R-22 & R-410A Systems

# Air Conditioner Repair Guide Electrical and Mechanical Test Procedures



- Step-by-step guide to problem solving

Publication # 34-4084-01

# Table of Contents


## Refrigeration Cycle

### Service Procedures

**Measuring Superheat** (4)

**Measuring Subcooling** (5)

**Airflow Calculation** (6-8)

### Solving Problems

**Identifying Low System Charge** (9-11)

**Identifying High System Charge** (12-14)

**Identifying Low Heat Load** (15-18)

**Identifying High Heat Load** (19-22)

**Identifying Liquid Line Restrictions** (23-24)

**Identifying Suction Line Restrictions** (25-26)

**Identifying A Restricted Metering Device** (27-30)

**Identifying An Overfeeding Metering Device** (31-32)

**Checking For Non-Condensables** (33-34)

**Identifying Condenser Circuit Restrictions** (35-38)

**Identifying Condenser Subcooler Circuit Restriction** (39-40)

**Identifying Evaporator Circuit Restrictions** (41-42)

## Compressors

### Service Procedures

**Diagnosing a Seized Compressor** (43-46)

**Performing a Single Phase Motor Winding Test** (47-49)

**Performing a Three Phase Motor Winding Test** (50-51)

**Testing a Run Capacitor** (52)

**Checking out a Hard Start Kit** (53-57)

**Checking for a Grounded Motor** (58-60)

**Detecting a 3 Phase Voltage Imbalance** (61-62)

**Performing a Valve Plate Check on Reciprocating Compressors** (63-65)

**Checking a Single and Three Phase Scroll Compressor for Mechanical Failure** (66-68)

### Basic Electrical Circuit Operations

**How the Single Phase Compressor Responds to Electrical Problems** (69)

**How the Three Phase Compressor Responds to Electrical Problems** (70)

# Measuring Superheat

**What you will need:**

- *Thermometer*
- *Refrigeration Gauges*

**Formula:**

**Suction Line Vapor Temperature**
**- Evap. Coil Saturation Temperature**
**Suction Vapor Superheat**

**Example:**

**Refrigerant: R-22**
**Suction Pressure: 70 PSIG**
**Corresponding Evaporator Saturation Temperature: 41F**
**Suction Line Temperature: 51F**
**51F - 41F = Superheat**
**Superheat = 10F**

## Procedure

1. **Run the condensing unit until suction pressure and suction line temperature stabilize.**
2. **Read and record the suction pressure (Fig 1).**
3. **Place a digital temperature probe against the suction line near the suction gauge pressure port (Fig. 2). Read and record the temperature.**
4. **Reference the face of your suction gauge or use a Temperature/Pressure chart and convert the measured suction pressure to the corresponding evaporator coil saturation temperature for the refrigerant being used. Record this value.**
5. **Next, subtract the saturation temperature from the measured suction line temperature. The result is your actual suction vapor superheat.**

**Fig. 1**

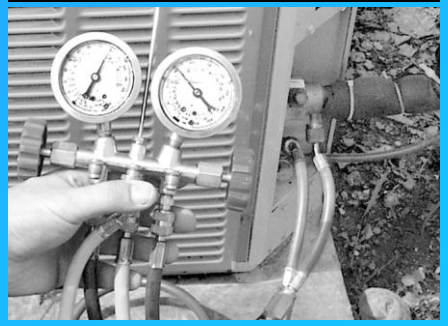
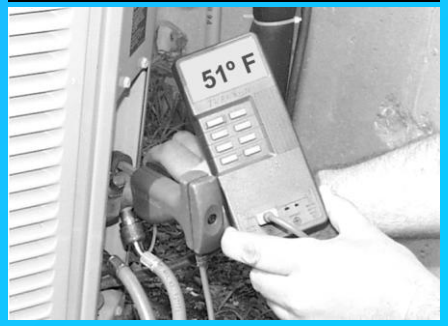


**Fig. 2**




END

# Measuring Subcooling

**What you will need:**

- ***Thermometer***
- ***Refrigeration Gauges***

**Formula:**

**Saturation Temperature**
**- Liquid Line Temperature**
**Liquid Subcooling**

**Example:**

**Refrigerant: R-22**
**Liquid Pressure: 200 PSIG**
**Corresponding Condenser Saturation Temperature: 100F**
**Liquid Line Temperature: 90F**
**100F - 90F = Liquid Subcooling**
**Liquid Subcooling = 10F**

## Procedure

1. **Run the condensing unit until pressures and temperatures stabilize.**
2. **Read and record the liquid pressure at the liquid line pressure port fitting at the condensing unit (Fig 3).**
3. **Place a digital temperature probe against the liquid line near the liquid gauge pressure port (Fig. 4). Read and record the temperature.**
4. **Reference the face of your high pressure gauge or use a Temperature/Pressure chart and convert the measured liquid pressure to the corresponding condenser coil saturation temperature for the refrigerant being used. Record this value.**
5. **Next, subtract the measured liquid line temperature from saturation temperature. The result is your actual liquid subcooling level.**

**Fig. 3**

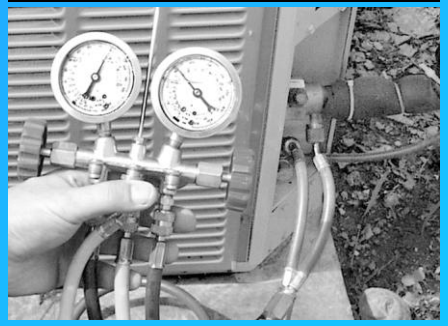


**Fig. 4**




END

# Airflow Calculation

**What you will need:**

- ***Thermometer***
- ***Calculator***

**Fig. 1**



**Fig. 2**



**Procedure (Gas Heating Temperature Rise Method)**

1. **Disconnect power to the furnace.**
2. **Set the furnace to run its' indoor blower motor on HIGH SPEED in heat mode operation. Restore power to the furnace.**
3. **Give the system a Call For Heat and confirm the heating section is running. If the system is Two-Stage, make sure both stages of heat are on.**
4. **Establish what the heating capacity of the gas furnace in BTUH Output (reference the furnace nameplate). Record this value.**
5. **Run the heating system and allow time for the system temperatures to stabilize. The indoor blower should be on.**
6. **Measure the temperature of the return air at the furnace filter rack (Fig 1). Record this value.**
7. **Find a position about 36" away from the supply air plenum and measure the temperature of the supply air at this point (Fig 2). Record this value.**
8. **Disconnect power to the furnace and place the indoor fan blower motor speed back to its' original setting for heat mode operation.**
9. **Subtract your measured return air temperature from your supply air temperature. This is your Delta-T(△T) value.**

**Continued on Next Slide…**

# Airflow Calculation

10. **Using your calculator, multiply your △T value by 1.08. Record this value on a piece of paper.**

11. **Divide your BTUH Output by the value you obtained in Step 11. The answer is your actual system airflow.**

**Formula:**

$$\text{CFM} = \frac{\text{BTUH OUTPUT}}{1.08 \times \text{Temperature Rise } (\triangle T)}$$

**BTUH: 100,000**

**Supply Air Temp: 120F**

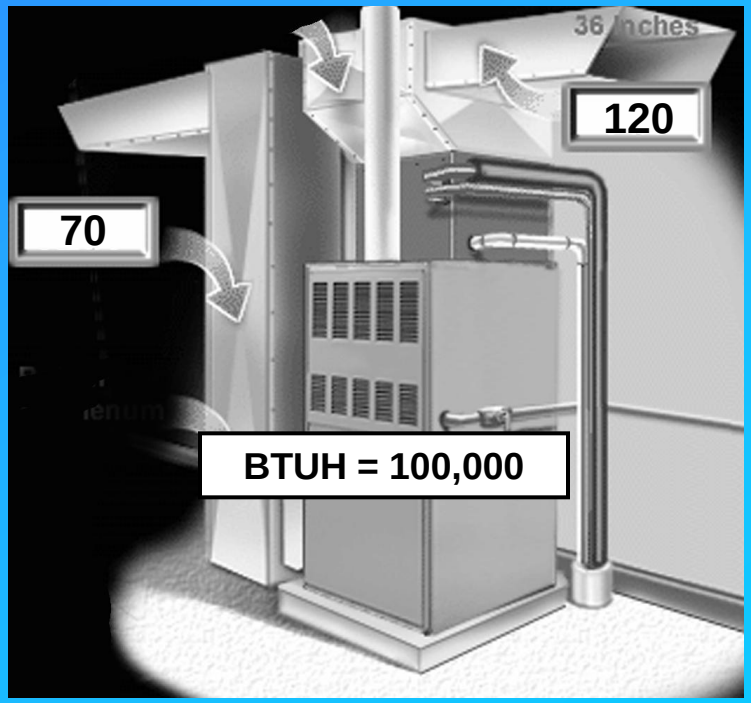
**Return Air Temp: 70F**

1. **120F - 70F = 50F (△T)**

2. $$\frac{100{,}000}{1.08 \times 50}$$

3. $$\frac{100{,}00}{54} = 1852 \text{ CFM}$$

**Example:**




END

# Airflow Calculation

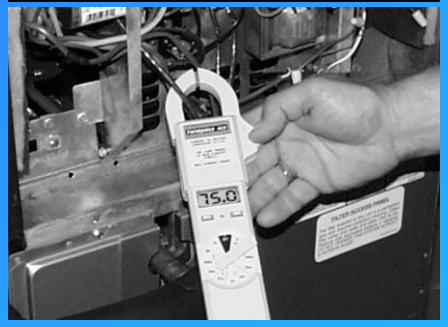
**What you will need:**

- *Thermometer*
- *Calculator*
- *Voltmeter*
- *Ammeter*

**Fig. 1**



**Fig. 2**



**Procedure (Single Phase Electric Heat System Temperature Rise Method)**

1. With power to the air handler heater section on, Call for Heat. Make sure all heater stages are energized.
2. Measure the supply voltage to the air handler (Fig 1) and record the value.
3. Measure the total amperage being drawn by the air handler. (Fig 2) Record the value.
4. Multiply the measured supply voltage by the measured supply amperage. Now multiply your answer by 3.414. This is your total BTUH Output. Record this value.
5. Once the temperature of the supply air has stabilized, measure the temperature of the supply air 36” from the supply air plenum. Record this value.
6. Measure the temperature of the return air at the air handler filter rack. Record this value.
7. Subtract your return air temperature from your supply air temperature to obtain your Delta-T value. Record this value.
8. Multiply the Delta-T value by 1.08. Record this value.
9. Divide your BTUH Output by the value obtained in step 8. The answer is your actual CFM.

**Continued on Next Slide…**

# Airflow Calculation

**Formula:**

$$CFM = \frac{\text{Voltage x Amperage x 3.414}}{\text{1.08 x Temperature Rise (}\triangle\text{T)}}$$

**Air Handler Supply**

**Voltage: 235 Volts**

**Air Handler Section Amperage: 75 Amps**

**Supply Air Temp: 110F**

**Return Air Temp: 74F**

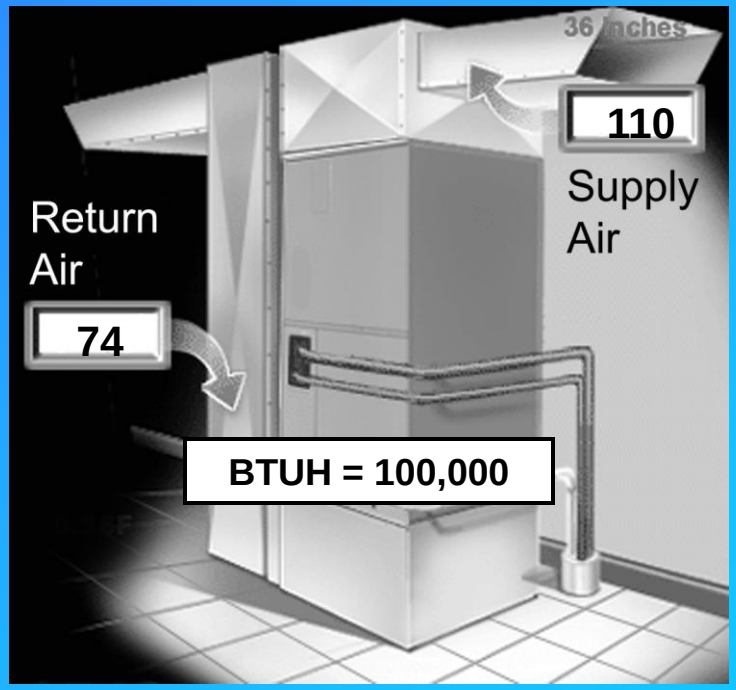
1. **235 Volts x 75 Amps x 3.414 =**
   **60171 BTUH Output**

2. **110F - 74F = 36F (△T)**

3. $$\frac{60171}{1.08 \times 36}$$

4. $$\frac{60171}{38.88} = 1548 \text{ CFM}$$

**Example:**




**Voltage = 235 Volts**
**Amperage draw = 75 Amps**

END

# Identifying Low System Charge (Fixed)

**OBJECTIVE**

**Low system charge can be caused by a leak or poor installation skills. A system running with a low charge will have low capacity, low efficiency, and a hot compressor motor.**

**What you will need:**



- ***Leak Detector***
- ***Refrigeration Gauges***
- ***Temperature Probe***

**Causes**

- **Poor Installation Skills**
- **Refrigerant Leaks**

**Procedure**

1. **Leak test the system.**
2. **Charge to OEM requirements.**

## Symptoms

**Systems running with low charge will run at pressures below factory required levels. Abnormally high superheat and low subcooling levels will be present. The compressor motor will run hot due to a lack of refrigerant vapor to cool the motor windings. The low suction pressure will create a cold evaporator coil which may form a coating of ice.**

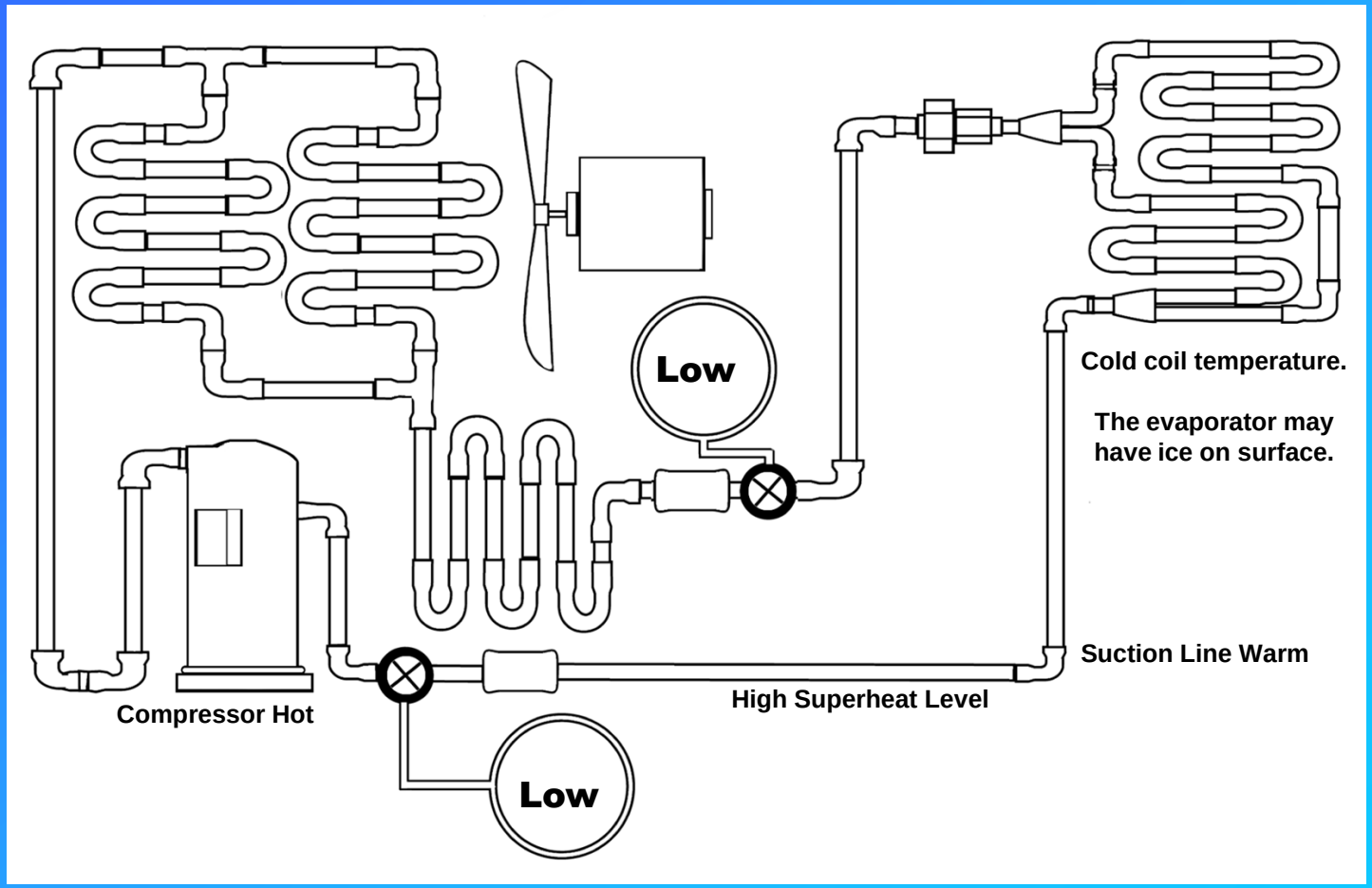
**Note:**

**When charging R-410A systems always charge in a liquid state only. R-410A is a near azeoptropic refrigerant. When repairing small leaks, you can simply top off the charge as minimum fractionation will occur.**

**Continued on Next Slide…**

# Identifying Low System Charge (Fixed)

**CYCLE CONDITIONS**




END

# Identifying Low System Charge (TXV)

## Symptoms

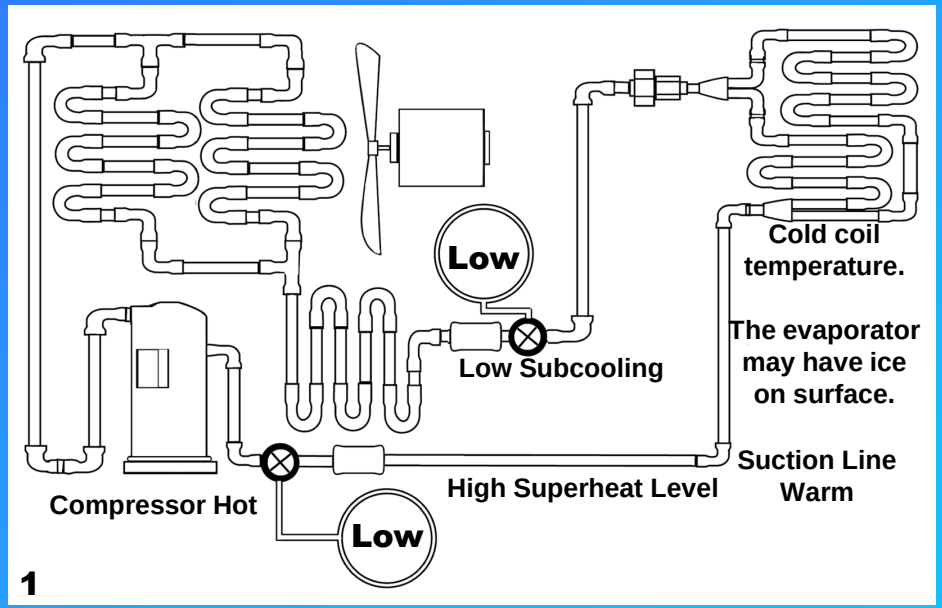
**When a system is undercharged with a TXV metering device, the TXV may open enough to maintain adequate suction pressure and suction vapor superheat. The condensing pressure will be low along with low subcooling. If the system charge is very low, the system will appear with the same symptoms as a fixed metering type.**

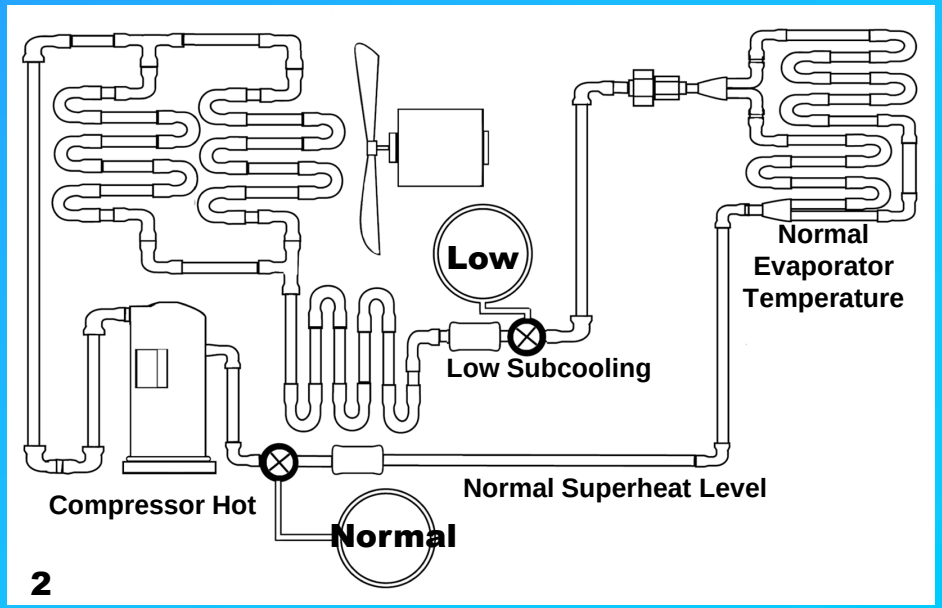
## Procedure

1. Leak test the system.
2. Charge to OEM requirements.

**Note: When charging R-410A systems always charge in a liquid state only. R-410A is a near azeoptropic refrigerant. When repairing small leaks, you can simply top off the charge as minimum fractionation will occur.**

**CYCLE CONDITIONS**




END

# Identifying High System Charge (Fixed)

**OBJECTIVE**

**High system charge is caused by poor installation skills. A system running with a high charge will experience excessive energy consumption, possible starting problems, internal overload tripping, indoor air humidity complaints, compressor failure due to liquid flood back.**

**What you will need:**



- ***Refrigeration Gauges***
- ***Temperature Probe***

**Causes**

- **Poor Installation Skills**

**Procedure**

1. **Charge to OEM requirements.**

## Symptoms

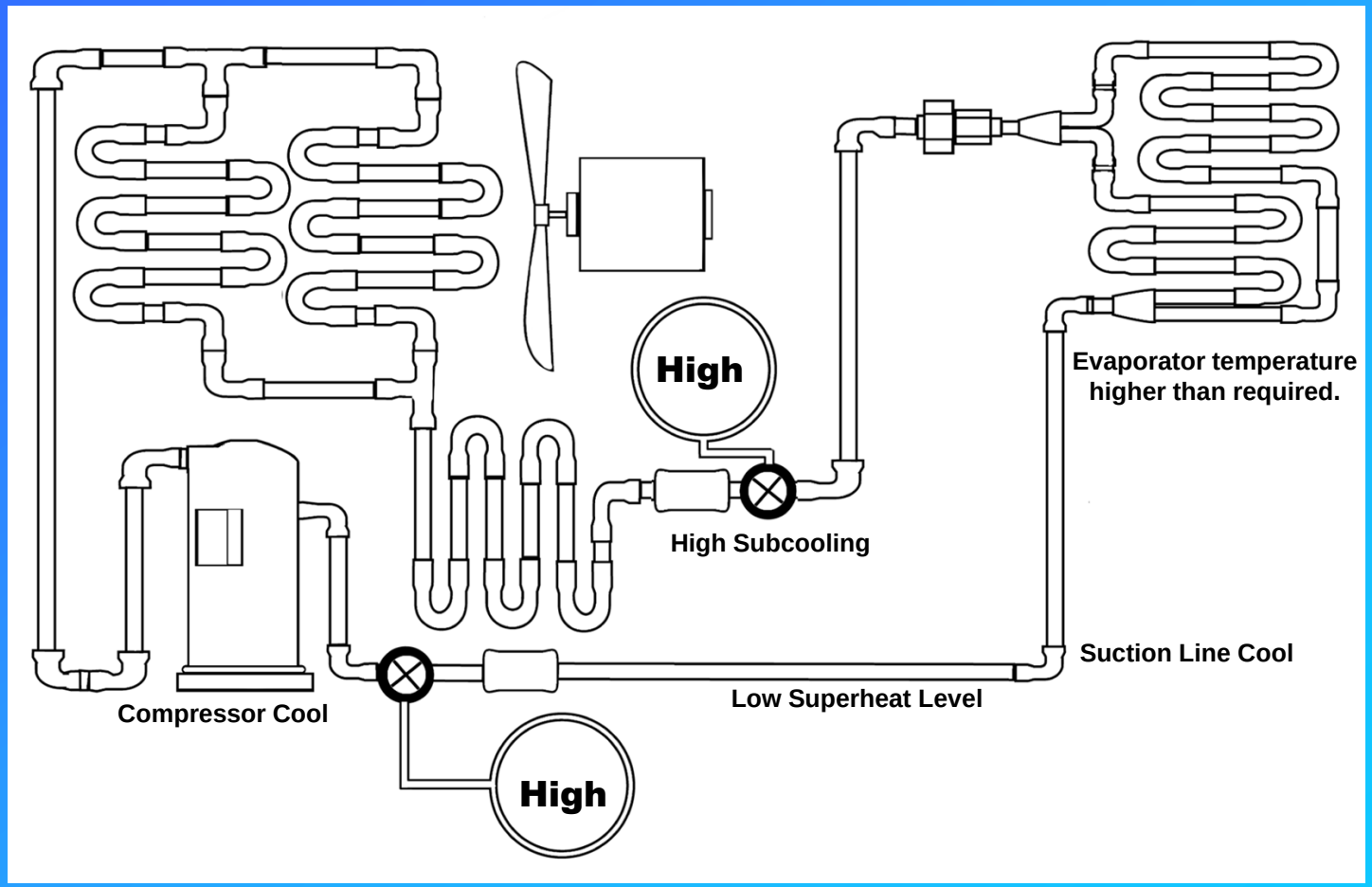
**Systems running with high charge will run at pressures above factory required levels. Abnormally low superheat and high subcooling levels will be present. The compressor motor may experience liquid flood back problems.**

**Note: When charging R-410A systems always charge in a liquid state only. R-410A is a near azeoptropic refrigerant. When repairing small leaks, you can simply top off the charge.**

**Continued on Next Slide…**

# Identifying High System Charge (Fixed)

**CYCLE CONDITIONS**




END

# Identifying High System Charge (TXV)

## Symptoms

**When a system is overcharged with a TXV metering device, the suction pressure and superheat may appear normal. The normal conditions are caused by the TXV as it throttles back the excess refrigerant flow into the evaporator coil. The excess charge is then stored in the condenser coil which elevates the head pressure and liquid subcooling levels.**

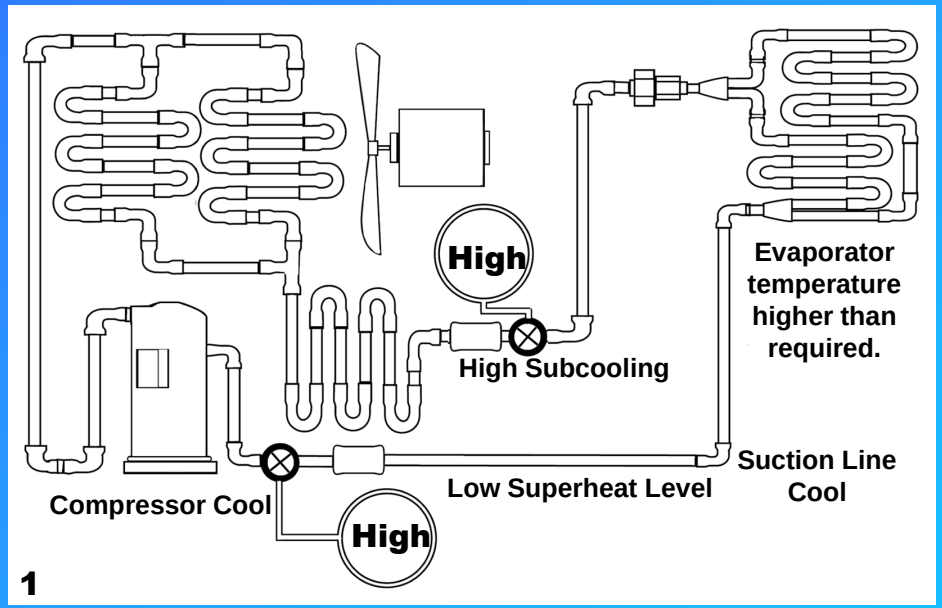
**If the charge is high enough, the suction pressure may be too high with slightly low superheat present.**

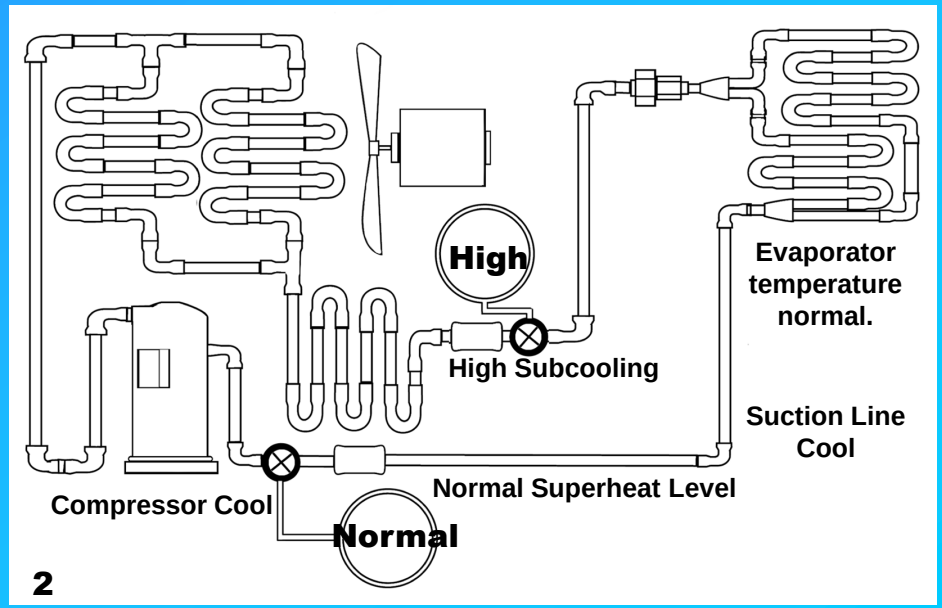
**Note: When charging R-410A systems always charge in a liquid state only. R-410A is a near azeoptropic refrigerant. When repairing small leaks, you can simply top off the charge.**

## Procedure

1. **Charge to OEM requirements.**

## CYCLE CONDITIONS




END

# Identifying Low Evaporator Heat Load (Fixed)

**OBJECTIVE**

**Low evaporator heat loading occurs when there is not enough heat entering the refrigerant at the evaporator coil. This condition can cause the evaporator coil to form a coating of frost or ice on its' surface. In extreme cases, superheat could fall to zero degrees and liquid can flood back to the compressor.**

**What you will need:**



- ***Refrigeration Gauges***
- ***Temperature Probe***

**Causes**

- **Dirty Return Air Filter**
- **Dirty Indoor Fan Blower Assembly**
- **Indoor Fan Motor Not On High Speed**
- **Undersized Ductwork**
- **Dirty Evaporator Coil**
- **Thermostat Setpoint Too Low**

## Symptoms (Fixed Metering)

**Systems running with low evaporator loading will run at pressures below factory required levels. Abnormally low superheat and subcooling levels will be present when the evaporator coil lacks heat load.**

**The low heat load condition could cause the evaporator coil temperature to be very cold. Ice or frost may form on the evaporator surface and suction line surface. The compressor shell may sweat and the hot gas temperature will be cool.**

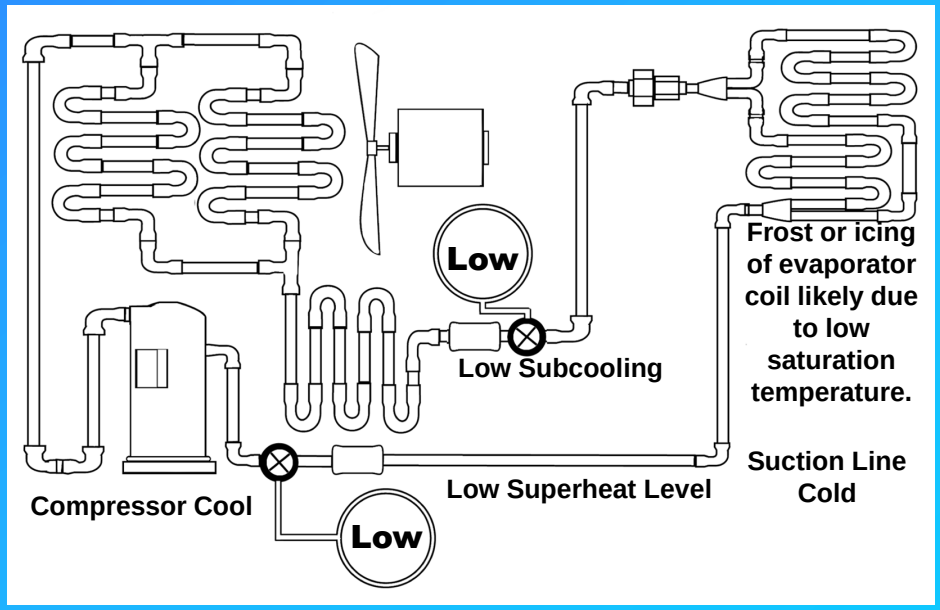
**Continued on Next Slide…**

# Identifying Low Evaporator Heat Load (Fixed)

## Procedure

1. Thaw out the evaporator coil if ice or frost is present.
2. Inspect the return air filter to determine if it is dirty. Replace if necessary.
3. Inspect the evaporator coil to ensure it is clean.
4. Inspect the indoor blower assembly to ensure it is clean.
5. Make sure the indoor blower motor is operating at high speed.
6. Make sure the supply and return air ducting are sized properly.
7. Perform an indoor airflow measurement to ensure you have adequate CFM present. Airflow should be between 350-450 CFM per ton of cooling capacity.

**CYCLE CONDITIONS**




END

# Identifying Low Evaporator Heat Load (TXV)

**OBJECTIVE**

**Low evaporator heat loading occurs when there is not enough heat entering the refrigerant at the evaporator coil. This condition can cause the evaporator coil to form a coating of frost or ice on its' surface. In extreme cases, superheat could fall to zero degrees and liquid can flood back to the compressor.**

**What you will need:**



***- Refrigeration Gauges***
***- Temperature Probe***

**Causes**

- **Dirty Return Air Filter**
- **Dirty Indoor Fan Blower Assembly**
- **Indoor Fan Motor Not On High Speed**
- **Undersized Ductwork**
- **Dirty Evaporator Coil**
- **Thermostat Setpoint Too Low**

## Symptoms

**Systems running with low evaporator loading will run at pressures below factory required levels. The TXV may hunt in an attempt to maintain proper superheat levels.**

**The low heat load condition could cause the evaporator coil temperature to be very cold. Ice or frost may form on the evaporator surface and suction line surface. The compressor shell may sweat and the hot gas temperature will be cool.**

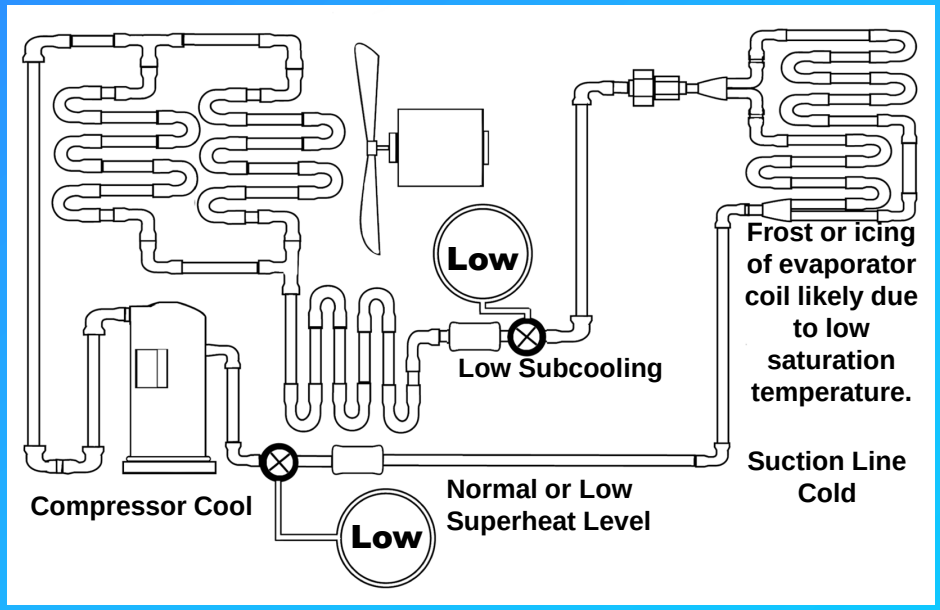
**Continued on Next Slide…**

# Identifying Low Evaporator Heat Load (TXV)

## Procedure

1. Thaw out the evaporator coil if ice or frost is present.
2. Inspect the return air filter to determine if it is dirty. Replace if necessary.
3. Inspect the evaporator coil to ensure it is clean.
4. Inspect the indoor blower assembly to ensure it is clean.
5. Make sure the indoor blower motor is operating at high speed.
6. Make sure the supply and return air ducting are sized properly.
7. Perform an indoor airflow measurement to ensure you have adequate CFM present. Airflow should be between 350-450 CFM per ton of cooling capacity.

**CYCLE CONDITIONS**




END

# Identifying High Evaporator Heat Load (Fixed)

**OBJECTIVE**

**High evaporator heat loading occurs when there is excessive heat entering the refrigerant at the evaporator coil. This condition can cause the compressor to shut off on its' internal overload, or trip the electrical circuit breaker.**

**What you will need:**



- ***Temperature Probe***
- ***Digital Thermometer***
- ***Refrigeration Gauges***

**Causes**

- **Infiltration of unconditioned air into the return duct**
- **New systems started on a very hot day**
- **Economizer/fresh air damper open on a hot day**
- **Temporary high people loads**
- **System undersized for structure heat gain**

## Symptoms

**Systems running with high evaporator loading will run at pressures above factory required levels. Abnormally high superheat and normal subcooling levels will be present when the evaporator coil is exposed to higher than allowed heat load.**

**The high heat load condition could cause the evaporator coil temperature to be very warm. The compressor shell and hot gas temperature will be extremely high.**

**Continued on Next Slide…**

# Identifying High Evaporator Heat Load (Fixed)

## Procedure

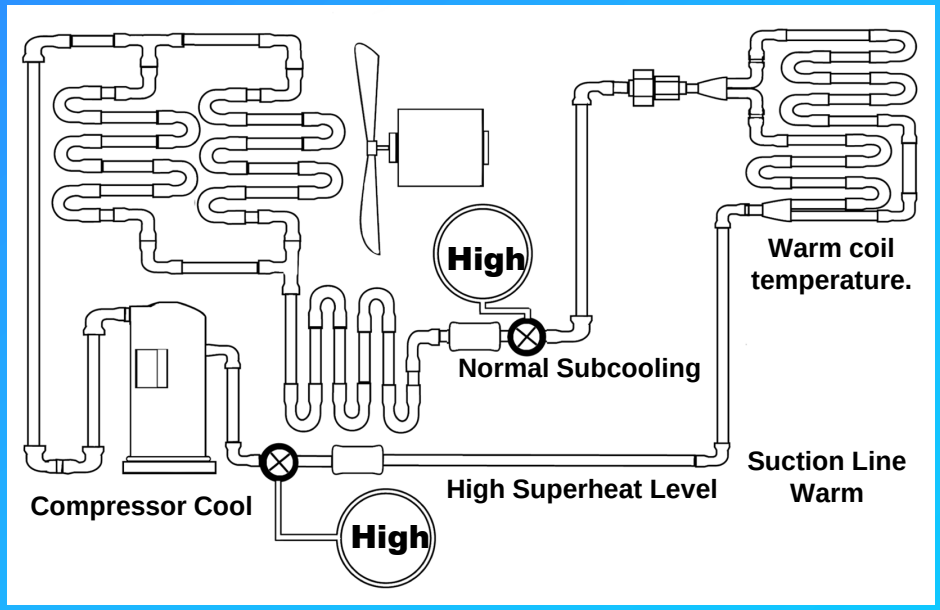
1. Measure the temperature of the conditioned space and then check the temperature of the air entering the evaporator coil at the filter rack. If the air entering the evaporator is warmer than the conditioned space, infiltration of unconditioned air is present.

2. If the system has an economizer or fresh air damper, make sure it is closed.

3. If the system is a new start up on a hot day, allow time for the indoor temperature to fall within charging chart range.

4. If the system is still overloaded and the outdoor air temperature is within design range for your area, run a heat load to determine if the system is properly sized.

**CYCLE CONDITIONS**




END

# Identifying High Evaporator Heat Load (TXV)

**OBJECTIVE**

**High evaporator heat loading occurs when there is excessive heat entering the refrigerant at the evaporator coil. This condition can cause the compressor to shut off on it's internal overload, or trip the electrical circuit breaker.**

**What you will need:**



- ***Temperature Probe***
- ***Digital Thermometer***
- ***Refrigeration Gauges***

**Causes**

- **Infiltration of unconditioned air into the return duct**
- **New systems started on a very hot day**
- **Economizer/fresh air damper open on a hot day**
- **Temporary high people loads**
- **System undersized for structure heat gain**

## Symptoms

**Systems running with high evaporator loading will run at pressures above factory required levels. The high heat load condition could cause the evaporator coil temperature to be very warm. The compressor shell and hot gas temperature will be extremely high. The TXV may keep superheat level close to the required range of 10-15°F. *In extreme cases of high load the superheat may go higher.***

**Continued on Next Slide…**

# Identifying High Evaporator Heat Load (TXV)

## Procedure

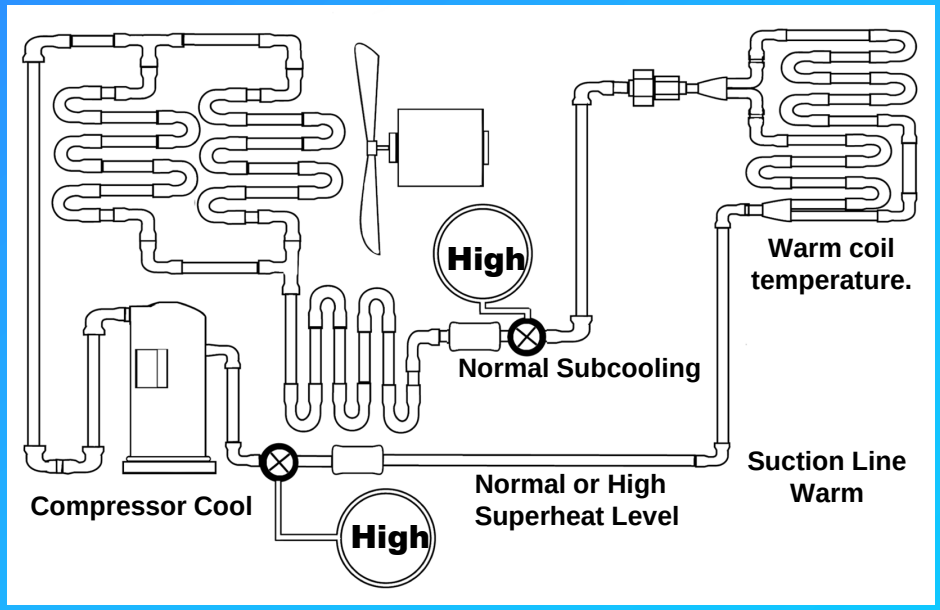
1. Measure the temperature of the conditioned space and then check the temperature of the air entering the evaporator coil at the filter rack. If the air entering the evaporator is warmer than the conditioned space, infiltration of unconditioned air is present.

2. If the system has an economizer or fresh air damper, make sure it is closed.

3. If the system is a new start up on a hot day, allow time for the indoor temperature to fall within charging chart range.

4. If the system is still overloaded and the outdoor air temperature is within design range for your area, run a heat load to determine if the system is properly sized.

**CYCLE CONDITIONS**




END

# Identifying Liquid Line Restrictions

**OBJECTIVE**

**Restrictions in the liquid line will prevent the evaporator coil from receiving the proper amount of refrigerant. The restriction will cause a large pressure drop between the condenser coil and the metering device. This large pressure drop can be detected by checking the temperature of the liquid line at the outlet of the condenser coil and at the inlet to the metering device.**

**What you will need:**



- ***Digital Thermometer***
- ***Refrigeration Gauges***

**Causes**

- **Restricted Liquid Line Drier**
- **Undersized Liquid Line**
- **Excessive Liquid Line Pipe Fittings**
- **Kinked Liquid Line**

## Symptoms

**Systems running with a liquid line restriction will have low suction pressure along with high superheat. The liquid pressure will initially be low which will make the system appear undercharged. When refrigerant is added to the system, the liquid pressure will rise but the suction pressure will remain low. At this point, you should be able to identify there is a problem in the liquid circuit. If subcooling is measured, at this time, it will be high. The high subcooling level is an indication that excess refrigerant is being stored in the condenser coil.**

**Look for frosting or sweating of the liquid line or liquid line drier.**

**Continued on Next Slide…**

# Identifying Liquid Line Restrictions

## Procedure

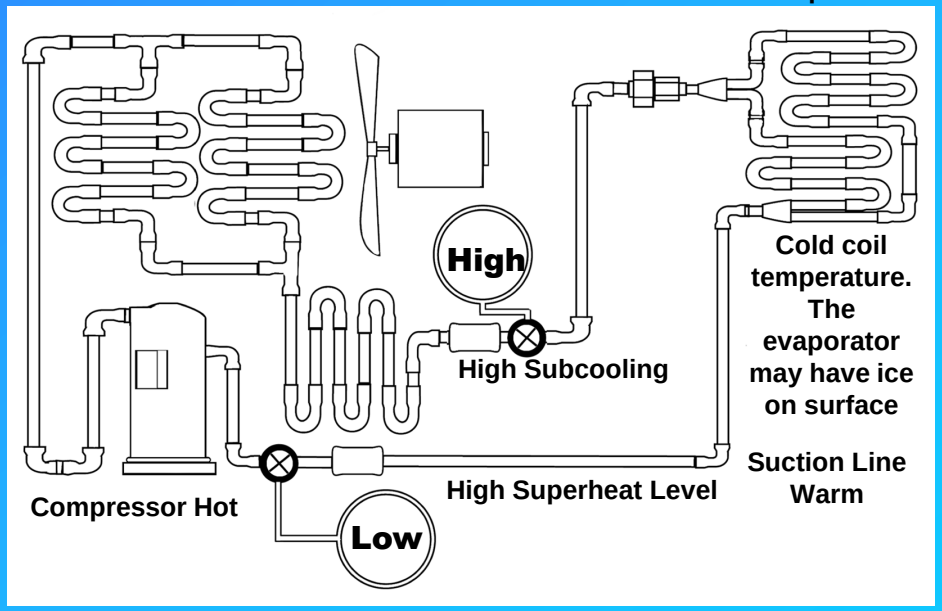
1. If the liquid and suction pressure are low, and no obvious sweating or frosting of the liquid line is present, begin to add refrigerant.

2. If the system is undercharged, both pressures will begin to rise. If the liquid pressure rises significantly, but the suction pressure remains low, the liquid circuit has a restriction.

3. Check the temperature of the liquid line at the outlet of the condenser coil and at the inlet to the metering device. No significant drop in temperature should be detected. If you detect a large temperature drop, there is a pressure drop between the two test points. Isolate the restriction and make the repair.

4. If there is no temperature drop between the outlet of the condenser and inlet of the metering device, yet the liquid pressure is elevated, suction pressure low, superheat and subcooling high, advance to a RESTRICTED METERING DEVICE.

**CYCLE CONDITIONS**




END

# Identifying Suction Line Restrictions

**OBJECTIVE**

**Excessive pressure loss in the suction line will cause low cooling capacity along with potential evaporator coil freezing.**

**What you will need:**



***- Digital Thermometer***

**Causes**

- **Undersized suction lines**
- **Kinks in the suction line tubing**
- **Restricted suction line driers**
- **Excessive use of suction line pipe fittings**

## Symptoms

**Systems running with a large pressure loss in the suction line will run at pressures below factory required levels. Because the pressure is being read downstream from the restriction, the actual calculated superheat will be inaccurate. Find the problem by checking the temperature of the suction line at the outlet of the evaporator coil and then comparing it to the temperature of the suction line at the inlet to the compressor. You should have a maximum temperature drop of 3 degrees. If the actual temperature drop is higher, find the cause of the pressure drop.**

**Continued on Next Slide…**

# Identifying Liquid Line Restrictions

**Procedure**

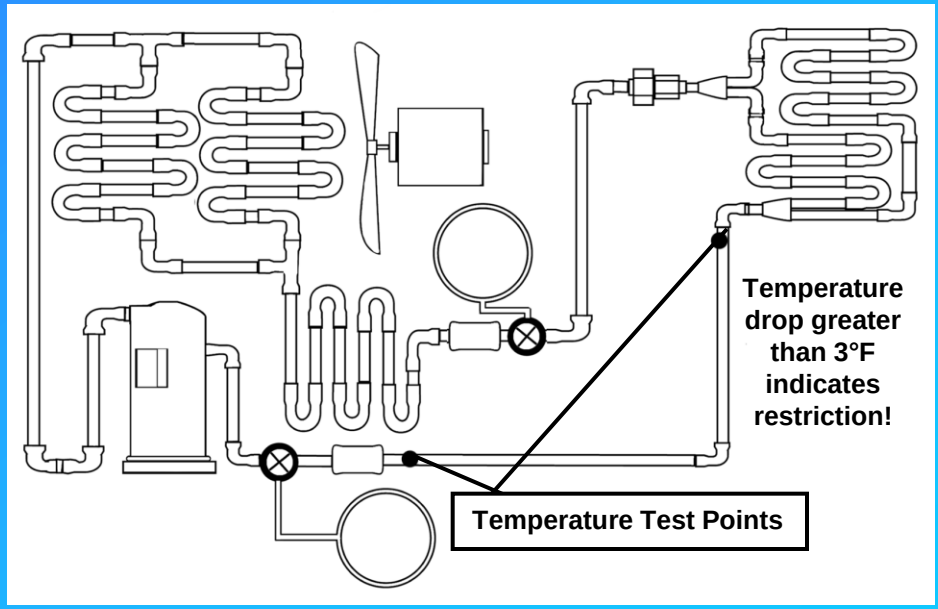
1. ***Run the system and allow temperatures and pressures to stabilize.***

2. ***Measure suction line temperature at the outlet of the evaporator coil and the inlet to the compressor. The temperature drop should not exceed 3F.(Fig. 1)***

3. ***If temperature drop is in excess of 3F, check for kinks in line. If no kinks are present, check suction line sizing chart to ensure proper size tubing is being used.***

4. ***If tubing size is too small, replace line set with proper size.***

**CYCLE CONDITIONS**




END

# Identifying A Restricted Metering Device

**OBJECTIVE**

**Restrictions in the metering device will prevent the evaporator coil from receiving the proper amount of refrigerant. The restriction will cause the suction pressure to be too low. With low suction pressure present, the saturation temperature of the refrigerant in the evaporator is very low. Because of the low saturation temperature, freezing of the evaporator surface is likely.**

**What you will need:**



***- Digital Thermometer***
***- Refrigeration Gauges***

**Causes**

**• Undersized Fixed Metering Device**

**• Failed Expansion Valve**

**• Debris In Metering Device (Poor Installation Skills)**

**• Moisture Freezing At Metering Device (Not Evacuated Properly)**

## Symptoms

**Systems running with a metering restriction will have low suction pressure along with high superheat. The liquid pressure will initially be low which will make the system appear undercharged. When refrigerant is added to the system, the liquid pressure will rise but the suction pressure will remain low. At this point, you should be able to identify there is a problem in the liquid circuit. If subcooling is measured, at this time, it will be high. The high subcooling level is an indication that excess refrigerant is being stored in the condenser coil.**

**There will be no obvious sign of frosting between the condenser coil and the metering device.**

**Continued on Next Slide…**

# Identifying A Restricted Metering Device

## Procedure

1. If the liquid and suction pressure are low, and no obvious sweating or frosting of the liquid line is present, add refrigerant (Fig. 1). If the system is undercharged, both pressures will begin to rise. If the liquid pressure rises significantly, but the suction pressure remains low, the liquid circuit has a restriction (Fig. 2).

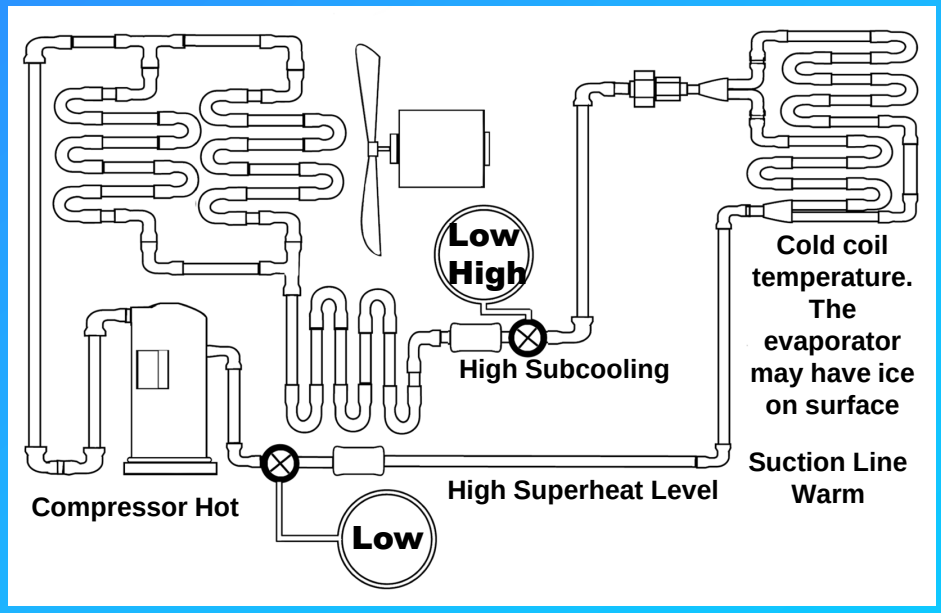
2. Check the temperature of the liquid line at the outlet of the condenser coil and at the inlet to the metering device (Fig. 3). If you detect a large temperature drop, there is a pressure drop between the two test points. Isolate the restriction and make the repair.

3. If there is no temperature drop between the outlet of the condenser and inlet of the metering device, yet the liquid pressure is elevated, suction pressure low, superheat and subcooling high, the problem is in the metering device assembly. (Fig. 4)

4. Pump the system down or recover the refrigerant and inspect the metering device assembly for proper size, operation, or debris. Replace if necessary.

**CYCLE CONDITIONS**

No temperature drop in liquid line.




Continued on Next Slide…

# Identifying A Restricted Metering Device

**Fig. 1**

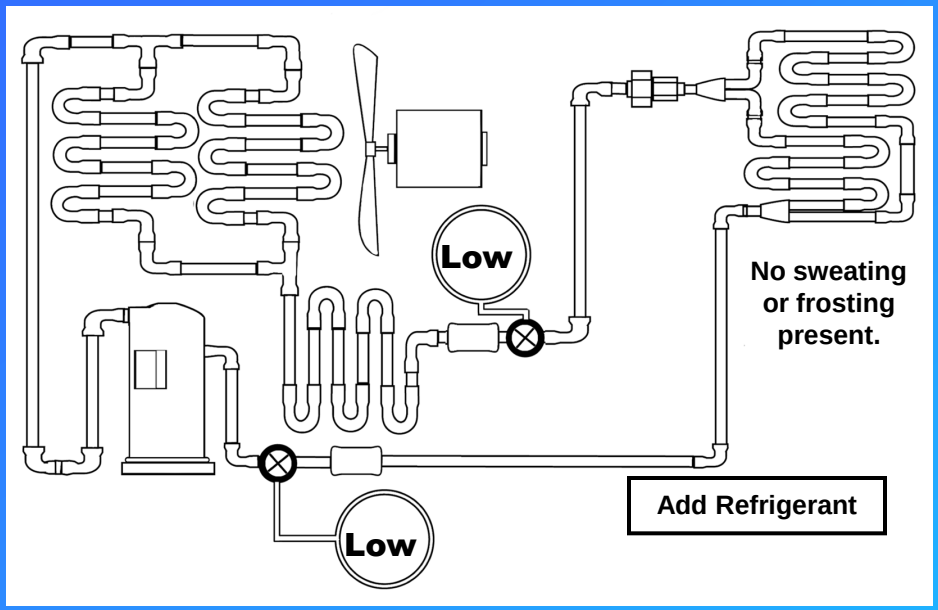
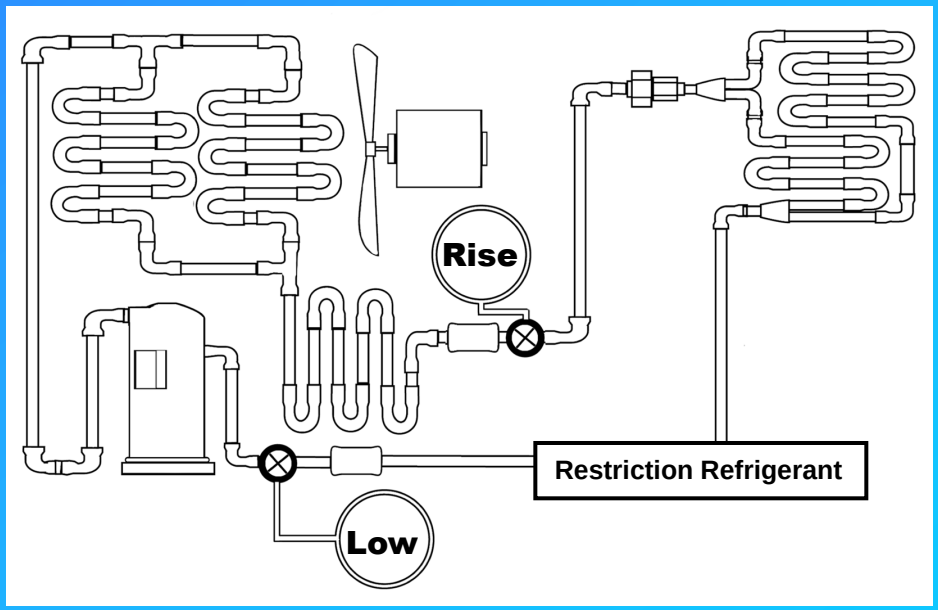



**Fig. 2**




END

# Identifying A Restricted Metering Device

**Fig. 3**

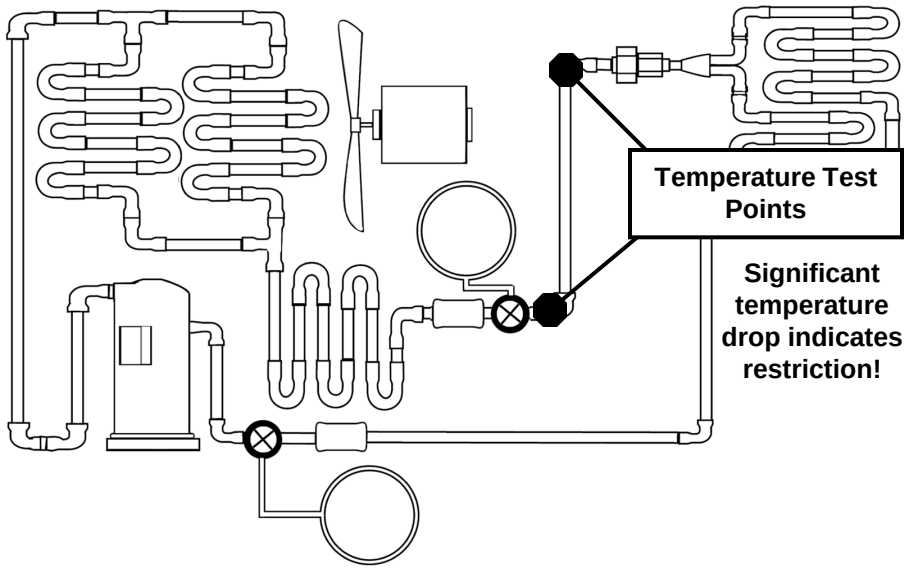
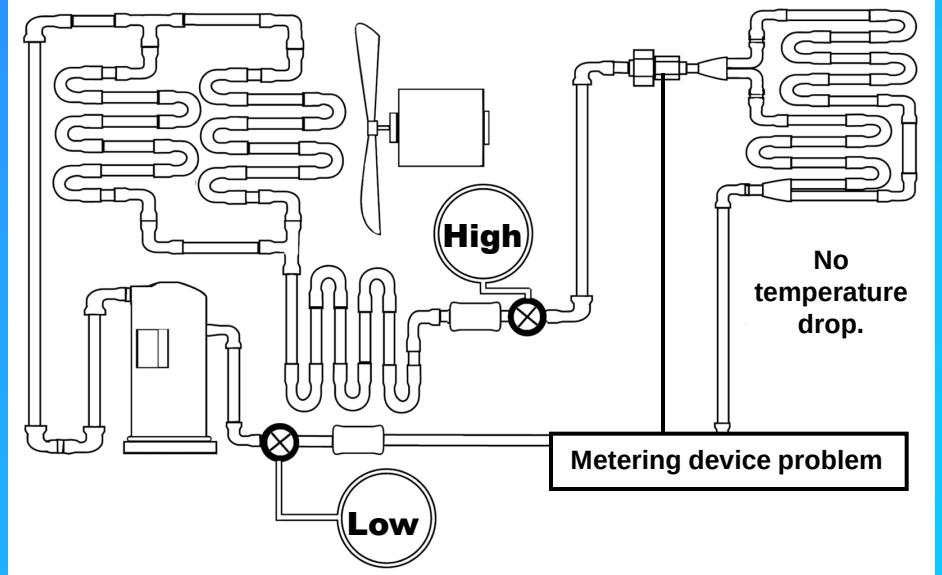



**Fig. 4**




END

# Identifying An Over-Feeding Restricted Metering Device

**OBJECTIVE**

**An evaporator coil that is receiving a higher than normal flow of refrigerant through the metering device will operate in a flooded condition. The system may experience high humidity complaints, compressor starting problems, or compressor failure.**

**What you will need:**



***- Refrigeration Gauges***

**Causes**

- **Too large of a piston (Fixed Metering)**
- **Dirty piston seat not allowing metering device to seat properly.**
- **TXV Sensing Bulb not insulated or in good contact with suction line.**

## Symptoms

**The metering device isolates the high side pressure from the low side pressure. When an overfeeding condition is present, the suction side of the system operates in a flooded state while the high side of the system operates in a starved state. The suction pressure will be high and the superheat low. The liquid pressure will be low and the subcooling will be low.**

**If the system is using a reciprocating type of compressor, it may appear that the compressor valve plate is bad.**

**Continued on Next Slide…**

# Identifying An Over-Feeding Restricted Metering Device

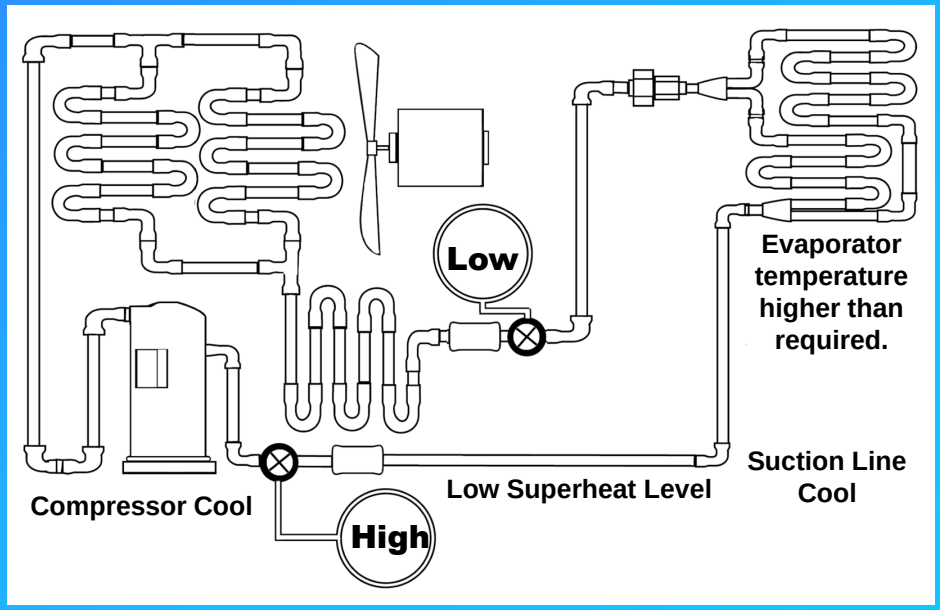
***Procedure***

1. ***Close the liquid service valve and pump the system down. If the system does not hold a pump down and the liquid line service valve is properly closed. Replace the compressor. (Recip Only)***

2. ***If the system holds a pump down cycle, inspect the metering device to determine if it is seated properly or too large. (Fixed Type)***

3. ***If the system is using a TXV, make sure the sensing bulb is properly insulated and in good contact with the suction line. If it is not, correct the problem. If it is, replace the TXV.***

**CYCLE CONDITIONS**




END

# Checking for Non-Condensables

**OBJECTIVE**

**Air, Nitrogen, Hydrogen and other foreign gasses present in a refrigerant system are referred to as non-condensables since they will not condense into a liquid at pressures encountered in a refrigeration system. These gases will accumulate in the condenser coil and take up valuable condenser coil circuiting.**

**What you will need:**



***- Digital Thermometer***
***- Refrigeration Gauges***

**Causes**

**• Poor Installation Skills**

**• Failure to properly evacuate the system after the system has been opened.**

## Symptoms

**Systems running with non-condensables present will experience higher than required head pressure. The suction pressure will be low if there is no subcooling present. If subcooling is present, the suction pressure may be slightly high with fixed metering systems and may be normal with TXV systems.**

**The subcooling level with non-condensables will be lower than required. If no subcooling is present, there will be flash gas in the liquid line before the metering device.**

**The superheat level will be high when flash gas is present. If there is subcooled liquid entering the metering device and the suction pressure is high with a fixed metering system, the superheat may be low. If the system is using a TXV, the superheat may be normal.**

**Continued on Next Slide…**

# Checking for Non-Condensables

**Procedure**

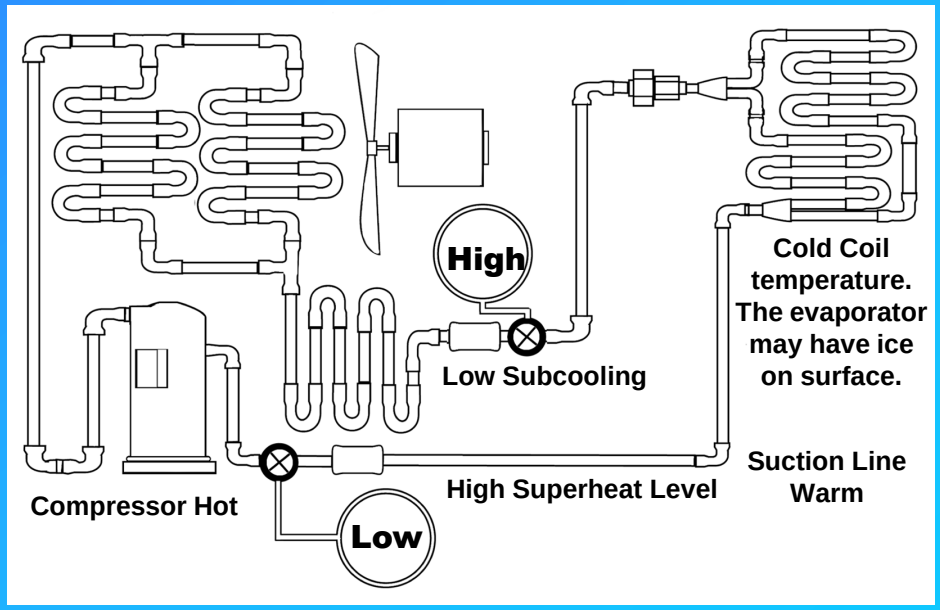
1. The system must have a discharge line pressure port to perform the test.

2. Pump the refrigerant into the condenser coil by running the compressor with the liquid service valve closed. Only pump the system down to 0 PSIG suction pressure. **Never run in a vacuum!**

3. Shut off the condensing unit when pump-down is finished. Disconnect power to the compressor and then call for cooling so that only the condenser fan runs.

4. Measure the temperature of the outdoor air and air leaving the condenser coil. When they are equal to one another. Shut off the condenser fan.

5. Compare the pressure in the condenser coil to the temperature of the outdoor air. The pressure you read should equal the pressure at the saturation temperature equal to the outdoor air temperature. If the pressure is higher than it should be, non-condensables are present. If non-condensables are present, recover the refrigerant, and recharge.




END

# Identifying Condenser Circuit Restrictions (Fixed)

**OBJECTIVE**

**When a parallel circuit is 100% or partially restricted, condenser surface area is decreased, resulting in decreased efficiency and performance.**

**What you will need:**



***- Digital Thermometer***

**Causes**

- **Debris**
- **Handling Damage**

## Symptoms

**Systems running with partially, or fully restricted parallel circuit will run at liquid pressures above factory required levels. The suction pressure could be high or low depending upon if there is enough condenser coil surface area to provide adequate subcooling function for the amount of liquid line present. If there is adequate subcooling, the high liquid pressure will flood the evaporator coil. In a flooded state the evaporator suction pressure will be high and the superheat level low. If there is not enough subcooling to overcome the pressure loss in the liquid line, flash gas will be present before the metering device. This condition will starve the evaporator coil and low suction pressure along with high superheat will be present.**

**The restriction in the circuit will cause a corresponding drop in refrigerant temperature. Therefore, the circuit with the restriction will have refrigerant leaving the circuit at a temperature much colder than the other circuits.**

**Continued on Next Slide…**

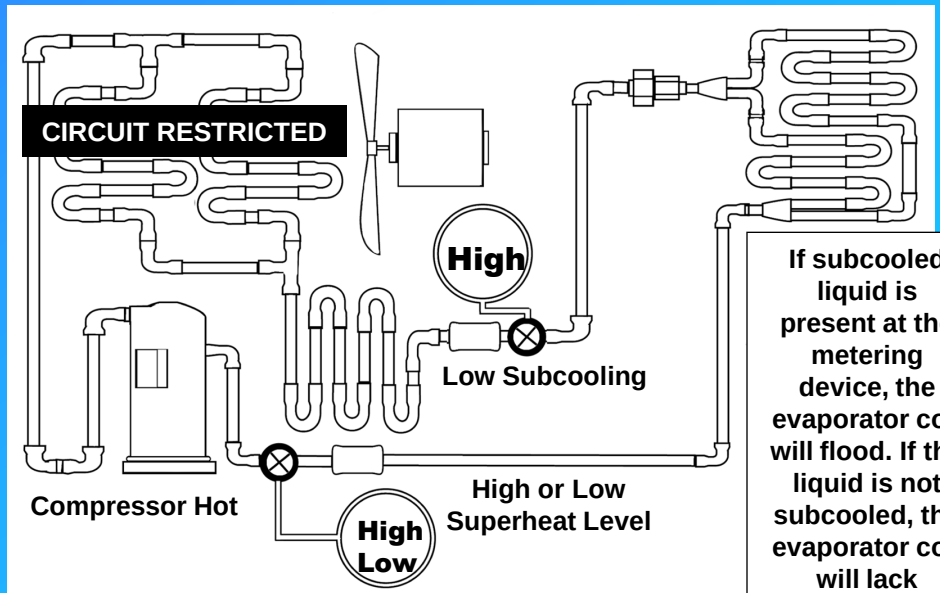
# Identifying Condenser Circuit Restrictions (Fixed)

**Procedure**

1. Call for cooling and run the system.
2. Measure the temperature of the refrigerant leaving the parallel circuits. (Fig. 1)
3. If the conditions indicate a restriction in the coil and one of the circuits has a considerable temperature difference (greater than 20 degrees) at its outlet, the circuit has a restriction.
4. Replace or repair the condenser coil.

**Fig. 1**






If subcooled liquid is present at the metering device, the evaporator coil will flood. If the liquid is not subcooled, the evaporator coil will lack adequate refrigerant and starve.

END

# Identifying Condenser Circuit Restrictions (TXV)

**OBJECTIVE**

**When a parallel circuit is 100% or partially restricted, condenser surface area is decreased, resulting in decreased efficiency and performance.**

**What you will need:**



***- Digital Thermometer***

**Causes**

- **Debris**
- **Handling Damage**

## Symptoms

**Systems running with partially, or fully restricted parallel circuit will run at liquid pressures above factory required levels. The system may have adequate subcooling for the liquid line pressure loss or it may not. If there is enough subcooling to maintain a subcooled liquid at the metering device, the evaporator will perform normally with the TXV. If flash gas forms in the liquid line due to inadequate liquid subcooling, the TXV will try to open and provide more refrigerant to the evaporator coil. If the TXV cannot feed enough refrigerant into the evaporator coil it will starve.**

**The restriction in the circuit will cause a corresponding drop in refrigerant temperature. Therefore, the circuit with the restriction will have refrigerant leaving the circuit at a temperature much colder than the other circuits.**

**Continued on Next Slide…**

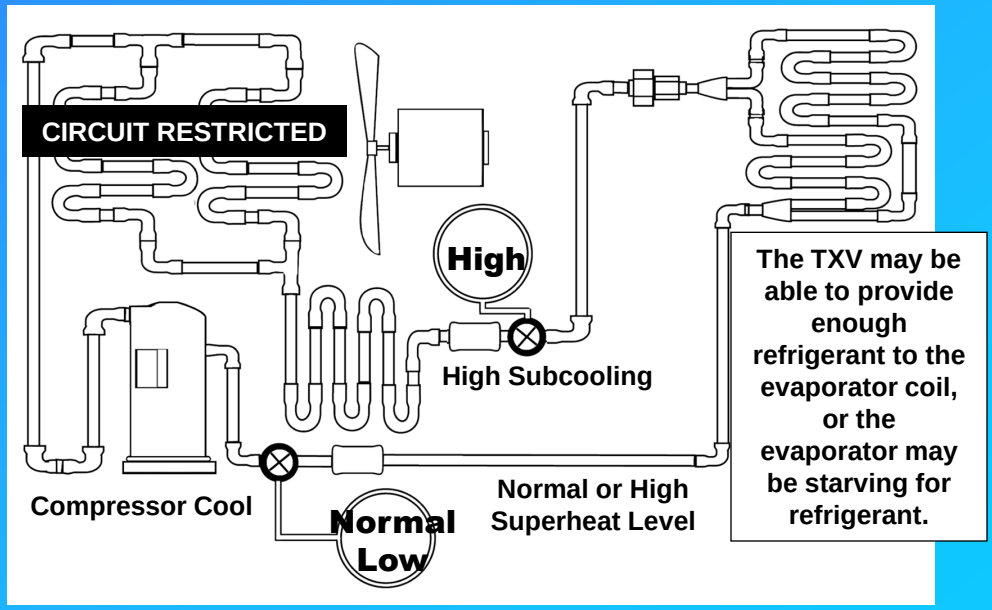
# Identifying Condenser Circuit Restrictions (TXV)

## Procedure

1. Call for cooling and run the system.
2. Measure the temperature of the refrigerant leaving the parallel circuits. (Fig. 1)
3. If the conditions indicate a restriction in the coil and one of the circuits has a considerable temperature difference (greater than 20 degrees) at its outlet, the circuit has a restriction.
4. Replace or repair the condenser coil.

**Fig. 1**






END

# Identifying Subcooler Circuit Restrictions

**OBJECTIVE**

**When a subcooling circuit is 100% or partially restricted, metering of the refrigerant will take place in the condenser coil instead of the metering device.**

**What you will need:**



***- Digital Thermometer***

**Causes**

- **Debris**
- **Handling Damage**

## Symptoms

**When the subcooling circuit is restricted, the refrigerant will be metered to a low pressure. Since the liquid pressure gauge is downstream from this restriction, the liquid pressure gauge will be low. The actual temperature of the liquid line will correspond to the saturation temperature equal to the pressure being read on the liquid gauge.**

**The refrigerant leaving the condensing coil will be below the temperature of the outdoor air circulating through the condenser surface. It is likely there will be frosting or sweating of the liquid line present.**

**Continued on Next Slide…**

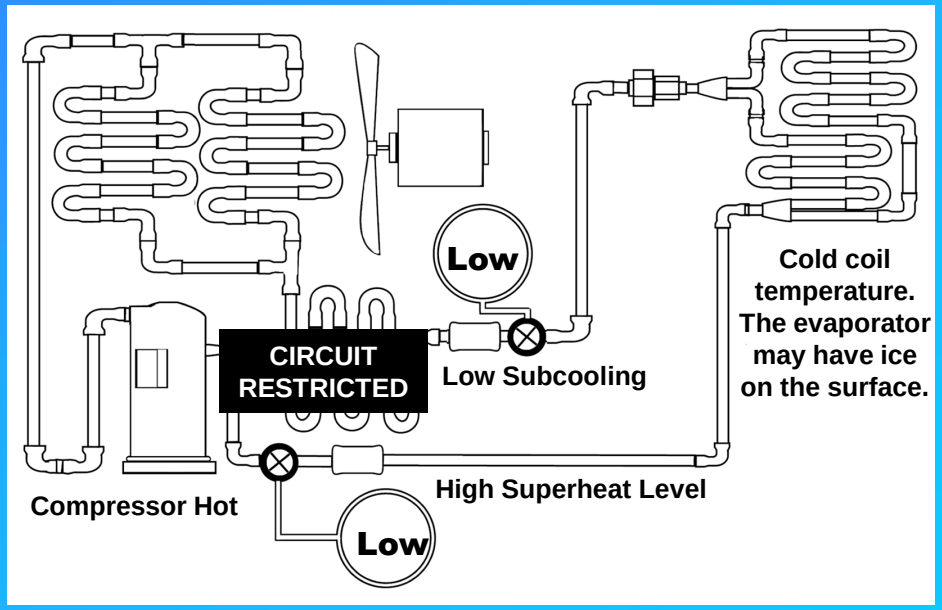
# Identifying Condenser Circuit Restrictions

**Procedure**

1. Call for cooling and run the system.
2. Measure the temperature of the refrigerant leaving the condenser coil subcooling circuit. (Fig. 1)
3. If the temperature of the refrigerant is below outdoor air temperature along with other symptoms, a restriction is present.
4. Replace or repair the condenser coil.

**Fig. 1**






END

# Identifying Evaporator Circuit Restrictions

**OBJECTIVE**

**A restriction within the evaporator coil will cause the system to exhibit the same operating characteristics as a restricted metering device.**

**What you will need:**



***- Digital Thermometer***

**Causes**

- **Debris**
- **Handling Damage**

## Symptoms

**Systems running with a restriction in the evaporator coil will have low suction pressure along with high superheat. The liquid pressure will initially be low which will make the system appear undercharged. When refrigerant is added to the system, the liquid pressure will rise but the suction pressure will remain low. If subcooling is measured, at this time, it will be high. The high subcooling level is an indication that excess refrigerant is being stored in the condenser coil.**

**There will be no obvious sign of frosting between the condenser coil and the metering device.**

**The system operation will appear to indicate a restriction in the metering device. If the metering device is OK, you need to check the distribution tubes that lead from the metering device fitting into the evaporator circuits to determine if any of them are restricted.**

**Continued on Next Slide…**

# Identifying Evaporator Circuit Restrictions

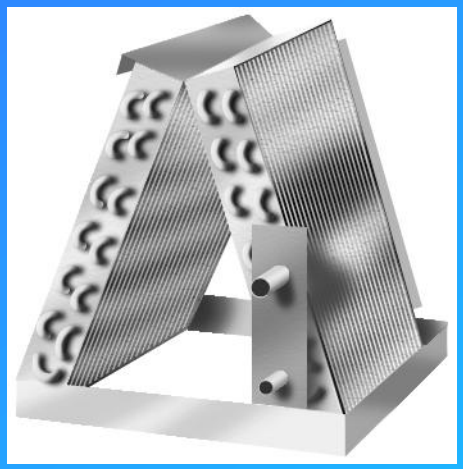
**Procedure**

1. Gain access to the evaporator coil so that you can see all of its surface area.

2. Disconnect power to the indoor fan motor and then call for cooling.

3. When the outdoor unit runs, frost will form across all of the evaporator circuits that are receiving refrigerant. If one of the circuits does not frost, it is not receiving adequate refrigerant (Fig. 2). Look for a restriction in either the circuiting or tubing that feeds the circuiting. Checking the tube temps will help find the actual restriction.

4. If a uniform frost pattern forms, there is no restriction evident at the evaporator.



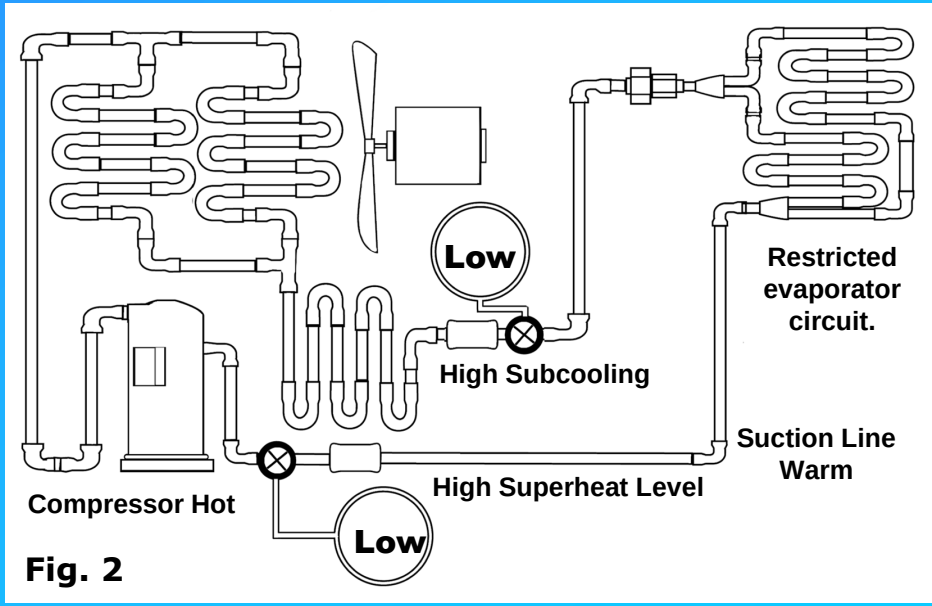



Fig. 2

END

# Diagnosing a Seized Compressor Single Phase

**Determining if a compressor is seized requires that you eliminate all other possible causes before condemning the compressor as seized.**

**The diagnostic process is as follows:**

## Symptoms

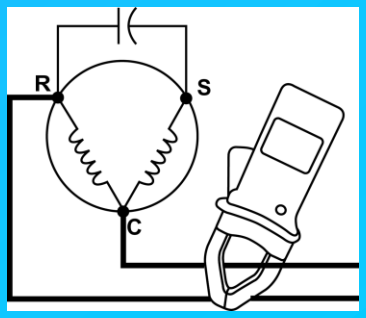
**A potentially seized compressor will try to start, hum, and then open its internal overload. The compressor will draw Locked Rotor Amps (LRA) as it tries to start. Electrical causes must be eliminated as a potential problem before condemning the compressor. Electrical problems that could cause a compressor to fail to start will make a compressor act as if it is seized. These problems include:**

- **Low line voltage**
- **A pitted set of contactor points**
- **A broken wire between the compressor and run capacitor or contactor**
- **A failed run capacitor**
- **Un-equalized system pressures when the compressor tries to start**

**Before beginning the electrical test sequence, make sure the compressor is not trying to start against Un-equalized system pressures. If it in fact the compressor is trying to start against Un-equalized pressures, check for refrigeration circuit restrictions or short cycling conditions.**

---

1. **Remove power to the outdoor condensing unit. Place an ammeter onto the common motor winding lead of the compressor. (Typically the BLACK WIRE coming from the compressor motor terminal cover.) Restore power to the condensing unit and call for cooling. Check the ammeter to be sure you are drawing LRA. If the compressor is trying to start, it should hum and then shut off on its' internal overload. If the compressor does not try to start, the Internal overload may be open. Allow time for it to reset. Once you have confirmed that the compressor is trying to start, proceed to Step 2.**




**Continued on Next Slide…**

# Diagnosing a Seized Compressor Single Phase

2. **Measure the voltage at the compressor contactor while it is under a load. Make sure you have the correct line voltage level at the LOAD SIDE TERMINALS (Fig. 1) of the compressor contactor. Typically this level must not be below or above 10% of the unit nameplate voltage rating. If the line voltage is too low at the LOAD TERMINALS, check the voltage to the LINE TERMINALS (Fig. 2) of the contactor. If the voltage is low at these terminals, there is a problem with the electrical supply to the condensing unit. If the line voltage is normal, but is low at the LOAD TERMINALS, check voltage across the contactor points (Fig. 3. Fig. 4) , with the contactor energized. You should measure 0 volts. If you measure voltage across the electrical points of the contactor, there is either pitting or an obstruction at the contactor. Correct the problem and then retry starting the compressor. If the voltage level at the contactor is within proper tolerance, continue on to Step 3.**

**Fig. 1**

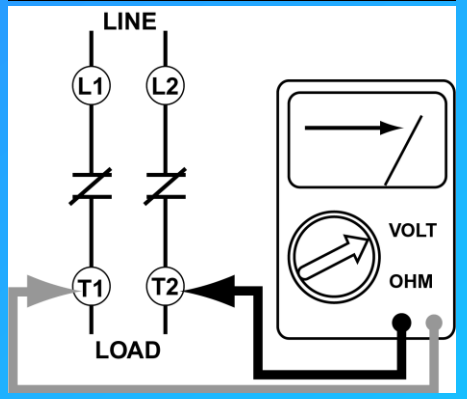



**Fig. 2**

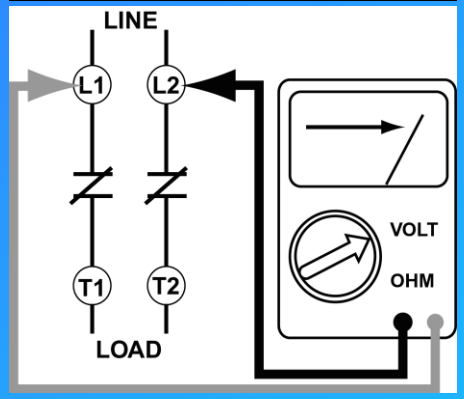



**Fig. 3**

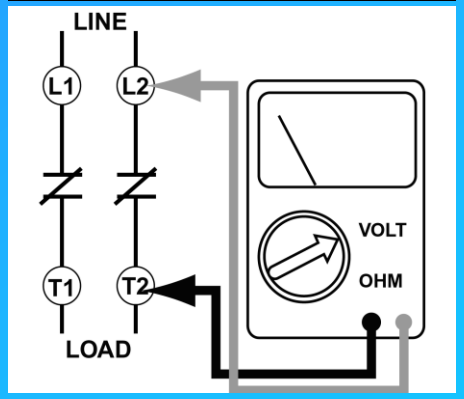
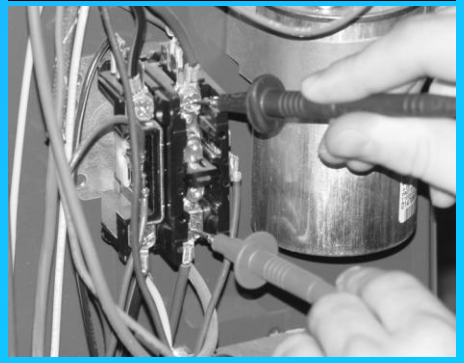



**Fig. 4**

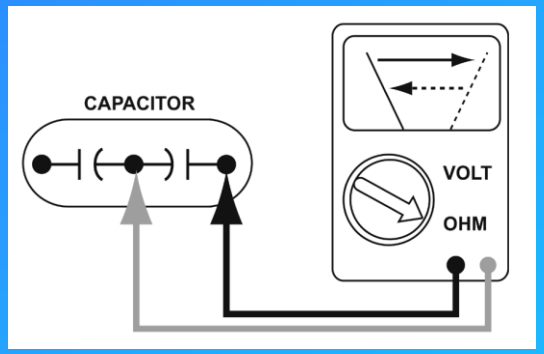


**Continued on Next Slide…**

# Diagnosing a Seized Compressor Single Phase

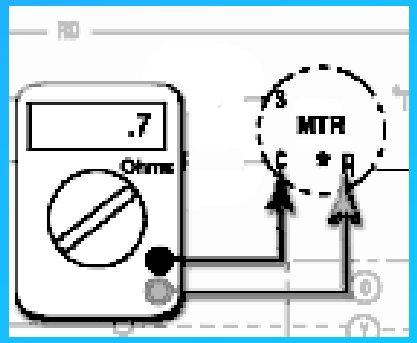
3. **Disconnect power to the condensing unit and discharge all capacitors. Remove the wires from the run capacitor. Using either an ohmmeter or a capacitor tester, check to ensure that the run capacitor is operating properly. (See "Checking a Capacitor.") If it is not, replace it with one of equal value. If the capacitor is OK, continue on to Step 4.**






4. **With power to the unit still off, disconnect the wires from the compressor common, run, and start terminals. Perform a motor winding test to check for an open run or start winding. (See "Motor Winding Test") If either winding is open, replace the compressor. If the windings are OK, proceed to Step 5.**

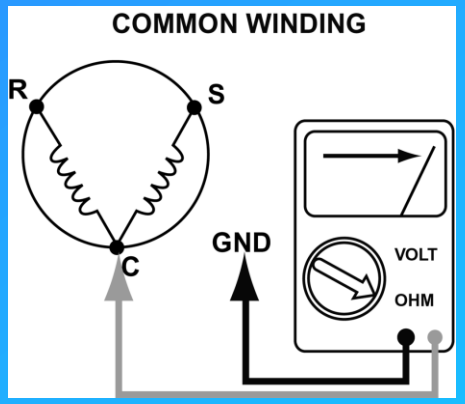





**Continued on Next Slide…**

# Diagnosing a Seized Compressor Single Phase

5. **Check for a grounded compressor motor. (See "Checking for a Grounded Motor.") If any terminal is shorted to ground, replace the compressor. If the motor is not shorted, proceed to Step 6.**




6. **If everything checks out good electrically, and the compressor is not trying to start against Un-equalized pressures, add a hard start kit. If the compressor fails to start, replace the compressor.**



END

# Performing a Single-Phase Motor Winding Test

**What you will need:**



-***Multimeter***

**This test procedure will determine if a PSC compressor motor has failed due to an open motor winding. This test will also detect a possible open Internal Overload. (IOL)**

## Symptoms

A compressor with an open winding will fail to start. The compressor may not do anything, or may in fact hum as it tries to start and then trip off on its internal overload. If the IOL is open, the compressor will not try to start.

---

1. **Remove power to the outdoor condensing unit and discharge all capacitors. Remove the cover from the terminal cover on the compressor and disconnect the wires from the compressor motor Start, Run, and Common terminals.**



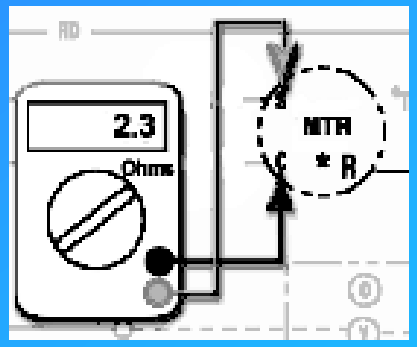
**WARNING: IF TERMINALS ARE CHARRED OR BURNED, DO NOT REMOVE THE WIRES FROM THE TERMINALS. PERFORM THE TESTS BY REMOVING WIRES FROM THE CONTACTOR AND CAPACITOR.**

**Continued on Next Slide…**

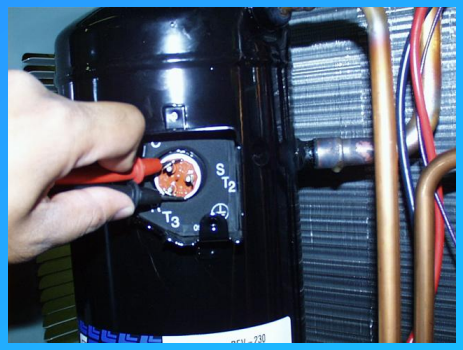
# Performing a Single-Phase Motor Winding Test

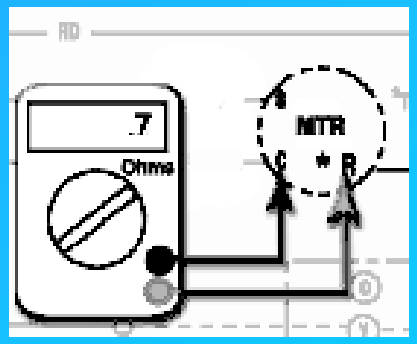
2. **Set your ohmmeter to read very low ohms. (Down to ½ of an ohm may be read.) Place one ohmmeter lead to the Start Terminal and the other ohmmeter lead to the Common terminal. You should measure a low resistance. If you measure a low resistance, the Start winding is not open. Next measure the resistance between the Run terminal and the Common terminal, you should measure a small resistance. If you do, the compressor does not have an open winding.**




**If you do not measure resistance between Common and either the Start or Run terminal, there is an open circuit between the Terminal and the Common Terminal. This may be due to an open IOL or an open winding.**



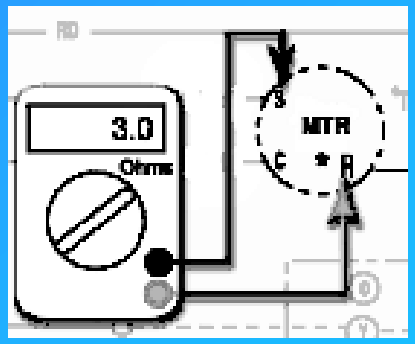

**Continued on Next Slide…**

# Performing a Single-Phase Motor Winding Test

3. **To determine if the problem is an open winding or an open IOL, check the resistance between the Run terminal and the Start terminal. If you measure resistance, the IOL is open. Allow up to four hours for the IOL to re-close. If the IOL does not re-close, replace the compressor.**

**If you do not measure resistance between the Run and Start Terminals, there is an open winding. Replace the compressor.**




END

# Performing a Three Phase Motor Winding Test

**What you will need:**

-***Multimeter***

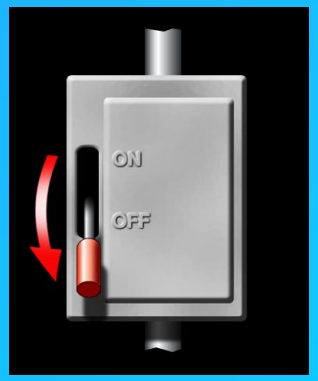
**This test procedure will determine if a three phase compressor motor has failed due to an open motor winding. This test will also detect a possible open Internal Overload. (IOL)**

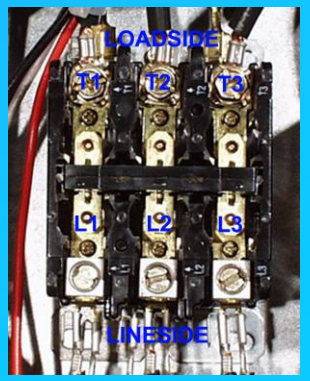
## Symptoms

**A three phase compressor with an open winding may fail to start. In some cases the motor may run on one phase. The compressor may not do anything, or may in fact hum as it tries to start and then trip off on its internal overload. If the IOL is open, the compressor will not try to start.**

---

1. **Remove power to the outdoor condensing unit. Disconnect the three wires to the compressor 1, 2, and 3 motor terminals at the LOAD SIDE TERMINALS on the compressor contactor.**



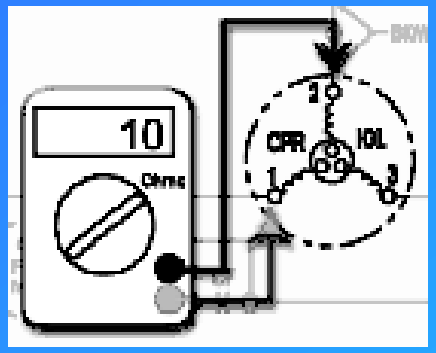

**Load side terminals are the terminals that connect the compressor motor to the contactor. NOT THE INCOMING LINE VOLTAGE.**

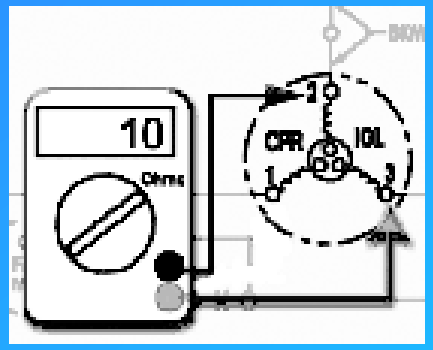
**Continued on Next Slide…**

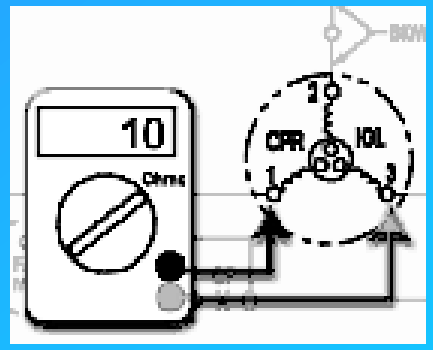
# Performing a Three Phase Motor Winding Test

2. **Set your ohmmeter to read very low ohms. (Down to ½ of an ohm may be read.) Check resistance between all combinations of motor terminals. For example, between terminals 1 to 2, 1 to 3, and 2 to 3. You should measure equal resistance between all terminal combinations. If you do not measure resistance between any terminals, the IOL may be open. Allow time for the motor to cool down and the IOL to re-close. This may take up to four hours. If the IOL does not re-close, replace the compressor.**

**If you measure infinite resistance between any combination of terminals, yet have resistance between other terminals, the compressor has an open winding. Replace the compressor.**




**NOTE: SOME THREE PHASE COMPRESSORS HAVE SEPARATE TERMINALS FOR THE IOL. CHECK THE SCHEMATIC DRAWING TO DETERMINE WHICH ELECTRICAL CONFIGURATION YOU ARE WORKING WITH.**

END

# Testing a Run Capacitor With a Ohmmeter

**What you will need:**

-***Multimeter***

**This test procedure will determine if a run capacitor is working properly.**

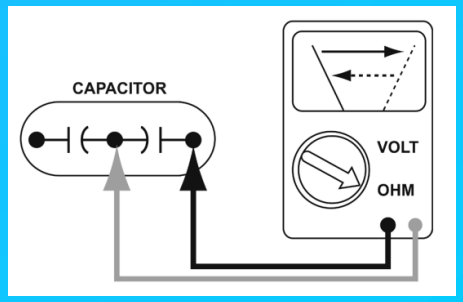
## Symptoms

**A compressor with an open run capacitor will fail to start. The motor will attempt to start, hum, and then shut off on its internal overload. (IOL)**

---

1. **Remove power to the condensing unit and discharge all of the capacitors. Check the capacitor for any bulging, open rupture disc, or case damage. Replace the capacitor if these conditions are detected.**
2. **Remove the wires from the capacitor terminals.**
3. **Place one ohmmeter lead to each capacitor terminal. The meter should charge and discharge the capacitor. Your meter will move its needle in response to the capacitor, or if it is a digital meter, the scale will ramp up and down with the charging and discharging state of the capacitor. If the meter does not respond, reverse the meter leads and test again. If the meter still does not respond, replace the capacitor with one of equal value. If the meter does respond, the capacitor is working.**






END

# Hard Start Kit

**What you will need:**

-***Multimeter***

**In this section troubleshooting of the single-phase compressor hard start kit circuit will be covered. When there is a problem with the hard start circuit, the problem will be either a failed potential relay or a bad start capacitor. Either component failure will result in compressor starting problems.**

## Symptoms

## Potential Relay

**If the potential relay contacts stick in an open position, the start capacitor will not be in the circuit during initial start up. This will cause the compressor to either have a hard time starting, or in some cases, it will fail to start. Tripping of the compressor's IOL is possible.**

**If the relay contacts were to stick in a closed position, the start capacitor would remain in the circuit during run operation. This would result in failure of the start capacitor. Obvious signs would include bursting of the capacitor casing.**

## Start Capacitor

**If the start capacitor were defective, the compressor would experience starting problems or in some cases failure to start at all. Tripping of the compressor IOL is possible.**



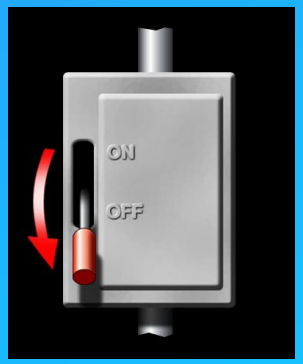
**Continued on Next Slide…**

# Hard Start Kit

**What you will need:**

-***Multimeter***

**Checking The Potential Relay Solenoid Coil**

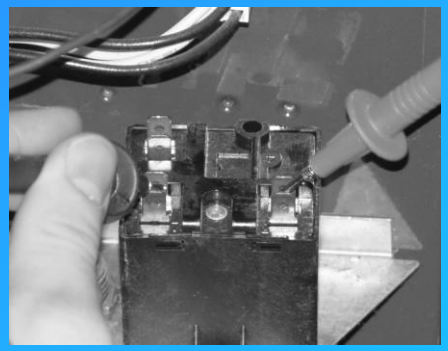


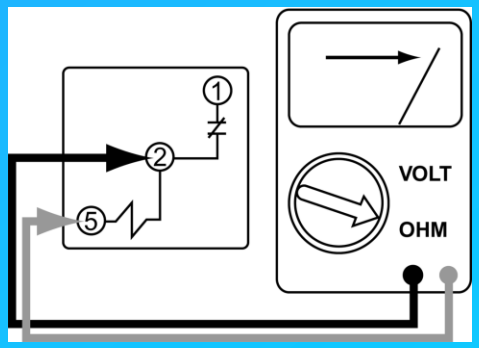

1. **Disconnect power to the unit and make sure the Start Capacitor is discharged.**

**FAILURE TO FOLLOW THIS STEP MAY CAUSE INJURY OR DEATH.**

2. **Remove the wires from the Potential Relay terminals.**

3. **Using your OHMMETER check for continuity between the potential relay TERMINALS #2 and #5. Do this by placing one meter lead to the #2 TERMINAL and the other meter lead to the #5 TERMINAL. If you read an open circuit, replace the relay. If you measure resistance, the relay coil is OK. (8.5K-15KOHM Typical)**





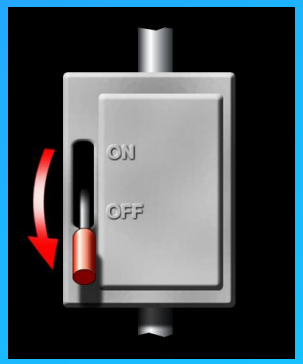

END

# Hard Start Kit

**What you will need:**

-***Multimeter***

**Checking The Potential Relay Contacts**

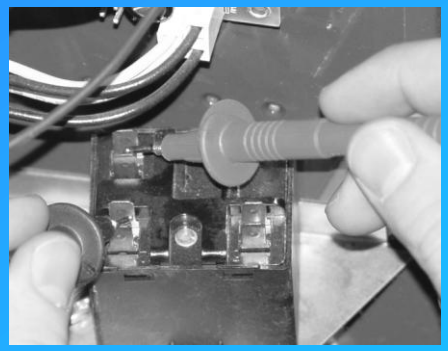


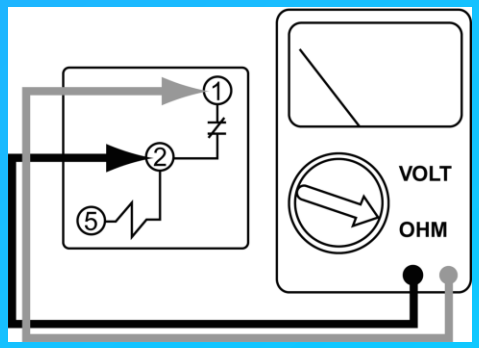

1. **Remove power to the unit and make sure the Start Capacitor is discharged.**

**FAILURE TO FOLLOW THIS STEP MAY CAUSE INJURY OR DEATH.**

2. **Remove the wires from the Potential Relay terminals.**

3. **Using your OHMMETER check for continuity between relay TERMINALS #1 and #2. You should read 0 OHMS.If you read infinite OHMS, replace the relay.**






END

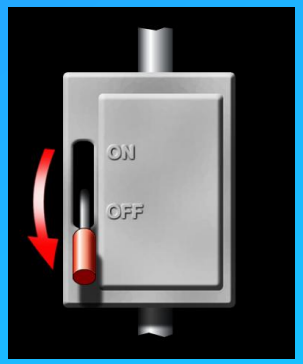
# Hard Start Kit

**What you will need:**

-***Multimeter***

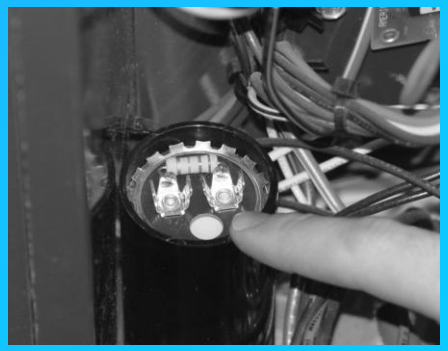
**Checking The Start Capacitor With an OHMMETER**

**1. Remove power to the unit and make sure the Start Capacitor is discharged.**




**Use a 20,000 OHM resister to discharge the capacitor. DO NOT TOUCH THE CAPACITOR LEADS WITH YOUR HANDS.**

**2. Visually check the capacitor for a cracked casing, loose terminals, or broken rupture disc in the capacitor top. Replace the capacitor without further tests if these symptoms exist.**



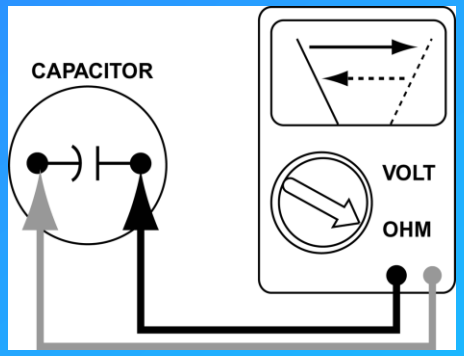
***Set your OHMMETER to the R X 1000 scale. (Zero adjust the meter if necessary)***

**Continued on Next Slide…**

# Hard Start Kit

3. **Place one ohmmeter lead to each capacitor terminal. The meter should charge and discharge the capacitor. Your OHMMETER will either move in response to the capacitor, or if it is a digital meter, the scale will ramp up and down with the charging and discharging of the capacitor.**






4. **If your meter does not react to the capacitor, reverse the meter leads and try again. If the meter still does not show charging and discharging, replace the capacitor.**

**If the Start Capacitor needs replacing, always replace it with one of equal microfarad rating. The replacement capacitor working voltage should be equal to or greater than the original capacitor.**

END

# Checking for a Grounded Compressor

**What you will need:**



-***Multimeter***

**This procedure will determine if a compressor motor is shorted to ground.**

## Symptoms

**When a compressor motor is shorted to ground, the circuit breaker or line voltage fuses will open whenever the compressor tries to energize. When the breaker has tripped, NEVER RESET THE BREAKER OR REPLACE THE FUSE WITHOUT CHECKING FOR A GROUNDED COMPRESSOR FIRST. FAILURE TO DO SO MAY RESULT IN INJURY OR DEATH.**

---

**NOTE: Under certain conditions, an ohmmeter may fail to detect grounded faults. Tecumseh Products recommends checking for a ground fault only with a megger or Hi-Pot.**

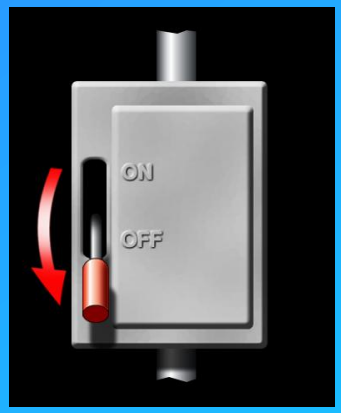
**A megger is a special type of ohmmeter that is capable of measuring very high resistances by using high voltages. A hi-pot is a device that uses high voltages to measure the flow of current across the motor insulation. Unlike an ohmmeter, a megger or hi-Pot can detect a breakdown in motor winding insulation before the failure occurs.**

**Continued on Next Slide…**

# Checking for a Grounded Compressor

**OHMMETER TEST PROCEDURE**

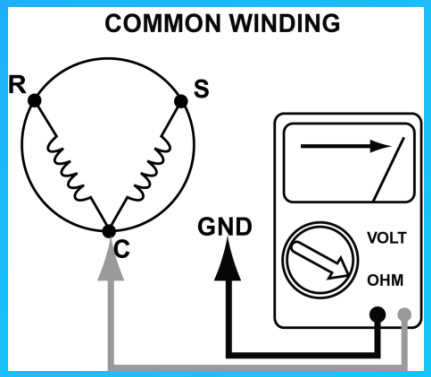
- **Disconnect power to the unit and discharge all capacitors. Remove the compressor motor terminal cover and disconnect the wires from the compressor motor terminals.**




2. **Set your ohmmeter to read the highest resistance scale. Place one meter lead to the common motor terminal and the other lead to the discharge line at the compressor.**

   **You should read either infinite ohms or resistance over 1 million ohms. If you do, that terminal is not grounded. (Tecumseh Compressors = Should be over 2 million Ohms.)**

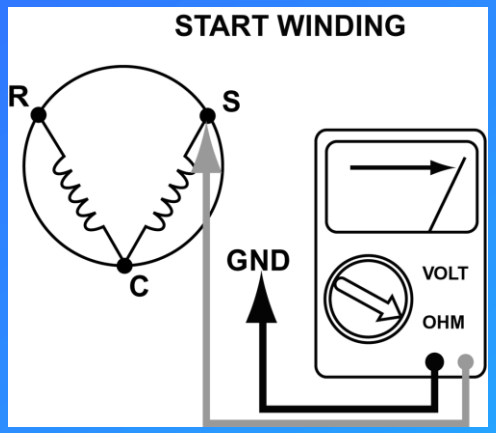


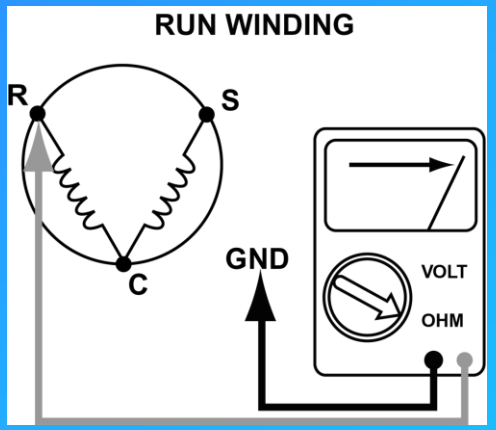



**Continued on Next Slide…**

# Checking for a Grounded Compressor

3. **Repeat the procedure for the run and start terminals. They too should read either infinite ohms or ohms over 1 million. If a lower resistance is read, replace the compressor.**




**For three-phase motors, follow the same procedure as above, but check resistance from motor terminals 1, 2, and 3 to ground.**

END

# Detecting 3 Phase Voltage Imbalance

**When three phase power is supplied to a commercial building, electricians take off power from different phase legs to power up 230 volt single phase equipment. If the same leg is used for the majority of the single phase power requirements, one three phase leg may drop its voltage too far below the other legs. In practice, a maximum of a 2% voltage imbalance is all that is allowed. This is due to the fact that voltage imbalances generate excessive heat in a three phase motor winding, such as those found in expensive three phase compressors.**

## Calculating Voltage Imbalance

**We can determine the voltage imbalance present at a job site by performing the following test:**

1. **Run the condensing unit and measure the voltage being supplied to the compressor contactor on all three legs. Make sure the compressor is running.**

2. **Next, add the three measured voltages and divide by three. You now have the average voltage.**

3. **Identify the leg with the largest difference from the average.**

4. **Divide the largest difference by the average voltage and multiply the result by 100.**

5. **The result is the percentage of difference from average. Please note that a maximum percentage of 2% is all that is allowed.**

**Continued on Next Slide…**

# Detecting 3 Phase Voltage Imbalance

**Example (Fig. 5)**

**We add them together =691 ⊇ and then divide by 3 which equals an average of 230 volts ∢. Leg L1 is the farthest from the average or 5 volts too high ⊂.**

**We then divide the difference of 5 by the average of 230 volts for a voltage imbalance of 2.17% ⊆.**

**In this example we are higher than the allowed imbalance of 2%. This imbalance creates an increase in the temperature of the winding in the phase where the L1 phase is connected.**

**To correct the problem, try moving the lines forward on the compressor contactor lugs such as L1 goes to L2 and L2 goes to L3 and then L3 to L1, and recheck the voltages. If the problem is not corrected, move the lines forward one more position and retest. If the problem is still not corrected inform the building owner to have an electrician analyze the buildings load distribution.**

**Failure to correct this type of problem will create the potential for premature motor failure at the compressor and indoor blower motor.**

**L1 = 235**

**L2 = 227**

**L3 = 229**

**Fig 5**

**⊇ (L1) 235 + (L2) = 227 + (L3) 229 = 691**

**∢ 691 ÷ 3 = 230**

**⊂ (L1) 235 (L2) 227 (L3) 229**

**- 230 - 230 - 230**

**5 3 1**

**⊆ 5 ÷ 230 = 2.17%**

END

# Compressor Valve Plate Check (Reciprocating)

**This test is for cooling units only. Heat pumps may not hold a pump-down due to reversing valve leakage.**

**What you will need:**



- ***Refrigeration Gauges***
- ***Allen Wrench***

**Causes**

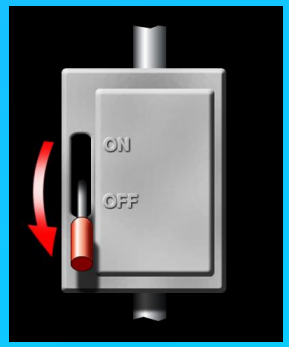
- **Evaporator Flooding**
- **Liquid Migration during the OFF cycle**

**Compressor valve plate failure can occur when saturated refrigerant enters the compressor's cylinder during operation. A compressor can pump vapor, but may break if liquid enters the compressor during the start or run cycles. If enough liquid enters the cylinder of a compressor, massive pressure is introduced into the cylinder, causing valve plate damage.**

## Symptoms

**Compressor valve plate damage will cause the suction pressure to be extremely high, along with low head pressure. The high suction pressure is a result of hot gas being forced back through the suction valve of the compressor during the up-stroke of the compressor's piston. When a compressor pumps hot gas back into the suction side of the circuit, it causes a drop in the high side pressure due to a lack of refrigerant in the condenser.**

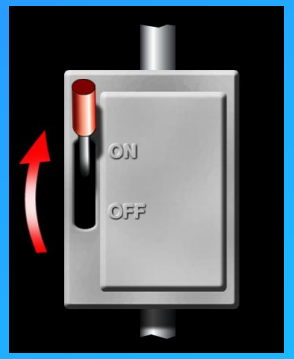
1. **Remove power to the condensing unit and jumper the low pressure switch if one is present.**




**Continued on Next Slide…**

# Compressor Valve Plate Check (Reciprocating)

2. **Restore power to the unit and run the system as in normal operation.**




3. **With the system running, close the liquid line service valve.**



4. **Notice that the suction pressure will begin to fall. Once the suction pressure reaches 0 PSIG, remove power to the unit.**



**WARNING: NEVER PUMP A COMPRESSOR INTO A VACUUM. COMPRESSOR FAILURE, OR PERSONAL INJURY, OR DEATH MAY OCCUR.**

**Continued on Next Slide…**

# Compressor Valve Plate Check (Reciprocating)

5. **Observe the suction pressure. If the valve plate is good, the suction pressure should maintain 0 PSIG. If it begins to rise, check the liquid line service valve to ensure that it is fully closed (if frost forms past the service valve, the valve is leaking).**

   **If suction pressure continues to rise, the valve plate may be allowing hot gas to escape through the suction valve.**



**NOTE: A SMALL RISE IN SUCTION PRESSURE MAY OCCUR AFTER THE COMPRESSOR IS SHUT DOWN DUE TO SOME REFRIGERANT REMAINING IN THE SUCTION SIDE OF THE SYSTEM. THIS SMALL RISE IN PRESSURE DOES NOT INDICATE BAD COMPRESSOR VALVES.**

END

# Checking a Compressor for Mechanical Failure

**What you will need:**



***- Refrigeration Gauges***

**This test procedure will determine if a single or three phase Scroll Compressor is mechanically operating correctly.**

## Symptoms

**When higher than normal suction pressure and lower than normal liquid pressure are present, many technicians begin to assume that the compressor is bad. In fact, there are other causes of high suction pressure and low liquid pressure other than compressor failure. These causes include:**

- **Bypassing or oversized metering devices**
- **Leaking heat pump indoor check valve assemblies**
- **Heat pump reversing valve leakage**

**Since valve plate leakage on compressors has been the primary suspected cause of high suction pressure and low liquid pressure, there is a problem with assuming that a scroll compressor is the problem. This is due to the fact that scroll compressors do not have valve plates.**

**To elevate the suction pressure and lower the liquid pressure, scroll compressors would have to allow some of the discharge gas to leak back into the suction side of the system. This condition is highly unlikely to occur with scroll designs. Many scroll compressors feature discharge line check valves that hold the discharge gas outside of the compressor shell. This discharge line check valve is not leak proof.**

**One area that can point to mechanical damage to a compressor is the amp draw of the compressor. If there is any additional drag within the compressor body due to mechanical friction, you should be able to detect it with an ammeter. The measured amperage would be higher than the published amps at the combination of indoor air heat load and outdoor air temperature. Unfortunately, many systems you work on will not have this data available at the job site, and in fact many systems will not have the correct indoor air volume present to reference the required amps.**

**Continued on Next Slide…**

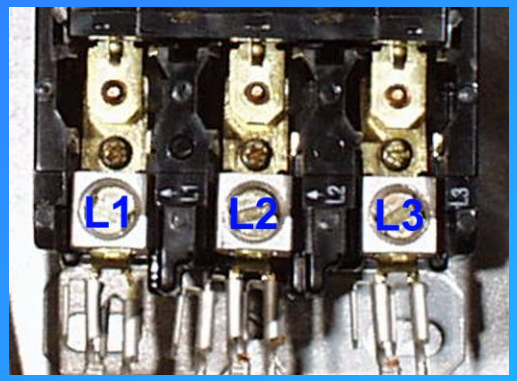
# Checking a Compressor for Mechanical Failure

**Checking a scroll compressor to see if it pumps**

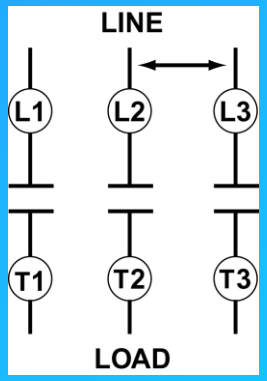
***(Three Phase Only)***

**Three phase scroll compressors can run backwards. When they run backwards they will not pump. If a scroll compressor runs backwards, it makes excessive noise. To change the direction of the scroll compressor rotation, reverse any two incoming line power phases.**

**Shut line power off to the condensing unit and then reverse the legs at either the line or load terminals of the compressor contactor, or line voltage terminal strip connection if present. Once you have reversed the leads, move on to Step 2.**




**To change direction, switch any two incoming line power phases (L1,L2,L3).**

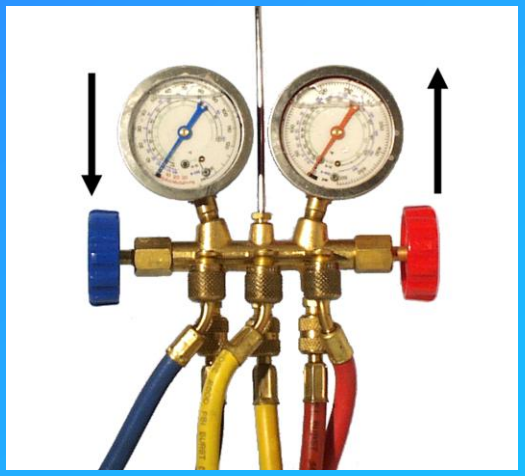



**SHUT OFF LINE VOLTAGE TO THE UNIT BEFORE REVERSING THE POWER LEADS OR INJURY/DEATH MAY OCCUR.**

**Continued on Next Slide…**

# Checking a Compressor for Mechanical Failure

**A scroll compressor cannot be checked mechanically by performing a pump down test. In fact, performing a pump down test on a scroll compressor may in fact damage the compressor. You can check the scroll compressor to see if it is pumping the refrigerant by turning the compressor on and watching the suction gauge and high side gauge. If the suction pressure falls and the head pressure rises, the compressor is pumping. If the gauges do not move, and the system has refrigerant in it, make sure the compressor motor is running. If the motor is running, the compressor is bad. Replace the compressor.**



END

# Single Phase Compressors

## How the Single Phase Compressor Responds to Electrical Problems

**The single phase motor circuit can fail electrically due to:**

1. **Failed Capacitor: Hums goes off on internal overload.**
2. **Open winding or IOL, does not hum does not try to start.**
3. **Seized: Draws locked rotor amps. Goes off on IOL or trips breaker.**
4. **Grounded Motor: Trips breaker.**
5. **Contactor Problem: May hum go off on internal overload or does not try to start.**

---

**The compressor responds to motor problems in the following ways:**

1. **If the capacitor fails, the motor will try to start. It will lack the phase shift boost provided by the capacitor. Because it lacks the phase shift boost, it will not be able to start. The motor will draw high current for a very brief moment and cycle off on its internal overload. The compressor will make a humming sound as it tries to start. When the internal overload resets, the compressor will repeat this pattern indefinitely.**
2. **If a motor winding opens, or if the IOL is open, there will be no electrical path for current to take. When the contactor closes, nothing will happen.**
3. **If the motor is seized internally, the compressor will draw Locked Rotor Amps. It will cycle on its internal overload or it may trip the circuit breaker. You will hear a humming sound as the compressor tries to start.**
4. **If the motor has an internal short to ground, the circuit breaker will trip when the compressor tries to start.**
5. **If the contactor contacts are pitted or have debris preventing them from completely closing, the compressor will lack adequate voltage to run. The compressor may try to start, hum, and cycle off on internal overload. If the contactor is not letting enough voltage to the motor, the compressor may not even try to start.**

END

# Three Phase Compressors

**How the Three Phase Compressor Responds to Electrical Problems**

**The three phase motor circuit can fail electrically due to:**

- **Contactor voltage drop due to debris or pitting of contacts.**
- **Internal motor winding failure of one or all three motor windings.**
- **Internal shorting to ground. Commonly caused by rotor drag. (Liquid damage to center bearing.)**
- **Phase imbalance from power company. All voltages to each leg must be within 3% of each other.**

---

**When a three phase compressor circuit has a problem, it is going to be due to either line voltage problems, internal motor problems, or contactor problems. There are no capacitors or start components used with three phase motors.**

1. **If the contactor has pitting or debris in its contacts, there may be a voltage drop between the line and associated load terminals. Just as with a PSC type motor, check for a voltage drop. There should be none. If there is a voltage drop, the motor may fail to start and trip on IOL. Or in extreme cases, the motor may fail to try and start.**
2. **If the motor has an internal winding open. There are three. The motor will try to start. It will hum. It rare occasions it may single phase and run on two windings.**
3. ***If the IOL opens, the motor will not try to start. Allow time for the compressor to cool down and the IOL to reset.***
4. **If the motor shorts to ground, the circuit breaker or fuses will blow. Nothing will run.**
5. **If there is more than a 3% difference in line voltage potential between L1, L2, or L3, the motor may experience internal winding failure. To correct a phase imbalance, contact the electrical utility.**

END