How-To

Install Marine Refrigeration

By Jack and Alex Wilken

Summer is here and with it the warm weather we enjoy, but we need a way to keep food from spoiling. We are writing this month about installing refrigeration in your boat. We all want the most refrigeration for the smallest energy consumption. Of course, lots of insulation and a block of ice does not drain your batteries. For those of you who want to go sailing for more than a couple of days, refrigeration will use power, but your food will be safe and sound.

Converting your boat's ice box and/or building or modifying a space for that use can be a lot of work, but with it comes a world of possibilities. We went cruising many years ago on a 33' fiberglass sloop that had a large ice box, but we converted a small space at the head of the quarter berth into a one cubic foot refrigerator that never drew much power. It had four inches of insulation all around and our 40 amp alternator kept up with that and the other electrical needs on the boat. Today, most people will want two-to-eight cubic feet, and while long distance cruising may be a different mindset, the weekend or fortnight in the San Juans deserves its amenities.

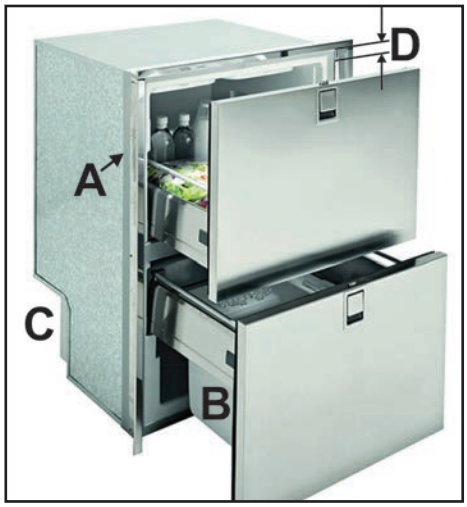

Figure 1: This is a refrigerator designed and built for recreational boats. The pull out drawers give you good access all the way to the back. "A" indicates the mounting flange and "B" shows that the lower drawer has full sides so that not as much cold is lost as with the upper when they are opened. "C" is the open space in the back where the compressor is mounted- not visible in this image. This is the reason why the lower drawer is shorter. "D" is the dimension for the possible thickness of insulation- about one inch.

The simplest system is an electric sealed compressor with evaporator. The evaporator will extract heat from the box whenever the compressor runs. The evaporator is a flat piece of metal, usually aluminum, with tubes formed into the plate that can be formed into a box, freezer compartment, or whatever shape is most convenient. The cooled refrigerant passes into the tubes of the evaporator and heat inside the box is absorbed and removed from the box.

Other systems employ a holding plate that freezes when the compressor does its work. The holding plate actually functions like an ice block that you can keep refreezing. While there are other ways than compressors to create refrigeration they are not as efficient or convenient for sailboats, so we shall focus on compressor driven systems. One possibility is a complete unit with compressor and evaporator all mounted in an enclosure with a sealing door, a completely integrated unit, aka, a refrigerator.

Installing a refrigerator is straightforward, especially once you have the place prepared. You will only need to provide electrical power in the form of wiring and a fuse or breaker: two conductors, positive and negative in the case of DC, and three wires for AC. You will not be able to use any irregular space, and the choice of anything but a top loading unit would mean losing cold every time you open the door. The level of insulation in an off-the-shelf refrigerator is typically far less than what one would install in a well-built box. What they do offer is easy access and usable space. The pull out drawer model (Figure 1) makes the bits way in the back feel like they are right up front while the cold is spilling out - well, you get the picture. One thing when planning the installation of any of these is that they need ventilation.

Once you identify the location of your new box, the next thing is to determine how much insulation is possible. As a general rule, four inches of closed cell insulation with a high R-rating is a good place to start. If you are insulating an old box by securing blocks of foam to the outside of it, you may be restricted (usually on the outboard side, if nowhere else, if it is close to the hull). You can fill in around the blocks with spray expanding foam. If you are building a box from scratch, a box inside a box approach can be taken. Start with a plywood outer box and then build an inner liner which will become the inside of your refrigerator. The inner liner needs to be waterproof with a drain fitting which can be closed and directed into the bilge. It could also empty into a sump to be pumped overboard- without getting anything that might create an odor into the bilge. You could insulate between the outer and inner box by mixing up the appropriate amount of expanding foam and pouring it into the space between the two boxes, but you need to be careful when doing so to fill all the space and brace the inner box so its sides do not collapse inward from the pressure of the expansion. You

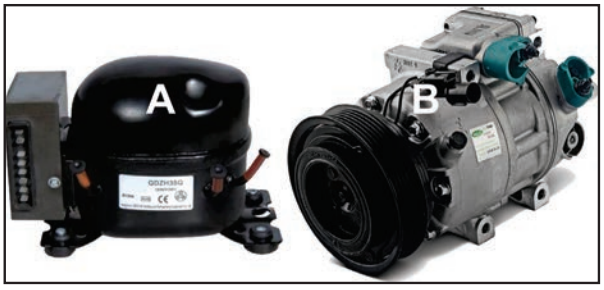

Figure 2: "A" is a sealed electric refrigeration compressor that can run either on 12 - 24 volts DC or 120 volts AC. This is usually paired with an evaporator. "B" is an open, belt-driven refrigeration compressor that can be mounted on the main engine or the generator. It is normally connected to a holding plate.

could instead use blocks of foam and cut, trim and fit around an inverted liner that is then placed into the outer box. Again, be sure to seal the joints; this can be done by fitting and then spraying the expanding foam on the open joint before you push and hold the piece into place. The outer box should be watertight. Epoxy is a good choice, and the inner liner can be made of fiberglass or welded metal, usually stainless steel. The door or lift out should be insulated and sealed with weather stripping or an appropriate seal.

The choice of a compressor is between a sealed electric and a mechanically driven unit similar to the one under the hood of your car for the AC (Figure 2, page 30). Usually we see the sealed electric compressor paired with an evaporator panel or box while the belt driven variety is more often used with a holding plate. These can also be combined into a hybrid system. The idea was that the belt driven unit can cool the plate quickly because of its ability to use a lot of energy over a short time and the cold plate stores energy. On the other hand, the sealed electric compressor uses as little energy as possible to keep an evaporator cool but cycles on and off all day long.

In order to cool or remove heat from inside the box you have to get rid of it outside of the box. There are different ways to do this, but the most common in the past was a small radiator that released the heat into the air from its cooling fins like the radiator in your car. This can be passive or a fan can be used to move the air past the fins. The more effective way to remove the heat is to use water as the medium. This can also be passive or active as the refrigerant tubing can pass through an especially designed thru-hull fitting or a keel cooler (Figure 3), or a pump can circulate water through a heat exchanger. Water conducts heat around 25 times faster than air. This means a refrigeration system using water rather than air for cooling will bring down your power bill and be worth the extra initial cost.

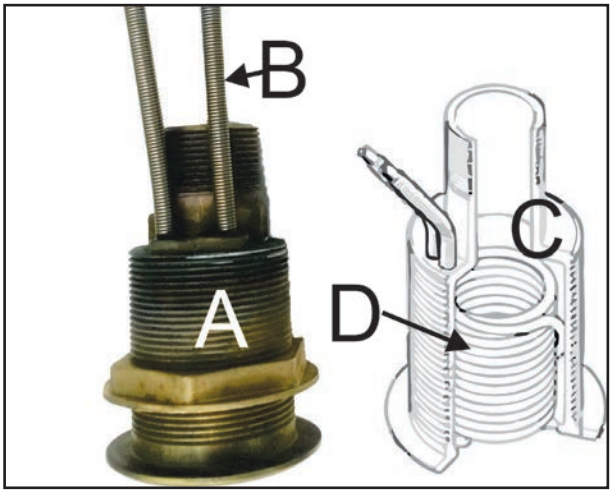

Figure 3: "A" is a special thru-hull fitting, used effectively to water cool some refrigeration systems, that is constructed with coils inside that exit at the top, "B." "C" is a cutaway drawing of the same thru-hull fitting that shows the coils, "D."

If you buy a system designed to convert or upgrade an insulated box to a refrigerator or freezer, it should come out of the box pre-charged with refrigerant and sealed with valves on the individual components.

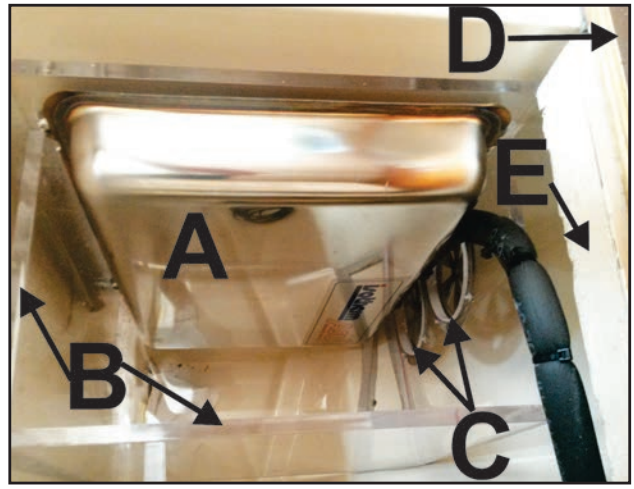

Figure 4: This image is looking into an open, insulated box where the holding plate "A" is mounted in the Plexiglas box, "B". "C" is the adjustable vents that are used to regulate the amount of cold that flows out of the freezer into the refrigerator space. "D" is the seal all around the opening for the lift out, and "E" is the foam insulation on the inside of the top.

These valves allow you to install the compressor, evaporator or holding plate, and possibly a separate heat exchanger and then hook them all together by passing the tubing through a sealed hole in the box and screwing the valves to one another.

The evaporator versus holding plate choice is multifaceted. The up front cost favors the evaporator as do some use conditions. It is possible to cool the box to lower temperatures with an evaporator, and, as long as the boat has a large enough house battery bank or a constant charging ability, shore power or solar, etc., it will maintain the box at a constant temperature. It does not store any excess energy when it is available, like when you run the generator or engine when motoring to get somewhere. It is possible that in the tropics it would run continuously and still not keep the box cold enough; this would depend on box insulation and the size of the compressor. The holding plate is a kind of artificial ice block usually made of stainless steel and filled with a eutectic solution. This solution is designed to freeze at a temperature less than 32° F so the box can be kept at a lower temperature. The idea is that it will stay frozen or store the thermal energy for around 24 hours, but it should be noted that once the stored energy is used, the energy to cool the box is less efficient than an evaporator. This means that each system is more energy efficient under different conditions, so they are both compromises as are most things on a boat. There are systems on the market that try to mitigate this compromise by using a holding plate with a power management module that regulates the speed of the sealed compressor depending on whether a charge voltage is present or not. This means that if you are plugged in at the dock or running your engine/generator it runs the compressor at max speed to cool a holding plate, and, when the boat is on batteries alone, it runs it as slow as it can.

Once refrigeration is installed, its efficiency will depend on it being used under the best conditions for the system - short term high charge holding plates, or low draw long term cycling evaporators using a low charge rate for a long duration, like solar, or a large battery bank - with both types of systems working well at the dock. Holding plate systems can be installed with a Plexiglas box so that the inside of it is the freezer with adjustable vents to allow the cold to spill out to cool the rest of the refrigerator (Figure 4).

Proper maintenance should be done like keeping the door or lid seal renewed and assuring that the seal where the tubing leaves the box stays intact so moisture does not get into the insulation by this or other avenues. Keep the radiator clean of dust and lint, or the keel cooler or coils cleaned off if it is water cooled. We will not make any stupid jokes about "be cool", but it is important to remember that refrigeration is likely to be the largest consumption of energy on your boat.

Jack and Alex Wilken are experienced boat builders and have cruised extensively. They hold USCG Captain's Licenses and are the owners of Seattle Boat Works LLC in Seattle.