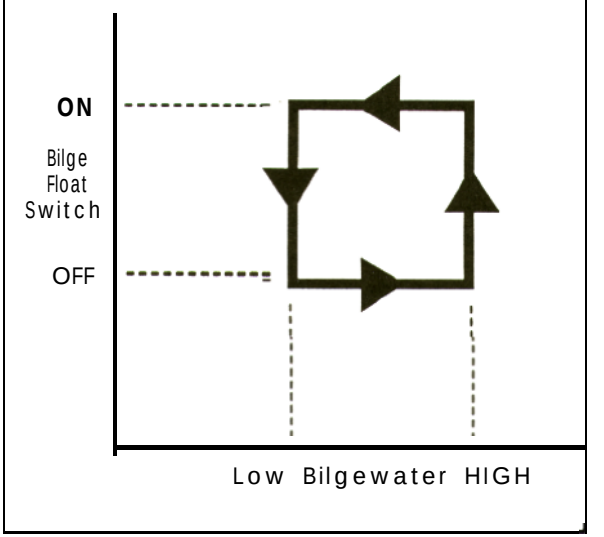
Hysteresis in Your Bilge?

by Robert J. Scott

While most bilges suffer from "halitosis," hysteresis is another matter. The word hysteresis comes from a Greek word meaning "to remain behind." A common word in engineering and physics, hysteresis is a control process in which the condition needed to start an action is different from the condition needed to stop the same action. For example, a thermostat controlling the heating of a home may turn the furnace on when the temperature drops to 70 degrees, but will not turn the furnace off until the temperature rises to 72 degrees. This differential of two degrees is built into the thermostat and is known as hysteresis.

While we're not interested in keeping our bilges warm, we are interested in keeping them as dry as possible, so let's see how the same hysteresis can efficiently control the bilge pump. Figure 1 is a hysteresis loop for a bilge pump switch turning on at a higher level of water in the bilge and turning off at a lower level. Why should we have such an interest in the hysteresis associated with bilge pumps and their switches? Mainly, because, as good seamen, we are very much concerned about staying afloat. While sailing, we face the dangers of grounding, of being holed by floating objects, and of the failure of hoses or seacocks below the waterline that could permit the intrusion of a large volume of water. Stated simply, if we can avoid water intrusion, we won't have to worry about sinking. Our only safeguard is to be certain that our bilge-water management system is the best that we can provide.

Figure 1. Hysteresis Loop



Deep bilges are found on many boats with internal ballast, where the unballasted portions of the keel are the deepest. These deeper bilges are generally associated with cruising sailboats, where additional space is required in the keel for machinery or tanks. While I have always had boats with deep bilges, there have been many times when I wished the bottom of the bilge were only inches below the cabin sole

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rather than several feet. Replacing a bilge pump, retrieving a dropped tool or fastener, and cleaning the bilge are just a few of the reasons why a shallow bilge is desirable. On the other hand, the ability of a deep bilge to contain several gallons of unexpected water without covering the cabin sole makes me forget my reasons for wanting a shallow bilge. Most of what I have to say deals with intrusive-water management in deeper bilges. Whether or not you find these techniques useful on your boat depends on the shape of your bilge, deep or shallow, wide or narrow.

How do we manage bilge-pump systerns? The simplest system is a manually operated switch controlling the bilge-pump operation. However, this may be dangerous for the skipper too preoccupied to notice the invasion of water into his bilge until it poses a threat to the survival of his vessel. It is much easier to find the source of intruding water when the water is contained in the bilge than when it is rising above the cabin sole.

A bilge pump with an automatic switch is better than a manual one in that it remains alert to the rise of water and pumps it from the bilge when necessary. This works fine when the rate of water intrusion is less than the pumping rate of the bilge pump, and when the battery is able to provide the power required to sustain the pumping.

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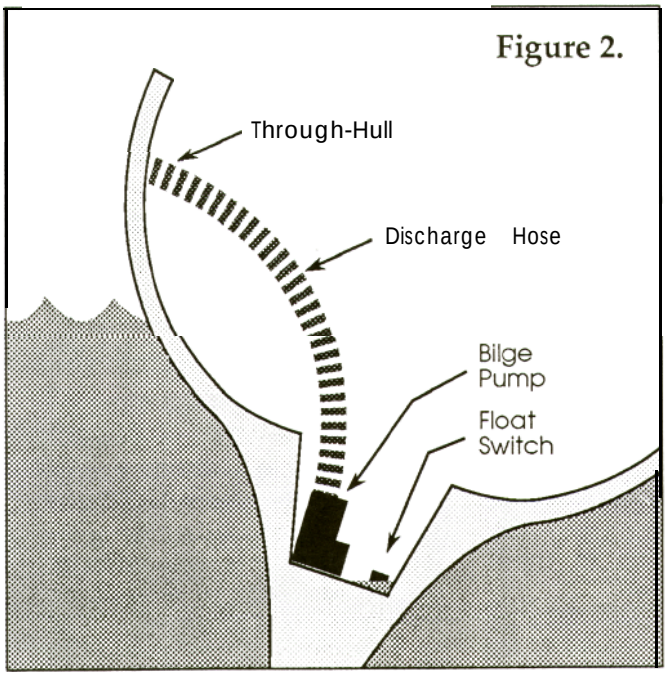


Better than either of these, and only slightly more complex, is a system I would like to propose that provides a high degree of protection for the skipper and his boat either at sea or in port.

Some sailors consider bilge-water management to be the same whether in port or at sea, but it should be noted that there are some good reasons for treating it differently. While under sail, with the bilge pump operating automatically, a skipper may be unaware of the frantic efforts of the bilge pump to rid the boat of unwanted water. The alternative of leaving the bilge pump off while under sail could be equally devastating. In that case, the first indication of a major leak could come when the skipper goes below and finds several inches of water above the cabin sole.

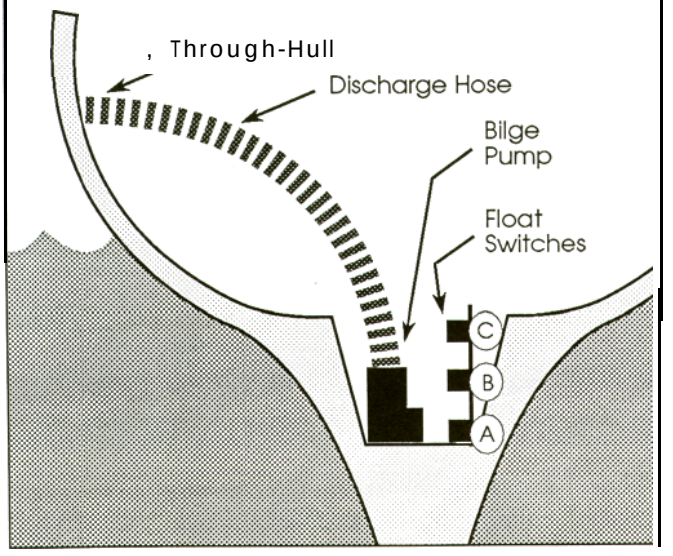
I recommend two separate bilge-water management plans, one for use while in port and the other while under sail. A wide bilge may present some problems under sail. I have seen bilges organized as in Figure 2. With the bilge pump on one side of the bilge, and the float switch on the other, heeling might cause water to activate the bilge pump even though the bilge pump is dry. In this situation, the bilge pump may continue to operate while the float switch is under water. This can lead to premature failure of the pump and draining of the battery. Furthermore, when activated at a high angle of heel, the float in a float switch is likely to stick in the "on" position, due to the friction against the body of the switch. On the other hand, while in port with the boat level, the system shown in Figure 2 can work quite well.

Another arrangement that leads to early pump failure is one where the hysteresis loop as shown in Figure 1 is compressed, so that only a small difference in water level causes the pump to turn on and off. With too small a difference, a boat with a deep bilge may have a large amount of water contained in a long discharge hose rising to the through-hull. When the pump shuts off, this water can empty from the hose back into the bilge due to gravity. This additional bilge water can once again activate the bilge pump, causing an almost continuous cycling of the pump.

Problems can also occur in port on an unattended boat. For example, a leaking stuffing box, through-hull, or hose can continue to cause repeated cycling of the bilge pump. Without some way of knowing the extent of pump operation while absent, the skipper may not be alerted to a condition requiring corrective action.

I believe my system, illustrated in Figure 3, will

Figure 3.



provide an effective means for dealing with many of these problems. The illustration shows the use of three bilge-pump switches, all of which can be adjusted in height above the bottom of the bilge. Float switch A should be as close to the bottom of the bilge as possible, since it is used to shut the pump off. Float switch B should be positioned sufficiently above switch A so that a reasonable amount of water must intrude before activating switch B which turns the pump on. The third and highest float switch directly activates an alarm bell. Under normal conditions, water should never reach a level to activate switch C and the alarm bell. Switches A and B provide the hysteresis loop which is greater than either switch operating independently. Removal of the entire system is facilitated if the three bilge pump switches are mounted on a single aluminum extrusion.

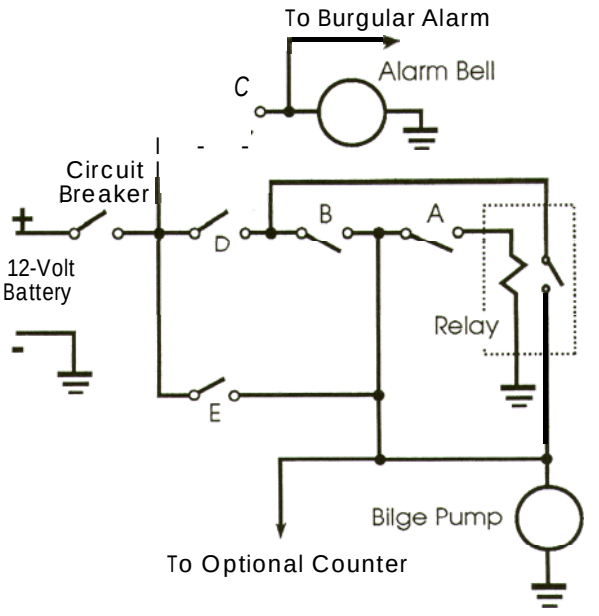
Figure 4 shows the schematic connections of these switches into a system that optimizes bilge-pump performance both in port and at sea. The two SPST toggle switches, D and E, the relay, the counter, and the circuit breaker are all located in my navigation station. The 12-volt relay is readily obtained from Radio Shack (part #275-218). I have added anelectro-mechanical counter in my nav station to keep count of the number of times the bilge pump is activated. I obtained the counter from H & RCorp. (401 Erie Avenue; Philadelphia, PA 19134-1187).

When leaving your boat, the bilge should be emptied manually with switch E; switch D should be placed in the automatic (on) position; and the counter value should be reset or recorded. Maintaining a record of counter values along with the times of recording should alert the skipper to any problem resulting in increased bilge-pump activity. On my boat, I use three Rule Super Switches mounted on a long aluminum L-shaped extrusion. The aluminum angle can be inserted and removed from the bilge for easy adjustment of the switch positions. The aluminum angle should be secured so that its position in the bilge under sail will not change. The angle also provides a protected path for routing the wires to the switches.

In operation, the sequence of events occurring as the bilge fills and empties is as follows: (1) float switch A closes; (2) float switch B closes; (3) the relay is energized; (4) the relay contacts close; (5) bilge pumps start; (6) float switch B opens (but the relay is still energized and operating the pump); (7) float switch A opens; (8) the relay opens; and (9) the bilge pump stops.

When under sail, I turn switch D to the off position so that only bilge pump switch C is actively connected to the alarm bell. Should the alarm bell ring, turning the manual switch E to the on position will activate the bilge pump. To avoid alarming the crew by the ringing of the bell, an occasional inspection of the bilge will permit the manual management of bilge water. The 12-inchbell that I use in the system produces enough sound in a marina to create attention should the bilge pump system fail to control intruding water while the skipper is away. The bell is also connected to my burglar-alarm system. ■

Figure 4.



The author, Dr. Robert J Scott, owns a Passport 40, Lands End, *which he sailed in the 1984 OSTAR. He is a university professor and a professional engineer with a deep love* of *sailing.*