

## **Bilge pump system design**

### **The task**

You're bilge pump system has to handle two situations – pumping out the normal accumulations of water from stern gland, condensation and minor leakage, and pumping out a large influx of water in an emergency.

The most likely causes of a catastrophic leak in a displacement boat are:

1. The loss of a seacock – either the hose becomes detached or the seacock itself breaks off the through hull.
2. Loss of a through hull transducer.
3. A disintegrating drive shaft stuffing box or stern gland.
4. An overheating engine which melts the exhaust system components and pumps water into the bilge.

Holes in the hull caused by grounding or collision, and flooding by waves could be any size; it's unrealistic to design for such freak occurrences.

Simple fact: A 1½" hole (such as an open seacock) located 2' below the waterline will let in around 60 US gallons (230 litres) per minute. That's 3,600 gallons per hour. That water weighs nearly 30,000 lbs. If you were so inclined you could calculate the amount of water your boat could accommodate before she sank. It isn't many hours for the size of boat most of us sail.

So, ideally, you need an emergency bilge pump system to handle around 4,000 gallons (15,000 litres) per hour. You also need a supplementary system to keep the bilge dry.

### **Types of pump and how to drive them.**

We can power our bilge pumps in three ways:

- Mechanically, off the engine.
- Electrically, from the batteries.
- Manually, by a crewmember.

Think about these options a little: To drive the pump mechanically the engine must be running; to drive the pump electrically there must be juice in the batteries; to drive the pump manually a crewmember must be available.

To cover all contingencies the bilge pump system will need to be a combination of pump types.

### **Capacity ratings**

Now, before we select the appropriate pumps, let's consider the pump capacity rating. I'm going to try and make this as simple as possible because not everyone wants to plough through charts and graphs and extrapolations to calculate the precise capability of a bilge pump.

An electric pump with a rated capacity of 2,000 gallons per hour will only do this if there is no hose connected and the batteries are bulging with volts. But in real life the pump has to lift the water out of the bilge and push it uphill to a discharge point. Furthermore, it has to push this water through a pipe, and various bends and probably a seacock. This combination of the uphill battle and the resistance in the system is known as the pressure head and it must be applied to the pump's rated capacity to get the real world capacity.

My rule of thumb for calculating pressure head in a typical 25' to 45' boat installation is to measure the height from the pump to the highest point of the pipe run and double this figure to give total pressure head. So, if you want a pump to move 2000 gph vertically 5' your total pressure head is 10' Now look at, for instance, a Rule 2000 electric pump which has an open flow rating of 2000gph and apply the 10' pressure head on the manufacturers chart; you will find that this pump does a little under half of the open flow rating at this pressure head.

So, my second, and simpler, rule of thumb is – down rate electric pump capacity to 40% of rated capacity. And be aware that this requires the batteries to be fully charged; depleted batteries and dodgy wiring will further degrade performance.

Your 2000 gph pump will actually handle around 800 gph.

Mechanical and manual pumps usually give the capacity at a particular pressure head so their selection is less confusing, but the rule about total pressure head stands.

The biggest manual pumps, such as the Edson 30, will pump one gallon per stroke and the Whale Henderson Mark 5 about half that rate. Although some manufacturers give pump capacity at hugely optimistic pumping rates, 70 strokes per minute for instance, be aware that 30 strokes per minute is hard work; if you can manage that you'll get 1800 gallons per hour from the Edson. These are physically large pumps and can be challenging to house on a small boat. Lower capacity pumps take up less room.

### **Types of pump**

Every boat should have at least one manual bilge pump. Manual pumps are diaphragm pumps and the best type are double acting – they pump on both forward and backward strokes of the handle. Think about its location and how easy it will be to operate in an emergency. A long handle that can be operated in a standing position is best; kneeling in the cockpit is less good. Do what you can.

Electric pumps are, most often, of the submersible, centrifugal type. Such a pump would form the basis of your non-emergency maintenance system – to keep your bilge dry under normal conditions. Equipped with a level switch it will cycle on and off as needed to keep nuisance water from building up. Float switches are notoriously unreliable so check them frequently; electronic switches with no moving parts, such as the Bilge Mate, are usually a better choice.

You may wish to add a second, higher capacity pump as an emergency pump and it should be designed to come on if the smaller pump isn't coping. It should have a level switch located higher in the bilge than the maintenance pump. This switch should operate an audio/visual alarm to tell the crew it has operated. You must be able to override the automatic function and force the pump to run if the switch fails.

If your boat can accommodate it the best of all pumps is a mechanical clutch pump, belt driven off the engine. A Jabsco Series 51270 engine driven pump will handle 4,100 gph at 10' total pressure head but is physically large and nearly impossible to house on smaller boats.

Your engine already has a pump on it, the cooling water pump, and some advocate that this be plumbed in such a way that by switching a valve it will draw its water from the bilge instead of outside. I'm very sceptical of this advice - the engine pump doesn't move an awful lot of water, and I'd hate to be jeopardising my engines cooling system when I already have an emergency on my hands.

So, to sum up: A typical bilge water management system will comprise a 12v submersible pump to handle normal seepage, one or two larger electric pumps to handle larger influxes and a manual bilge pump to supplement the electric pumps or replace them when the batteries are flat. An engine driven pump would be a very desirable addition.

Oh, and a baling bucket is a vital component of any leak management system. A Salty John folding canvas bucket has a big capacity and is easy to stow.

### **Installation considerations.**

It will be clear from the discussion of pump capacity that keeping the total pressure head as low as possible is important. The pump in the bilge should be located as close to being vertically in line with the discharge hole as is feasible so that the length of horizontal run is minimised. The maximum lift height will be determined by the distance between the pump

outlet and the discharge point, or the top of any loop, vented or otherwise, in the line. Sharp bends should be avoided. The pipe should have smooth interior walls. You're trying to make it as easy as possibly for the pump to move the water – don't put obstacles in its way.

You'll want the bilge pump discharge hose to be well above the heeled waterline. If you can't achieve this you'll need to consider a vented loop. Try hard to avoid that need.

Consider installing your electric pumps and their switches on a common base; I use a piece of Plexiglas. If your bilge is very deep you can attach a handle or lanyard to this base plate to allow you to lift the whole assembly within reach for maintenance and repair.

OK, those are my thoughts on bilge pump systems, but let me say right now that I have never had a boat in which the bilge pump system could evacuate 4,000 gph. In smaller boats it's just impractical to achieve this capacity, as you may have gathered from the above. Top priority, therefore, is to avoid a situation that would require such a capacity:

### **Prevention and preparation**

Minimise the number of holes in your boat. Use a manifold or seachest where appropriate to combine several functions into one seacock. Use suitable seacocks - bronze, stainless or Marelon. Use quality hose and double clamp it. Maintain your seacocks, engine stuffing box and rudder bearings scrupulously and regularly.

You have to be able to get to all your seacocks easily and quickly even when they're underwater. At each seacock you must have a soft wood or rubber bung of the appropriate size. Tie it to the seacock with a lanyard. Have a contingency plan for stemming the flow from a hull breach, stuffing box failure, displaced rudder or other catastrophe. Keep your cockpit drains clear and, if your boat doesn't have a bridge –deck (companionway sill) keep the lower companionway hatch board in place if there's a chance of shipping a wave.

It's a good idea to have an exhaust temperature monitor, such as the Sentry, on your exhaust pipe. A melted exhaust pipe will allow the engine to pump its raw cooling water into the boat. Melting of exhaust components can occur before the normal engine block temperature alarm sounds.

Note: In the forgoing discussion I've used US gallons and (litres) because that's what most pumps are rated in and it saves me making conversions. If you want figures in Imperial gallons multiply the US gallon figure by 0.83 or divide the litre figure by 4.5.