Marine A/C Troubleshooting Guide

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Table of Contents

Theory Of Operation

CLEAN AIR ACT AMENDMENTS OF 1990 [TITLE VI - SECTION 608(C-1)]

"Effective July 1, 1992, it shall be unlawful for any person, in the course of maintaining, servicing, repairing, or disposing of an appliance or industrial process refrigeration, to knowingly vent or otherwise knowingly release or dispose of any Class I* or Class II** substance used as a refrigerant in such appliance (or industrial process refrigeration) in a manner which permits such substance to enter the environment. De-minimus releases associated with good faith attempts to recapture and recycle or safely dispose of any such substances shall not be subject to the prohibition set forth in the proceeding sentence."

All FMS air conditioners are charged with a refrigerant that meets the current EPA standards. All units produced after Jan 1st, 2025 will be charged with “R32” or other acceptable refrigerants to meet new EPA requirements. Any unit produced before Jan 1st, 2025 can be charged with previous refrigerants and allowed to be sold until Jan 1st, 2028. Because FMS air conditioners are custom built to order, the transition to “R32” and other refrigerants will begin in late 2024. The new EPA requirements will allow parts and repairs on units and other refrigerants used previously, and will only affect the production of new units.

Theory Of Operation

1.) Introduction:

Before going over how each mode works on FMMS air conditioners we are going to give a brief explanation of how refrigeration works. This may help you understand the unit operation better and assist with explaning the troubleshooting steps later in this guide. This is not meant to be a complete explanation and is only for illustrational purposes.

Refrigeration is the method of moving heat from one area to another using a refrigerant. For this explanation the refrigerant used will be “R410A”. The basic components of a refrigeration system are: the compressor, condenser, evaporator, expansion device, and the refrigerant. This is a mechanical system and the compressor is driven by electricity in FMS air conditioners.

The compressor is a mechanical pump. Compressors have a wide variety of shapes, sizes, and methods to pump refrigererant. As it rotates it creates a suction force on the inlet and a compression or pressurized force on the outlet. As the compressor is running it produces a massive amount of heat and friction like the engine in a car. To overcome these effects the refrigerant contains oil for lubrication and the inlet gas entering the compressor doubles as a coolant for the electric motor inside. For the compressors on FMS air conditioners it is not uncommon for the shell (or outside) of the compressor to reach 200 degrees F or more.

Theory Of Operation

The condenser's job is to condense the refrigerant into a liquid. When the refrigerant leaves the compressor it is a very hot gas. The hot gas enters the condenser and as it flows from the condenser inlet to the condenser outlet it gets cooled and converts from a gas to a liquid. Condensers can take many different forms but on FMS air conditioners the condenser is the water coil that uses seawater or freshwater to cool the refrigerant gas into a liquid. The condenser is the location of very high pressure in the system and must be made of a very durable material. R410A operates between 300 to 500 psi based on various conditions and FMS water coils are rated for 650 psi during normal operation and are made of copper and cupronickel for durability. Close to the condenser is a high pressure safety switch that will stop the unit from running if the condenser pressure rises too high. This pressure switch is set to go off at 600 psi and reset at 475 psi.

The evaporator and the expansion device are paired together after the condenser to perform the opposite task. The cool liquid refrigerant hits the expansion device and as it passes through it moves into an area of low pressure in the evaporator coil. In the evaporator the pressure drops from the 300+ psi in the condenser down to between 110 and 135 psi under normal operation. In this low pressure environment the refrigerant changes from it's liquid state to a gas, and this transition creates a cooling effect. Air is passed over the evaporator coil and temperature and humidity are removed. The BTU rating of the air conditioner determines how much temperature and humidity are removed based on the volume of air that moves through the evaporator coil. As the refrigerant leaves the evaporator coil it heads back to the compressor to start the process all over again. This repeats until the thermostat tells the system to stop running.

The refrigerant is a clear and colorless chemical. At room temperature R410A is over 200 psi in a pressurized refrigerant tank or an air conditioner that is off and has not run recently. Caution is advised any time refrigerant charging or servicing is involved. Because of the very high resting pressure, any major leak or sudden discharge is cold enough to cause frostbite within several seconds of exposure. Any time connecting or disconnecting gauges is usually the point to be aware of refrigerant exposure to skin. Should any refrigerant contact the skin or eyes it should be immediately washed with lukewarm water. Refrigerant and oil in an air conditioner are designed to be compatible with each other and mix very well as they flow around the circuit. This oil is often helpful for finding leaks on joints or coils as the refrigerant leaves behind an oil residue near the leak location.

(Figure 1 and Figure 2) show a diagram of how a heat pump air conditioner works in the forward direction (cooling mode) and in the reverse direction (heat mode). For heat mode the only thing that changes is that the water coil becomes the evaporator coil and the previous evaporator coil becomes the condensing coil. All other descriptions remain the same.

Theory Of Operation

FIGURE 1

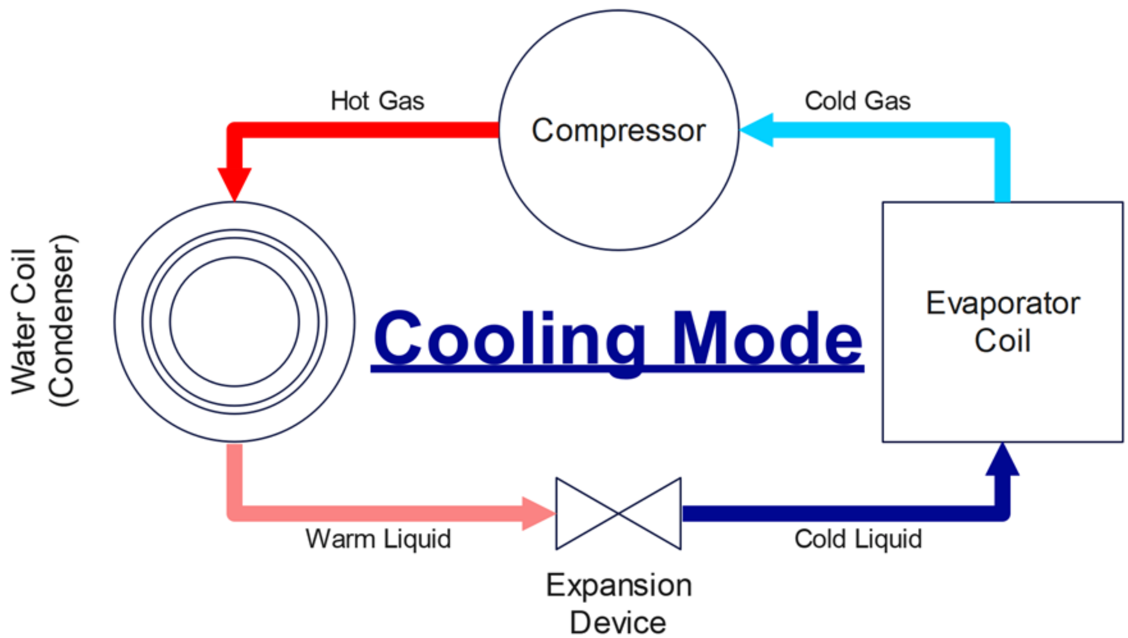
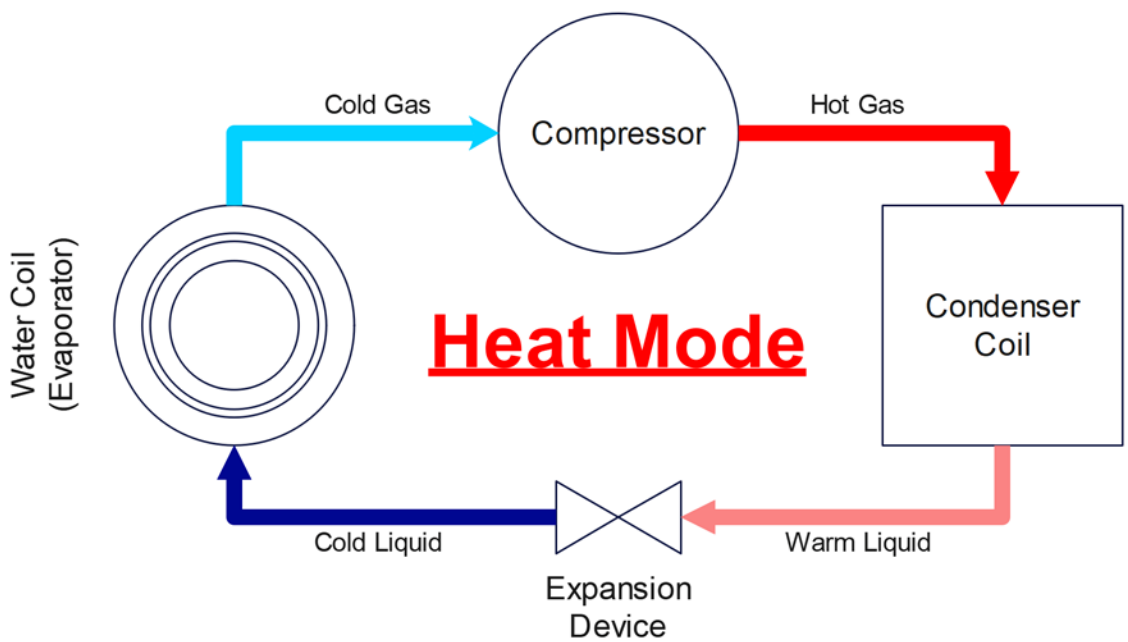


FIGURE 2



Theory Of Operation

2.) FMS Unit Operation:

Cool only units are just that, they only have cooling mode available to them. If the thermostat is placed in “heat” mode the fan will run but the compressor and pump will not operate. When the thermostat is placed in “cool” mode the compressor, pump, and fan will all come on and run until the thermostat meets the temperature it is set for.

Reverse cycle units have both heating and cooling modes which are driven by the compressor. The common name for reverse cycle units is “heat pump”. When the thermostat is in “cool” mode the compressor, pump, and fan all come on and run until the thermostat meets the temperature it is set for. When the thermostat is in the “heat” mode the compressor, pump, and fan all come on. In this mode the reversing valve is activated to change the direction the refrigerant is flowing and produce heated air instead of cooled air (See Figure 1 and 2). The unit will operate until the thermostat meets the temperature it is set for. The reversing valve typically remains powered all the time while the thermostat remains in the “heat” mode.

Electric heat units have both heating and cooling modes but the compressor only operates in cooling. When the thermostat is set to “cool” the compressor, pump, and fan all come on and run until the thermostat reaches the temperature it is set for. When the thermostat is in “heat” mode the fan comes on and power is also given to an electric heat strip located between the evaporator coil and blower motor. The blower and electric heat strip will remain powered until the thermostat reaches the temperature it is set for. This option is not available in 220V and is available for the M6 and M9 units.

3.) Electrical:

All FMMS units operate on 115 or 220 VAC. Power is applied to the air conditioner through the main circuit breaker through a dedicated air conditioner circuit breaker. This power is converted to 24 VAC using a step down transformer. The thermostats use the 24 VAC to activate relays and contactors inside the electrical box which supply main voltage power to the individual components.

4.) Cooling Water:

Cooling water enters the boat through the foot scoop under the boat, up into the boat through the sea cock, through the raw water strainer, through the pump, and into the “water in” on the air conditioner. As it passes through the air conditioner water coil the refrigerant exchanges heat with the water which is then expelled out the “water out” and overboard through the thru-hull fitting.

Theory Of Operation

5.) Condensation Removal:

While an air conditioner is operating the evaporator will almost always create condensation. This happens in both cooling and heating modes (in heat mode FMS units will sweat from the water coil due to it acting as the evaporator) and the condensation formed can be a substantial amount. The FMS M16 unit is a popular choice, and in a hot and humid environment it can produce over 5 gallons of condensation in a 24 hour period. This condensation falls into the drain pan where it accumulates and flows out the drain port. From here the choice of where the drain will terminate is up to the installer/owner. Choices include draining into the bilge, running to a nearby kitchen sink or shower, a condensate pump, or a device such as the FMS Condensator Kit. The FMS Condensator Kit is a favorite of many air conditioner owners and installers and the way it removes the condensate is by using a venturi effect created by the cooling water as it flows through the air conditioner. The condensate is sucked up and joins the cooling water as it flows out of the boat.

6.) Ductwork:

As the unit operates there is a large volume of air being moved through the unit and discharged into the conditioned space (the area being cooled or heated). The air is pushed through the ductwork and exits through vents placed strategically around the conditioned space. Based on the size of the unit the size of the ductwork and the recommended number of vents will change to allow the proper amount of airflow for operation. Undersized ductwork will lead to a unit freezing in cooling mode and going off on high pressure in heat mode. Oversized or too much ductwork leads to low air speed as it exits the vents and higher potential for biological growth. Oversized ductwork is extremely uncommon in marine air conditioning. Ductwork should be ran as straight as possible and sharp bends or loops should be avoided at all costs. Splitters, tee's, wye's, plenum boxes, etc. can all be used to send airflow in multiple directions and if the ductwork has a sweating risk it should be insulated to prevent this.

7.) Return Air and Filter:

The air exiting vents into the conditioned space is known as supply and the air being sucked through into the unit is known as return. In order for the unit to create the proper amount of airflow through the supply it needs to have access to the same amount or more of return air. This is achieved through a return grill/vent and a filter to prevent debris and buildup on the evaporator coil. Like the ductwork the return grill needs to be sized correctly and the filter needs to be regularly checked and cleaned. The return should be placed as far away from the supply vents as possible and no supply vent should be pointed directly at the return grill. If the return is fed supply air the unit will freeze in cooling mode and go off on high pressure in heat mode.

Troubleshooting Basics

Troubleshooting:

Before attempting troubleshooting it is recommended to review this entire guide. If at any point you do not feel confident or willing to continue troubleshooting alone, please contact FMS technical support for assistance. The basic steps are as follows:

-Check the main power
-Check the thermostat
-Observe unit operation
-Check the water flow

1.) Power:

Air conditioners pull a large amount of current at startup and while running compared to many other electrical devices. Main power flows from the source, to the boats main electrical panel, through a circuit breaker, to the air conditioner electrical box. Check each component in the pathway starting at the source.

If your boat is hooked up to a pedestal make sure the breaker on the pedestal is in the “on” position and is not tripped. If the pedestal is “off” or tripped nothing on the boat should have power unless you have an alternative source such as a generator or battery bank.

Check the main electrical panel of the boat by visual inspection and making sure every relevant power switch is in the “on” position and is not tripped. Check the dedicated air conditioner breaker as well by performing the same inspection.

Older “Mermaid” air conditioners used a 30 AMP inline fuse or glass fuse in a holder. Current FMS air conditioners use a 30 AMP resettable breaker and a 5 AMP fuse for the transformer. Make sure the breaker/fuse is not blown or tripped and reset it or replace it. Next to the breaker will be the main power input on the control box terminal strip. Make sure the wires are intact and connected properly. If you have a multimeter, place it in “VAC” mode and check for 115/220 VAC. If voltage is present proceed to the next sections.

2.) Thermostat:

Standard FMS units operate using a 24 VAC thermostat. The thermostat communicates with the air conditioner electrical box via 4 or 5 wires. The thermostat also has a set of batteries in the back that it will run it in 4 wire installations or when the main power is off to save your settings.

Troubleshooting Basics

Inspect the wires both behind the thermostat and at the electrical control box visually and confirm that they are connected properly. If you have a multimeter, place it in VAC mode and there should be between 24 and 28 VAC with one lead on the “R” wire and one lead on the “C/BR” wire in a 5-wire setup which is the current configuration for FMS units. If the thermostat has 4 wires there should be between 24 and 28 VAC with one lead on the “R” wire and one lead on a nearby ground.

If the thermostat has batteries and you are troubleshooting the unit, replace the batteries with a fresh set to make sure they are discharged. Many thermostats have an indicator of some kind that the batteries are low, but there are models that may not indicate this. If the thermostat is in a 4-wire setup the batteries are an essential component for the thermostat to function. If the thermostat is in a 5-wire setup with the optional “C” wire, the thermostat draws power from the air conditioner 24 VAC transformer to operate. This means that batteries can typically last for years or thermostats that do not have batteries are able to function such as “Wi-Fi” enabled thermostats.

Place the thermostat in the desired mode and wait the designated delay time for the unit to operate. Many thermostats have a 3 to 5 minute delay before the unit will operate. This is a short cycle prevention feature to make sure the unit has adequate rest time between off and on for system longevity. You may hear an audible click inside the thermostat when the communication pathway is activated to operate the unit.

If the thermostat is suspected to be faulty a jumper may be placed on the electrical box thermostat terminals to bypass the thermostat and its wiring. Always turn off the main power when attempting to place or adjust a jumper. Using a solid piece of wire to jumper between the terminals should result in unit operation as follows:

-A jumper placed between the “R” terminal and the “G” terminal will result in only the fan operating. No other component should operate or receive power. There is no harm in letting the fan operate for an extended period of time.

-A jumper placed between the “R” terminal and the “W” terminal will result in an audible “click” at the unit on a reverse cycle heat model. This is the reversing valve operating the switching solenoid. There is no harm in letting the solenoid remain powered for an extended period of time. It is not recommended to place a jumper between “R” and “W” on a cool only or electric heat model unit. In a cool only unit, nothing will happen. In an electric heat unit, the electric heat strip will become powered and if it remains powered for anything longer than a few seconds with no fan operation it will burn up a fusible link high temperature safety device and no longer function.

Troubleshooting Basics

-A jumper placed between the "R" terminal and the "BL" terminal will result in only the compressor and pump running. No other component should be receiving power or operating. It is not recommended to allow the compressor to operate for an extended period of time without the fan.

Warning

Never place a jumper between the "C/BR" terminal and any other terminal. The "C/BR" terminal is the 24 VAC ground. Any 24 VAC power that is applied directly to this terminal could cause the transformer in the electrical box to fail and will result in the repairs not being covered under warranty.

After verifying operation of each terminal separately, proper unit operation can be verified by combining jumpers. Combining several terminals together with jumpers will simulate normal thermostat operation. Be aware that as long as the jumpers are installed that the unit will run in the mode without stopping until main power is removed.

Cooling Mode:

Jumpers placed between the "R" terminal and both the "G" and the "BL" terminals will result in the compressor, fan, and pump operating. This will run cool only, reverse cycle, and electric heat models all in cooling mode. As long as main power is on and the jumpers are installed this should result in the unit operating indefinitely unless a safety device removes main power or disables the unit.

Heating Mode (not applicable to cool only models):

In a cool only model refer to the previous "cooling mode" section for the jumper configuration for proper operation testing.

In a reverse cycle model jumpers placed between the "R" terminal and the "G", "W", and "BL" terminals will result in the compressor, pump, and fan operating but also adds power to the reversing valve which allows heat to be produced instead of cooling. As long as main power is on and the jumpers are installed this should result in the unit operating indefinitely unless a safety device removes main power or disables the unit.

In an electric heat model jumpers placed between the "R" terminal and the "G" and the "W" terminals will result in the blower and electric heat strip operating. As long as main power is on and the jumpers are installed this should result in the unit operating indefinitely unless a safety device removes main power or disables the unit.

Troubleshooting Basics

If placing jumpers at the electrical box are successful in resolving the issue, the problem is in the wiring or the thermostat. Double check all connections and replace thermostat with a store bought unit or replacement from FMS or run a new wire to the existing thermostat to see if the issue is resolved. Contact FMS technical support for assistance if needed and review the thermostat installation section for wiring instructions.

3.) Observing Unit Operation:

If a unit is not operating as designed, observe the operation and go to the section of troubleshooting related to that issue. This guide is meant to be as thorough as possible and will be updated as needed as time goes on. If you are experiencing an issue that is not covered in this guide please contact FMS technical support for assistance.

4.) Checking Water Flow:

If the unit is operating the water pump should have power any time that the compressor is running. If the compressor is running and no water is flowing through the unit, depending on the mode the unit will either go out on high pressure or freeze protection. Check ball valves and make sure they are open, especially the sea cock. Check the pump strainer and make sure it is clean and flowing water properly. Make sure that the pump is primed and is not running dry. If the pump is not properly primed it can cavitate and will result in the air conditioner cycling on high pressure or the freeze stat because not enough water is flowing. Pumps can lose there prime in a multitude of ways, which often makes this the first check if the air conditioner is not functioning correctly.

Troubleshooting Continued (Specific Scenarios):

Note:

All of these troubleshooting scenarios assume that main power has been previously checked and verified. Power is often overlooked and checking what most would consider a basic step can save time, frustration, and cost associated with a step being missed. See the previous basic troubleshooting steps for a brief overview of often overlooked or easy to diagnose problems.

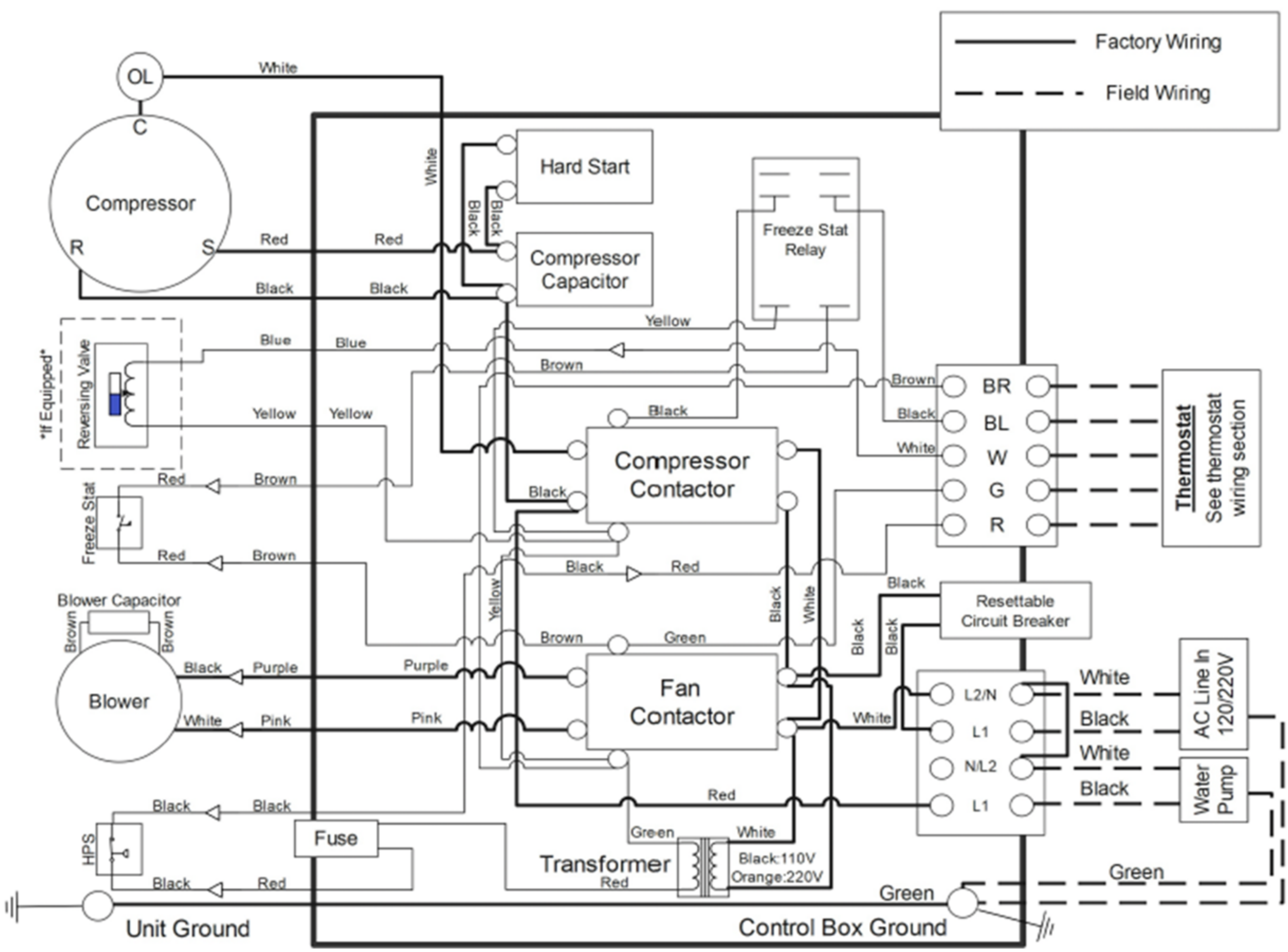
Unit Does Not Operate In Any Mode (No Fan, No Compressor):

If the unit was previously operating and suddenly shut down the unit may have shut down on high pressure. The high pressure switch will prevent all components from operating while the unit is cooling off. Allow up to 10 minutes for the unit to reset before moving on with diagnostic.

Troubleshooting Scenarios

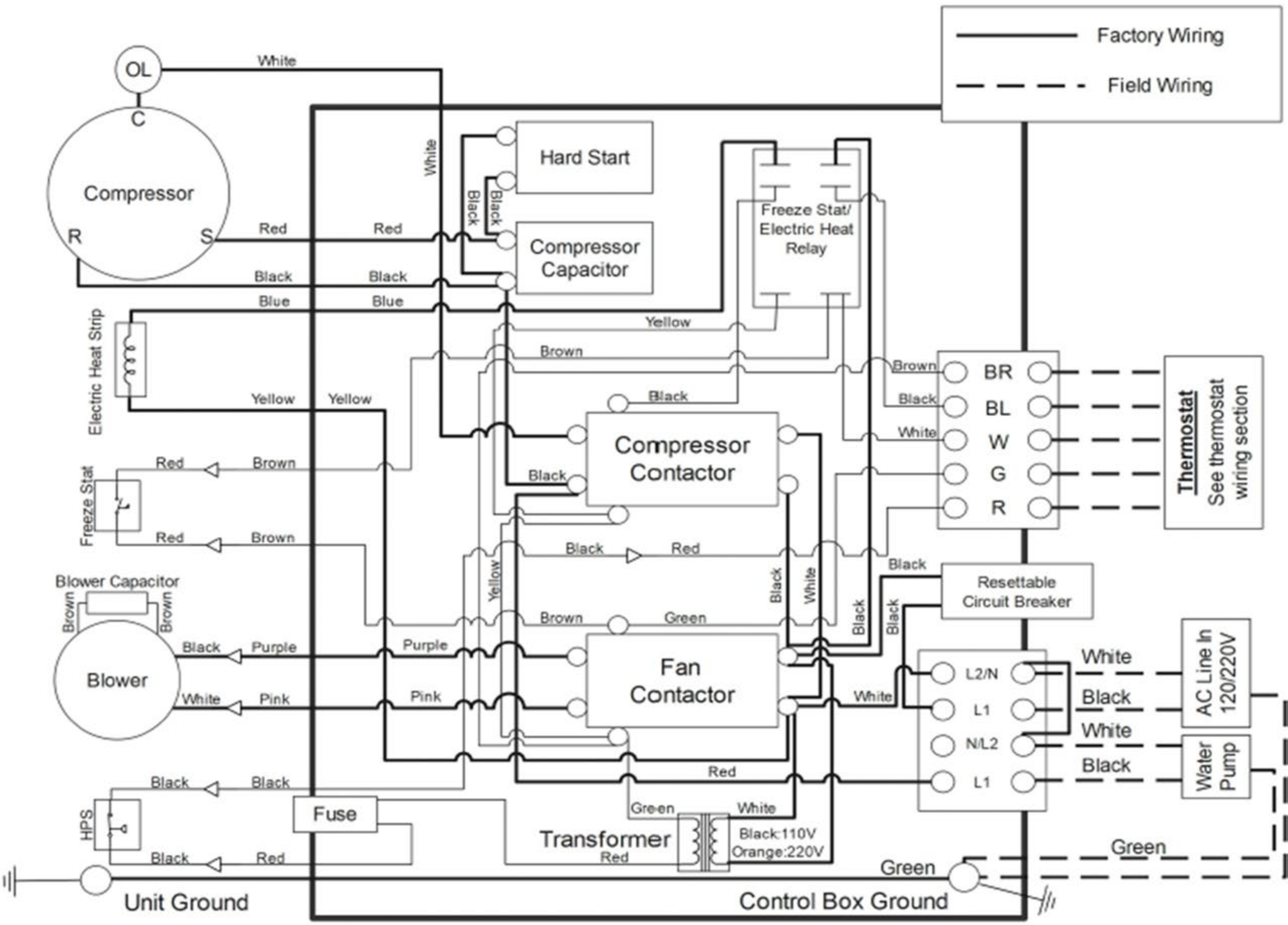
If the unit is not operating in any mode attempt the jumper method described previously to eliminate the thermostat and thermostat wiring as the cause. If the jumpers do not force the unit to operate proceed to turn off the power and remove the lid of the electrical box. Once inside the electrical box you will need to understand the pathways all the wires take in order to find where operation is being prevented. Review the following wiring diagrams for your model. If you have a cool only unit, the reverse cycle wiring diagram is the correct wiring to refer to. The only difference will be the absence of the reversing valve. Full size diagrams are available by request with our technical support team.

Reverse Cycle Wiring Diagram



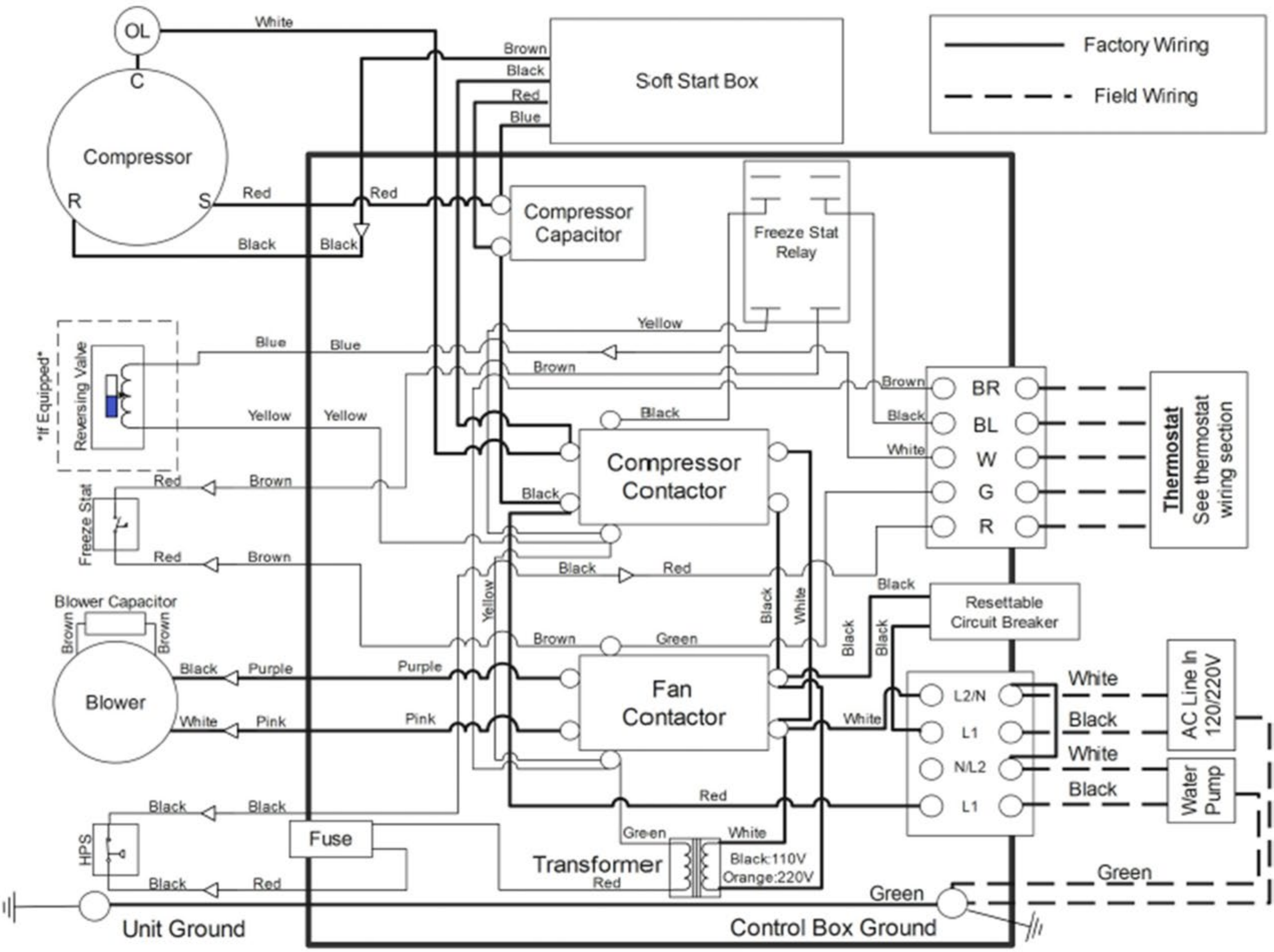
Troubleshooting Scenarios

Electric Heat Wiring Diagram



Troubleshooting Scenarios

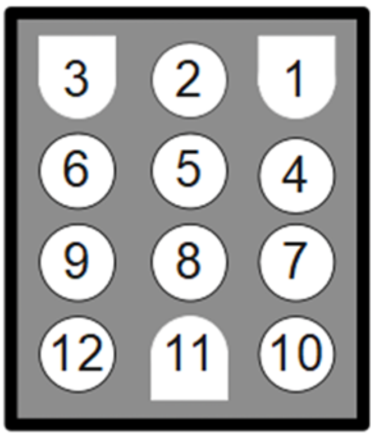
Soft Start Wiring Diagram



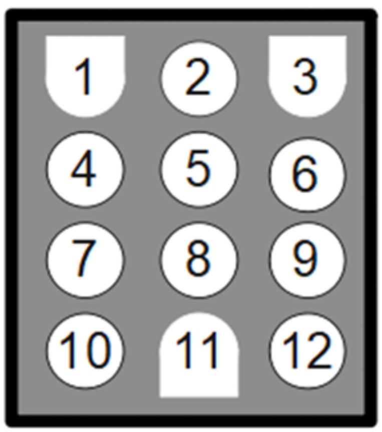
Troubleshooting Scenarios

12 Pin Plug Wiring Harness
Reverse Cycle

Female End
(On Control Box)



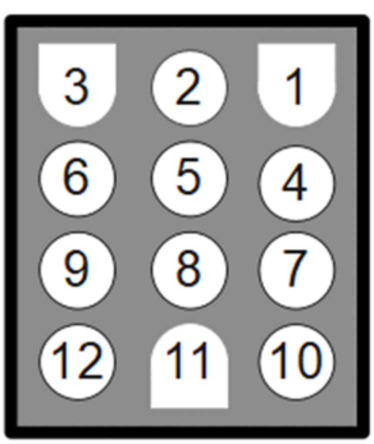
Male End
(Wiring Harness)



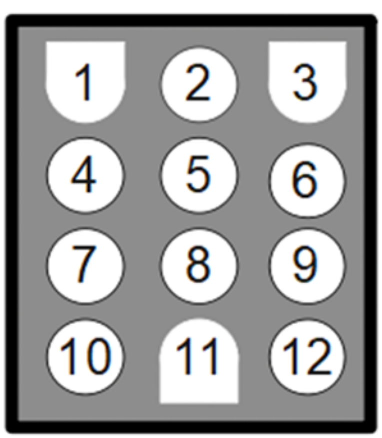
1: Reversing Valve (Yellow Wire)
2: Compressor S (Red Wire)
3: High Pressure Switch (Black Wire)
4: Compressor C (White Wire)
5: Reversing Valve (Blue Wire)
6: Ground (Green Wire)
7: High Pressure Switch (Red Wire)
8: Fan Power (Purple Wire)
9: Fan Neutral (Pink Wire)
10: Freeze Stat (Brown Wire)
11: Compressor R (Black Wire)
12: Freeze Stat (Brown Wire)

12 Pin Plug Wiring Harness
Electric Heat

Female End
(On Control Box)



Male End
(Wiring Harness)



1: Heat Strip (Yellow Wire)
2: Compressor S (Red Wire)
3: High Pressure Switch (Black Wire)
4: Compressor C (White Wire)
5: Heat Strip (Blue Wire)
6: Ground (Green Wire)
7: High Pressure Switch (Red Wire)
8: Fan Power (Purple Wire)
9: Fan Neutral (Pink Wire)
10: Freeze Stat (Brown Wire)
11: Compressor R (Black Wire)
12: Freeze Stat (Brown Wire)

Troubleshooting Scenarios

Once you have familiarized yourself with the wiring diagram for your unit and have reviewed the wiring of the 12-pin plug that connects the control box to the unit, make sure that the 12-pin plug is properly seated and connected to the control box and proceed with the diagnostic. Certain areas of troubleshooting are only possible with a multimeter and will be specified in the instructions. **Never place your multimeter in OHMS or CONTINUITY mode without shutting off the main power and verifying that no power is coming to the electrical box!**

With the electrical box exposed restore main power and place your multimeter in "VAC mode" or "AC Voltage Mode". The first place to check for power is going to be on the power wires going from the terminal strip on the outside of the electrical box to the fan and compressor contactors. There are screw terminals that have black and white wires connected to them on the "power side" of the contactor. The other side of the contactor is called the "load side" and passes power to the component that it operates. Place one lead on the "power side" screw terminal with the black wire(s) and the other lead on the "power side" screw terminal with the white wire(s). You should have 115 or 220 VAC, do not be alarmed if it is not exactly that number but it must read close to the rated voltage. If the multimeter displays 0 VAC and the outside of the control box is reading proper voltage then the inline breaker/fuse may be faulty. If the voltage is correct at the "power side" of the contactor move on and check the transformer.

The transformer high voltage wires are connected to the "power side" of the fan contactor. On the opposite side of the transformer are a RED and GREEN wire of smaller gauge. Those supply 24 VAC to the thermostat so that the rest of the control box can be operated. The RED wire passes into a fuse holder containing a 5 AMP glass fuse. Verify the fuse is intact with the power off. With the power on place one lead of your multimeter in VAC mode on the terminal of the RED wire and place your other lead either directly on the end of the GREEN wire by removing it from its terminal location or on the terminal that the GREEN wire is connected to. Your multimeter should be displaying 24 to 28 VAC. If it is showing 0 VAC then the transformer has failed and needs to be replaced. It can be replaced with a transformer from any HVAC supply store or a replacement can be aquired from the FMS factory. If it is reading 24 to 28 VAC at the RED wire perform the same check on the terminal leaving the fuse holder. If there are 0 VAC the fuse or fuse holder are faulty. If you have 24 to 28 VAC leaving the fuse holder and heading to the 12-pin plug but 0 VAC on the "R" terminal for the thermostat, then the high pressure switch is preventing voltage from passing through.

The high pressure switch interrupts all 24 VAC power coming from the transformer to the thermostat. To test whether it has failed, turn off main power and cut the wires going to the high pressure switch. Wire-nut them together to bypass the high pressure switch for

Troubleshooting Scenarios

diagnostic purposes. It is not recommended to run the unit long without the high pressure switch installed and is only meant to verify if it is faulty. If the bypass restores power and operation to the unit a replacement high pressure switch needs to be installed.

Compressor Comes On, No Fan (Cooling or heating mode):

Attempt the jumper method (”R” and “G” explained previously) activating the fan by itself before diagnosing further. If the jumper does not activate the fan move on to the next step by removing the cover on the electrical box with the main power turned off. Review the previous wiring diagrams to familiarize yourself with the electrical setup.

Because the compressor comes on we can assume several things. The main power is arriving at the electrical box, the breaker/fuse is not tripped, the transformer is working, the high pressure switch is not tripped, and because the jumper did not activate the fan we can rule out the thermostat and its wiring as faulty.

With either the fan jumper installed or the thermostat in “fan on” mode place your multimeter in “VAC mode” or “AC Voltage mode” and restore the main power. Follow the green wire from the “G” terminal to the fan contactor. Place one lead on the green wire from the “G” terminal and one lead on ground. Your meter should read 24 to 28 VAC. If it does not read 24 to 28 VAC then there is an issue with the wire going from “G” to the fan contactor. Replace the wire and test again. If it reads 24 to 28 VAC then place one lead on the terminal with the purple wire on the “load side” of the fan contactor and the other lead on the terminal with the pink wire on the “load side” of the fan contactor. It should read 115 or 220 VAC and if it does not the contactor is faulty and needs to be replaced. If there is proper voltage between the purple and pink terminals move on 12-pin plug as it passes through the box to the unit.

Inspect the 12-pin plug and make sure it is seated all the way with the clips on both sides clicked into place. Make sure no wires appear burnt or pushed out from either side of the plug. Inspect the wiring harness as it heads towards the unit. Check for cuts, slices, burns, etc. that could result in no power getting to the blower mode. If the plug and harness appear fine, move on to the unit itself.

At the unit follow the purple and pink wires to the blower motor. Visually inspect along the way and look for compromises to the wiring. If your multimeter has a “Non Contact Voltage Testing” mode place the meter in that and scan along the wires making sure the power makes it the full way to the blower motor. Turn off the main power and make sure the purple and pink wires are properly connected to the black and white wires of the blower motor.

Troubleshooting Scenarios

If you are able to verify with a multimeter in VAC mode that 115 or 220 VAC are present on the purple and pink wires restore the power and verify the voltage. If the wires have 0 VAC present check the 12 pin plug for proper connection and/or replace the purple and pink wires with the power off. If 115 or 220 VAC is present on the purple and pink wires then the blower motor has a fault (check following two sections) or is stuck. With the power off make sure that the blower wheel spins freely and does not impact anything as it spins. If it does not spin freely or impacts an object as it is spinning, attempt to free the wheel or remove the blockage. If the wheel will not spin freely it may be seized. Contact FMS support for additional steps or a replacement blower motor.

PSC Motor (With Capacitor)

If the motor has a capacitor that looks like a small black box with two wires going to it, ensure the main power is off. Discharge the capacitor by setting a multimeter to "VAC mode" or "AC voltage mode" and placing one lead on each terminal until the multimeter reads 0 volts. Once the capacitor is discharged, remove it and use a multimeter in "microfarad" mode to test if the capacitor is within specification. The capacitance value will be indicated on the side of the capacitor, and the multimeter should read within +/- 5% of that value. For example, if the capacitor is rated at 5 microfarads +/- 5%, it will be in spec if it reads between 4.75 and 5.25 microfarads. If it reads higher than 5.25 or lower than 4.75 microfarads, it is out of spec. If the capacitor is out of spec, replace it and test the fan again. Contact FMS technical support for replacement capacitors or a replacement blower if the capacitor is within spec and the motor will not function.

EC Motor (No Capacitor)

If the motor does not have a capacitor, turn off the main power and check the control wires of the motor. The motor should have two sets of wires. One set is connected to the purple and pink wires. The second set of wires will be multi-colored and either capped off or connected to each other. The red and yellow wires of this second set should be connected together in order for the fan to operate. Cut and reconnect the red and yellow wires together. Restore main power and test the motor again. If it begins operating correctly make a new permanent connection between the yellow and red wires. If the blower does not operate then the blower will need to be replaced. Contact FMS technical support for a replacement blower.

Fan runs but no compressor or pump (cooling or heating mode)

If the unit was previously running and suddenly the compressor and pump shut off while the fan continued to run, the freeze stat may have activated. This component is located on the suction line that is going into the compressor. Its purpose is to prevent the unit from freezing due to airflow problems in cooling mode or water issues in heat mode.

Troubleshooting Scenarios

Wait 5 to 10 minutes for the freeze stat to reset before proceeding. If you would like to bypass it and confirm that the freeze stat has shut down the compressor, remove one lead of the freeze stat that is connected to one of the brown wires going to it from the 12-pin plug. If the compressor and pump begin to operate the freeze stat has either not reset or is faulty. The unit will operate properly without the freeze stat installed for extended periods of time. Be cautious not to run in water that is too cold or preventing the unit from having proper airflow.

Attempt the jumper method ("R", "G", and "BL" explained previously) before diagnosing further. If the jumper does not activate the compressor or pump move on to the next step by removing the cover on the electrical box with the main power turned off. Review the previous wiring diagrams to familiarize yourself with the electrical setup.

Because the fan runs we can assume several things. The main power is arriving at the electrical box, the breaker/fuse is not tripped, the transformer is working, the high pressure switch is not tripped, and because the jumper did not activate the compressor or pump we can rule out the thermostat and its wiring as faulty.

With either the compressor jumper installed or the thermostat in cooling or heating mode place your multimeter in "VAC mode" or "AC voltage mode" and restore main power. Follow the black wire going from the "BL" terminal to the freeze stat relay and the compressor contactor. Place one lead on ground and the other lead on the black wire going to the freeze stat relay. Your meter should read 24 to 28 VAC. If it has 0 VAC the wire is faulty going from "BL" to this point and needs to be replaced. If there is 24 to 28 VAC keep one lead on ground and place the other lead on the black wire leaving the freeze stat relay. You should also have 24 to 28 VAC. If it has 0 VAC, the freeze stat is either activated or the freeze stat relay is faulty. To verify this remove either the yellow or brown wire going to the freeze stat relay and see if the voltage reads correctly. If it reads 24 to 28 VAC, the freeze stat is activated and either needs time to reset or is faulty and needs to be replaced. If it reads 0 VAC with the freeze stat unplugged, the freeze stat relay is faulty and needs to be replaced. If voltage leaving the freeze stat relay is correct, keep one lead on ground and follow the black wire from the freeze stat relay to the compressor contactor and place the other lead on that connection. If the meter reads 0 VAC, then the wire from the freeze stat relay to the compressor contactor is faulty and needs to be replaced. If the meter reads 24 to 28 VAC the contactor must be checked.

To check the compressor contactor verify that there is 115 or 220 VAC present at the "power side" of the contactor by placing one lead on each screw terminal at the "power side" connection. If there is 0 VAC, present the wires from either the terminal block outside the control box or from the fan contactor to the compressor contactor are faulty and need to be checked and replaced. Next check to see if there is power present on the "load side" of the

Troubleshooting Scenarios

contactor going to the pump and compressor. Place one lead on each screw terminal on the "load" side of the contactor. If there is 0 VAC, the contactor is faulty and needs to be replaced. If there is 115 or 220 VAC present, then the wire connections need to be checked and repaired if they are compromised.

Fan and pump are running but no compressor (cooling or heating mode):

Because the fan and pump are running no jumper is needed and we can assume several things. The main power is arriving at the electrical box, the breaker/fuse is not tripped, the transformer is working, the high pressure switch is not tripped, the thermostat is operating correctly, the freeze stat is not tripped, and the compressor contactor is operating correctly.

Before removing the cover to the electrical box turn off the main power and move to the unit itself and check the compressor. Remove the screw holding the black plastic cap on top of the compressor. Underneath will be (3) terminals arranged in a circle and on some compressors there will be a small circular component with a short wire connected to one of the (3) terminals in a circle and a terminal on top of itself that has either a black or white wire connected to it. Check the terminals for compromised wiring and repair as needed. Restore main power and wait for the fan and pump to begin running. There are (3) wires coming from the 12-pin plug to the compressor, a "RED" wire, a "WHITE" wire, and a "BLACK" wire. Place your multimeter in "VAC mode" or "AC voltage mode" and place one lead on the black wire and one lead on the white wire. If there is 0 VAC present the wires from the 12-pin plug are faulty and need to be checked and replaced. If there is 115 or 220 VAC present the compressor windings, overload, and capacitor must be checked.

The first thing to check is the compressor overload. The overload is a temperature and current device that prevents the compressor from operating if it overheats or pulls too much power. The overload may be internal or external to the compressor. If an internal overload is tripped while the compressor is cool, it is faulty and the compressor must be replaced. If the compressor is extremely hot to the touch and the internal overload is tripped the compressor needs to cool down before verifying the operation of the overload. An external overload is a small circular device located underneath the plastic cap of the compressor and is right next to the (3) terminals on top of the compressor. If an external overload is tripped while the compressor is cool it may be faulty. Wait up to 10 minutes for it to reset and if it does you should hear an small audible "click". If it has not reset after 10 minutes with the compressor cool, the overload is faulty and can be replaced without replacing the compressor. If the compressor is extremely hot it may take a little longer for the overload to reset but with the plastic cover off and main power turned off the overload should still reset within 10 minutes. To see if the overload is tripped for an external overload, remove the white or black white wire

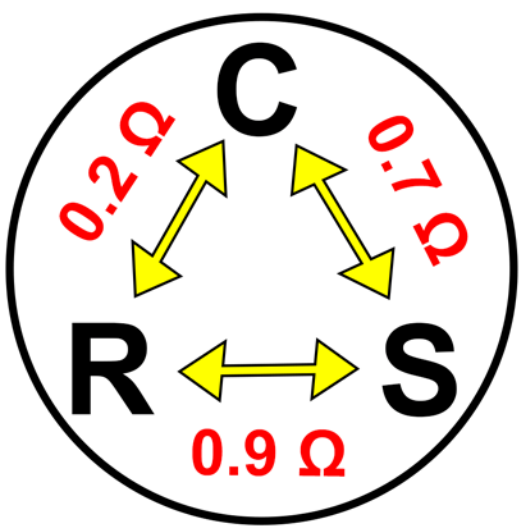
Troubleshooting Scenarios

attached to the top of the overload. Place your multimeter in “OHMS” or “continuity” mode and place one lead on top of the overload and the other lead on the compressor “C” terminal. If there is no continuity “beep” or the meter reads “OL” then the overload is tripped and if deemed faulty will need to be replaced. If the multimeter “beeps” or displays 0 OHMS then go to the next sections for testing the compressor terminals and capacitor. To see if an overload is tripped for an internal overload, remove the “BLACK”, “RED”, and “WHITE” wires connected to the “R”,”S”, and “C” terminals. Take note of what color goes to what terminal, it is a good idea to take a picture of the wires before removing them. Place your multimeter in “OHMS” or “continuity” mode and place one lead on the compressor “C” terminal and one on the compressor “R” terminal. If the multimeter reads “OL” then the internal overload is tripped and if deemed faulty will need to be replaced. If the multimeter reads any number, go to the next sections for testing the compressor terminals and capacitor.

Testing the compressor terminals will verify the resistance values between the windings of the compressor motor. Every electric motor has a designed amount of resistance when it is built to determine how it will operate. With a multimeter set to “OHMS” or “resistance mode” each terminal needs to be tested in regards to the others. “Continuity” mode is not recommended for this step unless your meter combines “OHMS” and “continuity” under the same mode. The value between “R” and “C” will be the lowest, the value between “S” and “C” will be in the middle, and the value between “R” and “S” will be the highest. The highest value will also be the sum of the previous two values. See the example diagram below:

R to C= 0.2 Ω
S to C= 0.7 Ω
R to S= 0.9 Ω

0.2 + 0.7= 0.9 Ω



Note:
This is an example ONLY, your compressor values will be different

Tripped Overload:

In the example above, if the overload is tripped the value between “R” and “S” will be 0.9 Ω as it is with the overload not tripped. The values betweeen both “R” and “C” as well as “S” and “C” will both display “OL” on a multimeter. When an overload trips, it severs the connection between the “C” terminal from both of the other terminals

Troubleshooting Scenarios

All values measured by the multimeter should be lower than 3 Ω typically, even for the highest value. If any combination of terminals reads higher than that the compressor may be deemed faulty and need to be replaced. If any combination of two terminals reads "OL" but the other two combinations show a number, then one of the windings has failed and the compressor will need to be replaced. If any value reads 0 Ω, that indicates a short and will typically trip the breaker/fuse at the control box or main electrical panel, the compressor will be deemed faulty and need to be replaced. A reading should also be taken from each of the compressor terminals to the ground screw located on the air conditioner base or control box. For each terminal the multimeter should read "OL", and if it reads any number (E.G. 14.5K Ω or 0 Ω) the compressor has a ground fault short and will need to be replaced. After the terminals are tested replace the wires to their respective positions.

Warning

Before proceeding make sure the main power has been switched off and you are comfortable and confident in your abilities to test a capacitor. If you are not comfortable or confident in your abilities please contact FMMS technical support for assistance or a certified repair technician! Improper handling can result in an electrical shock that can cause injury or death!

Testing the compressor capacitor requires the main power to be off and the electrical box lid to be removed. Capacitors take many shapes and sizes, but the most common two versions will be as follows: 1.) a silver cylinder with two groups of terminals on one end, 2.) a black plastic cylinder with one group of terminals on each end of the long side. Capacitors are like a battery and are how a camera flash and a taser both are able to charge and rapidly discharge to match their function. On a compressor the capacitor is essential for operation and efficiency. Put simply the capacitor gives the compressor motor both torque and direction to spin. If the capacitor has failed the compressor often will not operate at all and will just hum and cycle the overload on and off. Capacitors will rarely explode, but it is not out of the question when it comes to failure. If a capacitor has exploded and failed in a dramatic way, it will dump immersion oil out of the main body and potentially have some melted grey material that looks like metallic mashed potatoes that is protruding from the rupture point (speaking from 8 years of field experience, I only ever encountered this once, and I took it home and put it on a shelf to display it). **The oil in a capacitor is slightly toxic and skin contact should be avoided. Any oil should immediately be washed off.** The most common ways for a capacitor to fail are overheating and degradation. If a capacitor overheats, pressure will build up internally and the ends will go from flat to a more concave shape and bubble out. This is by design, as there are two very fragile wires going from the terminals to the capacitor internals, and when the body bubbles out, the wires will break which prevents any further electrical activity. If a capacitor degrades, it will do so over a period of time, and the degradation will speed up the

Troubleshooting Scenarios

more that the capacitor degrades. Degradation can be caused by a failing motor, heat stress that is not considered overheating, rapid motor cycling (on and off quickly), power surges, lightning strikes in a local area, dirty power (low voltage or extreme voltage), etc. Typically degradation can be caught before a catastrophic failure, but not always. This is why when an air conditioner is serviced, the capacitor should be checked if possible to avoid a future unwelcome repair. There is no expiration date on a capacitor, and they can remain in operation for as long as they test correctly and don't appear to be at risk from failure (bad rusting or dented being common reasons for a working capacitor to be replaced).

The capacitor must first be discharged before any work is performed to it! Capacitors can hold a large amount of charge and are able to discharge very rapidly! To properly discharge a capacitor, place a multimeter in "VAC" mode and place one lead on each group of terminals at the one end of the capacitor. If your meter reads 115 or 220 VAC the box is live and power has not been turned off! As the capacitor discharges the meter will slowly begin to read lower and lower values until it reads 0 VAC. At this time remove the leads and then re-apply them to the capacitor. If the meter shows 0 VAC the capacitor is safe to handle. If the meter shows any value above 0 VAC it may still be holding a small amount of charge. Continue to hold the leads of the multimeter on the capacitor until it reads 0 VAC and repeat the removal and re-application of the leads until the capacitor is consistently reading 0 VAC. Though many consider using a screwdriver or other tool as a "hack" or "pro-tip", it is not recommended to short out the two terminals to each other. The capacitor could arc and burn you or shock you, especially if the tool you are using is not properly insulated to protect you, and if the capacitor is fully charged it sometimes sounds like a gunshot with no hearing protection.

Once the capacitor is properly discharged remove any wires attached to the two groups of terminals. It is recommended to take a picture to make sure the wires return to their proper place before disconnecting the capacitor from the circuit. Once all the wires are removed, place the multimeter into "MICROFARAD" or "μF" mode and place one lead on each group of terminals on the capacitor. The meter should be showing a value (E.G. 44.6 μF or 51.2 μF) and this value should be within +/- 5% of the rating on the side of the capacitor (E.G. a 50 μF capacitor can read 47.5 μF to 52.5 μF and still be considered good). If the multimeter displays 0 μF, an "OL", or a value outside the 5% range of the capacitor, the the capacitor is faulty and needs to be replaced. It must be replaced with an identically rated capacitor in order for the compressor to function properly. Installing a different size capacitor can cause the compressor to fail prematurely and will void the warranty. Once the capacitor has been tested or the replacement has been installed, reconnect the wires to the positions they were removed from.

If the compressor does not operate, contact FMS technical support for assistance.

Troubleshooting Scenarios

Fan and compressor operate but no pump (cooling or heating mode):

Because the fan and compressor are running no jumper is needed and we can assume several things. The main power is arriving at the electrical box, the breaker/fuse is not tripped, the transformer is working, the high pressure switch is not tripped, the thermostat is operating correctly, the freeze stat is not tripped, and the compressor contactor is operating correctly.

Before any electrical diagnostic is performed, inspection of the pump and water piping components should be performed first. Check all ball valves or shutoffs and make sure they are in the “open” position. Check the pump strainer for a blockage and ensure there is water in the strainer basket for the pump to operate with. Make sure the pump has not lost its prime and become air locked. Attempt to prime the pump or bleed it using a bleed off valve. If the water connections and piping checks out move on to electrical troubleshooting.

The first thing to check is the pump wiring at the electrical box. Make sure the wiring is intact and connected properly. If not perform repairs with the main power turned off and try to run the unit again. If the wiring is good take a multimeter and place it in VAC mode. Put one lead on the “PUMP BLACK” terminal and the other lead on the “PUMP NEUTRAL” terminal. If the meter reads 0 VAC the main power needs to be turned off and the cover removed. The wiring going from the compressor contactor “load side” to the pump terminals needs to be inspected and repaired. If the meter reads 115 or 220 VAC then the pump has either mechanically or electrically failed and needs to be replaced.

Because cooling water is not flowing while the troubleshooting is performed the air conditioner may go out on high pressure or freeze protection depending on the mode it is in and the conditions of the environment. If you have the ability to run a hose to the water piping, you can flow water through the air conditioner indefinitely while you assess the pump. Allow the unit several minutes between attempts to troubleshoot the pump not working properly.

A common reason for cooling water to stop flowing or the pump to struggle is the water pickup under the boat becoming packed with barnacles, seaweed, or other debris (even jellyfish). If you have the ability to check and clean the water pickup, it is recommended to do so before attempting more in-depth troubleshooting.

Another common reason for cooling water to stop flowing is the pump losing its prime after the air conditioner shuts off or from the boat being moved. There are several ways to mitigate this issue: one solution is to put a check valve behind the pump to prevent water from flowing backwards out of the system, and another solution is to install a pump priming chamber like the one from March Pumps (contact FMS to order one).

Troubleshooting Scenarios

Cooling mode works but heating mode does not (reverse cycle):

Because the cooling mode is working we can assume several things. The main power is arriving at the electrical box, the breaker/fuse is not tripped, the transformer is working, the high pressure switch is not tripped, the thermostat is operating correctly, the freeze stat is not tripped, and the compressor contactor is operating correctly. Try the jumper method described previously for heat mode. If the jumper method makes heat operate the issue is the thermostat wiring or programming. Refer to the thermostat wiring and programming section for more information.

To electrically troubleshoot electric heat on a reverse cycle unit there is only one component in the circuit and that is the reversing valve coil. The circuit begins at the “W” terminal of the control box and goes straight to the 12-pin plug blue and yellow wires to the reversing valve coil. Follow the blue and yellow wires to the reversing valve coil from the 12-pin plug. Make sure the wires did not get knocked off the reversing valve coil during installation or from vibrations. Turn off the unit at the thermostat and place a jumper between “R” and “W” at the electrical box. Remove the blue and yellow wires from the reversing valve coil and place your multimeter in “VAC” mode. Place one lead on the blue wire and one on the yellow wire. If the meter reads 0 VAC then the thermostat or jumper is not allowing power to pass through the “W” terminal to the reversing valve coil. Turn off the main power, remove the electrical box cover, and inspect the wiring from “W” to the reversing valve coil and back to the electrical box. Perform repairs as needed and restore power to test again. If the meter reads 24 to 28 VAC the reversing valve coil may be faulty. Turn off main power and place multimeter in “OHMS” mode. Put one lead on each side of the reversing valve coil and measure the resistance. If the meter reads “OL” then the reversing valve coil is faulty and needs to be replaced. If the reading is a number (E.G. 14.7K Ω) then the coil is intact. If the coil is intact and it is receiving 24 to 28 VAC then the reversing valve may be faulty and needs to be replaced or it could be stuck. Turn the unit on at the thermostat and put it in heat mode with the reversing valve coil connected and installed on the reversing valve, then tap on the reversing valve body lightly with a hammer or other tool and listen for an audible “hiss” as the reversing valve operates. If the reversing valve coil is intact and the reversing valve does not seem to respond it will either need to be replaced or there is a refrigerant issue in the system. Contact FMS technical support for assistance.

Cooling mode works but heating mode does not (electric heat):

Because the cooling mode is working we can assume several things. The main power is arriving at the electrical box, the breaker/fuse is not tripped, the transformer is working, the high pressure switch is not tripped, the thermostat is operating correctly, the freeze stat is not tripped, and the compressor contactor is operating correctly. For electric heat if a jumper is

Troubleshooting Scenarios

tested, the “R” must be jumpered to both “G” and “W” otherwise the electric heat strip could burn up without the blower running. If the jumper method makes heat operate the issue is the thermostat wiring or programming. Refer to the thermostat wiring and programming section for more information.

To electrically troubleshoot electric heat units, the same steps must be followed as the previous section about troubleshooting the reverse cycle heat. The difference is the “W” terminal will operate the electric heat relay which sends 115 VAC through the blue and yellow wires to the electric heat strip. Using a multimeter verify that the electric heat relay is receiving 24 to 28 VAC from the jumper or thermostat and that 115 VAC is being sent out the yellow and blue wires to the 12-pin plug. With the power off the electric heat strip can be tested for resistance in the OHMS mode and if it reads “OL” the electric heat strip has failed or the fuse has blown on the heat strip. Contact FMS technical support for assistance.

Unit is operating but no water out (cooling or heating mode):

See previous section on unit running but no pump operation

Condensation pan is overflowing:

While the air conditioner is running in cooling mode, condensation will form on the evaporator coils and drip down into the drain pan. The drain pan of the unit will be connected to a hose and run off to a drain, the bilge, or a device such as our Condensator Kit, which is a venturi that siphons the water out of the drain pan and discharges it along side the seawater flowing from the air conditioner and outside the boat.

Some of the reasons the pan may be overflowing are: the drain nipple is plugged with debris, the drain hose is blocked or kinked, or the unit is tilted away from the drain and cannot drain properly. Fix or clear the hose and correct the tilt if needed.

The drain pan over time will buildup biological growth due to the environment being created by the cold condensate water. Drain pan tablets or regular flushing can remove or prevent a majority of this buildup to prevent the drain from plugging.

If using a FMS Condensator Kit check strainer for debris, hose for kinks or blockages, and dissasemble the Condensator Kit body and clean the orifice located inside as needed. If the Condensator Kit is newly installed and not working, check to make sure the orientation of the Condensator Kit is correct. It is a directional device and will not create a suction on the drain pan if installed backwards. Contact FMS technical support for assistance.

Troubleshooting Scenarios

Evaporator is freezing:

Every FMS unit is now equipped with a freeze stat to prevent evaporator freezing, however this is not meant to be a fix for freezing. If an evaporator is freezing there is a problem that needs to be addressed or the unit is being run in non-ideal conditions. Freezing can occur in both heating and cooling mode on the reverse cycle units.

If the evaporator is freezing it is usually an airflow problem. Make sure supply air vents are open and the correct size ductwork and number of vents are being used. Open vents and add additional ones as needed. If the fan is having issues like running too slowly or not running at all the evaporator will freeze due to reduced air flow. Make sure the filter is clean and the return air is not obstructed in any way.

One reason for freezing is one of the vents is pointed towards the return air or crosses over the air entering the return grill. If the unit is blowing its own cold air back into itself the air will get colder and colder until the unit has no choice but to freeze. This can happen over the course of a couple minutes to a few hours depending on how much air is being sent back into the return grill (this same scenario will also lead to a unit overheating in heat mode).

In the cooling mode it is not recommended to go below 70 degrees F on the thermostat. The lower the air temperature the colder the refrigerant has to be for the unit to continue removing heat. At 70 degrees F air temperature the evaporator is at roughly 40 degrees F to remove sufficient heat and humidity from the air. The water temperature also has an effect on the air conditioner in cooling mode. If the water temperature is 50 to 60 degrees F that will cause the air conditioner refrigerant to run much colder than at 70 to 80 degrees F. If you are in cooling mode at 70 degrees F on the boat and 55 degrees F water, a small amount of frost formation on the unit is normal. At any time a block of ice or the whole unit covered in ice is not normal.

In heating mode the freezing effect will be focused on the water flow. If the pump fails or the water flow slows or stops for any reason the water coil can very rapidly freeze and crack causing unit failure. The freeze stat is installed to prevent this from happening, but it is still not recommended to run the heat mode in water below 45 degrees F and the danger zone begins at 40 to 42 degrees F water.

Outside of air or water temperature, and waterflow or airflow, the only other reason a unit should be freezing is a refrigerant problem. Under normal circumstances the evaporator of an FMS air conditioner runs at 110-130 PSI or 35 to 45 degrees based on water and air temperatures. Once the pressure drops below 100 PSI the evaporator will begin to operate below 32 degrees F, which will lead to frost and ice formation. If the unit low side pressure is

Troubleshooting Scenarios

below the recommended PSI, then the unit needs to be recharged with more refrigerant to bring it back withing spec. If the unit loses pressure again in a short time period, or is visibly losing pressure while being recharged, there is a leak that needs to be found and repaired. Possible leak points include: brazed joints, reversing valve, txv (if equipped), ruptured water coil, ruptured evaporator coil, high pressure switch, and compressor body and joints. Leak detection bubbles or an electronic leak detector are the best methods to locate a leak. Contact FMS technical support for assistance if needed.

High pressure switch activates (cooling mode):

When the high pressure switch activates the entire unit will stop operating.* The fan, compressor, and pump will be turned off while the unit resets. Once the high pressure switch resets the thermostat should go into a brief delay mode to prevent short cycling the compressor. This can take up to 10 minutes to reset the cycle. The high pressure switch is automatically resetting but it should not be ignored.

*On previous models of Mermaid MFG. and FMS units, there was a manual reset high pressure switch. Before 2023, only the compressor and pump would cease to function when the high pressure switch activated. In 2023 the operation was changed to shut the whole unit down when the high pressure switch activated. Once it is reset, the unit should begin normal operation again.

In cooling mode if the high pressure switch is activating there is typically a water issue. The pump may have failed, the strainer plugged, the thru hull may have debris, etc. There are many reasons for the water flow to slow or stop. If the water flow is not adequate enough the unit will cycle on high pressure every time it runs which can cause damage to the air conditioner over an extended period of time. Check the pump and water circuit and maintain on a regular basis to keep water flow steady for the air conditioner.

If the water flow is strong and the unit is still going out on high pressure there may be build up and debris in the water coil which prevents the heat from being transferred from the refrigerant to the water. Periodically the water circuit and water coil need to be washed out and cleaned. The best way to do this is a mixture of “Actibrite” and water in a bucket with a pump that you attach to the inlet side of the water loop or air conditioner and the flow leaves the water loop and air conditioner back into the bucket. Let this cycle for up to an hour to remove all the buildup and debris that has become lodged in the water coil. Do not let chemicals sit inside the water coil as they may damage the materials over time and create weak points. Once the flush has been completed rinse the circuit with water to clean out any chemical residue. (See the “Maintenance” section for more information).

Troubleshooting Scenarios

High pressure switch activates (heating mode):

Same as the cooling mode, if the high pressure switch activates in the heating mode the fan, compressor, and pump will all shut off and allow the unit to reset.* This can take up to 10 minutes before the unit will begin operating again.

*On previous models of Mermaid MFG. and FMS units, there was a manual reset high pressure switch. Before 2023, only the compressor and pump would cease to function when the high pressure switch activated. In 2023 when the company changed ownership and name, the operation was changed to shut the whole unit down when the high pressure switch activated. Once it was reset the unit would begin operation again (a 5 minute delay should have been triggered on the thermostat when the reset button was pushed before the unit will operate).

In heat mode the unit is relying on airflow to prevent high pressure from occurring. If the filter is dirty, the ductwork is too small, there are too few vents, the blower is not working properly, etc. the unit will go off on high pressure. It is not recommended to run the heat mode when the air temperature is 80 degrees F or above and the water temperature should be lower than 80 degrees F down to 45 degrees F as a safe zone. Below 40 degrees F water is a danger zone for freezing. If the unit is ran in water that is too hot or the air is too hot the high pressure switch will activate quickly to prevent the unit from operating. Take note that an airflow problem may not present itself right away. Many systems can run with improper airflow for several hours before an issue will present itself. Please contact FMS technical support for more assistance.

Compressor, fan, and pump operate but no cooling/heating:

Because the compressor, fan, and pump are running no jumper is needed and we can assume several things. The main power is arriving at the electrical box, the breaker/fuse is not tripped, the transformer is working, the high pressure switch is not tripped, the thermostat is operating correctly, the freeze stat is not tripped, and the compressor contactor is operating correctly.

Typically in a scenario like this, the unit is having a refrigerant problem. There are several refrigerant problems a unit can be experiencing, and they will be explained in depth in the next few paragraphs. For units in warranty, any repairs need to be made at the FMS facility. If the unit is out of warranty, repairs can be made by any qualified technician. If a technician is not available or you would prefer, repairs can always be made at the FMS facility for the life of the unit. Any unit built before 2023 and into 2023 will be using an R22 replacement refrigerant such as RS-44B. Units manufactured in 2023 could be R22 replacement or an R410A. All units built in 2024 contain R410A refrigerant. R410A will be used in the following examples.

Troubleshooting Scenarios

Low refrigerant:
Low refrigerant is the most common refrigerant issue for almost all refrigeration systems ever made. Low refrigerant can happen suddenly or over time.

Sudden low refrigerant issues happen when a major component fails and allows all the refrigerant to leak within a few seconds to a few hours. The compressor blows out an electrical terminal, the water coil bursts and dumps all the refrigerant in the cooling water, a pipe breaks, and an evaporator coil pipe bursting are all examples of sudden refrigerant loss. In these and other situations, the unit will immediately cease to cool or heat even though all the components are running. If you are in the area to witness the refrigerant loss, you will see cloud that looks like white smoke or fog that has a distinct and almost sweet smelling odor. Shut down all power to the unit and use a fan to dissipate the refrigerant vapors. Refrigerant is not toxic, however it is not recommended to be in an enclosed space with a large amount of released gas. It is heavier than oxygen and displaces it, which could result in asphyxiation.

Low refrigerant that happens over time could take weeks, months, or years depending on the severity. Schrader ports, where a technician hooks up their gauges, is a common leak point especially when the refrigerant caps are not installed after servicing. They leak incredibly slowly and can usually only be detected with an electronic leak detector or refrigerant leak detection bubble solutions. This is an extremely easy issue to solve, as the schrader cores can be replaced with a core removal tool or a proper cap can be installed that contains a gasket to prevent leaking over time. Leaks in the refrigerant piping or components can be very tricky to diagnose. Some leaks only show up when a system is under vacuum and some only show up when the unit has very high pressure. Using an electronic leak detector, vacuum pump, nitrogen, and small amounts of refrigerant, a technician can perform a leak search and then perform repairs after the leak is found. Worn out areas of stress such as: the compressor discharge, the condenser, and evaporator can all be hard to discover leak points as they undergo a small amount of thermal expansion or contraction and the leak may not appear unless the right conditions are met. Areas of that undergo lots of vibration such as: the compressor discharge and suction pipes, high pressure switch, and reversing valve can form small leaks as the mechanical stresses take their toll. All of these “over time” refrigerant leaks should be easier to locate, since they leave behind oil residue. Like an engine the compressor needs oil to stay lubricated and live a long life, and when the refrigerant leaks out the oil comes with it. Since the oil is heavier it sticks around the spot the leak formed. Feeling around the refrigerant piping can often lead close to the source of a leak using the oil residue.

If a leak is discovered that needs to be repaired (other than a schrader core or replacement of a screw-on high pressure switch), then the system must be recovered and evacuated properly, then repaired and recharged all by a qualified technician.

Troubleshooting Scenarios

Low refrigerant is usually noticed when a unit begins to have trouble keeping up with the cooling or heating demand and then the unit can begin to freeze up while it is running. When an air conditioner is running normally the pressure in the evaporator (R410A) is between 115 and 130 PSI keeping the evaporator temperature around 40 degrees F. Temperature and pressure are directly related in a refrigeration system, so as the refrigerant leaks out the pressure begins to drop, and as soon as the pressure gets lower than 100 psi freezing begins to occur.

There are several situations where a unit can act like it is low on refrigerant when it is actually fully charged. The first is immediately at startup, if you have gauges hooked up to the unit you will see the pressures stay much lower than normal for about 5 to 10 minutes depending on the ambient conditions. A little bit of frost can form right at the metering device (orifice, cap tube, txv, etc.) during this time, but it will dissipate as the system continues to run. Once the unit has reached its equilibrium the pressures will return to normal levels. The second situation is low airflow. If the filter is plugged, ductwork is kinked, blower is weak or failing, vents are closed, and so on, the unit evaporator pressure will begin to drop as the airflow gets reduced. The airflow is what keeps the pressure in the evaporator high as the refrigerant cools and dehumidifies it. As the air slows down, it cools and loses its humidity much more rapidly which causes low load or no load on the evaporator and the refrigerant has no choice but to cool itself and in return brings the evaporator below freezing conditions. The third situation is feeding the supply air directly or accidently into the return air. If the air that already passed through the unit passes through it again before being mixed with the other air in the conditioned space, the same effect as low airflow takes place, but usually at a slower rate. The air already got cold and lost a majority of its humidity, so as it passes through the air conditioner again there is no choice but to get colder and lose more humidity. This cycle continues until the unit freezes up or the thermostat shuts the unit down. In this scenario it is unlikely that the thermostat knows what is happening, as it is usually in a different location, and the unit is instructed to keep running.

Compressor is not compressing:

This is a very straightforward refrigerant issue to identify. With gauges attached there will be no change in the pressures between the high side and the low side, or there will be a very slight change. In a R410A air conditioning system the high side is usually 3-4x the pressure on the low side depending on ambient conditions. E.g. if the pressures are 125 PSI low and 350 psi high, then the compressor is working. E.g. if the pressures are 205 PSI low and 225 PSI high, then the compressor is probably not doing anything and the heat being generated by the compressor motor is pushing a little refrigerant in the high side. Along with the pressures remaining steady, the amp draw of the compressor will be extremely low. E.g. the compressor RLA is 10 but you are getting a reading of 2.5 amps, then the compressor is probably not doing a lot of work. In this diagnosis, the compressor will almost always have to be replaced.

Troubleshooting Scenarios

Restriction:
The last refrigerat issue that will be discussed is a restriction. Restrictions are relatively easy to confirm visually or with gauges. With gauges you can see the low side head towards or into a vacuum, and visually you can often see ice formation right where the restriction is located. If its on a cap tube or fixed orfice, part of it will be clear and then the rest of it will be covered in ice or frost depending on the severity. Restrictions are the result of a blockage by a buildup of debris or mechanical failure (like a pipe getting bent and kinked). Restrictions caused by debris can happen almost anywhere in a system, but most of the time gravitate toward areas of very small passageways. The metering device is often the area of the smallest passageways in a refrigeration system, since this is where liquid refrigerant will begin the transition into a lower pressure environment and convert to a gas. Many metering devices, such as txv's, contain a filter screen to catch debris so it doesn't cause a catastrophic failure in the compressor. Once a system has been recovered and evacuated of all refrigerant, the filter screen can be cleaned or replaced. Some metering devices have flare nuts that unscrew for easy access and others have to be completely removed and replaced with a brazing torch.

If there is a refrigerant issue that was not covered in this section, please contact the FMS technical support for assistance.

Breaker tripping intermittently:

Breakers tripping are a sign that something is not functioning correctly. Breakers for an air conditioner are sized so that they can handle the amperage at startup, which is typically 5 to 6 times the amperage while the unit is running (e.g. the running amps of an AC are 10 amps, the startup amperage could be as high as 50 to 60 amps). Breakers can handle higher current than their rating for up to a few seconds before tripping, but they will trip instantly if there is a ground fault or major short. For FMS AC units the recommended breaker size is 25 amps minimum and 30 amps maximum. There are multiple reasons a breaker will trip and as many as possible will be exlained in the following sections. If your situation is not covered in these sections, please contact FMS technical support.

Ground Fault/Major Short:
Any of the wires going into the box that carry high voltage can cause a ground fault or short. In a 120V system the black wire is the high voltage wire, and in a 220V system the black and white wires both carry high voltage. To locate a ground fault or short, the first step is to turn off the main breaker and perform a visual inspection of the wiring. Check the wires between the control box and breaker and the wire connections on the outside of the control box. If any wires are burnt, melted, or show signs of wear, they need to be repaired or replaced. Once the main power wires are inspected, open the control box to inspect the wiring inside. The main power

Troubleshooting Scenarios

through the fuse/breaker and will be routed through the box to the components on the unit itself. If the control box has a motherboard, look for burn marks, scorched areas, melted or broken wires, and other damage on or around the motherboard. If the control box is mechanical, look for burned or scorched areas close to the contactors/relays, melted or broken wires, melted contactor coils or transformer windings, and other damage around the major components. If no damage is found in the control box, unplug the 12- pin plug and inspect both ends. Look for brown pins, burned wires, rust, corrosion, etc. Move on to the unit and inspect all the wiring along the harness to each of the individual components. Look for melted or broken wires leading to the compressor, blower, reversing valve (if installed), electric heater (if installed), high pressure switch, and freeze stat. If any are damaged, repair or replace them. Remove the cap on top of the compressor and inspect the wiring going to the three compressor terminals and overload (if equipped). If any wires are damaged in any way, repair or replace. If nothing stands out visually, then a multimeter will be required to test each component. Place a multimeter in “Ohms” or “Continuity” mode and make sure all wires are secured properly to their components. Take the wiring harness with the 12 pin plug that goes from the unit to the control box. Place one lead on the ground wire pin (only green wire in the 12 pin plug) and one lead on the metal base of the air conditioner. Make sure it reads 0Ω or makes an audible tone. If it does not read 0Ω or make an audible tone, move the lead to a different place on the metal base of the air conditioner until the meter reads 0Ω or makes an audible tone. This step is to confirm that the ground is connected properly. At the 12 pin plug, keep one lead on the ground wire pin and place the other lead on every other pin, one at a time, to test for a ground fault or short. Each pin should take about 10 seconds to test since some meters take a few seconds to get a good reading. The meter should read “OL” on each pin under normal circumstances. If there is a ground fault or short the meter will display a number or 0Ω. It does not matter what number (e.g. 50KΩ or 10Ω) that the meter displays, they all mean that there is a path for electricity to pass through to the ground and make the breaker trip. Use the wiring diagram or trace the wire that displays a number to figure out which component has the ground fault and repair or replace it. Contact FMS for parts.

<u>High amperage:</u>

There are two ways high amperage can be an issue, one is higher amperage for a long duration and one is very high amperage for a short duration. As stated earlier, breakers can handle higher than their rating for a short time, the number stamped on them is what they can handle without ever tripping. If the amperage is only slightly higher than the rating on the breaker, it will allow the power to flow according to an “tripping curve” determined by the manufacturer that ranges from fractions of a second to sometimes hours that it can sustain the load. E.g. certain brands have tripping curves published that show some breakers can handle two times the rated current for 10 seconds before it trips the circuit (a 20 amp can handle 40 amps for 10 seconds).

Troubleshooting Scenarios

Under normal circumstances the only component that can draw high current is the compressor. The pump and fan are usually only 2 or 3 amps of the full system amp draw and the compressor will make up the remaining. Compressor high current can come from several sources: 1.) failed capacitor, which causes the compressor to draw its startup current for several seconds until the breaker trips or the internal overload on the compressor trips, 2.) overcharged with refrigerant or very high head pressure caused by a dirty condenser that leads the compressor to work significantly harder than it should, 3.) locked up compressor which will draw the startup current until the breaker trips or until the internal overload on the compressor trips, 4.) compressor overheating and cycling on its overload (the hotter the compressor, the more amps it will be drawing), 5.) dirty power from the source (low voltage supply, faulty wiring, generator not producing the correct 60 Hz, etc.), 6.) undersized wire or burnt/pitted contact points in the electical system, and 7.) failing compressor. It is important to discover the reason for the high current, and not immediately shoot for the highest repair such as swapping the compressor. It is very likely in many of these situations that a brand new compressor will not solve the problem, and instead incurs extra cost and time. Many of the reasons for high current can be explored deeper in previous sections about troubleshooting different scenarios. Contact FMS technical support for additional assistance.

Weak/failing breaker:

A breaker that is wearing out or already at the end of life is very challenging to confirm without accidentally condemning another component such as the compressor. The simplest way to discover if the breaker is weak or failing is to use a multimeter with an amp clamp either built in or as a separate plug in sensor. This will allow you to get a representation of the current amp draw of the air conditioner. Some multimeters have live amp draw values and others have the additional feature of “inrush current” measuring. Measuring “inrush current” is very important when trying to diagnose issues when the unit turns on and the breaker trips without allowing the unit to begin operating. For example, the FMS M16 draws up to 55 amps at startup and should be on a 25 or 30 amp breaker. If the inrush current is less than 55 amps, there is no reason that a 25 or 30 amp breaker should trip when the unit turns on. If the inrush current spikes to 60 amps and beyond, there could be an underlying issue that needs to be addressed. If the unit brand new and the breaker is tripping immediately along with higher than 55 amps, there is a possibility of voltage drop due to other factors that needs to be addressed before the unit will run correctly, and if there is a voltage drop the breaker is most likely not failing or weak. If the amps spike very high, such as 100 amps or more, there is most likely a short or ground fault that needs to be discovered (this issue is covered in a previous section). If the breaker is tripping while the unit is running, use the amp clamp to measure the current draw of the unit after resetting the breaker and letting the unit restart. If the current of the unit is less than the rating on the breaker, then there is something wrong and it should be replaced.

Troubleshooting Scenarios

GFCI shore power and outlets:

Many marinas and boats are being retrofitted or newly built with GFCI as standard on the pedestals for shore power, the generators, and the outlets in the boat. These devices have added additional safety to boat electrical systems. There have been some reported issues with all brands of marine air conditioners, and mostly centered around inverter based systems. GFCI circuits are very sensitive to leakage current caused by AC to DC inverters, transformers, capacitor run motors, etc. and this can pose issues for air conditioner operations. If your GFCI trips when the air conditioner starts running or when it turns off, the best thing to try is a difference GFCI source. Some will trip for seemingly no reason at all and then others will work fine. FMS air conditioners have been tested onsite connected to GFCI devices and do not have any problems with tripping them. Contact FMS technical support if you are experiencing problems with a GFCI tripping.

System Maintenance

Airflow Maintenance:

The air conditioner is equipped with an air filter on the front of the evaporator. This filter should be removed and cleaned often to allow proper airflow. It should be cleaned at least once every (3) months, and it recommended to clean it more often if the unit is being used constantly or the filter is getting dirty quickly. It is important to note that FMS units airflow is based on the BTU rating, and as an example, the airflow of an M16 is 550 CFM (amount of airflow “Cubic Feet Per Minute”) is similar to a standard backpack leaf blower. This airflow is going to pick up dust, dirt, lint, hair, paper scraps, etc. and they will all get stuck in the filter, which reduces the airflow output of the unit and could lead to freezing in cooling mode or high pressure problems in heating mode. The filter can be cleaned by a vacuum cleaner or washed with water from a hose, sink, shower, etc. Make sure to let it dry before reinstalling so that it doesn’t get caked with dust and dirt immediately.

Behind the air filter is the evaporator coil, which looks a lot like a car radiator, that also will need to be cleaned and maintained over time. The air filter will catch a lot of the larger debris, but small particles will make it through and deposit on the evaporator fins. **The fins are very fragile and thin, which makes them easy to bend or break. Extreme caution is advised when cleaning the evaporator coil!** It is recommended to purchase a small brush with mildly firm bristles and a “fin comb” tool or pack of different “fin comb” sizes. With the air filter removed, use water or “evaporator coil cleaner” and spray down any debris and buildup on the evaporator while gently running the brush **straight up and down in each area. There should**

System Maintenance

be no side to side motion at all or the fins will bend and potentially break off. Once the coil is cleaned, rinse off the evaporator with clean water and rinse out the drain pan of any chemicals. After the cleaning is finished, go over the evaporator with the "fin comb" and gently straighten any fins that got bent before or during the cleaning. Any fins that are bent or flattened will reduce the overall system efficiency. Reinstall the filter when complete.

The only remaining airflow maintenance to perform would be a visual inspection of the blower motor and ductwork. Make sure there is no mold growth, moisture buildup, rips or tears, etc. along any of the ductwork and that the blower motor spins freely with no grinding or squealing. **Never oil the blower motor, even if it is making noise. Contact FMS technical support for assistance.**

Waterflow Maintenance:

In the water circuit for the air conditioner there are multiple components that need to be checked regularly and maintained in order for the unit to operate properly. The pump, water strainer basket, foot scoop or water intake on the bottom of the boat, and the water coil on the air conditioner are all places where lack of maintenance will lead to issues. The frequency of maintenance will increase or decrease based on the quality of water that the boat is sitting in. Very brackish or dirty water will foul up the cooling water system faster than fresh water will.

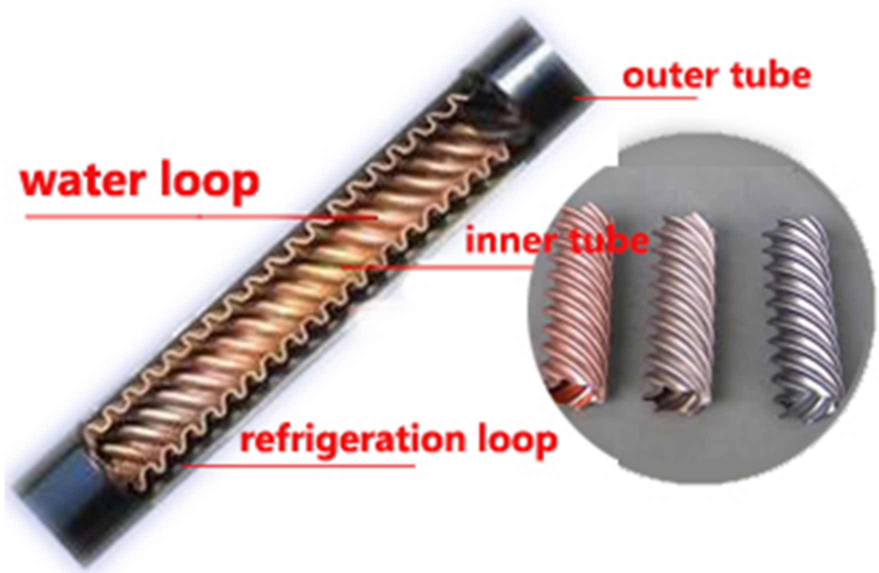
The pump is the place of least concern when it comes to water maintenance, but it should not be ignored. Pumps are generally very quiet, and if rattling, grinding, or other strange noises begin presenting themselves, it is a sign that the pump is failing or has debris inside it. This is more of an opinion based observation based on your particular setup, but if you notice the water flow begins to reduce with everything else completely cleaned and checked, it may lead to a discovery the pump is starting to struggle.

The strainer basket and the foot scoop or water intake will be the most common maintenance items of the water circuit. Both of them will be consistently exposed to debris and the unfiltered conditions of the water that the boat is sitting in. The strainer basket should be checked very frequently, as often as every few days, and cleaned out of any debris that has been caught. The finer the strainer basket screen, the faster the strainer will fill up with debris. On the other hand, the larger the strainer basket is, the slower it will fill up with debris. The foot scoop or water intake on the bottom of the boat does not have a mesh screen, but it is being exposed fully to the environment. Barnacles and other growth, vegetation, manmade trash, and other debris can get lodged in the water intake and choke off the water flow through the circuit. Whenever the water intake is suspected to be plugged or dirty, it needs to be cleaned from either inside the boat with a tool or outside the boat with a diver. This will be done as needed or alongside

System Maintenance

normal boat cleaning either in a drydock or with a diver in a marina. It is easy to blame the pump or a hose kink for bad water flow, so a full system check is very important to make sure something like a plugged up water intake is not the reason for low water flow through the water circuit of the air conditioner.

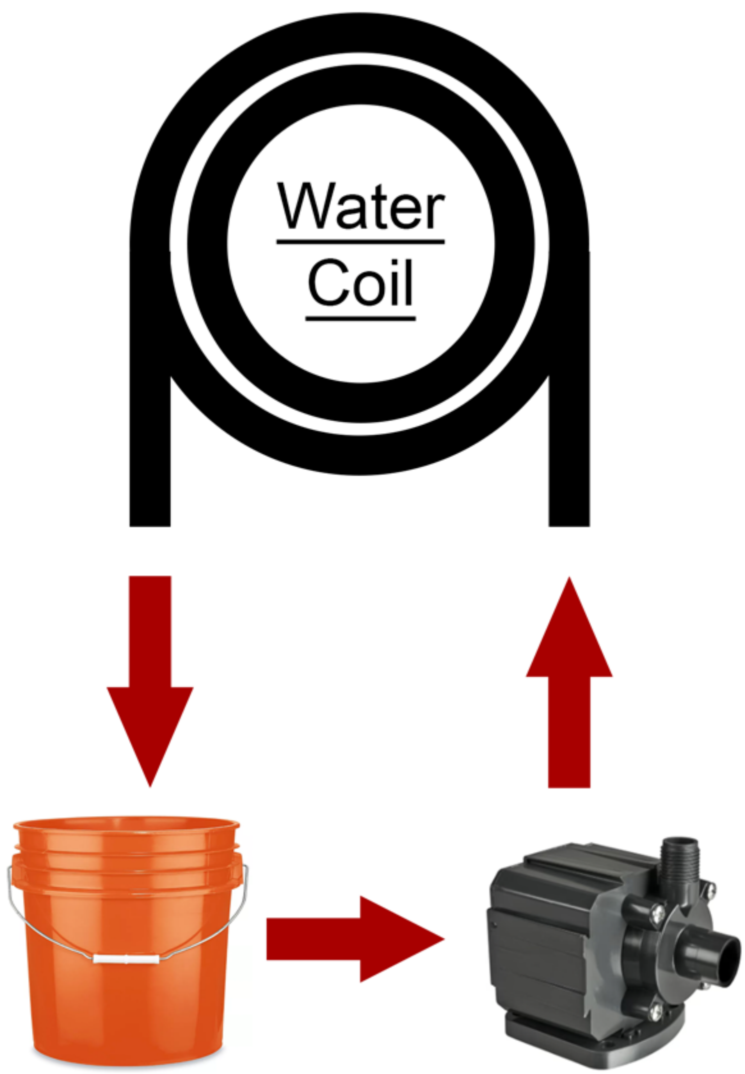
The water coil on the back of the air conditioner is essential to the proper operation of the system. Hot gas leaves the compressor and passes through the water coil condenser and exchanges its heat to cooling water before heading to the metering device and evaporator. If the water coil becomes fouled by debris and adverse water conditions, the heat transfer will lose efficiency and the pressure in the air conditioner will begin to rise. As the pressure in the system rises the power draw will increase and eventually the high pressure switch will activate or the compressor will overheat and cycle on its overload. To understand why water coil cleanliness is important and to also explain why they can get dirty, the following figures show cutaways of what the inside of a coaxial heat exchanger looks like:



Coaxial heat exchangers are designed to produce the most efficient heat exchange possible in as small of a space as possible. To do this, the exterior pipe is normal shaped, but the interior pipe is grooved and spiraled to create a “convoluted tube” that dramatically increases the surface area where the water and refrigerant can get very close to each other. The cooling water flows through the interior of the heat exchanger and most of the actual heat exchange happens in the spiral grooved regions. Most of the fouling from debris and growth also happens in the grooved regions and as a result the water flow can still be very strong, but the air conditioner can go off on high pressure or overheat. As part of maintaining the water coil on the unit, it will need to be flushed out and cleaned at certain intervals. Like the strainer basket and

System Maintenance

foot scoop or water intake, the frequency of cleaning will be dictated by the quality of water where you are located. Some FMS owners have reported needing to clean every month and some can go 10 years or more. The best way to clean and flush any buildup, debris, or growth is to "acid wash" the coil. The recommended way to acid wash the coil is to remove both the inlet and outlet water hoses from the air conditioner and make a circuit with a small circulating pump, two hoses, and a 5-gallon bucket. Hook up the outlet of the pump to the inlet or outlet of the air conditioner and then take the other hose from the unused port back into the bucket to create a loop from the bucket - to the pump - to the air conditioner - and back to the bucket. The best kind of pump is a small submersible aquarium pump so it rests at the bottom of the bucket and doesn't need to be purged before running. Mix 1 gallon of "Actibrite Biodegradable Condenser Coil Cleaner" (available in some stores or online) and 3 gallons of water together and let loop cycle for about an hour. If you cannot find "Actibrite", a chemical of similar capabilities will suffice. The air conditioner should be turned off this entire time at the thermostat or breaker so it does not run. The figures below show how to create the loop and what the recommended "Actibrite" solution looks like:



System Maintenance

If it is too difficult to disconnect the air conditioner from the water piping and you do not want to purchase another pump, you can use the existing water piping and water pump that the air conditioner uses for cooling water. Disconnect the pump inlet and hook it up to the bucket and find a way for the water leaving the air conditioner to come back into the bucket to complete the loop. The air conditioner cannot run during the acid wash, so the pump needs to be powered by an outlet or other source. Once the acid wash has run for about an hour, dispose of the acid wash mixture and replace with fresh water. Rinse the water coil with fresh water for a few minutes and then disconnect the acid wash components. Reconnect the normal water circuit piping and run the air conditioner. Check for water leaks and ensure the system is running better now that it has been cleaned out.

Note:

Maintenance is essential to proper operation. If a unit returns under warranty and the issue is due to a lack of maintenance, the repairs will not be covered under warranty. Contact FMS technical support for assistance or questions.

California Proposition 65 warning: California Proposition 65, The Safe Drinking Water and Toxic Enforcement Act of 1996, requires that all products sold within the state of California must provide a warning if the product contains any of the current list of chemicals known to cause cancer, birth defects or other reproductive harm. Our units use solder to braze piping connections within the unit, and our optional installation kits include a bronze foot scoop and a bronze sea cock. Solder and bronze contain traces of lead, a chemical on the list of toxic substances. It is believed that the amount of exposure to lead is so minimal that it poses no significant risk. However in the spirit of the disclosure act, be advised that there are trace quantities of lead used in the manufacture of this product. The company has not undertaken the cost to demonstrate and prove that a exposure can occur at a level to pose no significant risk.