Proper pump installation is as essential as maintenance. On this engine's raw-water pump, the sharp bend in the copper pipe will reduce flow and cause the pipe to erode at the bend.

SPRING MAINTENANCE BY STEVE D'ANTONIO

Know Your Pumps Inside and Out

The flawless flow of fluid depends on components that pulse, spin, and flex

NOT SO LONG AGO, I WAS walking down to a dock in Annapolis and saw smoke billowing from a boat's companionway. After the owner had shut down the boat's electrical system, he emerged from below, red-eyed and coughing. His domestic-water pump had caught fire. While trying to flush his water tanks, the owner had emptied and filled the tanks three times without giving the pump a rest. The pump overheated and ignited nearby insulation.

That's certainly one way to learn about your pumps. Fortunately, for folks who prefer not to puff on burning insulation, it's not the only way.

Pumps are essential to any cruising boat. They keep our bilges dry, our engines cool, and our marine heads flushing. The average cruising boat has more pumps than you might think. The engine, which is itself a large piston-style pump, has over half a dozen individual auxiliary pumps—the fuel-lift pump, the raw-water pump, the coolant-circulator pump, the lubricating-oil pump, the injection pump, and the alternator fan, which is a centrifugal air pump. The transmission has its own hydraulic or lube-oil pump.

All of these pumps are just for the power plant. Your boat's other systems require their own myriad pumps. So many different pump designs and applications can exist on a boat that even folks who think they know all about them may have to learn a few important, yet often overlooked, details the hard way.

The following profiles of the most common types of pumps will give you the background you'll need to put the wet stuff where it belongs reliably and efficiently—without singeing your eyebrows.

Impeller Pump

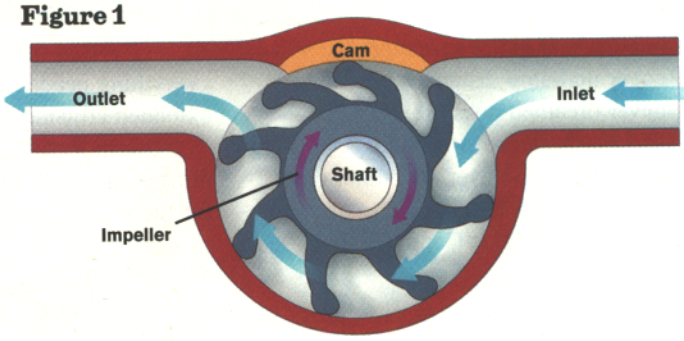
Pumps fall into two general categories: those that are self-priming and those that aren't. A self-priming pump will draw liquid from some point above the liquid's surface. The ubiquitous rubber impeller pump, also known as a variable-volume pump, is probably the most familiar self-priming pump aboard.

In an impeller pump, a flexible impeller turns in a housing made of bronze, plastic, or stainless steel. A small cam is mounted inside the housing. Each time an impeller blade passes over the cam, the blade is compressed. It then flexes back into shape after passing the cam. In the process, a vacuum is created between two blades. This draws in water or air, which is carried around to the exit port. The water or air is expelled when the cam compresses the blade again. (See Figure 1 below.)

This is the kind of pump that typically delivers seawater to a marine engine. Some domestic-water and washdown systems also rely on impeller pumps. They're ideal when you need self-priming, but they'll suffer damage if allowed to run dry, and they can't pass solids.

Impellers for flexible-impeller pumps are cast in various materials. Neoprene, the most common material, is flexible and durable. However, it's particularly susceptible to hydrocarbons such as fuel and oil and to some cleansers. Nitrile, however, will pump diesel and oil quite happily. Viton is also more resistant to hydrocarbons than neoprene is. One manufacturer, Globe Rubber Works (781-871-

Figure 1



FLEXIBLE IMPELLER PUMP: After passing the cam, the impeller blades expand to create a vacuum that draws in water. As the impeller rotates, the blades carry the liquid from the inlet to the outlet. The liquid is expelled at the outlet as the cam compresses the blades again.

STEVE D'ANTONIO, ILLUSTRATION BY HENRY HILL

An inside view of an impeller-style engine-cooling pump reveals the cam. This should be regularly inspected for corrosion or excessive wear. The cover-plate screws should be lubricated with grease to prevent seizure.

3700), offers an impeller manufactured from niprene, a material that not only resists diesel, oil, and gasoline but also is guaranteed to run dry for 15 minutes without damage. Most impellers are damaged beyond repair when run dry for only one minute.

Replace the impellers on engine water pumps once every season. This is the cheapest insurance against an overheated engine, and regular replacement gives the skipper a chance for routine inspection beneath the housing cover of this important pump.

These pumps require other maintenance checks. The impeller blades pass over the cam tens of thousands of times each season, eventually wearing it out. I usually replace the cam with every third impeller replacement, although this can vary, depending on the pump model and the turbidity of the water. Cams tend to wear gradually; the degree of wear can be hard to notice until the old one is compared with a new one.

Even impeller pumps used infrequently require routine servicing. Some cams are sacrificial, intentionally made of an alloy that's less noble than the pump body so that the cam corrodes before the more expensive pump. Any time a less noble metal is immersed in seawater with a more noble metal, the less noble metal will suffer galvanic corrosion. (See "The Softer Side of Metal," July 1998.) If the cam appears pink and crumbly, it's time to replace it. When replacing the cam, closely inspect its securing screw and gasket; these often require replacement, too.

The cover plate on the impeller housing also wears down through use. If you can feel grooves or indentations on the inside surface of the cover plate, replace it. Discoloration on the surface of the cover plate is normal and doesn't necessarily indicate wear or deterioration. Finally, this style of pump may need to be rebuilt every 500 to 700 hours of running time. Other components that may require replacement during a rebuild are the inner-wear plate (if the pump has one), bearings, and seals. A do-it-yourselfer can usually rebuild these pumps economically. Otherwise, depending on the make and model, replacement may be cheaper. One approach is to purchase a new pump, install it, and rebuild the old one for use as a spare.

Centrifugal Pump

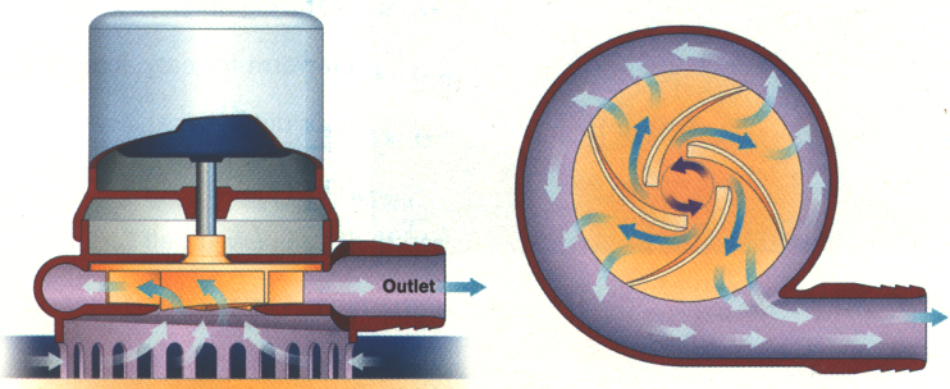
Although not as common as the flexible-impeller pump, the centrifugal pump is just as important, because most bilge pumps fall into this category. This pump is one of the few that isn't self-priming. On some diesel engines, the coolant-recirculation pump (usually belt driven) is a centrifugal pump, which is why you must carefully bleed the air from the cooling system when filling it. Centrifugal pumps are also used in some deck-washdown and refrigeration-cooling applications. They're also used to pump air—as in alternator cooling fans and "squirrel-cage" bilge and engine-room blowers.

A centrifugal pump operates by slinging liquid or air from the center of its rigid impeller outward. (See Figure 2.) This creates a vacuum at the center that perpetuates the pumping action as long as the impeller is turning. This pump's big advantage is its ability to pump high volumes of air or water. A properly installed bilge pump not much bigger than a coffee can is capable of pumping thousands of gallons of water an hour. Since the impeller of a centrifugal pump doesn't make contact with the body, it never needs to be replaced.

Neatness counts in hose and pump installations. This submersible centrifugal bilge pump and its accompanying caged float switch are easily accessible for service, repair, and cleaning. The corrugated hose, however, will reduce the efficiency of the pump.

The disadvantage is that it's not self-priming. When used in deck washdown systems or refrigeration condensers, a centrifugal pump must be installed so it remains below the waterline at all angles of heel. If the pump rises above the waterline momentarily while heeling, it can easily become air-bound. If this happens, you usually need to remove the discharge hose in order to purge the air bubble. Some installers fit a check valve to prevent problems with air bubbles, but a check valve can add resistance to the flow that the

Figure 2



CENTRIFUGAL PUMP: Liquid enters at the center of the pump, which must be located below the water level or primed before it will begin pumping. Centrifugal force created by the rotating curved impeller forces the fluid toward the outside of the pump housing, creating a vacuum which draws more liquid into the pump. The water is flushed out through the outlet.

STEVE D'ANTONIO, ILLUSTRATION BY HENRY HILL

pumps often can't overcome.

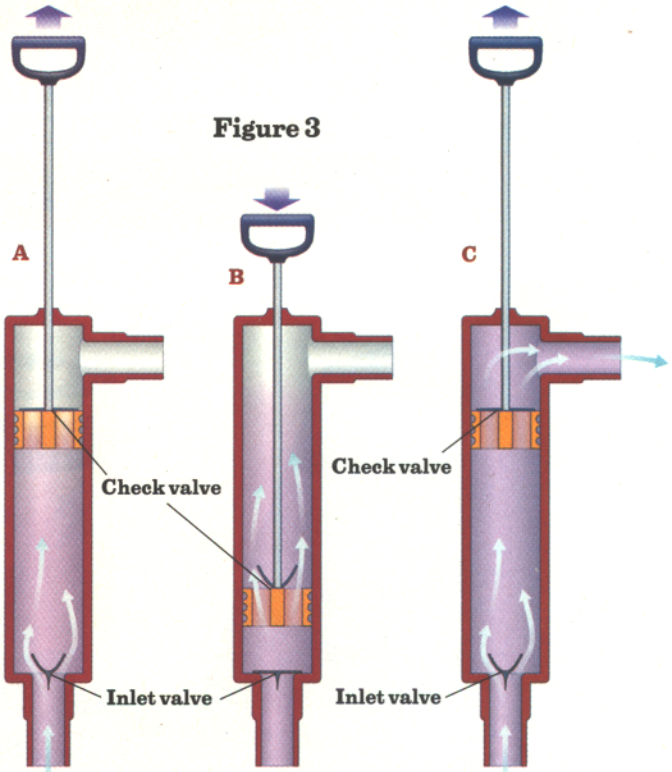
Maintenance for centrifugal pumps varies among models. Shaft seals on some submersible bilge pumps deteriorate with prolonged exposure to fuel or oil, so keeping bilgewater clean will prolong life. Most submersible bilge pumps aren't serviceable beyond cleaning the strainer. Nonsubmersible models, like the washdown and refrigerator pumps, are serviceable. They usually have seals and bearings that can be replaced. Although some air-conditioning and refrigerator pumps are offered in stainless steel, the motor housing is usually mild steel. A light coat of corrosion-inhibiting spray on the exterior will keep rust at bay.

Piston Pumps

A piston-style pump works by moving a piston inside a stationary cylinder. As the piston draws in, it increases the volume of the cylinder, which creates a vacuum, sucking any liquid or air into it. A valve arrangement allows liquid to be drawn in one port and expelled out another port. (See Figure 3.) A piston pump works well for heads, manual bilge pumps, crankcase oil-change pumps, and injector pumps. Its big advantage is its ability to pump solids as well as liquids and air. An injector pump, however, should never encounter a solid in its lifetime.

One drawback to the piston pump is its need for routine maintenance. The head versions of this style of pump need particularly close attention. Seals and flapper valves require periodic renewal.

Figure 3



PISTON PUMP: A. As the handle is lifted, the plunger creates a vacuum that opens the inlet valve at the foot of the pump and draws liquid into the pump cylinder. B. On the downstroke, hydraulic pressure opens the check valve in the plunger, trapping liquid above the plunger. C. On the next upstroke, the check valve in the plunger closes, flushing the liquid out and simultaneously drawing water through the inlet valve again.

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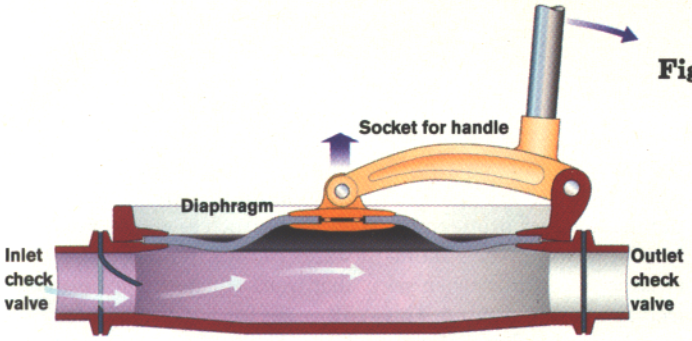
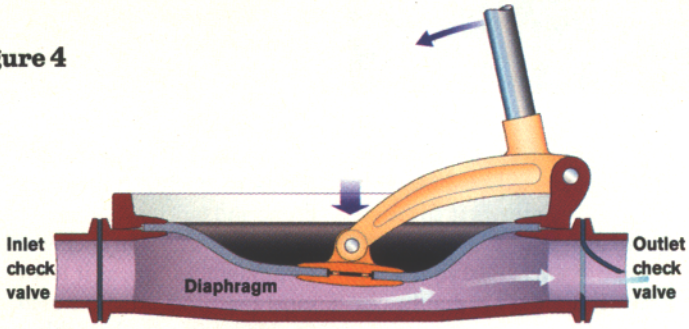
Figure 4



DIAPHRAGM PUMP: As the handle is pulled in one direction, the diaphragm expands to create a vacuum that causes the inlet check valve to open.



DIAPHRAGM PUMP: When the handle is pushed in the other direction, hydraulic pressure closes the inlet check valve and simultaneously opens the outlet check valve and flushes out the liquid.

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Some models use leather for the actual sealing material, and this can dry out if not used frequently. Some piston-style manual bilge pumps can be completely rebuilt with spare-part kits supplied by manufacturers. (See "The Key to the Throne," April 1998.) These are usually the brass- or bronze-tube variety, and they're well worth the time and expense required to rebuild them. The plastic dinghy models aren't. Manual piston oil-change pumps usually can't be serviced, but they tend to last a very long time without any real care. Only a specialist should service injection pumps.

Diaphragm Pump

The dependability of most domestic-water systems is due to the reliable diaphragm pump. These pumps operate by varying the volume of a chamber, not unlike the piston pump. However, instead of using a piston and cylinder, they use a rubber diaphragm. As the volume of the chamber is increased by either manually or mechanically flexing the diaphragm, it creates a vacuum that draws fluid or air into a port. Opposing check valves allow the air or liquid to be pumped out a different port. (See Figure 4.)

When used in domestic-water systems, these pumps will have a pressure switch. This turns the pump on and shuts it off at preset pressures—usually switching it on at around 25 pounds per square inch (psi) and off at 35 to 40 psi. Without a pressure switch, if you shut off the tap on your domestic water, the pump would trip a circuit breaker or could cause a hose to burst. The pressure switches on domestic-water and deck-washdown pumps are known to fail periodically, so these should be included in your spare-parts inventory.

The diaphragm pump also performs well as a bilge pump, but it doesn't have the capacity of a centrifugal pump. Its

primary advantage as a bilge pump is its self-priming ability, which allows it to be remotely mounted, out of the bilge. For very narrow or inaccessible bilges, a diaphragm pump can work well.

A common example of a diaphragm pump is the manual bilge pump. These have been around for over a hundred years, and with good reason. They're rugged and capable of pumping large quantities of water when they're in the hands of a motivated operator.

Mechanical, camshaft-actuated fuel pumps are also a version of the diaphragm pump. A newer twist on the diaphragm pump is the wobble-plate variety. This system uses the same principles as the conventional diaphragm pump, except it's noticeably more compact and cylindrical in shape. This pump also tends to be less vibration prone and quieter.

Disuse is the main enemy of diaphragm pumps, as it is for most machinery. Left unused for long periods, the rubber components tend to dry out. Corrosion is also an issue for some models. The main weakness in all diaphragm pumps is simply that the diaphragms and other movable parts deteriorate through wear and tear. But all diaphragm pumps, including some fuel pumps, are serviceable. Repair and rebuild kits are available and usually affordable.

Picking a Pump

Before considering what type of pump to choose for a particular job, it's important to consider whether or not the pump is self-priming. With the exception of centrifugal pumps, most are. Not all pumps, however, prime equally as well. Duty cycle is another issue to consider when selecting or using a pump. This was the lesson that unfortunate boat owner learned the day he decided his water tank needed a good flush.

Many electric pump motors have what's called a "duty cycle"—the duration for which they can operate without overheating or breaking down. For instance, a domestic-water pump may have a duty cycle of three minutes on, 10 minutes off. If the pump you're looking for requires continuous duty, that's what must be installed. Most submersible bilge pumps are rated for continuous duty.

Another issue to consider when fitting or servicing a pump is the type of hose to use. Pumps that create strong vacuums, such as engine raw-water pumps, require hoses that won't collapse. This usually calls for wire-reinforced hose. The vacuum or intake side of any pumping system must have hoses that won't collapse under any operating circumstances. Remember: In temperate climates, hoses that are stiff when installed in January may be soft and pliable in July, or in the engine space at any time of the year. Tight radiuses and sharp turns in hoses, pipes, or joints will quickly take the oomph out of your pump. In fact, every in-line fitting—from seacocks to 90-degree elbows—imparts some friction and reduces the rate of flow.

Hoses also create resistance, robbing the pump of efficiency. For every foot of added hose, a bilge pump that pumps 1,800 gallons per hour through a 1-inch hose will perform as though it's pumping the effluent .81 feet higher. This resistance is called "dynamic head." In general, the shorter and straighter any hose run, the better, especially with regards to bilge pumps. For this reason, choose smooth-wall hoses over those with corrugated interiors. (See photo, page 90.)

Another factor that affects electric-pump performance is voltage. Many pumps are rated at voltages that are only available while the engine or battery charger is operating: 13.8 volts. In the real world, voltage on board will be more like 12.4, and pump efficiency will drop, often dramatically.

Voltage drop through wiring also needs to be taken into account. When wiring bilge pumps, the voltage drop shouldn't exceed 3 percent. The American Boat & Yacht Council's (ABYC) *Standards and Recommended Practices for Small Craft* gives tables and guidelines to determine proper wiring configuration and wire size. For example, an average installation using a 12-volt, 2,000 gallon-per-hour pump with a 20-foot wire run (wire runs are calculated from

Selected Pump Sources

- **Attwood (electric bilge pumps): (616) 897-9241, www.attwoodmarine.com**
- **Beckson Marine Inc. (manual piston bilge pumps): (203) 333-1412, www.beckson.com**
- **The Bosworth Company (manual bilge pumps): (800) 377-2724, (401) 438-1110, www.bosworth.thomasregister.com and www.thebosworthco.com**
- **Edson International (manual bilge pumps): (508) 995-9711, www.edsonpumps.com**
- **FLOJET Corporation (various water-system pumps): (949) 859-4945, www.flojet.com**
- **Groco (Gross Mechanical Labs Inc.; several models of transfer and recirculating pumps): (410) 712-4242, www.groco.net**
- **ITT Jabsco (extensive line of purpose-built pumps): (714) 545-8251, www.jabsco.com**
- **Johnson Pumps of America Inc. (wide range of specialized pumps): (847) 671-7867, www.johnson-pump.com**
- **Lovett Marine Inc. (electric bilge pumps, shower sump pumps): (800) 673-5976, www.lovettmarine.com**
- **Oberdorfer Pumps (wide range of specialized pumps): (315) 437-0361, www.oberdorfer-pumps.com**
- **Rule Industries (electric bilge pumps): (978) 281-0440, www.rule-industries.com**
- **Whale Water Systems (wide range of pumps): (978) 531-0021, www.whalepumps.com**

the pump to the power source *and back*) would require size 10/2 cable. This assumes a 15-amp breaker or fuse is installed, and this is important.

The normal draw of the pump would be approximately 8.5 amps. However, if the pump's rotor locked, the draw could increase to 15 amps. As a fire-protection measure, both the ABYC and the U.S. Coast Guard specify over-current protection for virtually all onboard electrical devices. Although mandated for gasoline-powered boats, these measures are only recommended for diesel-powered boats. It's important to remember that the over-current protection—either a fuse or circuit breaker—must match the wire size and that the wire size must be matched to the demands of the pump under every possible load condition—including when the rotor locks.

When selecting a pump, check its ability to pass solid objects and trash. Flexible-impeller pumps and some diaphragm pumps are among the most sensitive to objects in the liquid stream. For instance, the check valves used in the belt-driven style of diaphragm pumps are particularly prone to failure when they try to handle even the smallest debris. Any of these pumps—especially bilge pumps—that are expected to encounter debris must be equipped with an in-line strainer. Other diaphragm pumps, such as the flapper-valve style, are renowned for their ability to pass solids. This type of pump is very popular for waste discharge.

Certain applications require a pump that will run dry without suffering damage. This is particularly true for bilge pumps and domestic-water systems. You can usually run dry centrifugal bilge pumps for a short periods without hurting them. However, if a centrifugal pump is run dry for a long time, the shaft seal will overheat and fail. Diaphragm pumps can usually run indefinitely without suffering any damage beyond wear and tear on the moving components. Most domestic-water systems use either the traditional belt-driven diaphragm pump or the newer wobble-plate variety. Both work well and are very durable, even when run dry.

When it comes to any system on board a cruising boat, performance and durability lie in the details. Pumps are no different. Take the time to familiarize yourself with your pumps, install them properly, learn how to service them, and find out what spares or tools you will need. And when choosing a new pump, be sure it's suited for the job it's going to do. As dependant as cruisers are on dry bilges, drinking water, cool-running engines, and heads that flush, we can't afford to neglect our pumps.

Steve D'Antonio is a *Cruising World* contributing editor and the manager of Zimmerman Marine in Cardinal, Virginia. To obtain a copy of standards for pumps, electrical systems, and other boat components, contact the American Boat & Yacht Council (3069 Solomons Island Road, Edgewater, MD 21037; 410-956-1050; www.abycinc.org).