Boat Heat

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By Terry Johnson, University of Alaska Sea Grant, Marine Advisory Program
4014 Lake Street, Suite 201B, Homer, AK 99603, (907) 235-5643, email: rftlj@uaf.edu

My first boat, a small diesel hand-troller, was heated by a cast-iron Washington Stove Works wood burner. I beach-combed bark and driftwood from shore and stored it in bins in the engine compartment. The stove emitted a cheery crackle and the stack a pleasant woody aroma when the stove was fired up, and since the entire living space was only about 20 square feet, it put out plenty of heat. But the firebox was so small that the thing would go out in less than an hour if it wasn't continually stoked, and debris from the wood bins choked my bilge pump. Plus I had to take a trip to shore every couple of nights to search for fuel. When I finally pitched the old Washington and installed a used bulkhead-mounted oil burner, I entered the lap of luxury.

That early experience highlighted the key characteristics of a good boat heating system:

- Keeps the interior living spaces warm and dry
- Is simple to operate, reliable, and relatively trouble-free
- Is compatible with the other systems in the boat
- Is economical to buy, install, and operate
- Is safe to use in the harsh working environment of a boat.

These five criteria are not easily met. Boat heating presents some difficult challenges and the solutions tend to be more complicated and expensive than one might expect.

Heat can be transferred into a living space via *radiation, convection, forced air,* or a combination of the three. These terms describe how the heat gets into the living space, not how it is produced.

Radiation is simply heat energy moving outward from a warm object into the surrounding atmosphere. If your boat has a diesel range or bulkhead heater, heat radiating from the body of the unit warms your living space. Likewise, systems that circulate hot water through radiators or finned tubes in the living spaces, and electric baseboard heaters, rely on radiation.

Pot burners remain popular on smaller vessels (Dickinson Model 00-BER).

Convection occurs when warm air rises and cool air sinks. The top of your oil range heats air that rises to the cabin ceiling and then spreads throughout the room, warming areas that don't benefit from direct radiation. Convection through radiators also distributes heat more evenly through spaces.

The simplest type of *forced air* heating is the "Red Dot"–type fan heater that uses engine coolant, circulated through a heat exchanger with a fan, which blows heated air into the living space. Two types of dedicated diesel-fired furnaces also distribute heat via forced air. One type employs a burner to heat the air and then blows it through ducts to registers in the living compartments. The other heats water (actually, a coolant mix) and pumps it through tubing to small fan heaters or finned tube radiators. The system is sometimes called "hydronic."

Types of Heaters

Several different types of heating devices are available for use on boats.

Fan heaters and radiators that use circulating engine coolant are very efficient but only work when the engine is running.

Electric space heaters, similar to those made for home use, can be installed or set up as temporary heat sources. They require a steady source of 110 volt AC power and draw too much amperage to work off an inverter and batteries for any length of time.

Vented propane bulkhead heaters are attractive, safe, and quite clean if proper propane connections and exhaust ducting are used. Continuous operation would quickly deplete a standard propane tank but for short duration use (a few days or less) they are convenient. The exhaust pipe exits through the ceiling or side of the boat.

Diesel pot burners use the same fuel as the main engine and distribute heat by radiation and convection. Exhaust is closed and exits usually via a flue or stack through the ceiling.

Diesel forced air furnaces use the same fuel but burn it in a chamber with an air-to-

air heat exchanger and a blower that distributes the warm air via ducting. The exhaust system is closed, usually through the ceiling or side of the boat.

Diesel "hydronic" or circulating coolant furnaces use an air-to-water heat exchanger to heat a coolant fluid, and a pump to circulate it to individual radiators or fan heaters. The exhaust system is closed and exits the ceiling or side of the boat.

Kerosene, white gas, and alcohol *portable heaters* are sometimes sold for marine use. They are non-vented, and the exhaust is open and introduces water vapor to the living space. If the space is not adequately ventilated this can cause oxygen depletion and carbon monoxide poisoning. These portable heaters have no place on an enclosed boat.

No type of open flame burner should ever be used for boat heating, including alcohol, kerosene, or propane burner cooktops or other open cooking devices. The risks of starting a fire, and of carbon monoxide poisoning, are too great. Under no circumstances should a Coleman stove or other portable gasoline or white gas appliance be used onboard, either for heating or cooking. A sharp roll could dump it on the floor, causing explosion and fire.

Pot Burners

Unless continuous engine heat or AC power for electric heat is available, some form of vented fuel burner is usually the most practical type of heater on a boat. The main choices are a passive system that distributes heat through radiation and convection, or an active central heating system that uses either hot air ducting or fluid piping to distribute the heat.

Most small vessels use the good old reliable diesel oil pot-burner, either a cookstove or a dedicated space heater, floor- or bulkhead mounted. They've been around for decades, use the same inexpensive fuel as the main engine, have no moving parts (other than a boost fan to create draft during startup), and with occasional cleaning and tinkering are virtually foolproof. Fuel is supplied by gravity from a day tank, or by a low-pressure (1.75-3.5 psi) electric pulse pump. The fuel meter—often called "carburetor"—is a simple adjustable float valve device that with the twist of a dial allows more or less fuel into the combustion pot. The valve control handle has little set screws that allow adjustment of maximum and minimum flow, and a fusible link that melts and shuts off the fuel if it gets too hot. The valve also is designed to stop the fuel if the fire goes out.

Sigmar has an optional temperature limit system which attaches to the flue that activates an electronic solenoid which cuts off the fuel.

Some old style pot burners use drip valves, which have no safety shutdown features and have been responsible for many a boat fire. A screw valve and a section of clear tubing allow monitoring of the fuel flow by counting the drops. There are still some around and they are simple to use and almost maintenance free, but should never be left unattended.

Two British Columbia–based companies, Dickinson and Sigmarine, the Danish firm Refleks, and the Swedish firm Nordic, all build attractive and efficient pot burner space heaters. Dickinson and Sigmar also make galley ranges. The compact bulkhead-mount units probably are the most popular heaters. Some of the slightly more bulky floor-mount types have the added advantage of a small cast iron stove top which can serve as a warming space for a coffee pot or even as a small cooktop. Most models use three-inch stainless flue pipe with through-deck fitting and flue pipe (cookstove pipe commonly is five inches) and the flue may be fitted with a safety shield and a barometric damper to prevent overheating in windy conditions. Prices range from about $500 to $1,000 for the heaters, up to about $2,000 for larger cookstoves, and components including flue pipe, deck ring caps, pumps, fuel filter, fuel line, etc., can add $500 to the total.

Some models have the option of installed water heating coils, although the option doesn't seem to be very popular. Some Refleks and Nordic models are designed with heating coils and optional panel radiators to provide remote space heating.

Sigmarine, Refleks, and Nordic offer a "balanced draft" option whereby combustion air is drawn through a pipe from outside the boat, rather than using ambient air inside the living space for combustion. The advantages: the stove doesn't draw cold air into the boat, there is no backdraft if the engine is sucking air from the living space, and downdrafts are less likely in windy conditions. Disadvantages: more expense plus additional space required for the pipe and fittings.

One downside to pot burners is that they don't burn as cleanly as furnaces, which have combustion air blowers, and some of the unburned fuel goes up the stack as smoke. Over time the stack will dust the boat's topsides with a fine layer of soot.

A variation on the pot burner for radiant heat is the propane burner. Dickinson and Force 10 offer compact and attractive bulkhead-mount units that vent via a flue pipe so no moisture or carbon monoxide enter the living space. Force 10 also makes a very small kerosene/diesel bulkhead heater that uses fuel from a special tank pressurized by a bicycle pump.

Central Heating

The chief disadvantage of the pot burner is that one unit effectively heats only one space, and heat doesn't flow downhill. A heater in the pilothouse isn't much help for the berthing area in the forepeak, let alone for separate cabins. Forced air furnace systems effectively distribute heat through all crew spaces, and coolant or "hydronic" systems do that and more.

Espar and Webasto are the big names in mobile central heating. Both companies build heaters for buses and trucks, and the units available for boats have been "marinized" with different wiring, terminal panels, and other components. Each company builds both forced air and coolant models in several sizes. Most units burn diesel fuel from the engine's tanks, are thermostatically controlled, draw combustion air from outside the boat, can be fitted with ducts and multiple registers or outlets, and are self-regulated by microprocessors to shut down automatically in case of overheating, low voltage, or other problems. They are designed to be installed in the engine room or in locker space out of sight and out of the way. Ducting or tubing is routed through lockers or storage areas, where a small amount of escaped heat helps keep storage spaces dry.

The furnace unit complete kits sell for prices ranging from about $1,000 for the smallest 7,000 btu units to over $5,000 for the big 40,000 btu burners. But the furnace is only the start; there is the fuel pickup and line, flexible exhaust hose and through-hull, electrical supply wiring and thermostat controls, plus ducting and registers for the forced air system. Coolant systems are more complex, with rubber tubing, water expansion tank, heat exchangers with blowers or radiators, shutoff valves, and extra connections to plumb the system into house water heater tanks and engine heat exchangers. It's easy to spend from $2,000 to $10,000 for the components for either type of system, depending on size, and as much as $20,000

Central “hydronic” systems heat multiple cabins, water, and more.

for a complete coolant system installed.

An additional consideration is electrical consumption. The newer designs and smaller models draw modest amounts but the medium and larger size units all draw at least a couple of amps at 12 volts, and the bigger ones like Espar’s D12L suck a whopping 16 amps when running.

While Espar and Webasto have long dominated the marine central heating market, they are challenged by several other makers. Ardic and Wallas are two brands from northern Europe, sold mainly into the yachting market by Scanmarine Equipment, Inc. of Seattle. Wallas makes only forced air units, in sizes ranging from 4,000 btu to 14,000. Ardic, made by Volvo, offers 12,000 btu forced air and 16,000 btu hot water models. Toyotomi offers a compact and inexpensive forced air unit that is thermostat controlled and rated at 9,800 btu. It runs on #1 diesel or kerosene. Toyotomi and Wallace also make vented diesel fired ceramic stove tops with blower options that double as forced air space heaters.

A couple of relative newcomers are competing in the coolant or hot water market. One is the Proheat X45, made by Teleflex in British Columbia. Also adapted from a truck heater, it is rated at 45,000 btu and the basic kit including burner, controls, exhaust system, plumbing, expansion tank, and fan heater sells for around $3,500. Another is called Hurricane, and includes six models ranging in output from 20,000 to 105,000 btu. It is made by International Thermal Research and is used in high-end yachts.

Hot Air or Hot Water?

Forced air heat is simpler, and more economical to install. The trick is to find space to route the 4-inch ducting. Control is by a central thermostat that sets the output for the whole system, so all spaces connected to it are heated at the same rate. Most units have the capacity to draw the makeup air to be heated (not the combustion air) from both interior and exterior areas. If only outside air is used too much energy is required to heat it, and if only interior air is used moisture and smells are recirculated inside the boat. Mixing outside air keeps the boat interior drier and fresher.

Coolant or hot water heat has some distinct advantages. It can be adapted to heat domestic water. By plumbing the hot water through a water-to-water heat exchanger the heater will preheat the engines which makes them start more easily in cold weather and prevents excessive engine wear. The same heat exchanger allows the engines to heat the boat while underway without running the heater’s burner. And hot water systems can be divided into zones for each living space to be heated, each with a separate control, so the different cabins can be kept at different temperatures.

People who have coolant systems seem to like them for the comfort and convenience they afford. The downside is they take up a fair amount of space, and there is a lot of installation work involved so they are much more expensive than forced air systems. The basic components alone are about the same price but the labor really adds up. Dealers estimate 80-120 hours of technician time at $55-75 per hour (Seattle rates) compared to 35-40 hours to install a forced air system. Reported experience, however, is that installation takes more like 120-160 hours. Which means that with all the bells and whistles, a complete medium size hydronic system can cost $20,000.

Whichever type is selected, it must be properly sized for the job. The standard formula is to total the volume of all the spaces to be heated in cubic feet, and multiply by 15 btu. For example, a single cabin 10x8x6.5 would need 7,800 btu capacity. For wintering in Alaska, multiply to 20 btu. True, you could take the chill out of the air with less heat, but remember that if the furnace is thermostatically controlled, it will continue to run until the room temperature reaches the set level. If the heater is only marginally capable, it will run continuously, which will cause it to burn out quickly. Unlike pot burners, furnaces are made to cycle on and off frequently so that the motors and fans can cool.

Maintenance and Troubleshooting Tips

Every heater requires some maintenance. Burners and exhausts have to be checked and cleaned, fuel filters replaced, and electrical contacts examined and treated with corrosion preventive. Burners and burner components wear out after time and must be replaced. Servicing should be done about once every two years. Dealers say the furnace owner should plan on spending an average of $200 a year on routine maintenance and more when overhauls are due. An owner with the time and skills can do some maintenance, but other work requires a specialist. Usually furnace burners have to be removed from the boat and sent in to a shop for repair.

Pot Burners

- Provide clean fuel, preheat adequately to vaporize incoming fuel, maintain adequate draft, and they are pretty reliable. The little boost fan, on models that have one, wears out after a while but is easy to replace. If the glass window gets blacked out by soot the burner probably needs to be cleaned. Sooting up can occur if the heater is run too cool.
- Fuel viscosity affects the way it flows through the fuel meter. Diesel #1 and #2 have different flow rates and heat outputs so the meter should be adjusted when changing fuels.
- If your boat tends to list or heel to one side for periods of time, ensure that the heater is installed so that the fuel meter and combustion chamber are in line fore and aft with one another. Otherwise, when the boat is heeled the burner will either starve

out or flood, and flooding a working burner can set the boat on fire. An athwartships alignment is OK if the boat merely rolls, but the burn will speed up and slow down as the boat rolls from one side to the other. If the boat is beached, put on a grid, or left unattended the heater should first be shut off.

- Unless the model has the "balanced draft" feature that draws combustion air from outside the boat, it is essential that the boat is adequately ventilated so that oxygen inside is not depleted.

Forced Air and Hot Water Furnaces

- Correct installation is critical, and each make is different. Some must be mounted perfectly level in the boat.
- The heater needs its own fuel system—either a dedicated tank or a separate draw tube in one of the main fuel tanks. Do not tee off of an engine fuel line.
- Routing of ducting and plumbing must be carefully planned. Instructions dictate the length of ducting runs and the total degrees of bends in ducting. Too many bends or constrictions not only decreases performance, but can cause the unit to overheat. Frequent automatic shutdown often points to overheating caused by restrictions in the ducting.
- Another cause of unintended shutdown is low voltage. Some units are very sensitive to voltage because they are designed to run off batteries that are constantly being charged. When the engine isn't running the heater burner and blowers quickly deplete voltage enough to trigger the shutdown mechanism. The answer could be shorter and heavier power leads, bigger battery capacity, or running engines or genset more frequently.
- Think carefully about exhaust outlet placement. Through-hull or through-cabin side exhausts are neat and convenient but it is important to determine sources of fresh air to the boat's interior and ensure that in any wind condition the exhaust can't be sucked back into the boat. This is especially important on installations where makeup air for the blower is a mix of interior and outside air. A boat that is tied to a dock or pier, for example, may experience breezes from the quarter or stern that could push exhaust into air intakes. Diesel burners produce carbon monoxide and have been implicated in fatalities.
- Plumbing for coolant heaters must be carefully installed to ensure that there are no air pockets or places that could trap bubbles that would stop the flow of fluid. A heater can burn itself out if vapor lock prevents proper fluid circulation.

With any kind of heater installation it is a good idea to install a smoke detector near the burner unit and carbon monoxide detectors in the living spaces.

Boat Ventilation

There is more to keeping a boat warm and dry than just producing heat. Proper air flow through all the spaces of a boat helps distribute heat, remove moisture, prevent rot and mildew, and keep the interior smelling fresh.

In his irreverent book *The Warm Dry Boat,* Roger McAfee describes how he uses smoke from his cigar to analyze a boat's ventilation. He details how to improve comfort aboard by making small changes to increase the boat's passive ventilation and, if necessary, how to augment it with mechanical ventilation. In cool conditions it may seem counter-intuitive to open portholes and vents, but often that's what is required to circulate heat and remove heat-robbing moisture. For more information on *The Warm Dry Boat* contact the author at Romac@Radiant.net. ◆