Refrigeration 101

Most refrigeration systems use pumps to compress a gas into a liquid and harness the expansion process in order to transfer heat from one place to another. The process starts at the compressor, where a refrigerant gas is compressed and pumped through copper tubing. Downstream lies the condenser, which sheds heat resulting from compression.

The units we tested all used air-cooled condensers. Water is far more efficient than air at removing heat, but air-cooled units don't require the complexity and power requirements of additional pumps and plumbing. (Another water-cooled option is Frigoboat's keel cooler, which circulates refrigerant through a custom through-hull fitting. This requires no additional pump and makes sense for boats cruising in southern latitudes.) After the condenser, the refrigerant is pumped to either an expansion valve or capillary tube. These devices precisely meter flow into the evaporator, rapidly decreasing the refrigerant pressure.

The refrigerant transitions into a gas in the evaporator, where the cooling process (actually the removal of heat, measured in British Thermal Units) takes place. Due to their limited capacity, 12-volt DC hermetic compressors are almost always used with aluminum or stainless "direct" evaporators, in which the heat exchange occurs directly at the surface of a metal plate. In some designs, a holding plate filled with eutectic solution is used instead of an evaporator plate, and the solution serves as an intermediary for heat transfer.

The change in pressure at the evaporator plate initiates the final liquid-to-gas transformation, and during this change of state, heat in the box is absorbed by the refrigerant and conveyed out of the box, back to the compressor. Finally, the gas arrives at the suction side of the compressor and reenters the cooling cycle.

Cooling efficiency refers to how much energy is consumed in order to derive a given amount of cooling. Cooling capacity refers to how much heat energy can be removed in a given amount of time. Sound engineering principles dictate the right relationship between box size, evaporator or plate surface area, and the capacity of the compressor. Naturally, a large evaporator and a small compressor is a mismatch in capacity. Ideally, fridge run times of 50 percent or less should be the goal, but hot weather, warm beer, and lots of box opening can change the picture.

The Sea Frost features a stainless-steel evaporator plate (above left) built for durability. Though better at transferring heat, aluminum plates tend to wear out in eight to 10 years.