Refrigeration for the Cruiser

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Over the past 22 years, first with a CSY 44 and now a St Francis 44 catamaran, I have spent countless hours and way too much money messing with my refrigeration systems. Early on, I needed professional help before attempting modifications, maintenance or repairs. Now, after more than 20 years at it (for me, learning these things takes time), I am a bit smarter and can do most of the work myself. Below find some of what I have learned along the way about refrigeration design and equipment.

Which System

Since the refrigeration system is by far the largest energy consumer on most cruising boats, it is worthwhile having the most energy efficient and reliable system possible. Older systems are based on a big compressor and multiple cold holdover plates. The plates have a eutectic solution inside around the refrigerant tubing that allows running the system for about 2 hours a day. I started in 1996 with a big engine driven Crosby cold plate system, then modified it to work with a ¾ HP Leeson 12v motor, added a separate 3 cubic ft freezer box, and finally sold all that in 2008 and purchased two modern Frigoboat Keel Cooler systems. Two years ago I added the same Frigoboat system to our catamaran and built a new 8 cubic ft refrigerator box.

Modern marine systems based on Danfoss compressors and using thin evaporator plates are much easier to install and understand than the cold plate systems. They are just as efficient, more reliable, require less maintenance, allow a much tighter box temperature differential, half the weight, almost silent running, and less expensive. And since the compressor load is spread over 24 hours, drawing 3-6 amps instead of 30-40 amps, there is little effect on battery voltage when running.

Frigoboat Keel Cooler Installation

Several companies sell a hybrid system with Danfoss compressors and holding plates for those people who prefer that.

Cooling

Using water rather than air to provide heat exchange in the tropics is considerably more efficient, and ensures that the heat goes outside the boat, rather than inside. Using an external keel cooler system, without the need for a fan or water pump, is more efficient still. The Frigoboat keel cooler is the more efficient of the two keel cooler systems available, as there is no constriction around the heat

exchanger. However, you must grit your teeth and drill a 1.5" hole in your hull for the keel cooler. With the Isotherm system, which can be located within an existing thru hull fitting, there must be some water motion in and out.

Boxes

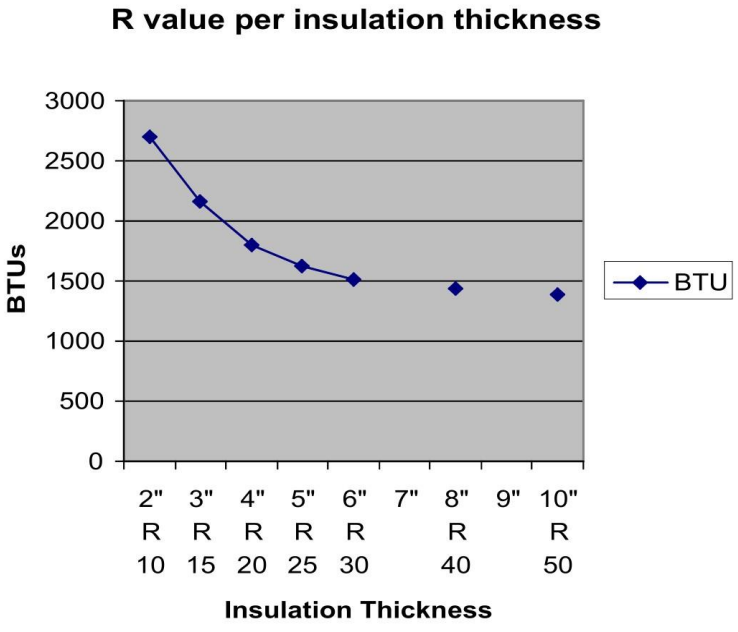
For a refrigerator, a side loading box is far more convenient and can be as energy efficient while cruising as a top loading box (according to Glacier Bay, a well-known refrigeration maker, who did considerable testing). We have found this to be true ourselves, and really appreciate the ease of access to refrigerated items. This is not the case with a freezer, which should be top loading, due to the significantly increased differential between the inside and outside box temps.

I made our current interior box of ½" sheet expanded PVC and the external box of ½" marine plywood well sealed with fiberglass, with insulation between the two boxes. We like a refrigeration box of 8-10 cubic ft and a separate freezer box of 3-4 cubic ft. This gives us a significant storage capacity for chilled items, and the occasional large fish, during a long cruise in the boonies. Having two separate boxes reduces the frost buildup inherent in a "spillover" system. Our amp hour cost for properly constructed, insulated and gasketed boxes of that size with Frigoboat keel cooler systems is a total of about 80 ahrs per day in the tropics. Our 800 watt modern solar system has no problem keeping up with that and the rest of our daily load.

Insulation

Insulation R value is an indication of insulation resistance to heat flow from the warmer outside of a box to the colder inside. The established goals are R20 for a refrigerator and R30 for a freezer. Less than that increases a compressor's run time in order to remove the increased heat in a box. More than that does little to improve efficiency but reduces the available box size, as seen in the chart below.

According to Nigel Calder and Glacier Bay, the best commonly available insulation is extruded polystyrene (such as Dow blue or Owens Corning pink board in one or two inches thickness) with an R value of up to 6.5 per inch at refrigeration temperatures. It also does not absorb moisture. Properly installed vacuum panels have a better R value but are fragile, extremely expensive and subject to puncture damage. Two-part foam absorbs moisture and deteriorates over a relatively short time.



Glacier Bay's R value per insulation thickness

The best door gasketing material is solid ribbed EPDM rubber commonly available at most big hardware stores. Double gasketing is recommended for freezers to reduce heat gain in that area. Test the air tightness all around with a dollar bill slid between the gasket and door.

Compressor
Sealed Danfoss refrigeration compressors are made by the thousands for commercial, marine and household use. Marine direct current BD versions come in three sizes and have variable speeds which allow for adjustable heat removal capacities from an evaporator plate. They are very robust and usually maintenance free for their service life. The compressor itself is immersed in the refrigerant. They are sealed and cannot be repaired, but replacement is relatively easy if the system uses sealed tubing connections. They get quite hot when running and must be cooled by an external muffin fan if running on the higher speeds. There are many inexpensive digital thermostat devices available on the internet as options to the much more expensive thermostats sold by refrigeration companies.

Electronic Control Module (ECU)
This is the small rectangular plastic box that plugs into the side of the compressor. Because it contains electronic components, it is heat and moisture sensitive. Therefore, it should live in a cool dry place. It will have a vertical string of push on connections that accommodate accessories such as fans, thermostats and speed controls. If the number of wires needing access to the main positive and negative connections is more than a couple, it is best to rig a separate terminal block. It is the highest failure rate item in a refrigeration system making it worth carrying a spare. The ECU also determines the electrical configuration of the compressor (12/24v and/or 110v, or 220v).

Capillary Tube
This is the modern equivalent to the older adjustable thermal expansion valve on cold plate systems. Both devices restrict refrigerant flow causing a change of refrigerant state, which allows for heat absorption from the box. Cold plate systems had much larger refrigerant capacities, sometimes exceeding 4 pounds, and often needed valve adjustment. Modern systems typically have 6-8 ounces of refrigerant and need no adjustment. About the only thing that can go wrong with a capillary tube is that it can get clogged with moisture, ice crystals, construction or repair debris, or compressor winding deterioration debris. An inline filter drier will usually prevent this problem. See the Frigoboat website below for detailed instructions about how to trouble shoot this and other system problems.

Evaporator Plate
These are the flat plates mounted inside the box that carry refrigerant and facilitate its transferring heat out of the box. They can be made of soft aluminum or stainless steel. The aluminum is better at absorbing heat but the stainless steel is more robust. Those with top loading boxes should consider the stainless steel units, as there is more chance of damaging the plate from stacked food. They are sold in several sizes that match installation constraints and heat absorption requirements.

Efficiency
In addition to the above recommendations, system efficiency can be significantly increased by running the Danfoss compressor at its lowest speed on a normal basis. More on this next month when we look at refrigeration system maintenance and repair.

Details

Much more detail is readily available in Nigel Calder's 3rd or 4th edition Mechanical and Electrical Manual and in the many excellent refrigeration articles on the Frigoboat website at:https://www.coastalclimatecontrol.com/index.php/blog.html

Or see our website here: http://svsoggypaws.com/frigoboat_installation.htm

Hopefully, the above information will be of use to those of you willing to learn more about designing, building or improving your refrigeration system. At the very least maybe it will be of help to you when you get that first professional quote for installing your new refrigeration system or repairing it later on. For me it gets down in writing down some of what I have learned about refrigeration before my mind's hard drive does a data dump due to old age overload.

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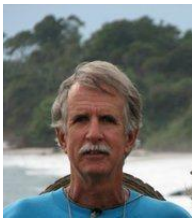

Author: Dave McCampbell is a retired US Naval Diving and Salvage officer with over 40 years cruising and 8 sailboats worth of maintenance experience. He and wife Sherry, currently based in the Philippines, recently spent 8 years crossing the Pacific. They have sold Soggy Paws, their CSY 44 monohull of 19 years, and moved to the 'enlightened side', purchasing in 2015, Soggy Paws, the St Francis 44 catamaran.

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