



Marine Air Chilled Water System

Installation, Operation & Maintenance Manual



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INTRODUCTION

Congratulations on the purchase of your Marine Air chilled water system! This manual will provide necessary information for the proper installation, operation, and maintenance of your system. Marine Air units are well-engineered, well-built, and thoroughly tested at the factory. They will provide many years of trouble-free comfort if properly installed, operated, and maintained. And if you need help, you have the comfort of knowing you have the marine HVAC industry's largest world-wide network of factory trained dealers to promptly and professionally service your equipment. Moreover, you are backed by Marine Air's well-earned reputation for above-and-beyond, world-class customer care.

SAFETY

RECOGNIZE SAFETY SYMBOLS, WORDS AND LABELS

The following symbols and labels are used throughout this manual to indicate immediate or potential safety hazards. It is the owner's and installer's responsibility to read and comply with all safety information and instructions accompanying these symbols. Failure to heed safety information increases the risk of personal injury, property damage, and/or product damage.

**WARNING**

The word "WARNING" indicates hazards or unsafe practices which **COULD** result in severe personal injury or death.

**CAUTION**

The word "CAUTION" indicates hazards or unsafe practices which **COULD** result in minor or moderate personal injury, product damage, or property damage.

OPERATIONAL SAFETY

Installation and servicing of this system can be hazardous due to system pressure, moving parts, heat, and electrical components. Only trained and certified service personnel should install, repair, or service equipment. When working on this equipment, always observe precautions described in the literature, tags, and labels attached to the unit. Follow all safety codes. Wear safety glasses and work gloves and place a fire extinguisher close to the work area. Do not work alone.

**WARNING**

Never install your air conditioner in the bilge or engine room areas. Ensure that the selected location is sealed from direct access to bilge and/or engine room vapors.

Do not terminate condensate drain line within 4 feet (1.2 m) of any outlet of engine or generator exhaust systems, nor in a compartment housing an engine or generator, nor in a bilge, unless the drain is connected properly to a sealed condensate or shower sump pump.

Failure to comply may allow bilge or engine room vapors to mix with the air conditioner's return air and contaminate living areas which may result in injury or death.

**WARNING**

Electrical shock hazard. Disconnect voltage at main panel or power source before opening any cover.

**WARNING**

To minimize the hazard of electrical shock and personal injury, chillers, airhandlers, and all electrically powered equipment must be effectively grounded. Refer to installation guidelines for further information.

HOW IT WORKS

Your chilled water air conditioning system consists of the chiller, airhandlers installed throughout the vessel, freshwater piping connecting the chiller to the airhandlers, and the seawater system. The chiller consists of three major components: the compressor, the condenser, and the evaporator (or heat exchanger). The chiller is charged with a refrigerant that circulates throughout these components. The airhandlers consist of two major components: the blower and coil. Fresh water circulates through the piping from the chiller to each airhandler and back.

In cooling mode, warm cabin air is drawn (or blown) across the airhandler coil by the blower. Heat is removed from the air as it passes across the coil. The cooled air is then blown back into the cabin. The heat from the cabin air is transferred to the fresh water circulating through the coil. The warmed water is pumped back to the chiller. The water is circulated through the chiller's

evaporator where the heat is transferred to the refrigerant in the evaporator coil, thus cooling the "chilled" water. The "heated" refrigerant gas is returned to the compressor, compressed, and then circulated through the outer tube in the chiller's condenser coil. Seawater is circulating through the condenser via the seawater system. The heat is transferred from the refrigerant to the seawater and pumped overboard taking the original cabin air heat with it. The circulating, "chilled" water (not seawater) is then pumped back through the piping to the airhandlers in a continuous loop as the cycle repeats.

If the vessel is heated, it is either by reverse cycle or electric heat. Each method pumps warm water from the module to the airhandlers. For reverse cycle heating, the module's refrigerant flows in the opposite direction through a reversing valve, thus adding heat to the fresh water loop, instead of removing it as in the cooling mode. Electric heat systems use a heater barrel to warm the fresh water. Some systems also use electric heating coils built into the airhandlers that warm the air directly.

APPLICATION & INSTALLATION STANDARDS

The application and installation must comply with the applicable standards of American Boat and Yacht Council (ABYC). All ABYC recommendations must be followed, but those sections dealing with breakers, branch circuit protection, circuit ampacity, grounding, and bonding are especially noteworthy.

ABYC standards are available from:

American Boat and Yacht Council
613 Third Street, Suite 10
Annapolis, MD 21403 USA
Phone: +1 410-990-4460
Fax: +1 410-990-4466
www.abycinc.org

INSTALLATION

A circulated water system will only perform as well as the quality of the installation. This consists mainly of plumbing and wiring, which can be handled by most boatyards. Each aspect of the installation should be thoroughly planned to minimize time-consuming mistakes and maximize performance.

CUSTOM INFORMATION

Because Marine Air often provides customized, one-of-a-kind solutions for our customers, some systems are sold with a custom drawing, also called a "customer sign-off drawing", and/or a custom wiring diagram. If so, it may have other information about the correct manner of locating, lifting, mounting, installing, operating, wiring, or maintaining the unit or system. Information on that drawing or wiring diagram takes precedence over the instructions in this manual. Likewise, be sure to check for labels on the unit itself. Such labels frequently identify points where one should (or should NOT) lift the unit or make the various water connections.

MOUNTING

LOCATION OF COMPONENTS

When selecting the site for a piece of equipment, try to choose a location which will keep noise to a minimum, but also allow for future servicing.

Chiller

The chiller is usually located in the engine room or other mechanical space. Select a horizontal surface of sufficient strength to withstand both static load and dynamic forces when boat is in motion. When choosing a location, keep in mind this is an electromechanical piece of equipment and on occasion may need maintenance, repair, or replacement. Always provide adequate visual and physical access. The Marine Air Applications department is available to help with the design of the system, or to answer any specific questions one may have about either the equipment or the installation.

Controls

The control panel contains all of the necessary controls to operate the chiller. Mount the panel to a flat horizontal or vertical surface. The location chosen should be free from water spray and heavy moisture and should also provide adequate visual and physical access. The location should also be close enough so the factory connected leads will reach the unit.

Temperature Sensors

If plastic piping is used, a dry probewell should be used, since the plastic pipes will not transfer heat well enough for accurate sensing. The probewell should be in the stream of flow, and a thermal compound should be used to ensure good thermal contact between the sensor and the well. Insulate the piping and probewell together.

Variable Frequency Drives (VFD)

Mount the VFDs close to the compressors on a vertical surface (+/- 10°) mounted in an accessible location. The drives need at least 2 inches (50 mm) clearance on the top, bottom, and both sides. Remove the protective cover (the sticker) on the top of the drive. Removing the protective cover and providing clearance allows the drives to dissipate heat. The drives are IP20. Install them where they will not get wet. For more information, refer to the manual that comes with the VFD. The VFD manual itself takes precedence over these general VFD guidelines.

LIFTING

Individual units with lifting eyes should be lifted by the lifting eyes. Otherwise, individual modules (nominal 2 - 10 ton cooling capacity) should be lifted by the condenser assembly and the tab that is welded on the compressor, or by the base. Always make sure wiring is clear to avoid damaging the unit, and never use the refrigerant tubing to lift the unit.

When lifting pre-framed units, lift by the eye bolts, if provided, or sling from underneath.

To prevent damaging the frame rails, note the minimum 60° strap angle shown in Figure 1, and the correct strap configuration around the frame rails.

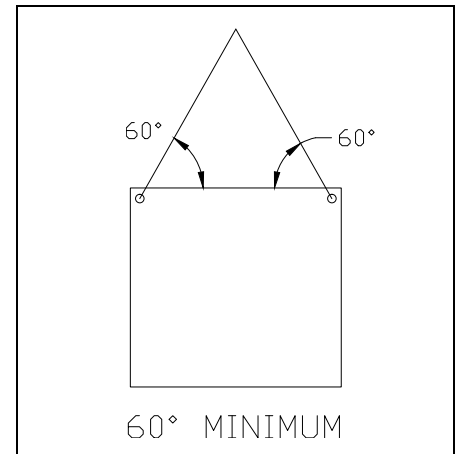
MOUNTING INDIVIDUAL MODULES

Individual modular units are contained in a condensate pan, which is then secured to the boat. Secure the unit on all four corners using the included mounting brackets. Do not bolt through bottom of pan.

MOUNTING FRAMES

Holes are provided in the base rails to secure the frames. If stacking one frame on top of another, the frames will overlap and the units should be bolted together. Be sure to secure the top of the frame to prevent movement.

Figure 1: Minimum Strap Angle



PLUMBING

GENERAL CONSIDERATIONS

Careful attention should be paid to this section, because one of the most common sources of problems with chilled water systems is the plumbing.

PIPING SUPPORT

Piping should be secured firmly with the correct fittings. Support all the piping by the boat's structure and do not rely on the equipment for support. Neither the pump nor the chiller is designed to support the weight of the piping and water. For chilled water pipes, be careful that the supports do not pinch or otherwise compromise the insulation.

TIGHT CONNECTIONS

Always be sure to double-check connections (especially hose clamps) for correct placement and tightness.

SERVICE VALVES & UNIONS

Use unions and service valves to connect modules to the manifolds for ease of service in the future. Always use full-flow ball valves. The union goes between the valve and the module. Flanges may be used as an alternative to unions.

Some chillers have unions. These unions are leak-tested at the factory, but may still develop leaks in the field. Thus, they need to be checked and tightened as necessary in the field. This is a normal part of start-up and maintenance.

WATER HAMMER

Ends of main and branch chilled water lines should be extended and capped with threaded caps or plugs. This will help to balance the water pressure, act as a cushion against "water hammer", and provide a clean-out port.

REVERSE RETURN

Reverse return helps evenly distribute the water (see Figure 2). Reverse return is always good practice for seawater (or with keel coolers). For chilled water, reverse return is always a good idea on the chiller manifolds.

For the airhandlers, reverse return is only needed if the airhandlers do NOT have flow controls.

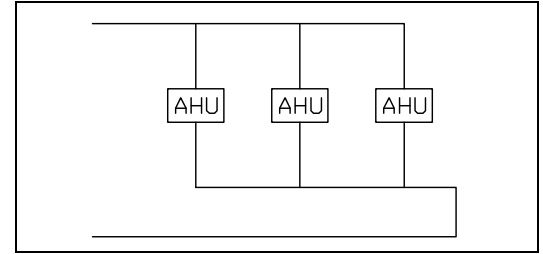
SPARE PUMPS

When a back-up pump is to be installed along with the main pump, there are some special considerations which should be followed to ensure proper operation. The backup pump should be installed in parallel with the main pump, with full flow valves on the inlet and outlet of both pumps to allow total isolation of either pump. A power transfer switch must be provided to select which pump operates. This should be located near pumps to lessen the chance of running a dry pump, which could damage the pump and/or compressor. To ensure that the spare pump will operate when needed, the main and back-up pumps should be switched at regular intervals so they are run evenly. Be sure to open the valves BEFORE turning on the pump - do not run the pump with its valves closed.

Another option would be to completely "winterize" the back-up pump (i.e. keep it dry). This should help keep the pump seals in good condition and prevent the pump impeller from freezing up. Labels identifying the switch and valves in the system would help prevent operator error, and a note on the pumps to tell the user to keep both of the valves on the inactive pump closed might stop a well meaning person from opening all valves which would just circulate water in the pump loop.

An easier and less expensive method might be to install the main pump with cut off valves and unions on the intake and discharge. This would allow a failed pump to be easily replaced with a spare carried aboard. The spare pump could have union fittings attached for a quicker installation, if desired.

Figure 2: Reverse Return Schematic



CHILLER CONDENSATE

Each module has two 1/2" FPT condensate drains, one at each end. Connect these outlets to proper tubing and route to an appropriate location such as an overboard fitting or sump. Do not permit condensate to puddle in the bilge.

CIRCULATING WATER SYSTEM

WATER IN/OUT

Note the arrows on the unit indicating direction of water flow. Reversing the flow can cause a number of problems, such as the flowswitch not working properly. For most chillers, the chilled water should enter through the upper copper connection and leave through the lower copper connection. Seawater enters low and exits high.

RETURN OVER SUPPLY

Always put chilled water return lines (water returning to the chiller) above the chilled water supply lines (water coming from the chiller). This is so that any air in the system will travel upwards with the water flow.

AVOIDING AIR & WATER TRAPS

A typical system will have the circulating pump as the lowest point in the water loop (or as low as possible), with the chiller being the next highest piece of equipment followed by the airhandlers. Ideally, the only changes in the vertical direction will occur at the airhandlers where the built in vents can be used to bleed any trapped air.

To avoid air and water traps, all piping should have constant inclining and declining slopes. Any time the piping reverses the vertical direction, an air or water trap is created. Air traps can cause noise, and restrict or even stop the flow of water; and therefore one must have a means of venting the air. Traps are a great hindrance when trying to fill, bleed, or drain a system. A vent (or "bleeder") should be installed wherever an air trap is possible. To maximize the usefulness of the airhandlers' bleeders, all piping should be installed so that the airhandlers are local high points. (Exception: If autobleeders are installed, the autobleeder should be higher than the airhandlers.) A water trap will prevent complete draining of the system (for repair or winterizing), so there must be a drain at the water trap.

AIR BLEEDERS

Manual Bleeders

Provision must be made to remove air from the system. All airhandlers and most chillers include bleeder valves. In addition to these, a main bleeder must be installed at the highest point in the system and routed to a valve and discharge in the engine room. This allows the system to be conveniently filled and vented at the same time. Typically 1/2" or 3/4" piping works well. There may also be "local" high points which need their own bleeders.

Engine Room Autobleeder - Spirovent®

The Spirovent® is an inline autobleeder. Install the Spirovent® in the main return line upstream of the circulating water pump but downstream of all airhandlers, the fill assembly, expansion tank, strainer, etc. In applications where the system water flow would exceed the maximum recommended flow rating of the Spirovent®, the Spirovent® may be installed in a sidestream (i.e., parallel circuit). The sidestream should be located above the main return line such that air bubbles can easily flow up into the sidestream. Isolate the Spirovent® with ball valves to allow for service. The bottom port of the Spirovent® should be plugged. The bottom port is used to clean out accumulated debris, so do not use it as a place to connect other components. Spirovent® and Spirotop® are registered trade names of Spirotherm, Inc.

High Point Autobleeder - Spirotop®

The Spirotop® is a single port autobleeder. Install a Spirotop® at the top of each return riser, or anywhere that air might collect. A Spirotop® may be installed at any high point instead of a manual bleeder. It is important to ensure positive pressurization at the Spirotop®. If the water pressure at the Spirotop® is less than atmospheric pressure, then any autobleeder will actually draw air into the system rather than bleed air out. Isolate the Spirotop® with a ball valve to allow for service. Spirovent® and Spirotop® are registered trade names of Spirotherm, Inc.

Plan for Water

Note that when air is bled from the system, some water is usually released. This is true of manual AND automatic bleeders. The water may be collected in a sump or a bucket. Plan ahead and avoid a mess.

STRAINER REQUIREMENTS

- Strainers are mandatory in the condenser/seawater circuit AND in the circulated water circuit. Failure to follow these guidelines will void the warranty!
- The circulated water strainer should be a 20-mesh "Y-strainer". Finer meshes will clean the system better, but they are likely to need cleaning too often and thus become a nuisance. More open meshes must not be used because they will not adequately protect the components.
- The basket must be serviceable. Acceptable strainers have an arrow indicating proper direction of flow. The arrow must be in the direction of flow. The arrow may point horizontally or down. The arrow may NOT point up. If the arrow is horizontal, the basket should be below the pipe - never above it.
- The strainer must be positioned upstream of the chillers so as to protect the heat exchanger from debris. Typically, the strainer is just upstream of the pump, and the pump is just upstream of the chiller. Putting the pump upstream of the strainer is acceptable, but not recommended. There must not be any airhandlers between the strainer and chillers.
- Install pressure gauges before and after the strainer. This will make it easy to see when the strainer needs cleaning. (Refer to the section on pressure gauges for more information.)
- Install ball valves before and after the strainer. This will make it easy to clean the strainer without releasing excessive water.

MATERIAL

We recommend type "L" copper for circulated water.

CLEANLINESS

The strainer cannot catch fine dirt, so it is important that the system be assembled from clean pipe and components. Otherwise, this dirt and debris will collect in the evaporators and cause failure. FROZEN EVAPORATORS WITH MUD OR DEBRIS IN THEM ARE NOT COVERED UNDER WARRANTY! The best way to avoid this is cleanliness. Inspect pipe and other components for cleanliness before installing them. If they are dirty, clean them. Pipes in storage should have the ends covered to keep out dirt and other undesirables. A little dirt evenly spread out through a system becomes much dirt once it collects in the bottom of an evaporator.

A mud separator can provide added protection, but it is unnecessary if the system was assembled with clean components and filled with clean water. (Refer to the section about flushing the system for more information about mud separators.)

SIZE

The recommended pipe sizes shown in Table 1 are designed to keep pressure losses to a reasonable minimum. The next larger pipe should be used whenever the capacity being served is near the upper limit of the range and any of the following is true:

- The pipe run has numerous bends.
- The run is an extremely long distance.
- Possibility of adding more capacity.

Note that grossly over-sizing pipes can be harmful too. The drastic changes in water velocity can cause extra losses and noise in the system.

Add up the total BTUs of the airhandlers served by a given pipe to determine the size of that pipe.

Note that chillers are typically sized to be approximately 80% of the total airhandler load. Smaller vessels often use a higher percentage. Larger vessels may be able to use a smaller percentage.

Hose to an airhandler should match the hosebarb that comes with the airhandler. The ball valve for an airhandler should be ¾" full port for all airhandlers up to 24K. Airhandlers 30-36K should be 1" full port.

Table 1: Circulated Water Pipe Sizing Chart

Capacity Range (BTU/hr x 1000)	Pipe Size (ID)
4 - 21	3/4"
24 - 45	1"
48 - 81	1-1/4"
84 - 129	1-1/2"
132 - 225	2"
228 - 405	2-1/2"
408 - 600	3"

INSULATION

- **When to insulate:** Leak checking the system after everything is insulated is sure to create frustration. Before the leak check, it is OK to insulate straight lengths of pipe, but do not insulate the joints or fittings until AFTER the leak check. If there are any leaks, they will probably be at the joints or fittings. Having the joints and fittings still uninsulated will make the leaks easier to find and fix. After checking for leaks, insulate the joints and fittings. Any exposed pipe can sweat and cause water damage so it is very important to insulate the piping thoroughly.
- **Insulation material:** We recommend closed cell insulation at least 3/4" thick insulation on the pipes. Piping through unconditioned space or other areas where the dewpoint may exceed 74°F will require thicker insulation.
- **Size:** The internal diameter of the insulation should match the external diameter of the pipe. If the insulation is too large, air will get between the insulation and the pipe and create condensation that may run down the pipe and show up some place else. This condensation will be minimal if the air cannot circulate, but it is better to avoid it altogether by avoiding the air gap. If the insulation is too small, it will be difficult to install. If split insulation is too small, it may eventually split open. Taping the split insulation all around will prevent this. The ideal solution is un-split insulation that closely fits or is just a little snug.
- **Separate supply and return:** Supply and return piping should always be insulated individually and clearly identified.
- **Thorough:** All piping should be thoroughly insulated to prevent condensation. Improper insulation is a common problem with chilled water systems, and very difficult to find and correct, even after the water damage is noticed. A gap in the insulation will produce condensation on the pipes, which can run down inside the insulation to a different location. Insulation must be air tight.
- **Cover the ends:** When putting the recommended closed cell foam insulation over the pipes, cover the ends of the piping to prevent foreign material from getting inside the piping.
- **Split insulation:** If using split insulation, seams should be closed tightly, sealed with glue or tape. Completely wrapping split insulation with a sturdy cloth tape will also make it more durable and much less likely to split back open. All water fittings, connections, valves, etc. in the system should be well insulated, after the system is leak tested.
- **Do not pinch the insulation:** Do not compress the insulation. For example, do not use tie wraps on insulation. The localized compression will cause poor performance, condensation, and eventually damage the insulation.

DRAIN

The system drain is placed at the lowest point in the loop to allow for easy servicing. Other drains may be necessary elsewhere if water traps are unavoidable. (Refer to "Avoiding Air & Water Traps" on page 4.)

CIRCULATION PUMP

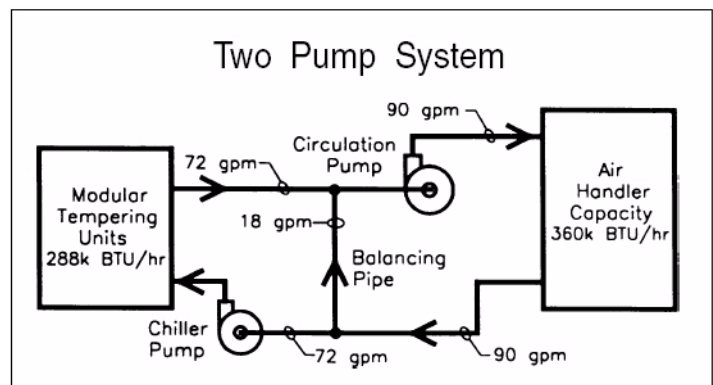
- The circulating pump should be located near the chiller, pumping water into the chiller first, and then through the loop.
- The pump discharge should be directed in a vertically upward position, with a straight run of vertical pipe leaving the pump, to prevent air from becoming trapped in the pump head. Trapped air is a common problem which can prevent proper flow causing flow switch shut downs, and can eventually damage the pump.
- The immediate pipe at the inlet and discharge of the pump head should be straight for a length of at least 12". This is especially important at the inlet so a uniform flow of water enters the pump.
- The pump and fittings should be protected from being stepped on or hit by other objects and all connecting piping should be well supported so as not to put any undue stress on the pump head or fittings.
- Resilient pump mounts should be used to prevent excess vibration from being transmitted to the boat structure.
- The fittings connecting the pipe to the pump should provide valves and unions to allow removal the pump for maintenance and repair. Always use full flow ball valves.
- Note that the correct size of the system piping is determined by the volume of the water flow, not the connection sizes on the chiller, airhandler, or pump head.
- Install pressure ports and gauges before and after the pump. (Refer to "Pressure Gauges & Pressure Ports" on page 7.)

TWO-PUMP SYSTEMS

When larger systems are installed, (chiller capacity over 20 tons) often two circulating pumps are used to ensure proper water flow. One pump (sized to loop capacity) will serve the airhandlers, and a second pump (sized to chiller needs) will draw water from the airhandler loop and supply the chillers. The balancing pipe allows both pumps to provide the correct water flow to each side of the loop. This is a self balancing system, and a bypass flow control (BFC) is not needed.

A full-flow valve can be installed in this balancing pipe which will allow one pump to supply the entire system, providing at least partial operation in the case of a pump failure. The minimum size of the balancing pipe can be figured from Figure 3 by using the difference in capacities to select pipe size.

Figure 3: Diagram of a Typical 2-Pump System



FLOW CONTROLS

Marine Air recommends a flow control on each airhandler. The chillers do not need flow controls. Balancing flow controls are available in many different capacities. Connections range from ½" female NPT to 1 ¼" female NPT.

If the total airhandler capacity exceeds the total chiller capacity by more than 10%, then a bypass flow control may be needed if the pump cannot force the full airhandler flow through the chillers. In this case, the bypass flow control balances the system by allowing only the correct amount of water to bypass the chillers.

If the total chiller capacity exceeds the total airhandler capacity, then a bypass flow control may be needed if the pump cannot force the full chiller flow through the airhandlers. That will certainly be the case if the airhandlers have flow controls. In this case, the bypass flow control balances the system by allowing only the correct amount of water to bypass the airhandlers.

EXPANSION TANK

The expansion tank should be connected on the inlet side of the circulating pump.

It is a good idea to install a service valve at the expansion tank to facilitate future maintenance. However, the valve handle should be removed to prevent the tank from being isolated from the main loop.

The tank will function properly in any position, but it must not stress the connection to the supporting pipe. Thus, the tank should usually be mounted vertically. Do not install the expansion tank (and its service valve) in such a way that its weight is a big lever that stresses the pipe connection or pipe.

PRESSURE GAUGES & PRESSURE PORTS

The Y-strainer should have pressure gauges to measure the pressure differential across the strainer. This will indicate when it is time to clean the strainer.

A pressure gauge at the pump inlet is MANDATORY. The pump inlet pressure gauge should be located to allow good visibility when operating the fill valve.

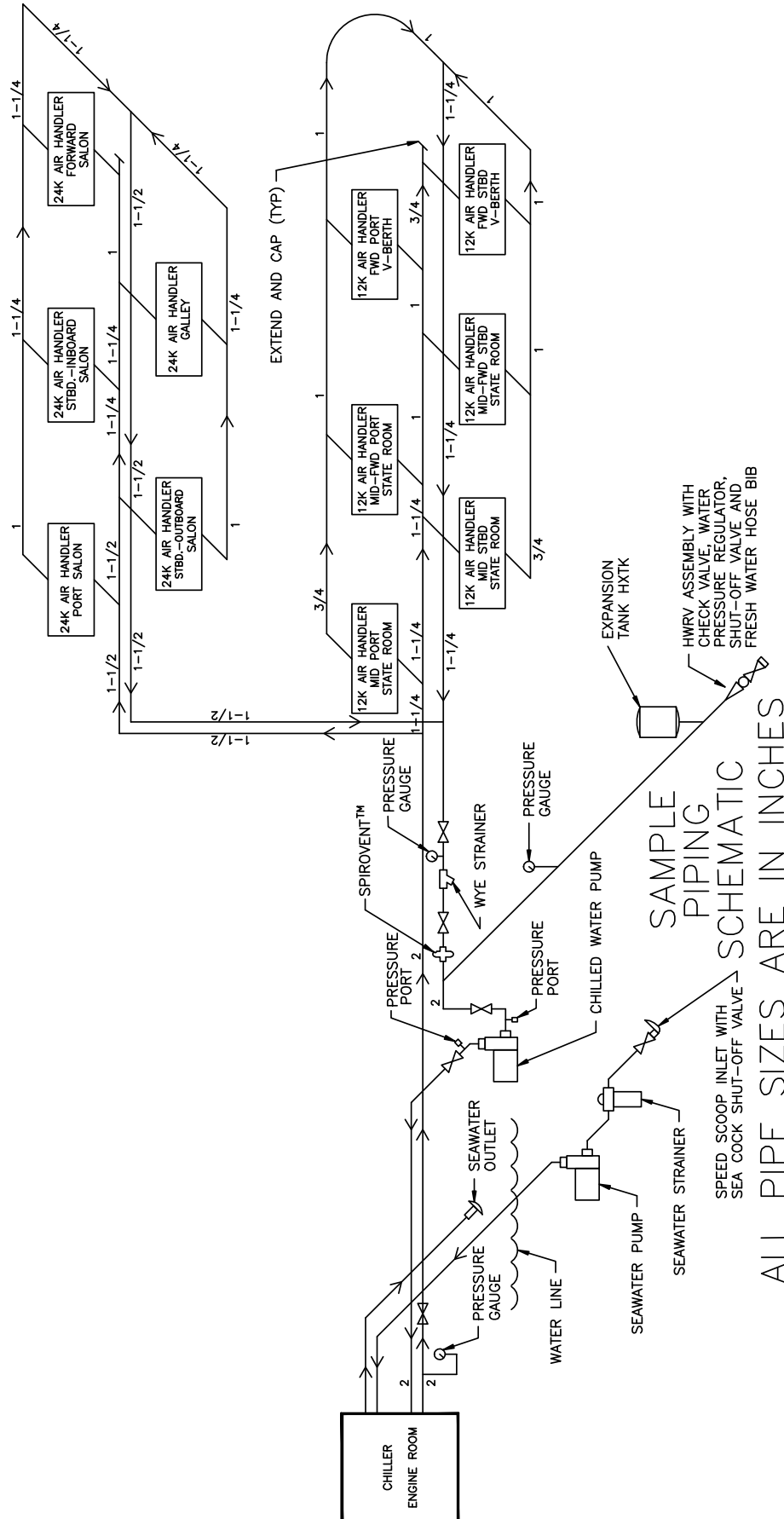
A pressure gauge at the discharge of the pump is recommended. The gauges at the inlet and discharge of the circulating pump will assist in properly filling the system and diagnosing flow restrictions. However, this pair of gauges usually cannot render pump pressure differential accurately enough to allow the flow rate to be deduced.

Install pressure ports immediately upstream and downstream of the circulating pump, before any bends or restrictions of any kind. This will allow the pump flow to be deduced by comparing the pressure difference with the pump curve. For this purpose, both pressure measurements should both be taken with the same gauge. For best results, use one very accurate gauge with ½ psi or smaller graduations and simply move it from one port to the other. Thus, these ports are IN ADDITION to the system pressure gauges mentioned below. For the ports, use ¼" Schrader valves or ¼" tube connections. We offer valves for this purpose, part number 4073420 - ¼" male NPT x ¼" tube.

SAMPLE PIPING DIAGRAM

Refer to Figure 4 to see a sample piping schematic diagram.

Figure 4: Sample Piping Schematic Diagram



FILL VALVE

**WARNING**

If the fill valve might be connected to a potable water supply, then a Reduced Pressure Zone (RPZ) backflow preventer is required to prevent possible contamination of the potable water supply.

PRESSURE RELIEF VALVE

**WARNING**

If an electric or a fuel-fired water heater is used to heat the loop, a 30 psi relief valve must be installed and the discharge plumbed to a safe location. Boats with very high head requirements may need a setting higher than 30 psi—usually not more than 50 psi. If a higher setting is required, be sure that the pressure setting of the relief valve does not exceed the pressure rating of the weakest system component.

BALL VALVES

Ball valves are required before and after the pump, before and after the strainer, before and after each airhandler, and as needed to isolate anything else that needs to be serviced with a minimum release of water.

SEAWATER/CONDENSER WATER SYSTEM

GENERAL DEFINITION - SEAWATER PIPING

The seawater cooling system consists of a through-hull fitting, water shut-off valve or seacock, strainer, seawater pump, water pipe or marine grade hose, and overboard discharge fitting.

WATER IN/OUT

Note the arrows on the unit indicating direction of water flow. Reversing the flow can cause a number of problems, such as lost performance or an air-locked system. For TWCs, MTCs, and MTDs, the seawater should enter the chiller at the lower of the two headers, and leave the chiller through the upper header. The headers are usually plastic, but may be bronze and cupronickel. "Headers" are the small vertical manifolds that connect the condensers on an individual module. Small modules do not even have seawater headers because they have only one condenser circuit. They have cupronickel stubs instead of headers. Regardless, the seawater should always flow from low to high to encourage air to migrate out and thus avoid air locks. So, seawater enters the chiller low and exits high.

AVOIDING AIR TRAPS - SELF-DRAINING SYSTEMS

It is imperative that the seawater plumbing be routed continually uphill, without loops and dips, from the pump to a high point between the condenser assembly and the overboard discharge. The system is said to be self-draining because if the boat were to be lifted out of the water, all of the water would drain out of the system. This will help prevent air lock if air is ever drawn into the system, and also makes winterizing the system much easier. A properly plumbed system is absolutely necessary.

Air can easily get into the system if the boat is in heavy seas or makes a sharp turn. If this air is not expelled, it can become trapped in the pump. With air in the pump, no pressure can be produced and the water flow stops. Trapped air can sometimes block flow even if the air pocket is not in the pump itself.

The high point of the system is at the overboard discharge. This will allow any air which may be drawn into the system to escape. If the discharge must be lower than the chillers, there should only be one high point. This way, when the seawater pump cuts off, the water in the system will drain out (to the water line), preventing the system from becoming air locked.

STRAINER

The in-line basket type strainer should be placed in the seawater line between the seacock and the pump. It should be situated to provide easy access for regular cleaning. Make certain the seawater strainer is oriented properly. The arrow on the strainer housing should point in the direction of the water flow, toward the seawater pump.

MATERIAL

Use 90/10 cupronickel or equivalent. Confirm with your pipe supplier that it is compatible with the application.

SIZE

See Table 2 for recommended pipe sizing. If the hose or pipe is a long run or with many fittings, use the next larger size.

Table 2: Seawater Water Pipe Sizing Chart

Chiller Unit Capacity Range (BTU/hr x 1000)	Pipe or Hose Size (ID)
4 - 21	3/4"
24 - 45	1"
48 - 81	1-1/4"
84 - 129	1-1/2"
132 - 225	2"
228 - 405	2-1/2"
408 - 600	3"

THROUGH-HULL FITTING

A separate through-hull fitting and seacock should be used for each air conditioning seawater pump.

Special attention should be given to the location of the inlet through-hull fitting. A dedicated through-hull for the air conditioning system should be located no more than 6 inches (15.2 cm) from the keel, and ahead of the stuffing box and engine intake through-hull. Do not attempt to draw seawater from the engine or generator through-hull fitting. If a sea chest arrangement is used, special precautions must be taken to ensure that the chiller will have adequate raw water flow.

A scoop-type through-hull is preferred for most installations, especially on faster boats. It should be facing forward and located near the keel or centerline, where it will always be underwater whenever the air conditioner is running. Beware of the change of location of the through-hull fitting relative to the waterline, given the motion of the boat.

Special attention should be given to sail boat applications, as the extreme heel angles they experience could result in the through-hull fitting coming out of the water and air locking the pump.

Over-board discharges may be placed above or below the water-line. Both methods are acceptable if done properly. It is a matter of preference. Above the water line, one can easily get visual confirmation of seawater flow. It is also easier to make the system resistant to air traps. (See "Avoiding Air Traps - Self-draining Systems" on page 10.) Putting the overboard a short distance above the water-line will reduce the noise from splashing water. Below the water line, there is no noise from splashing water. Remember to use a seacock if the overboard is below the water line.

SACRIFICIAL ANODE

A sacrificial anode (typically zinc) must be installed upstream of the seawater pump. The size and type of anode needed is determined by many factors. Consult with your anode supplier for more details.

PUMP

The seawater pump must be placed in a location that is below the water line and near the chiller. The centrifugal pump is not self-priming and water must flow freely to it. The pump may become air locked if air is drawn into the seawater system. Sailboats may require special considerations to prevent air locking when heeling.

The pump head should always discharge upward with a straight run of vertical pipe leaving the pump. This will help prevent air from becoming trapped in the pump head. Trapped air is a common nuisance that prevents proper flow and may damage the pump.

Bolt the pump securely on a horizontal surface with the discharge connection as the highest point. The pump should be installed with resilient mounts to prevent vibrations from being transmitted to the structure of the boat. Make certain that the pump is easily accessible for service. Be sure the location chosen will not allow the pump to be stepped on or hit by other moving machinery. The fittings connecting the pipe to the pump should include valves and unions to allow removal of the pump for maintenance and repair.

Note that the piping is determined by the volume of the water flow, not the connection sizes on the pump head. The immediate pipe to the inlet of the pump head should be straight for a length of at least 12" so a uniform flow of water enters the pump. Do not install any type of check valve in the seawater system as this can cause the pump to air lock if any air gets into the system.

WIRING

PUMP WIRING

The only wire to be connected to the pump will be the power wires from the output of the pump relay or control panel. Pay close attention to the wiring schematic label on the side of the pump motor. Many of the pumps used in Marine Air systems are dual voltage. Determine the supply voltage, and connect the pump accordingly. Connecting the wiring incorrectly could destroy the motor.

There are some cases where the pump is supplied with a dual rotation motor. Be sure that the pump is rotating in the proper direction, usually indicated by an arrow on the pump head. All field wiring should only be done by qualified people and the correct wire size and proper terminals should always be used.

AIRHANDLERS

Note that the air handling units are not electrically connected to the chiller or panel control. Please refer to the wiring diagrams included with your airhandler. The airhandler diagram is affixed inside the lid of the airhandler junction box. The airhandler control diagram is affixed inside the lid of the control box.

TIGHTENING CONNECTIONS

All electrical connections are tightened and retightened at the factory. However, they can still loosen with time, temperature, and/or vibration. Go through all electrical connections and make sure they are tight. This includes every place where a screw is used to make a tight electrical connection.



WARNING

Failure to maintain tight electrical connections can start fires or create dangerous electrical shorts.

VOLTAGE RANGE

Power to the unit must be within the operating voltage range indicated on the data plate. Operating outside the specified voltage range may cause the chiller to draw excessive amps. Operating more than 5% outside the specified voltage range will damage the compressor over time and void the warranty.

MAX FUSE - CIRCUIT BREAKERS

"Max fuse" is indicated on the unit's label. It is the maximum allowable size for the HACR breaker or fuse. Smaller sizes are allowable and may be desirable. However, sizing the breaker too small invites nuisance trips. Breakers are usually sized at 175% to 200% of the current load. Curve 10 breakers should be used for the chillers due to the starting loads of the compressors. Always check with regulation codes (ABYC or Coast Guard) for final sizing of breakers or wiring.

MCA -MINIMUM CIRCUIT AMPACITY

MCA is indicated on the unit's label. Your wiring must be designed to continuously carry this electrical current. Be sure to read ABYC concerning wire type, size, ambient conditions, etc.

ELECTRICAL GROUNDING AND BONDING

All chillers are supplied with a terminal strip mounted inside the electrical box. The electrical supply, ground wires, and pump circuits are all connected at this terminal strip. All units must be effectively grounded to minimize the hazard of electric shock and personal injury.

The chiller must be connected to the ship's bonding system to prevent corrosion due to stray electrical current or voltage. This will help eliminate any possibility of corrosion due to stray current or voltage.



CAUTION

Failure to properly ground and bond the system will void the warranty.

Ensure the following:

1. AC (alternating current) grounding (green wire) must be provided with the AC power conductors and connected to the ground terminal (marked "GRND") at the AC power input terminal block of the unit(s), per ABYC standard E-8, or equivalent.
2. Connections between the vessel's AC system grounding conductor (green wire) and the vessel's DC (Direct Current) negative or bonding system should be made as part of the vessel's wiring, per ABYC standard E-9, or equivalent.

3. The AC ground of the chiller must be connected to the AC ground of the boat. Within the boat itself, the AC ground bus must be connected to the DC ground bus at exactly one place (no more, no less).
4. All pumps, metallic valves and fittings in the seawater circuit that are isolated from the unit by PVC or rubber hoses must be individually bonded to the vessels bonding system also.

3-PHASE NOTICE

For all 3-phase units and pumps (power source is either 208-230VAC/3 or 380-460VAC/3), it is extremely important to ensure that wiring and phase sequencing of the three phase power source is correct. Marine wiring standards call for power source phases L1, L2, and L3 to be color-coded BLACK, WHITE, and RED, respectively. These must be connected to the unit with the proper sequence. Otherwise, it will not operate properly.

If the wiring sequence is incorrect, the unit's compressor (Scroll type only) and pump (if applicable) will run in the reverse direction, usually at a significantly increased noise level. Reverse compressor operation will result in increased suction pressure and reduced head pressure. No cooling will be produced. If the circulating pump runs in the reverse direction, the closed water loop will not achieve high enough operating pressures and air cannot be eliminated from the system. If the seawater pump runs in the reverse direction, it will not deliver cooling water to the condenser. The electric heat may work properly, but reverse cycle heating will not.

If this problem is encountered, simply swapping any two power wires—L1 and L2, for example—should cause the unit to run properly. Just be sure to modify the wiring as necessary so that the wire colors are also correct according to the standard mentioned above.

VFD - VARIABLE FREQUENCY DRIVE

Frequency drives are also known as VFDs, variable frequency drives, VSDs, variable speed drives, and sometimes just "drives". Frequency drives are used primarily to eliminate the sudden current inrush that can cause lights to flicker when a compressor turns on. Frequency drives can also be used to convert single-phase power to 3-phase.

The chiller must have a 3-phase compressor, but the VFD can use either 1- or 3-phase input power. The control panel should match the ship's power, whether 1 or 3 phase. Power wiring typically goes from the control panel to the VFD, and from the VFD to the compressor. The VFD functions as the contactor/starter. The control box typically provides a dry contact for the VFD to control when the VFD turns on/off.

CONTROLS

Marine Air offers a variety of control solutions. The limited wiring information provided in this manual is applicable regardless of what style controls are used. Your controls manual has more information specific to the particular type of controls used on your system. Be sure to read it carefully.

START-UP

LEAK TEST

COPPER PIPE

It is a good practice to leak test the loop plumbing throughout the installation of the system, as well as after the installation is complete. This is especially important when joints will be concealed and therefore very difficult to get to in case of a leak.

A simple procedure of pressurizing the pipes with air will indicate whether that section of plumbing is sound. The piping should be able to hold 75 psi over a 12 hour period (minimum). Note that fluctuations in pressure may be noticed due to temperature changes, but a drop of over 5 psi indicates a leak, which should be found and fixed.

Large leaks will be easily heard, but small leaks can be difficult to find. There are several ways of locating small leaks:

- Add some water to the system before pressurizing with air. The water will travel to the leak and add to the noise as it escapes, as well as create a wet spot.
- If a joint is suspected to be leaking, a liquid leak detector (such as soap bubbles) can be applied to pinpoint the problem.
- Electronic devices are available which can help identify leaks by "listening" for high frequency noises characteristic of a leak.

Finding leaks before the initial filling of the loop with water will save you from having to drain an entire system to fix leaks, as well as avoid expensive water damage to a completed vessel.

PLASTIC PIPE

Do NOT put pressurized gas into plastic pipe. It is unsafe.

FLUSH

As a condition of warranty, the installer is required to provide clean circulating water. Otherwise, dirt can collect in the evaporators causing them to freeze and rupture. Airhandler valves and other components can also become clogged or otherwise harmed by the dirt and debris.

The best way to provide clean water is to assemble the circuit from clean components, fill the circuit with clean water, and then thoroughly flush the circulating water before connecting the chillers and airhandlers. However, even then it is common for the assembly process itself to generate debris such as bits of Teflon tape or pipe dope. **Do not operate or run water through the chiller or airhandlers until the circulated water system has been thoroughly flushed.**

After the circulated water system has been completely installed, leak tested, and bled of most air, the circulation circuit should be flushed to remove any contaminants or debris in the piping. Follow these instructions for flushing the circulation circuit:

1. Shut off the service valves to the airhandlers and auto-bleeders.
2. Remove the flexible hose connection from the inlet hose barb on each airhandler.
3. Remove the flexible hose connection from the outlet hose barb on the chilled water circuit.
4. Connect these two hoses using a hose barb. Do this at the chiller and each airhandler. The objective is to bypass the water flow and avoid running water through the chiller or airhandlers or other components where debris or sediment could do harm. NOTE: The circuit may be flushed prior to attaching airhandlers by following steps 4-9.
5. Use the Y-strainer on the suction side of the circulation pump to catch any particles. Optional: Temporarily install a mud separator to remove sediment too fine for the Y-strainer. Since the chiller was disconnected and bypassed, that may be a good place to make the temporary connection. (Refer to "Removing Fine Dirt" on page 14 for more information. Follow the directions that come with the mud separator.)
6. Locate the main system vent and open the valve (or vent tube) at this location. If this valve cannot be operated from the location of the fill valve, a second person will be required to conduct this procedure.
7. Open the fill valve and allow water to enter the system until it spills out of the vent line with no visible air bubbles. Bleed the system of as much air as possible, then close the fill valve and the vent. If sections of the circuit are air locked, then they will not be flushed out because the water will not pass through.
8. Run the circulation pump for fifteen minutes or until the strainer begins clogging.
9. Turn off the circulation pump and close the service valves to isolate the strainer.
10. Remove, clean, and replace the strainer basket.
11. Open the strainer's service valves and run the circulation pump until the strainer begins to clog again.
12. Repeat steps 9 -11 until no particles or contaminants are visible in the strainer basket and the mud separator is not removing anymore dirt. The interval between cleanings will increase as the system gets cleaner. The entire process can be expected to take from 4 to 24 hours depending on the boat. Rarely, exceptionally dirty applications may take up to 72 hours. Build with clean components!
13. Upon completion of the above, drain the circulation circuit and reconnect the airhandlers and auto-bleeders if installed.
14. Watch the water as it drains, and collect some water in a bucket and look at it. It should be clean.

REMOVING FINE DIRT

Dust, dirt, silt, and other fine particles will generally NOT be caught by a strainer. They are too fine and will pass through. They will collect in the bottom of evaporators and, if there is sufficient quantity, cause the evaporators to freeze and rupture. THIS IS NOT COVERED UNDER WARRANTY! Much of this dust can be avoided. (Refer to "Cleanliness" on page 5.)

The same company that makes Spirovent[®] and Spirotop[®] also makes a version that effectively removes fine sediment from the water (a "mud separator"). Mud separators are relatively expensive and are not usually necessary as a permanently installed component if the system was assembled with clean pipe, filled with clean water, and adequately flushed. But, mud separators are an effective means of removing dirt and silt.

OEMs and dealers are encouraged to invest in one or more good mud separators. Temporarily install a mud separator downstream of the strainer to assist while flushing the system. Continue running water through it until the water is consistently clean and crystal clear. After the system has been effectively flushed, the mud separator can be removed and used to clean another boat. Spirovent[®] and Spirotop[®] are registered trade names of Spirotherm, Inc.

FILLING AND BLEEDING

The loop requires filling and bleeding before initial startup and after any servicing which requires draining of the system.

The water should be clean, such as potable water, and warm, if possible, so as to lessen the amount of air dissolved in the water. Check the system thoroughly for leaks after the initial fill.

1. Locate the main system vent (or the highest airhandler vent if a main system vent is not provided) and open the valve (or vent tube) at this location. If this valve cannot be operated from the location of the fill valve, a second person will be required to conduct this procedure. Open the fill valve and allow water to enter the system until it spills out of the vent line with no visible air bubbles.
2. Close the vent line and allow the static pressure to build to approximately 20 psi, and then close the fill valve.
3. Begin bleeding air from the chiller and each of the airhandlers, starting with the lowest and working toward the highest. It may be necessary to add more water if the pressure drops much during the bleeding process. After this initial bleeding is complete, open the fill valve and recharge the system back to 20 psi.
4. NOTE: Low water pressure can cause some airhandlers, especially those high up, to be put into a negative pressure situation. Whenever an airhandler's bleeder valve is opened, air or water should come OUT. If that doesn't happen, it means there is not enough water pressure in the system.
5. Turn the power on to the chiller, circulating pump, seawater pump and all the airhandlers.
6. Adjust the temperature setting of the cabin controls to ensure that the bypass valves will remain activated in the heating mode.
7. Switch the control switch to the heating mode (air separates better from warm water). The circulating pump should start immediately and the red heating control light should illuminate. The chiller will not start immediately due to a built-in time delay. If the fault light remains on, the system may have to be shut down and bled again in order to establish flow through the chillers. Once the system is running, allow the water to heat to set point.
8. After the system has operated in the heating mode for several minutes, shut it off by switching the control switch to the off position (no lights should be lit on the panel).
9. Let the water come to rest and then begin bleeding the equipment again, working from the lowest to the highest.
10. Restart the system and observe each airhandler's air discharge temperature to confirm adequate air temperature difference. If there are some that are not acceptable, they may require additional bleeding.

In most cases, the bleeding process will have to be repeated after the system has been in operation for several weeks.

ANTI-FREEZE

Antifreeze is mandatory in all chiller systems. It must be added to the water after the bleeding process is complete and any leaks have been fixed. The recommendation is 20% by volume of non-toxic propylene glycol, such as Dowfrost™ brand by Dow Chemicals. Do not allow the freeze point to rise above 20°F. Check the protection level whenever water is lost or added, and at least once per year.

FAILURE TO MAINTAIN ANTIFREEZE MAY VOID THE WARRANTY. The antifreeze not only prevents damage in the event of circulated water freezing in the loop, but additives in the antifreeze protect the system from corrosion and deposit build-up which would lower the system's efficiency. Note that excessive anti-freeze will reduce system capacity.

An easy way to add the antifreeze is to drain the system just enough to release the static pressure. At the highest airhandler in the loop, open the vent tube and place in a container of antifreeze. Carefully open the system drain again so that the draining water siphons the antifreeze into the loop through the vent tube.

Use a refractometer to measure the concentration of antifreeze. Dometic recommends the ATAGO Digital Coolant Refractometer (PAL-89S or PAL-88S for Propylene Glycol, available at www.amazon.com or www.mitchellinstrument.com) or equal.

FINAL INSPECTION

Prior to starting the system, conduct a final inspection of the installation using the following checklist:

SEAWATER SYSTEM

- Is the seawater pump properly sized for the system?
- Is the pump wired for proper voltage and correct motor rotation?
- Is the pump oriented correctly and mounted securely?
- Is the centrifugal seawater pump located so as to be below the water line at all times?
- Are the inlet and outlet thru-hulls secure, properly sealed and properly oriented?

- Are all seawater hoses double clamped and tight?
- Are the inlet and outlet pipes connected to the correct fittings on the chiller?
- Are there any loops or dips in the seawater plumbing that might cause the system to become air locked?
- Is the strainer located between the seacock and the pump, and is it correctly oriented?
- Are all valves open or closed as appropriate?
- Sacrificial anode installed upstream of pump?

CHILLER UNIT

- Is the chiller unit mounted securely?
- Are the water connections accessible if it is necessary to remove the unit for service later?
- Are condensate drains properly routed to an overboard discharge or sump?
- Is all wiring connected properly?
- Is the balancing flow control the correct size and properly installed?
- Are the unions tight and leak free?

AIRHANDLERS

- Are the units securely mounted?
- Are condensate drains properly routed to an overboard discharge or sump?
- If only one condensate drain is used, have any other drain holes in the condensate pan been plugged?
- Are the inlet and outlet pipes connected properly?

LOOP PLUMBING

- Are joints tightened?
- Are joints and tees properly insulated?
- Are pipes individually insulated?
- Are pipes fastened securely to the boat as needed throughout their length?
- Leak test loop and repair any problems.
- Does the system have the proper amount of antifreeze? Have you tested it with a refractometer?

AIR DISTRIBUTION SYSTEM

- Is there unobstructed airflow from the return-air grille to the coil?
- Is there a lint screen or filter in the return-air path where it is accessible for regular cleaning?
- Have flexible ducts been pulled tight to remove bends and constrictions?
- Are grilles and ducts correctly sized for the system?

CONTROLS AND WIRING

- Is the return-air sensor properly located and secured in the return air path, out of direct sunlight, and out of direct contact with any metal objects?
- Are all wiring harnesses properly secured?
- Are wiring connections made, color to color, correctly at terminal strips?
- Are plugs and pins properly aligned and securely connected?
- Are all components properly grounded?
- Are proper sized circuit breakers used?
- Are terminal strips located in a dry, safe place and properly covered?
- Check high voltage wiring.
- Check low voltage wiring.
- **IMPORTANT:** Tighten all feed-through terminals and any other electrical connections that use screw pressure to make good contact.

OPERATION

NORMAL OPERATION

The following steps should be followed when starting the system.

1. Switch on all circuit breakers for the air conditioning system at the boat's main distribution panel.
2. Be sure to include the breakers for any pump relays.
3. Open the seawater inlet valve and make sure the seawater strainer is clean.
4. Check to see that all service valves in the circulated water system are open and that 15-20 psi of static water pressure is indicated on the circulated water loop.
5. Switch on the circuit breaker(s) on the control panel(s) for each chiller that is to be operated.
6. Switch on any pump breakers.
7. Using the chillers' controls, turn the chillers on in the desired mode (cool or heat). The pumps and chillers should turn on after a time delay.
8. Verify that seawater is flowing from the overboard discharge(s).
9. Adjust airhandler thermostat set points as desired.

The chillers operate entirely by sensing loop water temperature, and will cycle off when set point is reached. When the loop water temperature changes more than the set differential (due to the airhandlers adding or removing heat from the water), the chiller will cut back on.

LOAD AND POWER MANAGEMENT

One of the advantages of a chilled water system is the ability to manage the heat loads by shifting capacity to the airhandlers that most need it. This happens under normal operation as the boat cools down and the airhandlers shut off at set point. But in cases where the chillers can only be operated at reduced capacity (such as a power supply problem or a unit down for repair), the system operator can effectively utilize the available capacity by turning off airhandlers in areas not occupied, or changing the set points so they have longer off cycles. This "shifts" the capacity to the desired areas.

With multiple chillers, the control panel or panels will normally be set in stages based on loop water temperature, so that only the required number of units will operate to keep the loop water in the desired range. In the case of limited power availability, individual units can be shut down by turning off their circuit breakers. This will not affect the operation of the other chillers.

SEAWATER TEMPERATURE

In extreme seawater temperatures, your Marine Air system may experience a reduction in capacity. In the cooling mode, the best efficiency is achieved when the water temperature is below 80°F (27°C). At higher water temperatures, the cooling capacity will be reduced, but should continue to provide cooling even in seawater temperatures up to 110°F (43°C).

In the heating mode, the opposite is true. As the water gets colder than 55°F (13°C), heating capacity diminishes. However, the unit will continue to provide some heat with seawater temperatures as low as 40°F (4°C).

CONTROLS

Marine Air supplies a variety of controls for airhandlers and chillers. Refer to the appropriate control manual for more information.

MAINTENANCE

DAILY

SEAWATER STRAINER

Check the seawater strainer daily. Remove any debris. If you are in waters where jellyfish or other debris are a problem, you may find it necessary to add a strainer on the outside of the through-hull fitting.

MONTHLY

AIR FILTERS

Dirty filters will reduce airflow and capacity. At least once a month, check the lint screen or filter behind the return-air grille or on the face of the airhandler. Replace or clean if necessary. The pleated, Breath Easy™ microparticle filters should be replaced, not cleaned. Reusable plastic filters should be vacuumed or washed with tap water. Do not use soap or solvents.

RUN THE SYSTEM

It is recommended that systems be operated regularly. Vessels not in use should have their chillers and airhandlers cycled on 30-60 minutes once a month. Vessels in use should cycle on limited-use components in similar intervals to those above. Systems should also be cycled to their reverse mode (cool to heat, heat to cool). This helps to maintain pump seals and internal mechanical contacts, while reducing the fouling effect of marine growth in the seawater circuit.

EVERY THREE MONTHS

SYSTEM WATER PRESSURE

There should be a pressure gauge at the inlet of the circulation pump, near the fresh water fill valve, which shows the loop water pressure. Check the pressure at the inlet to the pump while the water is cold (45-60°F), the chillers are off, and the circulation pump is running. For most boats, the return pressure should be 12-20 psig. If the system pressure has dropped below that, then more water needs to be added. Do not overfill as the expansion tank will not work properly.

If the system pressure drops frequently, then there is probably a leak which should be located and fixed. Check all airhandler and chiller bleed valves for leaks and tighten as needed.

If upper deck airhandlers' bleeders suck air IN rather than discharging water/air OUT, that is also a sign that water needs to be added to raise the system pressure. Whenever an airhandler bleeder is opened, water or air should come out.

CONDENSATE DRAINS

Check the airhandler and chiller condensate drains for obstructions by pouring a quart of water rapidly into the condensate pan. If it does not drain completely within 30 seconds, check the drain outlets for clogging. Remember that many Marine Air systems have two drains, one at each end of the unit.

ELECTRICAL CONNECTIONS

Electrical connections should be inspected and tightened as needed. Heat and vibration can cause connectors to loosen, causing poor contact and voltage drop or arcing. This can cause components to operate poorly, nuisance trip, or prematurely fail. To service electrical components:

1. Disconnect main power supply before repairing or replacing components or wires.
2. Tighten all loose connections at terminal strip and components (contactors, timers, relays, etc.).
3. Inspect connectors for burn marks, frayed wires, etc. If any are found, the connector or connection should be repaired/replaced.
4. Voltage to the equipment should be measured periodically to insure a proper power supply. Pumps, fans, etc. typically allow voltage +/-10% of their nominal voltage rating. Compressors typically allow +/-5%.

SEAWATER CONNECTIONS

Verify that all seawater connections are tight, and check for water flow from the overboard discharge.

ANODE

Check the condition of the sacrificial anode. Replace if necessary.

YEARLY

REFRIGERANT

The modular chiller is pre-charged with refrigerant gas at the factory and is adequate for the life of the system. Routine "seasonal" charging of the system is not necessary. If the refrigerant charge is low, there is a leak which should be fixed before resuming operation.

WINTERIZING

Check for the proper amount of antifreeze in the circulated water loop, especially in extremely cold weather. If the unit is not going to be operated in cold weather, the seawater system should be drained, including the pump head, seawater strainer, and all pipes to and from the chiller.

PUMPS

Remove oil, dust, dirt, water and chemicals from exterior of motor and pump. Keep motor air inlet and outlet open. Blow out interior of open motors with clean compressed air at low pressure. Regularly drain moisture from TEFC motors. Check the pump housing and impeller shroud for excessive wear. Worn or pitted impellers will reduce the water flow and should be replaced. Excessively worn or corroded housings can develop leaks. Any signs of corrosion should be addressed immediately.

AIRHANDLER VALVES

Airhandler motorized water valves should be inspected for corrosion that may bind the gear.

1. With the airhandler off, access the water valve and remove the motor case. Inspect the gears and remove any build-up on the motor gear and/or the valve gear.
2. Dry thoroughly and lubricate with a silicon spray or equivalent.
3. Manually test the gear mechanism using the lever on the top of the valve before reassembly.

SENSORS

All control probes and sensors should be inspected for proper location and fastening. Improperly located and/or secured probes will provide erroneous readings, causing improper operation.

1. Inspect all temperature probes and sensors on the chilled water unit.
2. Those inserted into probe well in the circulation circuit should be inserted all the way into the well, filled with a thermal mastic for efficient heat transfer, and insulated on the end to hold the probe in place and prohibit condensation.
3. Those externally fastened to coils, pipes, etc. should be securely fastened with thermal mastic between the contact surfaces and insulated when necessary to provide accurate readings.
4. Check all sensors at each airhandler for proper location. Water sensors should be securely fastened and insulated on the supply connection (water inlet) of the airhandler. If the built in air sensor on the controller display panel is not utilized, the remote air sensors should be located in the return air stream as close to the cabin area as possible without being in contact with any other hot or cold surface.
5. All sensors should be securely fastened.

AS NEEDED

CIRCULATING WATER STRAINER

Circulating water strainers must be cleaned as needed. New installations and modifications may introduce contaminants. Thus, it is important to check the strainer hourly after any new installation or modification.

Measure and record the pressure drop across the strainer when it is clean. As it gets dirtier, the pressure drop will increase. As soon as the pressure drop has increased by 2 - 5 psi, the strainer needs to be cleaned. Over time, the strainer will clean up the system and maintenance frequency will decrease. Hourly becomes daily, daily becomes weekly, then monthly, or even yearly. Frequency must be determined by experience and good sense. The gauges recommended above will make it easy to know when cleaning is required.

CLEAN SEAWATER CIRCUIT

Condenser coils and seawater plumbing below the waterline can become fouled over a period of time due to marine growth and/or scale build-up inside the coils. This both obstructs water flow and prohibits proper heat transfer, causing continuous compressor operation with high pressures, temperatures and amperages.

- Condenser coils and seawater hoses can be flushed and cleaned by connecting a closed loop system and circulating a solution designed as a scale dissolver. See "Cleaning Condenser Coils" on page 19 for details.
- Most authorized servicing dealers or large boatyards can provide this service.

CLEANING CONDENSER COILS

Condenser coils should NOT be cleaned unless there is a good reason for it. Excessive exposure to acidic cleaning compounds by frequency, duration, or concentration will reduce the life of the condenser with no commensurate benefit.

EXCESSIVE CLEANING WILL VOID THE WARRANTY. Therefore, a factory-approved dealer should carefully document the amps, pressures, temperatures, and water flow rates that justify the coil cleaning BEFORE cleaning the coil. Coil cleaning is NOT a routine maintenance item and should NOT be done unless these symptoms are present: Over a period of weeks or months, dirty coils will gradually cause the head pressure and amperage to rise, while the capacity decreases.

There are two types of condensers commonly used: Coaxial and Shell-And-Tube. The cleaning procedures for both are described below:

COAXIAL CONDENSERS

1. With the system turned off at the circuit breaker on the ships panel, disconnect the inlet and outlet connections of the condenser coil manifolds.
2. Use chemical resistant hoses (MAS white 5/80 I.D.) and adapter connections to connect the inlet and outlet of the manifold to a chemical resistant, submersible pump (MAS PML-500 pump, etc.).
3. Place the pump into a container filled with a 3-5% solution of muriatic or hydrochloric acid and fresh water. Use as large of a container as possible to hold the solution (5-25 gal.). Premixed, over the counter solutions can be used, or mix water proportionately with acid (muriatic or hydrochloric). Caution: avoid spilling or splashing the solution. Follow all warnings and recommendations given by the manufacturer of any acids or pre-mixed solutions.
4. Power the pump and circulate the solution through the manifold for 15-45 minutes depending upon the size of the coils and the extent of the contamination. Visual inspection of the solution in the container should indicate when contamination removal has stopped.
5. Circulate fresh water through the coil to flush any residual acid from the system.
6. Restart the system and check operational parameters (pressures, amperage, etc.) to ensure thorough cleaning has taken place. Additional cleaning(s) may be necessary with extreme contamination.



CAUTION

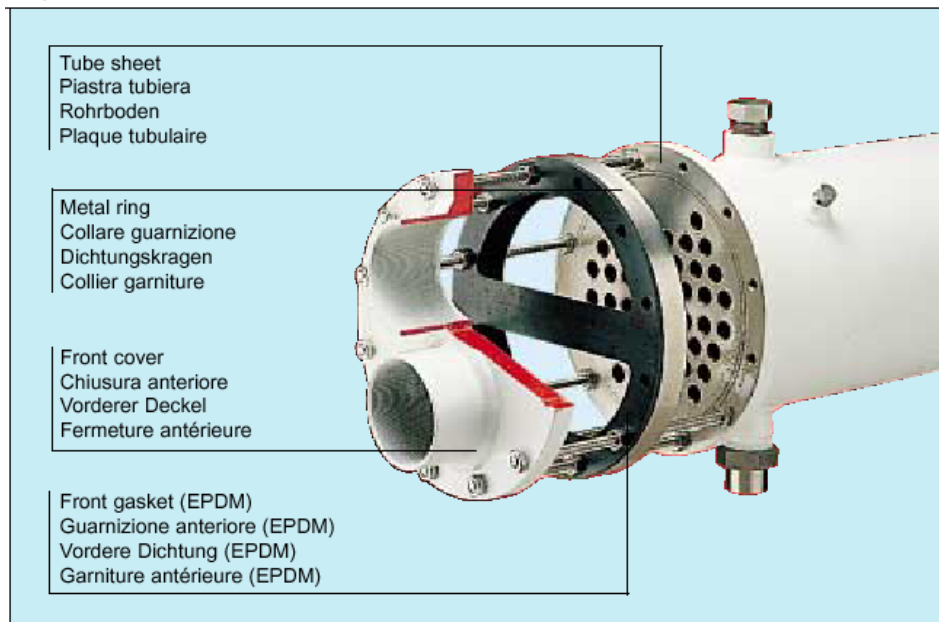
For the purpose of protecting the environment, dispose of any contaminated acid solutions in accordance with federal, state and/or local regulations.

SHELL-AND-TUBE

- **Soft deposits:** Soft deposits are biological growth in the form of mud, slime, and algae. This is best cleaned using a pneumatic tube cleaning gun which forces plugs down the tubes. Some have a brush between two rubber plugs and others are specially designed plugs which scrape the tube walls as they travel down the tube.
- **Scale:** Scale is minerals that have been deposited on the inside of the tubes resulting from the use of water with high alkalinity. These deposits are harder to clean and require special equipment. These systems use a flexible shaft which rotates a brush as it is fed down the tube, they can also simultaneously flush out the tubes with water. There is a wide variety of brushes and tools available that attach to the shaft to clean both soft and hard deposits.

SHELL-AND-TUBE SPECIAL CONSIDERATIONS

Figure 5: Shell-and-Tube Components



FIXING A LEAK - RESPOND QUICKLY!

Shell-and-tube condensers are sturdy and rarely develop leaks. If they do, one advantage of a shell-and-tube is that it can be repaired—IF it is caught in time.

Water flows through the tubes. Refrigerant flows through the shell. If there is a leak, it is very important that water not be allowed to enter the shell. If water enters the shell, the system will be contaminated and the shell itself may corrode inside, damaging its ability to withstand pressure. If water has entered the shell, then the condenser should be replaced.

If the leak is very small and the refrigerant pressure is higher than the water pressure, then water will not enter the shell. Once a leak is detected, close the condenser's isolation ball valves (if any). Remove the condenser's end plate and completely drain the water from the condenser. This will keep water from entering the shell even when there is no more refrigerant pressure. Because there are so many tubes, one (or more) tube(s) can be plugged without significantly affecting performance.

ANODE REPLACEMENT

Some shell-and-tube condensers include one or two sacrificial anodes in the end cover. Those that do are designed to weep a little seawater when the anode is depleted.

1. The anode screws into the anode support. Only the anode needs to be replaced.
2. Remove the end cover from the condenser.
3. Remove the anode support from the end cover and brush the threads clean.
4. Remove the anode from the anode support and brush the threads clean.
5. Apply Loctite 511 to the threads of the anode. Careful! There is a hole in the axis of the anode. Do NOT get any Loctite in the hole.
6. Screw the anode into the anode support.
7. Apply Loctite 511 to the threads of the anode support.
8. Screw the anode support into the end cover.
9. Reattach the end cover to the condenser. See "Bolt Torque" on page 21.

EXTERNAL ANODES

Sacrificial anodes offer protection against galvanic corrosion. If the condenser itself does not have an anode, the installer must provide one separately. Maintain a sacrificial anode in the seawater pipe upstream of the seawater pump. How often it needs to be replaced will depend on the application and the size of the anode. **FAILURE TO USE AN ANODE MAY VOID THE WARRANTY!** See "Sacrificial Anode" on page 11 and "Electrical Grounding And Bonding" on page 12.

CLEANING

See "Cleaning Condenser Coils" on page 19.

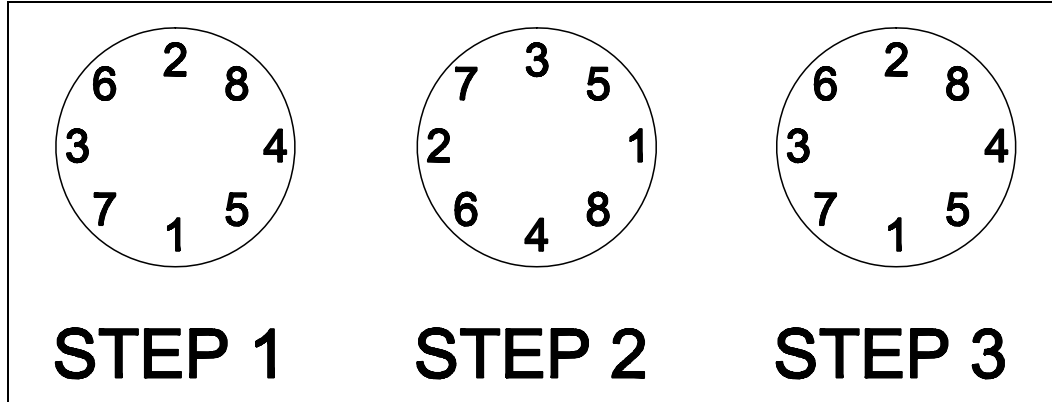
NO STAGNANT WATER

Do not allow water to stagnate in the condenser for more than 36 hours. Leave the pump running, or drain the condenser by removing the end cap.

BOLT TORQUE

When putting the end cap back on, tighten the bolts in three steps:

1. First, tighten all the bolts to 30 foot-pounds in the order shown in Figure 6 for Step 1.
2. Second, further tighten all the bolts to 50 foot-pounds in the order shown in Figure 6 for Step 2.
3. Finally, further tighten all the bolts to 70 foot-pounds in the order shown in Figure 6 for Step 3.

Figure 6: Bolt-Tightening Pattern

EXTERNAL RUST

Due to the strength requirements of a large pressure vessel, the shell is made of steel just like the compressor. Inspect the shell annually for rust. If rust is found, clean it down to the metal, then prime and paint with a polyurethane paint.

TROUBLESHOOTING



CAUTION

Do not leave any safeties (i.e., flowswitch, high-pressure switch, low-pressure switch, freeze sensor) switched/jumped out. They are safety devices designed to protect the system. Damage to the chillers could result if the safety devices are not working.



CAUTION

If a safety trips, it is important to find out WHY it tripped and fix the root problem. For example, a chiller may be able to adequately cool a boat despite the fact that the flow switch trips intermittently. But if a flow problem goes uncorrected, it will likely cause the evaporator to freeze and rupture. This is considered negligence and is NOT covered under warranty. DO NOT IGNORE THE SAFETIES! Find and fix the root cause.

FLOWSWITCHES

CIRCULATING PUMP

The circulating pump should come on as soon as the system is put in either cooling or heating mode. If not, check:

- AC power panel breakers
- Pump relay circuit

AIR IN LOOP

Air in the system can block water flow through chillers. Refer to "Filling And Bleeding" on page 15. Also check if the circulating pump is air locked, especially if pump outlet isn't in vertical position. An air bleeder may need to be installed if not already fitted.

PLUMBING

Is water getting to the chillers? Make sure:

- All valves in loop are open.
- Spare pump (if installed) is valved OUT of loop.
- Water flowing in proper direction.
- Pipe sizes are correct.

WATER STRAINER

If the circulated water Y-strainer is clogged with debris, the chiller may not be getting enough water flow.

FLOW SWITCH OPERATION

All of the above checks assume the flow switch is working properly, and that there is adequate flow through the unit. Otherwise, check the switch as follows:

- Correct micro-switch position is the normally open position (NO).
- Arrow on flow switch should point in the direction the water is flowing.
- If sliding the micro-switch to the normally closed position (NC) eliminates the fault, and there is flow through the unit, then the paddle may be stuck. (Do NOT attempt to change the NO/NC setting on black plastic flow switches.)

HIGH- AND LOW-PRESSURE SWITCHES

High pressure can occur due to:

- Loss of seawater in cooling mode.
- Loss of circulated water in heating mode.
- Refrigerant over charge.
- Fouled condenser coils.

Low pressure can occur due to:

- Loss of refrigerant charge.
- Loss of circulated water flow in cool mode.
- Extremely cold circulating water in cool mode.
- Loss of seawater flow in heat mode.
- Extremely cold seawater in heat mode.

Note that the low-pressure switch (and possibly the high-pressure and flow switches on early control panels) may be bypassed briefly when the compressor first starts. This is to avoid nuisance faults.

A properly charged system running at normal operating loop water temperatures should have a cold and sweaty return line to the compressor. The compressor itself should be hot on top, and cool on the sides.

FREEZE FAULTS/LOW-TEMPERATURE FAULTS

Freeze protection generally senses the discharge water temperature from each chiller module. If that water is too cold, the affected module will turn off and indicate a freeze fault. Note that different controls may have slightly different set points—usually around 33 - 36°F. See your controls manual for more information.

If the freeze control circuit is suspected, follow the steps below:

1. Measure the circulated water temperature differential between the plate coil inlet and outlet. In the cooling mode, a temperature drop greater than 10°F (5.6°C) indicates restricted water flow through the unit. **THIS MUST BE CORRECTED. THE EVAPORATOR WILL BE DESTROYED IF WATER IS ALLOWED TO FREEZE!!** Note that the flow switch should have caught this, so there may be a flow switch problem also.
2. Check that the sensor wells have ample thermal mastic. Check if the sensors are installed correctly, and working. See wire schematic of fault circuit. If you move the sensor to read a warm temperature (i.e., greater than 40°F), the sensor should eventually satisfy and allow the unit to run. You may have to reset the controls. This is for diagnostic purposes **ONLY. DO NOT LEAVE THE SENSOR LIKE THIS!** Do NOT try this unless you know what you are doing. Otherwise, you can freeze the evaporator and cause severe damage.

WARRANTY AGREEMENT

This system may be covered under Dometic's Unit Warranty or Dometic's Part Warranty. For more information, please refer to the specific warranty data sheet packaged with your equipment.

GLOSSARY

- AIRHANDLER:** The fan coil unit that circulates air into a specific area for heating or cooling.
- ANTIFREEZE:** An additive (typically propylene glycol) for the circulating water used to lower the freezing point and inhibit corrosion.
- BACKFLOW PREVENTER:** A device used to prevent contamination of a potable water supply when the potable water supply is temporarily connected to a non-potable system such as for flushing or filling a chilled water system. "RPZ" or "Reduced Pressure Zone" backflow preventers are used when the non-potable water system might contain hazardous substances or pathogens.
- BLEEDER PORTS:** Capped ports connected to 1/4" flexible tubing located on the airhandlers for purging air from the chilled water circulation system.
- BONDING:** In the vessel's electrical system, any metal that might come into contact with salt water is connected to the bonding circuit to help alleviate the effects of electrolysis (follow ABYC standards).
- BTU:** (British Thermal Unit) A common term used to define and measure capacity or refrigeration effect.
- CFM:** Abbreviation for "cubic feet per minute", a term used to specify the volume of airflow through the airhandlers and ducting.
- CHILL CHASER:** An auxiliary electric heater located in the airhandler.
- CHILLED WATER CIRCULATION CIRCUIT:** This is supply and return piping from the chiller to the airhandlers. The supply piping carries chilled water (in cool mode) from the chiller to the airhandlers. Return piping carries warmed water (in cool mode) from the airhandlers back to the chiller. The supply and return piping form a continuous closed loop.
- CHILLED WATER CIRCULATION PUMP:** A centrifugal pump used to circulate the fresh water between the chiller and the airhandlers for heat transfer. Since this pump is located in a "closed loop" system, it does not need to be installed below the water line of the vessel. Whereas the seawater pump does need to be installed below the water line.
- CIRCUIT BREAKER:** An electrical device which provides high current and short circuit protection for the compressor, airhandlers and pumps used in the chilled water system. HACR (heating, air conditioning & refrigeration) type circuit breakers are recommended for the ship's panel. HACR circuit breakers have a long delay to compensate for the electrical surge associated with compressor.
- COMPRESSOR:** An electrical motor/pump that draws cool, low-pressure refrigerant gas and compresses the gas into a hot, high-pressure gas.
- COMPRESSOR OVERLOAD:** An electrical device used to protect the compressor from excessive heat or current draw.
- CONDENSATE DRAIN PAN:** The pan directly under the airhandler's coil for removal of the "condensed" moisture taken out of the cabin air. Two drain spud attachments are provided for connection to drain hoses for proper removal of the water to a sump. There is also a condensate drain pan located under each chiller and the chilled water pump.
- CONDENSER:** The heat exchanger through which heat is transferred between the refrigerant in the chiller and the seawater flowing through the coils and manifold.
- CWMC:** "Chilled Water Master Controller", a type of chiller control related to the DDC.
- DDC:** "Digital Diagnostic Controller", a type of chiller control.
- DOWFROST™** is a trademark of Dow Chemical Company. It is a heat-transfer fluid containing specially formulated packages of food-grade industrial inhibitors that help prevent corrosion.
- ELECTRIC HEAT:** Electric resistance heaters are used as a chill chaser in the airhandlers to warm the air, or in the chiller heater barrels to warm the circulating water in heat mode.
- EXPANSION VALVE:** See "Thermostatic Expansion Valve".
- EXPANSION TANK:** A container housing a diaphragm (20 psig) to cushion against any water hammer in the circulation system piping. It also provides for expansion of the water volume as the water is heated.
- FAN SPEED CONTROL:** An "on/off" switch that also regulates the amount of voltage supplied to the fan motor, thus controlling the speed at which the motor turns.
- FILL ASSEMBLY:** The point where a water hose is temporarily attached to the circulating water circuit in order to fill it. The fill assembly typically includes a ball valve and a pressure reducing valve.
- FLOW SWITCH:** A control device located on the chilled water supply side of each of the brazed plate heat exchangers that prevents the system from operating until water flow has been established, and turns the system off if the water flow is insufficient.
- FREEZE STAT:** A low temperature thermostat used as a control device to sense chilled water temperatures and shut the entire condensing unit off when supply water temperatures in the circulation piping system reach 38°F. This prevents the possibility of rupturing the chilled water evaporator coil, as well as any other piping in the system, due to the water freezing.
- FREQUENCY DRIVE:** An electronic device that can change the frequency (measured in Hz) of the voltage leaving it. It can also convert 1-phase power to 3-phase power, but not vice-versa. It is typically used to reduce the inrush current that would otherwise accompany compressor start-up. Also called "variable frequency drive", "VFD", "variable speed drive", and "VSD".
- FRESH WATER FILL SYSTEM:** Components installed on the return line to the chiller for filling the circulation circuit piping system.
- GPM:** Abbreviation for "gallons per minute", a term used to specify the amount of water flow through the chilled water or seawater system.

HIGH LIMIT SWITCH: A high temperature thermostat used as a safety device to shut down the condensing unit when the water temperature in the circulation piping circuit reaches 120°F. This prevents the possibility of damaging any PVC piping or any other components due to the water getting too hot.

HIGH/LOW PRESSURE SWITCHES: Electrical control devices operated by high and low side system refrigerant pressures respectively. If pressure is too high (425 psig) or too low (35 psig) the appropriate switch automatically opens the electrical circuit and shuts down the respective compressor. These switches reset automatically.

LINE REACTOR: An inductor, like a large transformer - a big coil of wire around an iron block - used to stop the transmission of electrical (NOT audible) noise. It is installed in between the power source and the frequency drive to reduce the amount of harmonic distortion that the frequency drive can impart onto the ship's AC power supply. The frequencies affected by a line reactor are the fundamental AC line frequency (50 or 60Hz) and its first 50 harmonics.

MOTORIZED WATER VALVE: An electrically operated 3-way water regulating valve on an individual airhandler controlled by the thermostat. This valve provides water flow through the airhandler when opened, and bypasses water flow from the supply side to the return side when closed.

PUMP RELAY PANEL (PRP): Used with more than one chiller, the PRP is a circuit board module wired between the chillers and the chilled water or seawater pump (one PRP for each pump). When any of the chillers is turned on to heat or cool both PRPs are energized and switch each pump on. Each PRP should have its own circuit breaker sized for the pump, but not to exceed 20 amps.

REFRACTOMETER: An instrument used to determine the freezing point of the solution (i.e., of the mixture of circulating water and antifreeze). The refractometer determines the refractive index of the solution. Using data provided by the antifreeze supplier, the refractive index is used to determine the concentration of antifreeze in the solution (i.e., the mixture of circulating water and antifreeze). The concentration of antifreeze determines the freezing point of the solution.

REVERSING VALVE: (on reverse cycle units only) An electromagnetically controlled valve that reverses the flow of refrigerant between the condenser and evaporator of the chilled water condensing unit, thereby permitting heat to be extracted from the cabin in the cooling mode and added into the cabin in the heating mode.

RFI FILTER: "Radio Frequency Interference" filter. RFI filters are typically used with frequency drives to reduce conducted, high-frequency electrical noise. RFI filters are typically mounted as a sub-base to the frequency drive. They are installed in the wiring between the power supply and the frequency drive. RFI filters increase the frequency drives EMC rating from Class A to Class B.

RUN CAPACITOR: An electrical storage device used to reduce amperage to some electric motors for more efficient operation.

SEAWATER PUMP: A pump and motor combination that provides a continuous water flow through the condenser coil(s). The seawater pump must be installed below the water line for proper operation.

SEAWATER STRAINER: A housing containing a screen made of metal or nylon to filter out debris drawn into the seawater circuit that could foul up the seawater pump or piping. The strainer must be located between the thru hull inlet and seawater pump.

SMARTSTART™ is a trademark of Dometic Corporation. It is a proprietary device that takes the place of a start relay and start capacitor. It greatly reduces the starting current of 1-phase compressors.

SPIROTOP® is a registered trademark of Spirotherm, Inc. It is a device used to remove air from circulating water. It is typically installed at high points in the system.

SPIROVENT® is a registered trademark of Spirotherm, Inc. It is a device used to remove air from circulating water. It is typically installed inline in the circulating water piping in the engine room upstream of the pump.

START CAPACITOR: An electrical component that assists the compressor by releasing stored current during initial start up.

START RELAY: An electrical device that controls the duration of voltage supplied from the start capacitor to the compressor on start up.

THERMAL MASTIC: Thermal mastic is a paste-like substance with a high heat transfer coefficient. It is used to encourage heat transfer, especially between a temperature sensor and the surface whose temperature it is sensing.

THERMOSTAT: An adjustable control device that senses room temperature, via an air thermistor or sensor, and operates the motorized valve (if installed) on an airhandler for water flow. For example, it is necessary in most sensor wells.

THERMOSTATIC EXPANSION VALVE (TXV): A metering device used to convert high-pressure liquid refrigerant to low-pressure liquid refrigerant.

THRU-HULL FITTING: There are two different thru hull fittings used in the seawater circuit. The speed scoop strainer inlet fitting is mounted below the water and serves as the inlet for the seawater circuit. The discharge thru hull fitting is mounted above the water line and serves as the outlet for the seawater circuit.

TON: In refrigeration/air conditioning, a ton is the amount of heat absorbed in melting a ton (2000 pounds/908 kg) of ice over a 24-hour period. The ton of refrigeration is equal to 288,000 BTU in 24 hours. Divide 288,000 by 24 and get 12,000 BTU per hour. Therefore, one ton of refrigeration = 12,000 BTU/hr.

TWLC: "Tempered Water Logic Controller" a type of chiller control.

Y STRAINER: A serviceable inline device used to filter debris from the water. It has a physical shape reminiscent of the letter "Y".

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