Cabin heaters require good air circulation to be effective. They also need to be installed so that if used at sea you cannot fall into them on either tack. Both of these installations are out of the traffic pattern. Note the use of tiles as a heat sink to protect surrounding joinerwork.

HEATING

Heating systems vary tremendously with cruising grounds and seasons. For temperate latitudes, even in winter, you can get by with the most rudimentary of systems. But as the latitude increases and/or the cruising season is extended, better heating systems become a critical category of cruising gear.

HEATING BASICS

Several factors determine the best type of heating system and the amount of heat required. The first is outside air temperature, then comes humidity. Water temperature plays a big part in heat load, too.

Next is the insulation level of the vessel. A straight fiberglass laminate, without core, requires perhaps double the Btu of a cored boat. Metal hulls, with sprayed-foam insulation, are among the most efficient to heat, and to keep cool.

In considering heat load, it's also necessary to factor in the amount of hatch area, size of companionway opening (and how often it is opened), and the amount of outside air required for ventilation.

For a 36-degree temperature differential (i.e., maintaining 68 degrees inside the boat when the outside is freezing) a good rule of thumb on sailboats is to multiply the cubic volume of the interior by 12 to get Btu capacity. On powerboats this goes up to 15. If there are 2 inches of foam insulation on the hull sides and deck, these factors can be cut in half.

If water is being heated, if dodger or pilothouse windows are on a defroster, or if lockers are on a warming circuit, add these factors into the equation.

Condensation

Dealing with condensation is as important as heating, in our opinion. Air holds more moisture at warm temperature than when it's cold. So the air inside the boat will have a higher moisture content than that of the outside ambient air. To this normal humidity level will be added byproducts of cooking, showers, and even body sweat.

The result is a high humidity level below. When this saturated air comes into contact with a cooler surface — perhaps a hatch, deck, or hullside — the air cools and can no longer hold its moisture. The result is a film of condensation, leading to drips over your bunk, damp clothes and bedding, and mildew.

Safety

There are a number of safety-related issues with heat. First is oxygen, or a lack thereof. If you're using any form of flame inside the cabin, without a dedicated outside air supply, that flame competes with you for oxygen. If the boat is closed up to keep out the cold, eventually the oxygen will be depleted. Always keep a hatch open when using unvented heat sources.

Next is the heat itself. Convection heaters (both burners and stove pipes on deck), kerosene lamps, and other direct interior heat sources can all cause nasty burns and should be installed where the risk of using them for a handhold is minimal. Even if you decide to use heat only at anchor, the wake of a passing vessel might give you a lurch some day.

While many of the automated diesel heaters have a variety of failsafe systems, convection heaters and other open-flame sources should never be left on unattended.

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Circulating Air

Since warm air rises, you'll find that the air at the deck is probably 15 to 20 degrees warmer that at bunk level. The same fans that cool you off in the tropics can be used to move air down from the deck, and to circulate it from the heat source — perhaps the stove or a convection heater — to other areas of the boat.

Using the Stove

For years we cruised with nothing but the galley stove to heat the boat. With a couple of the burners going, it's amazing how toasty the interior will become.

We have found that for California in the winter, New Zealand in spring and fall, or Cape Town in fall, the stove was fine. (An old-fashioned ceramic flowerpot over the burners will help to radiate heat better).

This was on a solid fiberglass hull, with little insulation value. The negative with stoves is that they don't dry out the interior. Instead, the combustion process adds moisture to the air. Still, for temperate work they're certainly an acceptable source of warmth.

Kerosene Lamps

Surprisingly, kerosene lamps give off a substantial amount of heat. We used to have an amazing model with a mantle to improve combustion. But along with giving off moisture, they eventually leave an odor, and if used for a long enough period they will begin to darken the headliner. As a result, we use the stove more than the lamps.

Convection Heaters

Diesel- or wood-fired heaters or stoves can provide a simple, relatively inexpensive source of heat, using inside air for combustion. Of course, they depend on convection to heat the surrounding air, which then is moved about the boat by natural processes or with a fan assist.

Most convection heaters can be purchased with water-heating coils. These allow you to keep the galley and bathwater nice and toasty, and to circulate hot water throughout the boat if necessary.

I remember walking on ice one winter to a 40-foot steel yacht moored in Copenhagen, Denmark, and marveling at how warm it was below with the little diesel convection heater. In this extreme climate, my hosts lived aboard during the winter. They piped heated water to the sleeping cabins to keep them temperate.

The most critical aspect of a convection heater installation is the smokestack. This has to draw well for the heater to combust fuel properly. That is a function of stack height, location (surrounding structures create eddies), and apparent wind.

One of the major negatives with this form of heating comes when the burner needs maintenance, or when the stack draw is incorrect. Then, instead of a nice clean exhaust, there are clouds of oily soot settling over the deck, sailcovers, and neighbors.

This heater (above) is located at the forward bulkhead on one of our old Deerfoot designs. It should not be used at sea as the exhaust stack makes a tempting handhold.

You can shield the exhaust stack with an open grill (left) to keep body parts away, but still allow good air circulation. Still, the safest plan is to mount the heater where it can't be accidently touched.

For taking the chill off the cabin on occasion, a portable propane-fired heater will work. However, take extreme care to have good ventilation so you are not overcome by oxygen starvation. An infrared heating element is more efficient than the stove.

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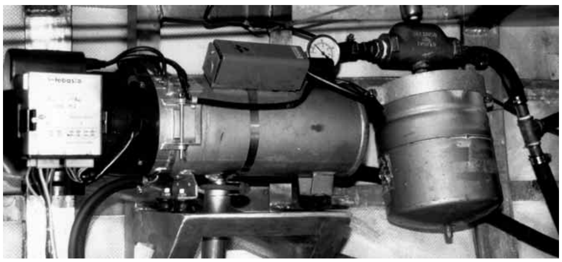
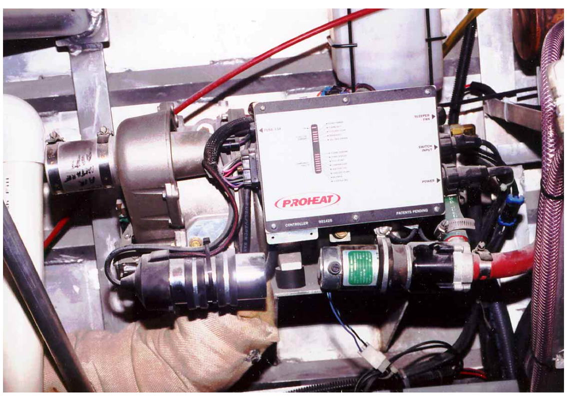
A Webasto hot-air heater. These units work well on yachts up to around 50 feet (15.4 m) in temperate climates and are quite easy to install. The main negative is that the hot-air ducts take quite a bit of storage room.



A 50,000-Btu Webasto hot-water heater installation. Note the large expansion tank (1.5 gallons/7.8 liters) with an air-purge valve mounted on top. This is a closed, pressurized system. The Webasto is a real workhorse — low on maintenance and easy to fix when something does go wrong.



A new Teledyne hot-water heater. This 30,000-Btu unit is computer-controlled and looks like it may be an improvement in some ways on the Webasto. We've tried one on *Beowulf*. So far, it seems to run quite well without maintenance problems. It seems to be somewhat quieter and uses less power than the Webasto.

However, the computer control, which allows you to interrogate the CPU with a portable computer, is a concern over the long haul. Only time will tell.

FORCED AIR

Forced air is a step up in cleanliness, heat output, complexity, and cost. Now that the bugs have been ironed out of many of the systems, they've become very popular with those who cruise in the higher latitudes.

The heaters have to use outside air for combustion and a heat exchanger to heat additional outside air, which is in turn blown into the interior via large ducts. The heater can be located anywhere that is dry and convenient for service. Ducting runs are limited to the 30- to 40-foot range, although auxiliary booster fans can be added. Typical systems take about 50 watts per hour to operate.

The advantage in a forced-air system is fast heating. All that hot air spewing out of the ducts will turn the interior toasty in no time. But therein lies a problem. Because of the fast heating, the heater unit cycles on and off rapidly. And, while on, there are drafts from the ducts as well as fan noise to contend with.

The ducting running through cabinets will dry out the hull sides and lockers to some degree.

HOT-WATER SYSTEMS

If you take essentially the same heater as is used for air and put in an air-to-water heat exchanger, you can now pump hot water throughout the boat. This has a number of advantages.

First, the basic installation is probably somewhat easier since you're using 1-inch (25mm) pipe instead of 4- to 6-inch (100 to 150mm) ducts. Second, since convection radiators are normally used, the on/off cycling and drafts of the air system are eliminated.

Next, if you use copper pipe through the bilges, under bunks, and in lockers, the entire boat can be heated with dry heat, rather than just the living areas.

The engine can be tied into the system as well, helping to start in cold weather and allowing the waste heat of the engine to warm the boat when powering.

At the same time, an extra heat exchanger in the hot-water heater gives an almost unlimited supply of hot water.

Of course there has to be a negative — cost. Typically, hot-water systems are 30 to 50 percent more expensive than air systems.

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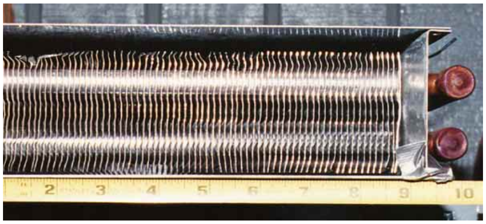
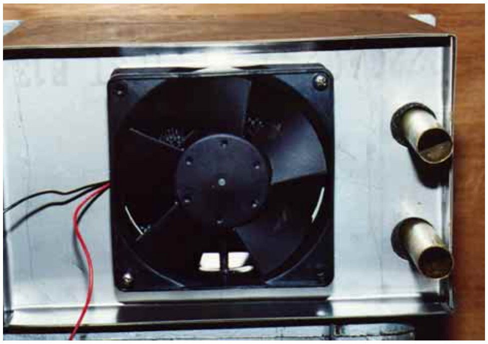




Hot-water heating systems use finned tube convection coils to radiate heat. Used passively, without fans, they will give off from 500 to 1,000 Btu per foot (0.3 m), depending on configuration and air flow. Passive coils are quiet, since there is no fan noise to contend with, and since they require no additional power. However, they take up quite a bit of space.

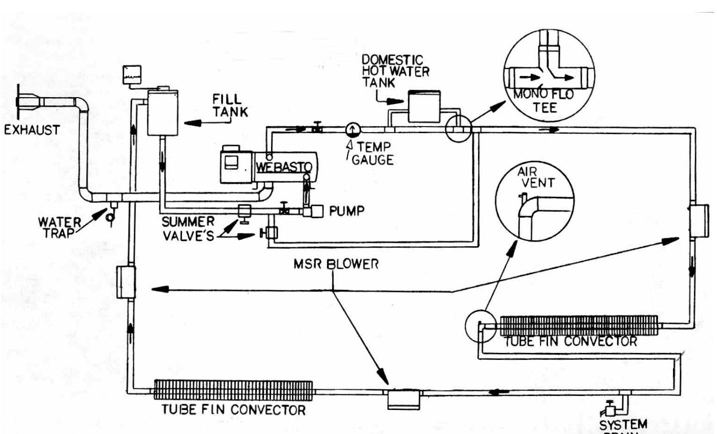
If you add a fan to the equation (left middle photo) Btu ratings jump exponentially. A coil smaller than a shoebox can be used to generate 5,000 to 7,000 Btu's.

With convectors you need an air source at the bottom and an air escape at the top (convection will draw the cool air down low over the coil). Your system's efficiency depends on the size of the slots and their orientation. When you get it right, the result is plenty of quiet, hot air.

Here is a plumbing diagram for a non-pressurized hot-water system from Jim Schimke at Sure Marine in Seattle.

Note the summer valves that restrict water flow to the domestic hot-water tank (for showers and washing), keeping it away from the interior radiators.

Each high spot in the system requires a bleeder valve.



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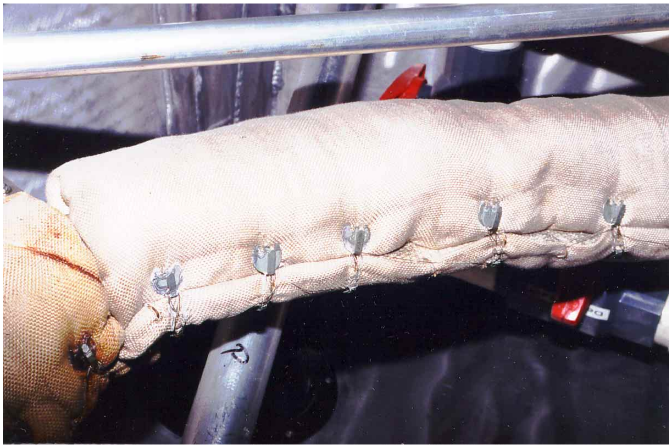
Installation Issues

The first consideration is clean fuel. The fuel-injection nozzle in the heater will be most unhappy with any foreign particles. We fit an extra dedicated fuel filter after the main filters for the heater. Most heaters won't draw fuel from much of a distance, so some form of day tank or booster pump is usually called for. The heater exhaust needs a provision to keep it dry in rain, in following seas, and for expelling condensation. There are flaps made for some exhausts, and a plug or gate valve will be necessary in heavy weather.

Obviously, good access for maintenance is a major consideration.

With hot-water systems there's a choice for radiating heat of using finned convectors alone or in combination with fan coils. Since the convectors are a fair amount of work to install attractively, frequently a combination of the two approaches is in order.

With any of the dedicated heating systems, there are a variety of tricks to getting the system right, as well as a host of small bits and pieces required to do the job (which really add up in cost). It's always better to work with a supplier familiar with the equipment you'll be using. We've found Sure Marine in Seattle to be extremely knowledgeable about most of the systems on the market.



With a heater that exhausts through the deck, make sure that heat is dissipated into the surrounding air rather than into the deck structure (especially if fiberglass). The "heat sink" in the upper left provides a finned mass around which air can circulate.

Exhausts from hot air and water boilers need to be lagged with insulation to protect nearby body parts or stowed gear from burns. Lagging typically is supplied in blanket form with hooks that are tightly wired together. We use multistrand stainless-steel seizing wire.

While boiler units have internal fans to force combustion air into and/or out of the boiler, drip-fed diesel heaters and stoves rely on convection and ambient wind for their draft. The shape of the smoke hood is therefore critical. Properly designed and installed, it will work well. Otherwise, the heater will smoke and operate fitfully.

This is very much a trial-and-error situation. When you get it right, the result is a clean flame (and clean decks).

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All sorts of copper fittings (above) are available for your hot-water system. Keeping the bends a generous radius reduces the chances of trapping air and makes it easier for the pump to push the hot water around the system.

The lower photo shows an air-purge valve, mounted at the very highest point in the system, usually right near the boiler.

Air tends to accumulate at every high spot in the system. The easiest way to deal with this is to have little spigots at each high spot. Just make sure they are easy to get to. Once the air is out of the system, until it is used again you should not have to access these.

Plumbing Design

There are two basic issues in plumbing a hot-water system — heat distribution and maintenance. Because water is being cycled throughout the system, it's very important to get all the air out of the pipes. Otherwise, the air forms blockages that slow down or stop the water flow.

Good layout helps with water flow. The heater should be at the top of the system. The plumbing runs should be constant in angle, avoiding droops and loops that could trap air. Of course there will be ups and downs as the pipes enter and leave various heat convectors. At each high point a vent must be installed to allow for bleeding. Remember when installing these that several times a year someone will have to open the vent, bleed the air, and clean up the liquid that comes out at the same time. If access is limited, sometimes it makes sense to braze on a piece of pipe or a fitting for hose and carry this up to a spot with better access and drainage.

Next, a drain at the lowest point is helpful for both emptying and reloading the system. I like to have a combination pressure/temperature gauge at the same spot. To make refilling easier, plumb in a direct connection from the pressure freshwater system.

At the top of the plumbing loop, next to the heater, will be located the circulating pump. Regardless of pump type, eventually the seals will go bad from the heat. To make it easier to change the pump, put a valve on each side. This allows you to open the circuit to remove the pump without introducing air back in.

Next, there will be some form of an air-purging device, a header tank or an expansion tank (if you're using a closed system). The air bleed should be the very highest fitting in the system.

Piping

Connecting all the fittings will be a combination of copper pipe and (high-temperature) rubber hose. What is used depends on heater capacity and how much heating/drying is necessary between the interior and the hull side.

If pipes are insulated, all heating capacity is devoted to the living spaces. But this probably means condensation inside lockers and under bunks.

If the heater has the capacity, leaving plumbing exposed does wonders for condensation. Depending on how the plumbing is run, rubber hose radiates about 50 to 70 Btu per foot, while 3/4-inch copper pipe radiates 100 to 150 Btu. If the plumbing is low in a locker and raised 1 inch off the furniture (so air can circulate all the way around and then rise), it will be most efficient.

In the foul-weather-gear locker, 24 feet of pipe in the shape of an M, with a pegboard covering to keep foulies from burning, will dry out wet gear and jackets. Twelve feet of copper under each mattress (again with pegboard covering) eliminates condensation. Stainless pipe can be configured into ser-

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If you tie a towel rack into your heater system (left), you'll end up with warm towels and faster drying after a shower, together with a toasty head compartment.

However, remember to put an air bleeder at the top of the pipe. Care must also be taken with protecting your body from coming into contact. This photo is from one of *Sundeer*'s heads. When the heater was on we had to be sure a towel was always over the rack. Otherwise, if you weren't careful sitting down, you'd get a rude surprise!

An expansion tank is required as the liquid in the heating system expands as it heats up. To ease the air-bleeding process and future maintenance, some form of connection to the pressure water system is a help.

Note the temperature gauge mount just after the heater.

pentine towel racks to heat the head compartment and provide warm dry towels. When this is done the towel racks should be plumbed in parallel with the normal circuit, with a T between circuits and a valve to adjust water flow and rack temperature.

Btu Capacity

When the system is worked up on paper, the total Btu requirements of plumbing, water heaters, interior fan, and passive coils all must be added together. Ideally this total will be less than the full capacity of the heater unit. For full-time usage, the heating engineers like to see a 40- to-50-percent duty cycle. So if there's a total of 10,000 Btu in the heating circuit, the heater should be about 20,000 Btu (although most of the systems will run for long periods at 100-percent duty cycles in really cold weather).

Water heaters will have an aquastat — or temperature-sensing device — at the heater to turn it on and off as the water heats and cools. These usually have a range, turning off at about 170 degrees and on at about 135. The greater the differential between the on-and-off point, the more efficient the system will be on electrical consumption.

There are two basic ways to deal with the exhaust on diesel boilers. One is corrugated stainless steel, as shown here. However, over four or five years with heat and salt air, it will start to leak. The other approach is to use mild steel exhaust tubing, like on a car. Yes, it does rust, but it seems to last as long as the stainless and can be fabricated to your exact requirements.

Windshields

Windshield defogging is a special art, requiring lots of air movement (CFMs) and Btu to get the job done. Red Dot makes several popular squirrel-cage blowers (designed for truck cabs), frequently used on power- and sailboats. But these babies take a lot of power! One of the larger units consumes 120 watts while delivering 26,000 Btu at 290 CFM. Obviously this is something that's run only occasionally under sail. In moderately cold climates, natural thermocycling between the cockpit and interior can be used in lieu of a permanent defogger.

On *Sundeer* we decided to try the hot-water system, since we were planning some high-latitude cruising, and both Linda and I have an aversion to being cold. We ended up working with Jim Schimke and Sure Marine. He was most helpful in getting this tropical sailor up to heat, and while I grumbled at the space we lost to all of the heating units — not to mention the added complexity — the first time I stepped down into our toasty interior and slipped under warm, dry bedding, I was seduced!

Electrical Consumption

The only big negative of this category of heaters is their electrical consumption. Added up over a 24-hour period, it can be substantial. Considering that refrigeration needs will increase as you heat, there's a double hit. This means heating needs must be factored into battery-bank size and charging capacity.

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