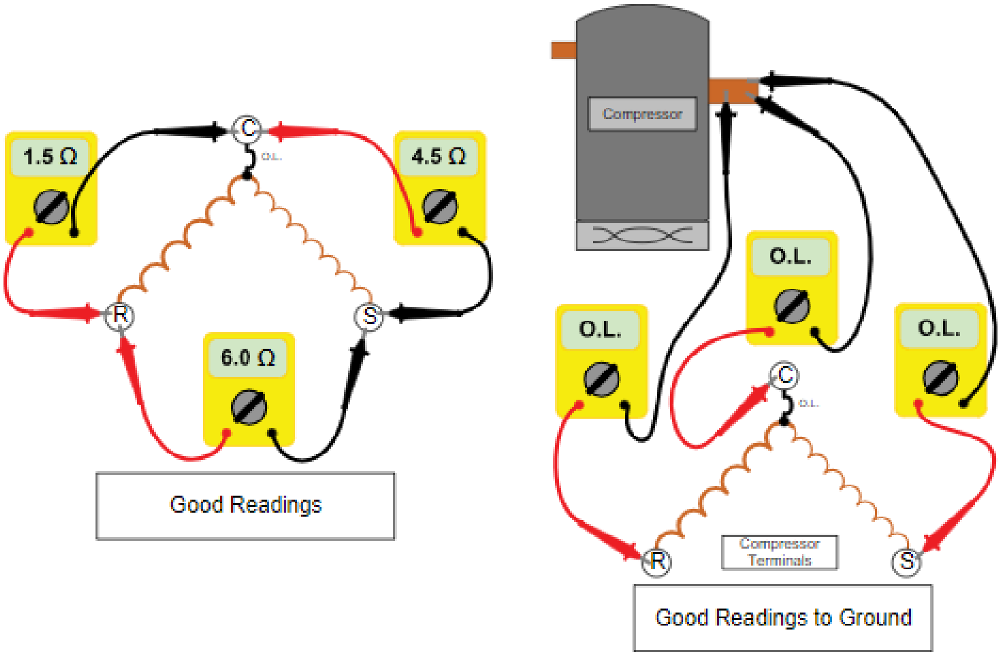


Diagram of “S”, “R”, “C” Windings

Example:

The highest resistance reading should be between Start "S" and Run "R". The lowest resistance reading should be between Run "R" and Common "C". The middle resistance reading should be between Start "S" and Common "C.



Example of Good Resistance Readings for Single Phase Compressor

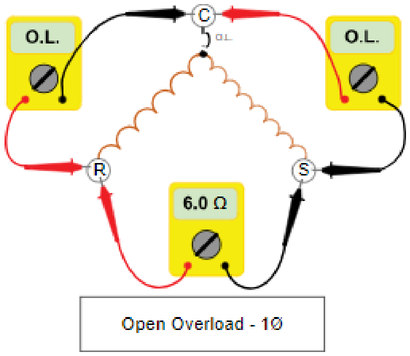
Internal Overload

Terminal "C" is common for both windings. A thermal overload is wired internally between the "C" and "R" terminals and the "C" and "S" terminals and is often indicated as "OL" on a wiring schematic. In the event of an over temperature condition, the normally closed overload opens and takes both the run and start windings out of the circuit to protect the compressor. This is often misdiagnosed as a faulty compressor.

To determine if the internal overload has opened, an ohmmeter can be used to read the resistance between each of the three terminals. If an open or infinite reading is measured between "C" and "R" and between "C" and "S", but resistance is read between "R" and "S", the internal overload has opened and must be given time to cool off and reset.

Example: Open Internal Overload

"C" to "R" = Open
"C" to "S" = Open
"R" to "S" = 6 ohms



Example of Open Internal Thermal Overload on Single Phase Compressor

Common issues that may cause an internal overload to open include:

- Low refrigerant charge causing high superheat and inefficient cooling of the compressor
- Excessive airflow across the indoor coil during cooling
- Excessive indoor heat load across the indoor coil during cooling
- Restricted airflow through the outdoor coil during cooling and through the indoor coil during heating
- Excessive refrigerant charge
- Non-condensable within the system

After the internal overload resets, the system should be started and monitored to determine the cause of the internal overload opening. The problem should then be corrected prior to leaving the job site.

Both the "RLA (Rated Load Amperage)" and "LRA (Locked Rotor Amperage)" values for a compressor are listed on the compressor and the unit's rating plate.

The RLA (Rated or Run Load Amperage) is the typical current the compressor will draw-measured in Amps-on a properly set up system under design test conditions. The RLA value can be read by using a clamp style ammeter around the "C" or common lead to the compressor. The RLA reading on a system will vary depending on the ambient conditions and the system charge.

The LRA (Locked Rotor Amperage) value is the electrical current the compressor will draw when attempting to start. On systems with an adequate supply of voltage and properly sized conductors, the LRA period should be short. If the compressor is struggling to start, the compressor will be drawing LRA for a longer period. This can also be verified with an ammeter clamped around the "C" lead of the compressor. When a compressor fails to start, the current draw of the compressor moves to LRA then drops to zero amps. This indicates the compressor's internal overload is momentarily opening. This may repeat until the compressor's internal overload opens and takes both the run and start windings out of the circuit.

If the compressor has cooled down and the internal overload will not reset, the compressor should be replaced.

Good Readings

The first reading in the example is the total combined resistance of the start winding and the run winding, which is the resistance reading between "R" and "S" in the diagram, or 6 ohms.

The second reading in the example is taken between "C" and "R". This indicates that

The run winding has 1.5 ohms of resistance. This also indicates that the start winding should have a resistance reading of 4.5 ohms when a reading is taken between "C" and "S".

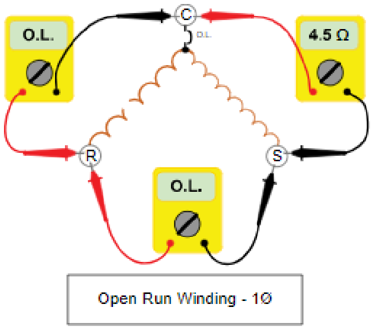
Example of Good Readings Between Terminals on Single Phase Compressor

Example: Single Phase Compressor
"R" to "S" = 6.0 ohms
"C" to "R" = 1.5 ohms
"C" to "S" = 4.5 ohms

Run Winding

The run winding is the main winding in a single-phase compressor. This is because the run winding is in the circuit 100% of the time the compressor is operating. To evaluate the run winding, the electrical disconnect must be locked out and an ohm meter used to measure the resistance of the compressor. The compressor should have a resistance reading between "R" and "S" and a reading between "R" and "C".

The run winding will have the lowest resistance reading on a good compressor. If the technician were to take a resistance reading between "C" and "S" and the resistance was 4.50s, then the start winding has continuity, and the internal overload is closed. If a second reading were taken between "C" and "R" and the ohm meter indicated "open", the compressor has an open run winding.



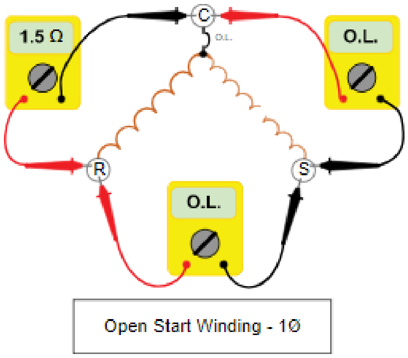
Example of an Open Run Winding on a Single Phase Compresor

Example: Open Run Winding
"C" to "S" = 4.5 ohms
"C" to "R" = Open
"R" to "S" = Open

Start Winding

The start winding has the smallest diameter and highest resistance wire of the two windings on a single-phase compressor.

If the resistance reading between "C" and "R" is 1.5 ohms, the run winding has continuity, and the internal overload is closed. If the second reading between "C" and "S" is "open", the compressor has an open start winding as indicated in the diagram below.



Example of an Open Start Winding on a Single Phase Compressor

Example: Open Start Winding
"C" to "R" = 1.5 ohms
"C" to "S" = Open
"R" to "S" = Open

Shorted Windings

The highest resistance reading on a single-phase compressor should be between the "R" and "S" terminals because the reading is of both the run and start windings in series with each other.

The second highest reading will be of the start winding between terminals "S" and "C" and the lowest resistance reading should be between terminals "C" and "R". The resistance readings between "C" and "R" and between "C" and "S" should add up to the resistance indicated between "R" and "S". If the resistance is significantly less than each of the windings added together, then the windings are shorted together as indicated in the diagram below.

Example: Single Phase Shorted Windings

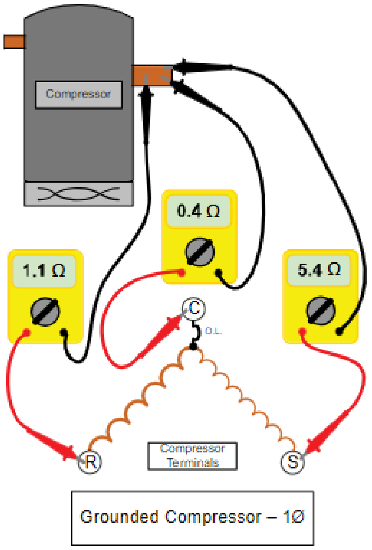
"C" to "R" = 1.5 ohms
"C" to "S" = 4.5 ohms
"R" to "S" = 1.9 ohms

Grounded Compressor

If the circuit breaker blows immediately on compressor startup, the breaker size, wire size, and supply voltages should be verified and within the equipment tolerances according to the unit rating plate and Installation Manual. If all are correct, an ohmmeter is used to determine if a compressor winding is shorted to ground. To do so, lock-out and tag-out the equipment disconnect. The three leads to the compressor should be disconnected and a resistance reading measured from each terminal to the shell of the compressor.

When taking resistance readings, good contact with the compressor shell, the suction line, or discharge line attached to the compressor is essential. This is because the compressor has a heavy layering of paint on the shell and could cause a false reading.

All readings should read "open" or "infinite" when measured from the compressor shell to any of the terminals. If continuity is read between any lead and the compressor shell as indicated in Figure 7-30, a winding is shorted to the shell and the compressor has been grounded. Any time a motor has become grounded, it should be replaced.



Example of a Grounded Single Phase Compressor

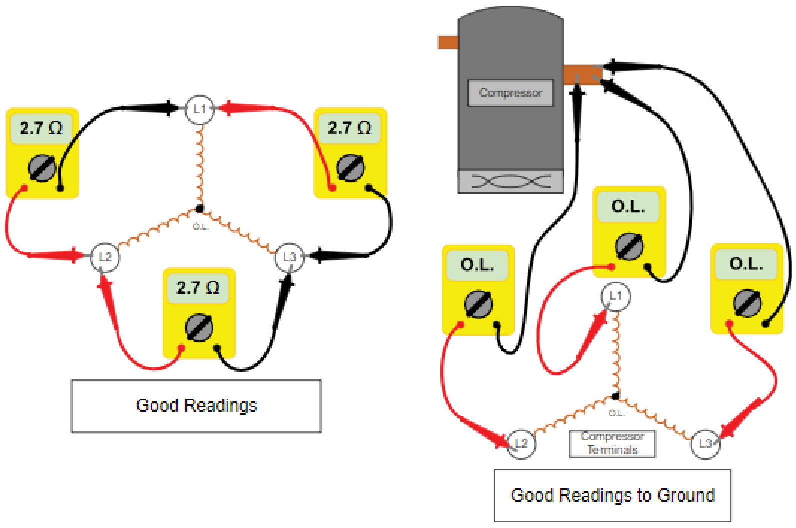
Example: Grounded Compressor

"C" to "R" = 1.5 ohms
"C" to Shell = 0.40s "C" to "S" = 5.0 ohms
"S" to Shell = 5.40s "R" to "S" = 6.5 ohms
"R" to Shell = 1.10s
A compressor can have what are normal readings between the windings yet be grounded at the same time.

Three Phase

Three phase compressors have three equally sized windings. When measuring the three windings' resistance, the ohm readings should be about the same between any two terminals. The diagram in the diagram below is an example of equal resistance readings between windings.

Good Readings



Example of Good Resistance Readings on Three Phase Compressor

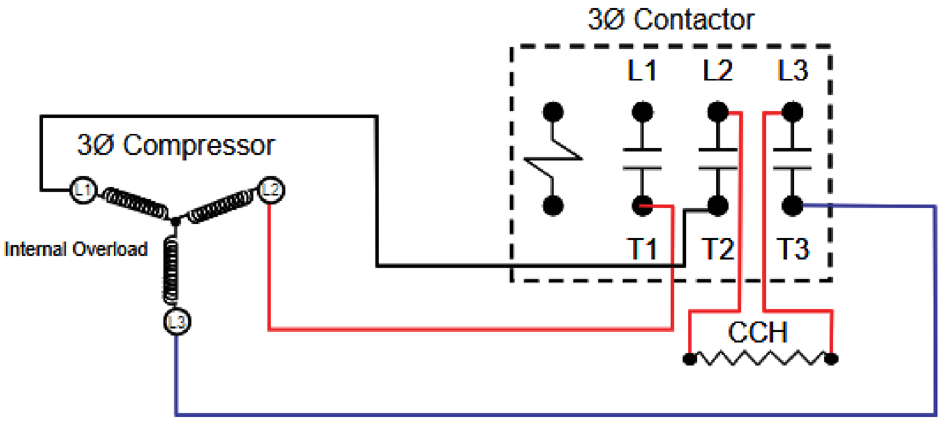
Example: Three Phase

"L1" to "L2" = 2.7 ohms
"L1" to "L3" = 2.7 ohms
"L2" to "L3" = 2.7 ohms
If the windings of a three-phase motor do not have similar resistance readings, the readings may be used to determine if the motor has failed, or the thermal overload has opened to protect the motor.

Note

Proper rotation of three phase compressors must be established to prevent damage to the compressor.

If the rotation is not correct, reversing any two of the 3 lines of power supplying the compressor as indicated in the diagram below will reverse the rotation of the compressor.



Electrical / Reversing Two Legs of Electrical Power

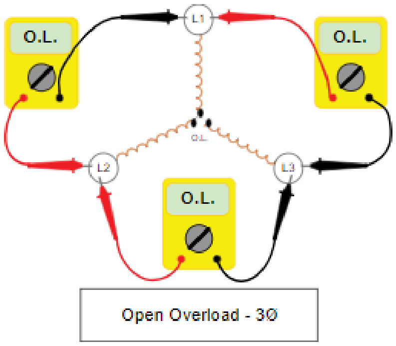
Open Overload

When the internal overload of a three-phase compressor is open, the resistance readings between the "L1", "L2" and "L3" terminals will all read open as shown in the diagram.

Example: Three Phase Open Internal Thermal Overload

"L1" to "L2" = Open
"L2" to "L3" = Open
"L1" to "L3" = Open

When an open overload has been identified, the compressor must have adequate time to cool down and reset the overload. If the overload does not reset, the compressor should be replaced. Although it would be unusual, this could also represent that all 3 windings have burned open.



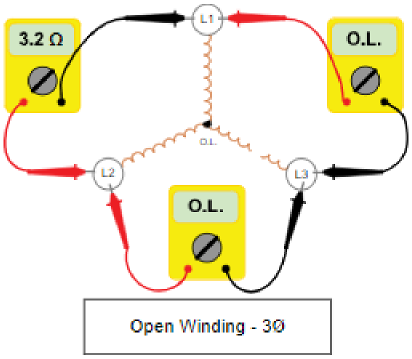
Example of Open Internal Thermal Overload on Three Phase Compressor

Open Winding

An open winding on a three-phase compressor will usually be indicated by continuity between two of the windings and an open present between the remaining terminals as shown in the diagram below.

Example: Three Phase Open "L3" Wingding

"L1" to "L2" = 3.2 ohms
"L2" to "L3" Open
"L1" to "L3" = Open



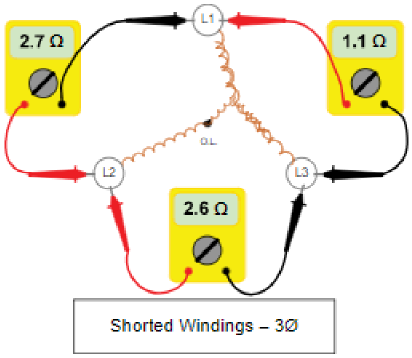
Example of Open Winding on Three Phase Compressor

Shorted Windings

On 3 phase compressors each of the 3 resistance readings between any 2 terminals should be the same. When a 3-phase compressor has shorted windings the resistance readings between 2 of the compressor terminals will be less than the other 2 readings. In this example, the reading between terminals "L1" and "L3" indicates a resistance of 1.1 ohms of resistance. This is less than the other 2 readings of 2.7 and 2.6 ohms of resistance, which indicates that there is a short between the "L1" and "L3" windings.

Example: Shorted Windings

"LI" to "L2" = 2.7
"L2" to "L3" = 2.6
"LI" to "L3" = 1.1



Example of Shorted Windings on a Three Phase Compressor

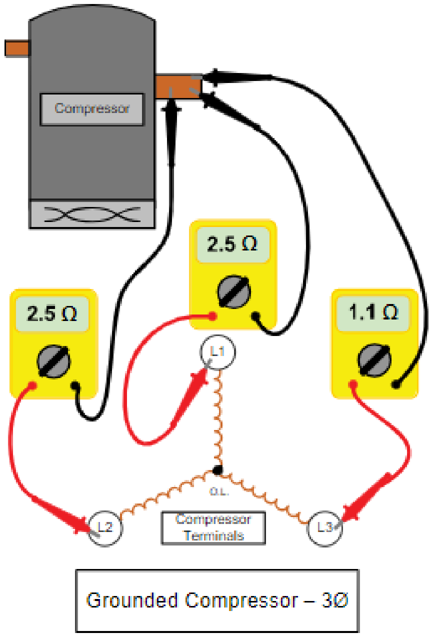
Grounded Compressor

As identified in the single-phase compressor section, any resistance reading to the compressor shell indicates a grounded compressor. In the diagram below, although the resistance readings between windings may appear to be normal, it is the readings between each terminal to the compressor shell that are of concern. The only readings that should be measured from any of the 3 terminals to the compressor shell should be "Open" or "Infinite".

Example: Grounded Compressor

"LI" to "L2" = 3.6 ohms
"LI" to Shell = 2.5 ohms
"L2" to "L3" = 3.6 ohms
"L2" to Shell = 2.5 ohms
"L1" to "L3" = 3.6 ohms
"L3" to Shell = 1.1 ohms

Compressors with open, shorted, or grounded windings are usually caused by problems external to the compressor. A thorough evaluation of the electrical system should be completed prior to installing a new compressor. An acid test should also be completed to evaluate the compressor oil for acid content. If acid is present, the system has experienced a severe burnout and must have a thorough cleanup to remove the contaminated oil before installing a new compressor. If a system with a severe burnout is not cleaned up properly, the new compressor will fail, and all warranties will be voided.



Example of Grounded Three Phase Compressor

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Maintenance

General Maintenance

Preventative maintenance is crucial to proper system operation and meeting the equipment's rated efficiency standards.

- The technician should provide the owner with the equipment owner-operators maintenance procedures that accompany the equipment.
- The technician should also offer to provide the customer with service contracts to have the system cleaned and serviced on a regular maintenance schedule.
- It is recommended that the heating systems are inspected once a year by a qualified service professional.
- For proper and safe operation, the gas heating section of the unit needs air for combustion and ventilation.
- Air openings or spacing around the unit must not be blocked or obstructed.
- The area around the gas heating system must be kept clear and free of combustible materials, gasoline, and other flammable vapors and liquids.
- Snow or debris should not be allowed to accumulate in or around the unit.
- Overhanging structures or shrubs must not be permitted to obstruct the outdoor unit air discharge or the vent outlet on the indoor unit. These provide air for combustion and ventilation.

Thermostats & Control Boards

Thermostats and control boards must be evaluated during an annual maintenance inspection. The thermostat should be level and tightly secured to the wall. Dust accumulation should be gently blown out and exposed contacts checked for deterioration. The integrity of all electrical connections and terminals on the thermostat and control boards should be evaluated. Any loose or corroded connections must be repaired and properly tightened. Corroded or loose thermostat connections can cause improper equipment operation and component failure.

Return Air Filters

Return air filters must always be used and kept clean. Filters should be checked monthly and changed or cleaned when filters become dirt laden. Dirty filters will reduce system efficiency and increase energy consumption.

Dirty filters not only restrict airflow during the cooling cycle but can also cause heat pumps to trip on high head pressure. Dirty air filters can restrict the airflow across the heat exchanger (when applicable) and may open the limit switch during supplemental heating.

The Installation Manual lists the proper filter sizes and filter/frame kits for the specific unit.

Indoor Coil

The indoor coil is designed to absorb heat from the conditioned space during cooling operation and reject heat into the conditioned space during heating operation. It is essential that the coil is kept clean and free of debris to ensure that the equipment has unrestricted airflow across the coil.

The indoor coil can be kept clean with regularly changed return air filters. The coil should only be cleaned according to the manufacturers approved methods, which include:

- Coil brushes
- Vacuum cleaner attachments.
- Water (aluminum coils)
- Approved, non-acid coil cleaners.

Note
If water or cleaners are used to clean the coil, lock-out tag-out procedures must be followed to remove the supply voltage to prevent personal injury. The Material Safety Data Sheets (MSDS) should be read, and the proper Personal Protective Devices (PPDs) utilized prior to and during the application of chemical cleaners.

Outdoor Coil

The outdoor coil is designed to reject heat from the refrigerant to the outdoor air during cooling operation and absorb heat from the outdoor air during heating operation. It is essential that the equipment has the designed airflow across the coil to absorb or reject the proper amount of heat and maintain system efficiency in both the heating and cooling cycles. The outdoor coil must be kept clean and free of debris. The coil should be cleaned according to the approved methods.

Approved methods include:

- Coil brushes
- Vacuum cleaner attachments.
- Water
- Approved, non-acid coil cleaners.

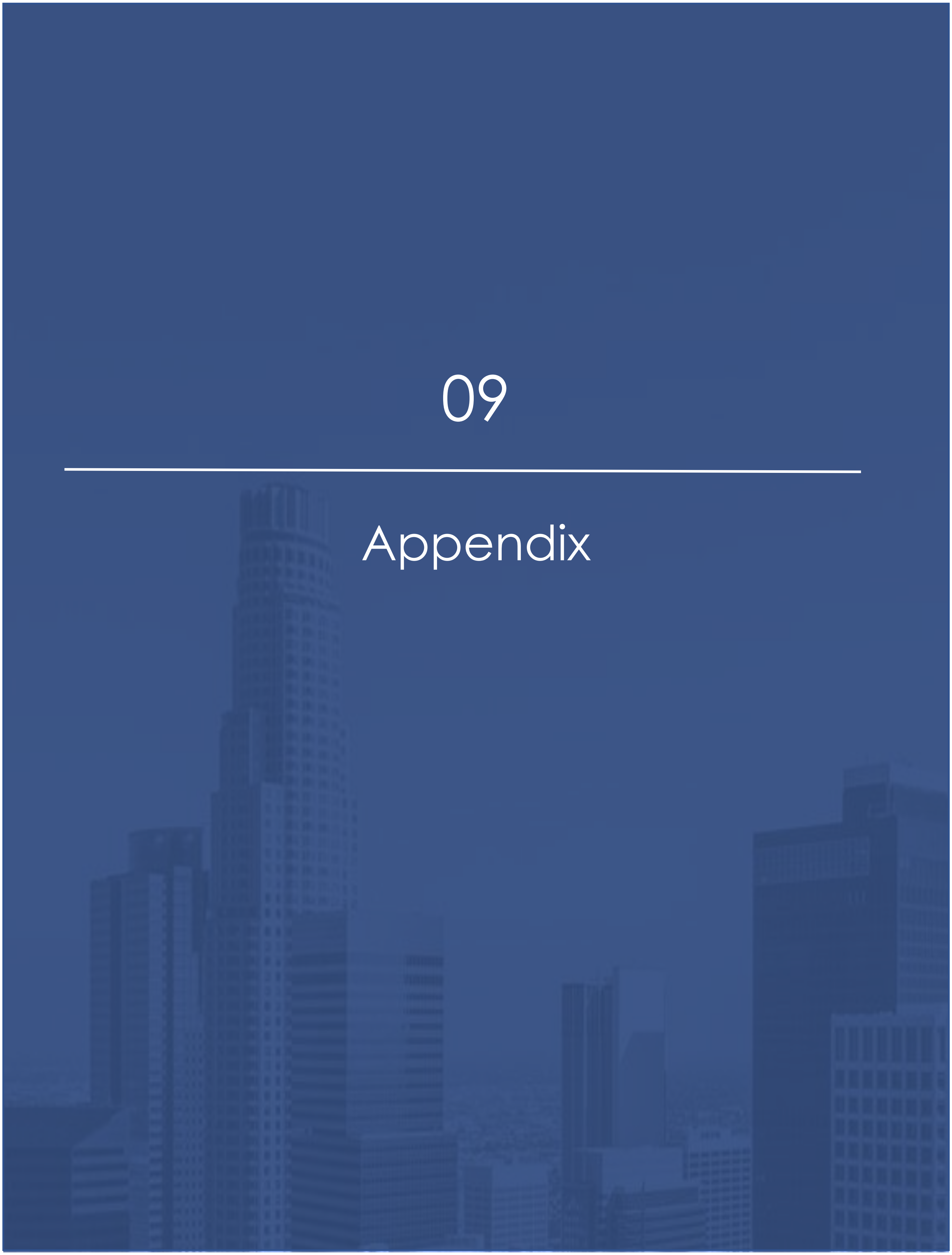
Note
If water or coil cleaners are being used, the unit should have supply voltage removed and proper lock-out tag-out procedures followed to prevent personal injury. The technician should read the Material Safety Data Sheets (MSDS) and wear the proper Personal Protective Devices (PPD) prior to applying chemical cleaners.

Fan Motors

The heat pump outdoor fan motor and indoor fan motor installed in Ducted Systems gas furnaces and air handlers are permanently lubricated and require no maintenance.

Even with good filters properly in place, blower wheels and motors will become dust covered after months of operation. The entire blower assembly should be inspected annually. If the motor and wheel are heavily coated with dust, they can be brushed and cleaned with a vacuum cleaner. In extreme conditions, a hose can be used after the motor is removed to clean the blower wheel.

Caution
Caution must be taken to lock-out and tag-out the unit when evaluating the fan motors for cleanliness and for excessive play or wear to the motors shaft assembly.



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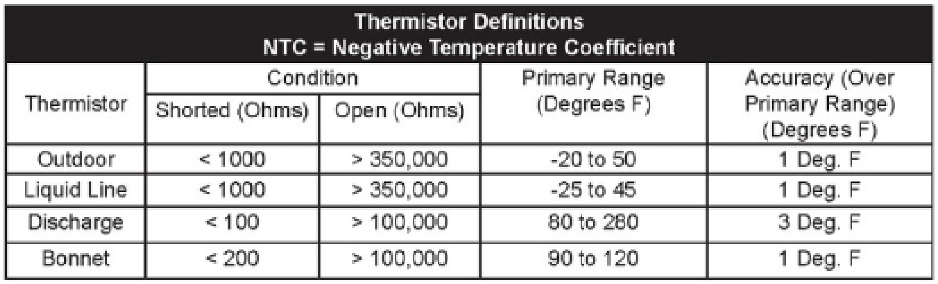
Appendix

Various Sensor Resistance Charts

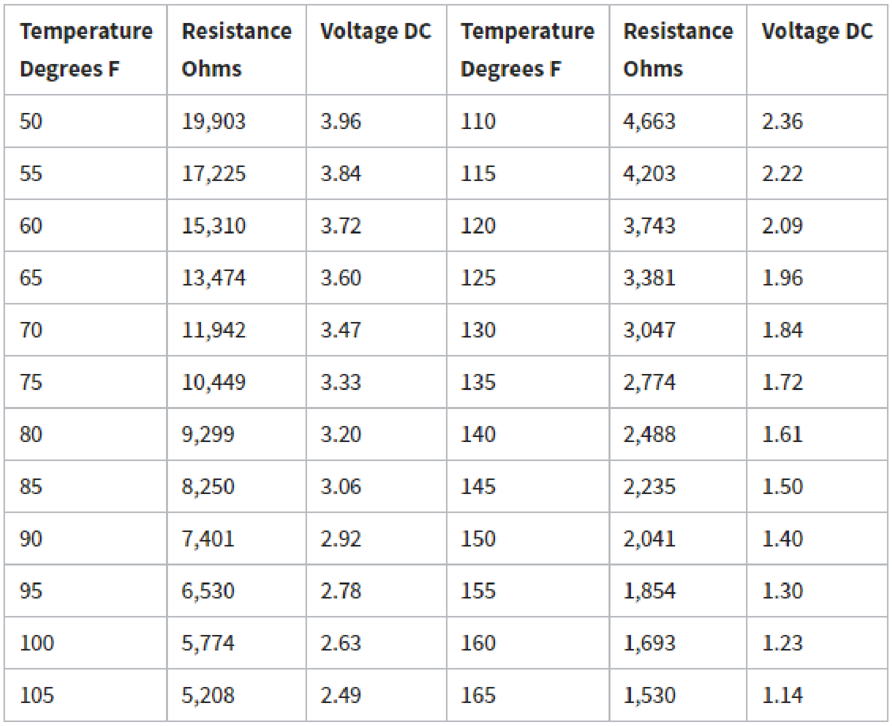


Thermistor Definitions NTC = Negative Temperature Coefficient				
Thermistor	Condition		Primary Range (Degrees F)	Accuracy (Over Primary Range) (Degrees F)
	Shorted (Ohms)	Open (Ohms)		
Outdoor	< 1000	> 350,000	-20 to 50	1 Deg. F
Liquid Line	< 1000	> 350,000	-25 to 45	1 Deg. F
Discharge	< 100	> 100,000	80 to 280	3 Deg. F
Bonnet	< 200	> 100,000	90 to 120	1 Deg. F

Ambient (Outdoor) Sensor Temperature / Resistance / Voltage – Conversion Chart

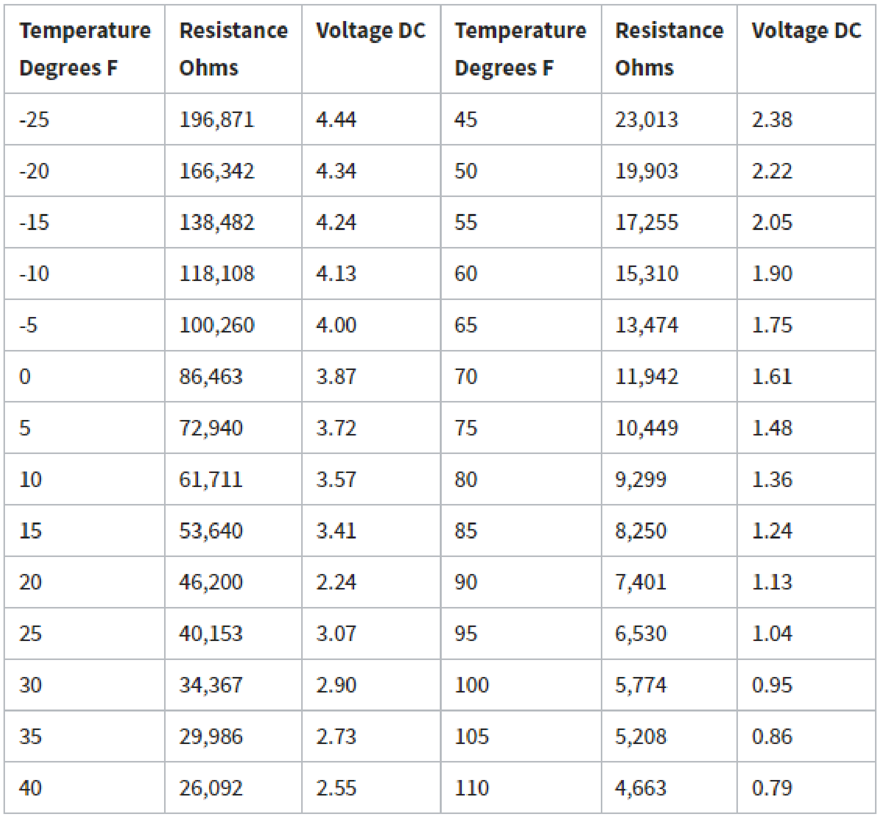
Temperature Degrees F	Resistance Ohms	Voltage DC	Temperature Degrees F	Resistance Ohms	Voltage DC
-25	196,871	4.44	55	17,255	2.05
-20	166,342	4.34	60	15,310	1.90
-15	138,482	4.24	65	13,474	1.75
-10	118,108	4.13	70	11,942	1.61
-5	100,260	4.00	75	10,449	1.48
0	86,463	3.87	80	9,299	1.36
5	72,940	3.72	85	8,250	1.24
10	61,711	3.57	90	7,401	1.13
15	53,640	3.41	95	6,530	1.04
20	46,200	3.24	100	5,774	.095
25	40,153	3.07	105	5,208	0.86
30	34,367	2.90	110	4,663	0.79
35	29,986	2.73	115	4,203	0.72
40	26,092	2.55	120	3,743	0.65
45	3,047	2.38	125	3,381	0.60
50	19,903	2.22	130	3,047	0.54

Bonnet Sensor Temperature / Resistance / Voltage – Conversion Chart



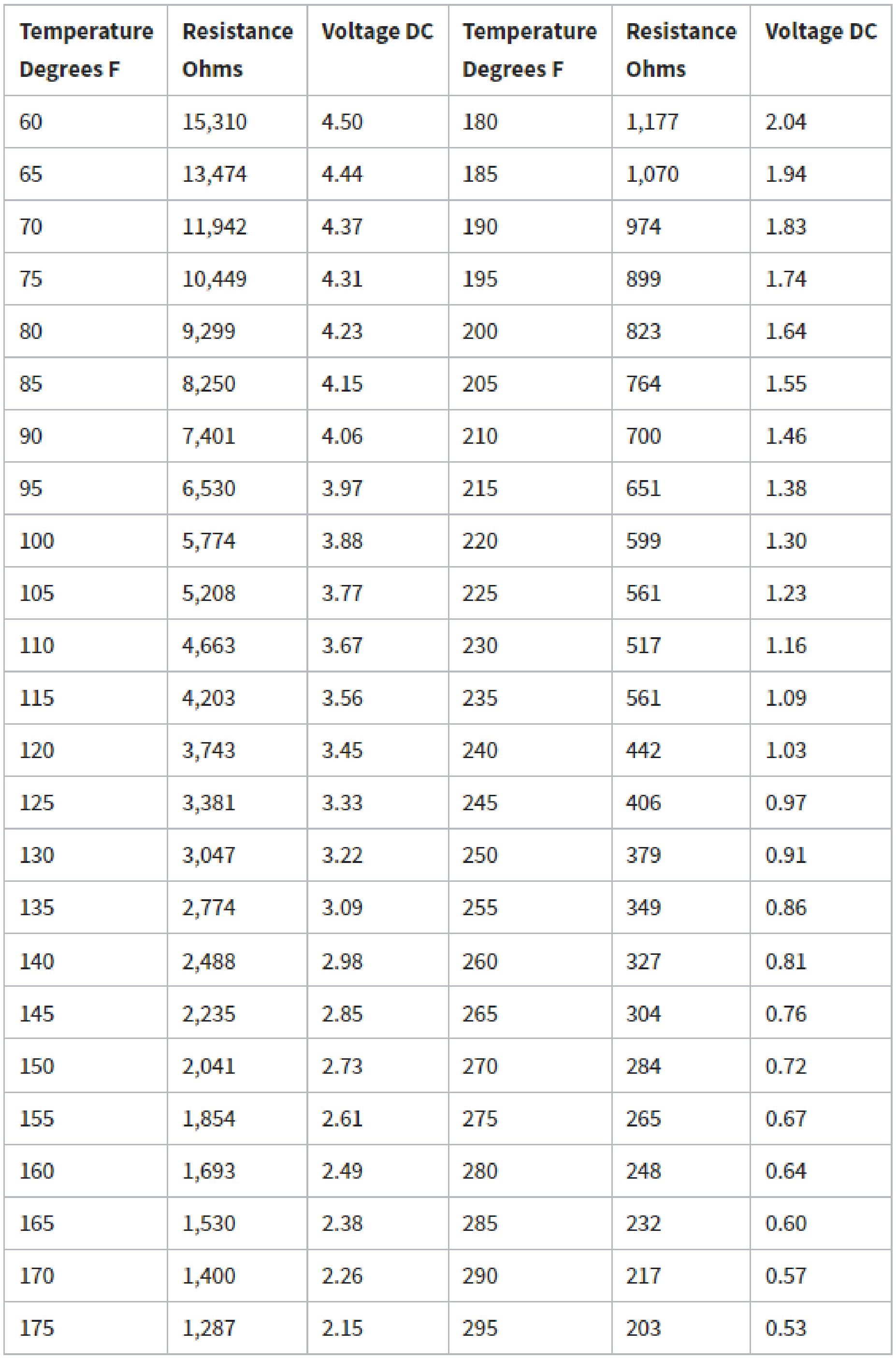
Temperature Degrees F	Resistance Ohms	Voltage DC	Temperature Degrees F	Resistance Ohms	Voltage DC
50	19,903	3.96	110	4,663	2.36
55	17,225	3.84	115	4,203	2.22
60	15,310	3.72	120	3,743	2.09
65	13,474	3.60	125	3,381	1.96
70	11,942	3.47	130	3,047	1.84
75	10,449	3.33	135	2,774	1.72
80	9,299	3.20	140	2,488	1.61
85	8,250	3.06	145	2,235	1.50
90	7,401	2.92	150	2,041	1.40
95	6,530	2.78	155	1,854	1.30
100	5,774	2.63	160	1,693	1.23
105	5,208	2.49	165	1,530	1.14

Liquid Line (Coil) Sensor Temperature / Resistance / Voltage – Conversion Chart



Temperature Degrees F	Resistance Ohms	Voltage DC	Temperature Degrees F	Resistance Ohms	Voltage DC
-25	196,871	4.44	45	23,013	2.38
-20	166,342	4.34	50	19,903	2.22
-15	138,482	4.24	55	17,255	2.05
-10	118,108	4.13	60	15,310	1.90
-5	100,260	4.00	65	13,474	1.75
0	86,463	3.87	70	11,942	1.61
5	72,940	3.72	75	10,449	1.48
10	61,711	3.57	80	9,299	1.36
15	53,640	3.41	85	8,250	1.24
20	46,200	2.24	90	7,401	1.13
25	40,153	3.07	95	6,530	1.04
30	34,367	2.90	100	5,774	0.95
35	29,986	2.73	105	5,208	0.86
40	26,092	2.55	110	4,663	0.79

Discharge Line Sensor Temperature / Resistance / Voltage – Conversion Chart



Temperature Degrees F	Resistance Ohms	Voltage DC	Temperature Degrees F	Resistance Ohms	Voltage DC
60	15,310	4.50	180	1,177	2.04
65	13,474	4.44	185	1,070	1.94
70	11,942	4.37	190	974	1.83
75	10,449	4.31	195	899	1.74
80	9,299	4.23	200	823	1.64
85	8,250	4.15	205	764	1.55
90	7,401	4.06	210	700	1.46
95	6,530	3.97	215	651	1.38
100	5,774	3.88	220	599	1.30
105	5,208	3.77	225	561	1.23
110	4,663	3.67	230	517	1.16
115	4,203	3.56	235	561	1.09
120	3,743	3.45	240	442	1.03
125	3,381	3.33	245	406	0.97
130	3,047	3.22	250	379	0.91
135	2,774	3.09	255	349	0.86
140	2,488	2.98	260	327	0.81
145	2,235	2.85	265	304	0.76
150	2,041	2.73	270	284	0.72
155	1,854	2.61	275	265	0.67
160	1,693	2.49	280	248	0.64
165	1,530	2.38	285	232	0.60
170	1,400	2.26	290	217	0.57
175	1,287	2.15	295	203	0.53