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Chapter 12. Bilge Pumps and Water in the Boat: Why Boats Sink at the Dock

A pump judged by the water it moves, with an automatic switch that has power while you are away

When nobody is aboard, what takes water out of your boat is its bilge pump, started by its automatic switch. This chapter shows you how to make sure that switch has power, starts the pump by itself and that the pump moves water out of the boat — and what to do when it does not.

AFTER THIS CHAPTER YOU CAN

- take the first step for each of three failures — a pump that stays silent, a pump that runs while the water stays, an automatic switch that does not start the pump — and know when the card for water in the boat comes first;
- tell which pump switch you have and where its automatic switch takes its power, and find your pump's own fuse;
- find where a silent pump circuit is open, with every reading taken against the battery negative terminal;
- tell a float switch, an electronic water sensor and an automatic switch built into the pump apart, and know how each one starts, waits and fails;
- estimate how much water your pump really moves, and why the number on its label is not that;
- check the pump, its high-water alarm and its hose by water leaving the boat, and accept a pro's work the same way.

Read first: → 1.7, → 3.7, → 4.2

12.1 Water is coming in, or the automatic switch isn't working
12.2 The pump circuit: anatomy and the "silent" route
12.3 Float switches and electronic water sensors
12.4 Rated flow and real flow
12.5 The high-water alarm
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12.7 The monthly check and acceptance by function
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12.1. Water is coming in, or the automatic switch isn't working

Is water rising in the boat, or has it reached the batteries? Then go to the card "Water in the boat — the pump can't keep up or is silent" (→ emergency card) now: its first actions come before anything in this section. If the water is not rising and the batteries are dry, the first move is one look: run the pump by hand and watch the place where its water leaves the boat. What you see there sorts every bilge-pump problem into one of three cases — the pump is silent, it runs while the water stays, or it works by hand but does not come on by itself — and the route below takes each case to its first check.

A bilge pump has to work when nobody is aboard, so its power cannot depend on the battery switch that you turn OFF when you leave. Pump makers' instructions run the pump's power from the battery through its own fuse. MFR

ABYC permits the wires that supply safety equipment, bilge pumps among it, to be connected on the battery side of the battery switch; it permits this and does not require it. ABYC

A circuit wired around the battery switch stays live in every position of the battery switch. So it starts at the battery with its own fuse, the one protection between the battery and its wire (→ 4.2).

WHY IT WORKS

The battery switch sits in the positive path between the battery and everything after it. Turned OFF, it opens that path: a pump wired after it loses its power, and its automatic switch — a float switch, a sensor or one built into the pump — has nothing left to switch. The water does not wait for the switch: rain and seepage go on filling the bilge while the boat sits with its switches OFF. A pump wired around the switch takes its power ahead of that opening, so turning the battery switch changes nothing for it. It still stops when something in its own circuit fails — its fuse, its pump switch, a splice or its negative (→ 12.2 · p. 9) — or when its battery has nothing left to give: a lead-acid battery discharged by the pump itself, or a lithium bank whose battery management system (BMS) has disconnected it, and with it everything on that bank (→ 11.4).

WHAT CHANGED BEFORE THE PROBLEM?

- after you installed or changed a device → the pump switch and the battery switches, as you find them now: step 2
- after charging → the battery switches and the pump switch, set back after charging: step 2
- after rain or washing the boat → how much water the bilge holds and whether it rises: step 1
- after the boat sat unused → the pump by hand, then its automatic switch: step 3, then step 5
- after switching sources (shore power, generator, inverter) → the battery switches as you found them: step 2
- nothing you noticed → step 1

ROUTE: THE FIRST MOVE — THE PUMP, ITS SWITCH AND ITS OUTLET ON → FIG. 12.1 · P. 10

GASOLINE VAPOR · AC — PRO · HOT BATTERY · BILGE PUMP · SHOCK IN WATER

1. Look at the water before you touch any switch: how high it stands, whether it rises while you watch it for a minute against a mark you can see — a stringer, a hose clamp, the

pump's own body — and whether water has reached the battery terminals.

You will see: Rising, at the battery terminals, or a gasoline smell in the boat: the card "Water in the boat — the pump can't keep up or is silent" (→ emergency card); the route stops here. Standing still, below the batteries: step 2. You cannot see the water at all — a closed bilge, a hatch you cannot open: step 2, and judge the later steps by the outlet.

2. Look at the pump switch and at the battery switches, and write down where you found them.

You will see: A three-position switch at OFF feeds neither the pump nor its automatic switch; a battery switch at OFF stops a pump wired after it (→ 12.2 · p. 9). Either one is the first thing to check, not yet the cause: step 3 shows whether the pump runs.

3. Run the pump by hand: put the pump switch in MAN (on some panels, ON), or, with a separate manual switch, put that switch ON. Hold a spring-return switch in MAN. A pump with no manual switch at all: go to step 5. Watch the outlet — the fitting on the hull or the transom where the pump's hose ends — and the water level for a minute.

You will see: Water leaves at the outlet in a steady stream and the level falls: the pump, its circuit and its hose work — step 5. The motor hums or runs, and no water leaves, or only a trickle: step 4. Nothing — no hum and no water: the route "the pump is silent" in → 12.2 · p. 9. Water leaves at the outlet and the level holds or still rises: water comes in as fast as the pump moves it, or faster — the card (→ emergency card); the places where water comes in at the dock are named below, under "The pump is not made for a leak in the hull". You cannot see the outlet: follow the pump's hose from the pump to the hull; if you still cannot see it, or you are alone with a switch that springs back, judge by the level against your mark — falling means water leaves.

4. The pump runs and no water leaves. Set the pump switch so that nothing runs the pump by hand — a three-position switch to AUTO, a separate manual switch to OFF — and look, without touching, along the path the water takes from the pump to the outlet: a hose kinked, flattened or pinched; a seacock at the outlet closed; the pump's intake or its strainer clogged with debris; the pump lying in less water than covers its intake. Water that does not cover the intake leaves the

pump nothing to move yet: go to step 5, which pours enough. A closed seacock on the outlet: open it if its hose is whole, clamped and rises in a vented loop high above the waterline (→ 12.6 · p. 36, → Fig. 12.3 · p. 37). A clogged strainer or intake: the pump can start by itself while your hand is there, so first make its circuit dead by the procedure "Making the pump's circuit dead before work" (→ 12.2 · p. 9); clear the strainer with your hand, in the bilge water; then put the fuse and the AC sources back as the first two items of that procedure's restore say. Run the pump in MAN again.

You will see: Water now leaves at the outlet: what you opened or cleared was holding it — step 5. Still nothing, with the hose clear and the intake clean: the pump itself — its impeller or its motor — or a check valve stuck shut in the hose (→ 12.6 · p. 36); who replaces it → 12.8 · p. 41. A closed seacock whose hose has no vented loop, or is cracked: the seacock stays closed, and the outlet is a pro's job (→ 12.8 · p. 41). A pump mounted away from the bilge, which draws the water up a hose to itself, has valves of its own: its manual names what to look at. You cannot reach the strainer or the hose: bail with a bucket or a manual pump while the water is in the boat, and the hose and the pump go to a pro.

5 The pump works by hand; now its automatic switch. Set the pump switch so that the automatic switch has power and nothing runs the pump by hand: a three-position switch to AUTO; a separate manual switch to OFF, because its automatic switch has power of its own. Then take steps 2 to 4 of the check that the automatic switch has power (→ 12.2 · p. 9): water poured into the bilge at the pump until the pump starts or the water stands about 1 in above the automatic switch's starting level, and up to two and a half minutes of waiting, with your eyes on the outlet.

You will see: The pump starts by itself and water leaves at the outlet: the automatic switch works now, and what held it before is the next thing to find — water that never reached its level, debris against the float (step 3 of the route in → 12.3 · p. 23), or a switch found where its automatic switch had no power (step 2). The pump starts and no water leaves: step 4. The pump stays silent, with the water above that level: a pump that moved water in MAN in step 3 — the route "the pump does not come on by itself" in → 12.3 · p. 23; a pump with no manual switch — the route "the pump is silent" in → 12.2 · p. 9.

PUT THE BOAT BACK IN SERVICE

- A seacock you opened in step 4 stays open: you opened it only on a whole hose with its vented loop, and the pump's water leaves through it.
- The pump switch as step 5 set it — a three-position switch at AUTO, a separate manual switch OFF. Step 5 is itself the check that the automatic switch has power: the pump started by itself and water left at the outlet. If the route went on to → 12.2 · p. 9 or → 12.3 · p. 23, that route ends with the check. If it ended at step 4 with a pump that moves no water, the check cannot pass: the boat has no automatic pump, and the entry of the BILGE PUMP sign says what you do when you leave the boat.

Three cases, and what each one tells you

A silent pump has lost one of three things: its power, its negative, or its motor. Power can stop at a battery switch that the pump is wired after, at the pump's own fuse, at its switch, at a splice that has corroded open, or at the battery itself. A meter finds which, point by point, against the battery's negative terminal (→ 12.2 · p. 9).

A pump that sits in the bilge water and moves it with an impeller — the kind this chapter draws — and runs while the water stays has a motor that turns and an impeller that moves nothing. The impeller throws water outward and up the hose; it cannot do that with air at its intake, with a strainer packed with debris, or against a hose that is closed. Every restriction between the pump and the sea takes some of its flow, and above a certain height of outlet it moves none at all: one maker gives its 1100 GPH pump a maximum head of 10 ft. One maker's pump with level sensing built in senses this case itself: when its motor runs for more than 15 seconds doing little work, it stops and tests for water again every two and a half minutes (→ 12.3 · p. 23). MFR

A pump mounted away from the bilge, which draws the water up a hose to itself, works another way: one maker's pump of this kind has a diaphragm and valves of its own, and its manual, not the impeller's causes above, tells what stops it moving water. MFR

A pump that works by hand and not by itself has a sound circuit from its switch to the sea. What remains is the automatic switch and its own feed: power that does not reach the automatic switch, an automatic switch that is held or has failed, water that never reached its starting level, or a sensor that waits before it starts the pump (→ 12.3 · p. 23).

Give the pump water to move whenever you test it: a pump run dry shows only that its motor turns, and one pump maker's manual says of its pump, "Do not run dry." MFR

On someone else's boat, the pump switch belongs to the level "switches and buttons", which you may use; lifting the float with a dry stick from above the water is the gray zone, done only with the permission of the base or the owner (→ 2.6, → 12.8 · p. 41).

Bilge water and the AC side

Bilge water conducts. An AC wire or device that bilge water reaches — a pump or a water heater on the AC side, a shore cord, an outlet in a space that floods — can put line voltage on that water through a fault in its insulation, and nothing you can see in the bilge tells you whether it has. A hand in that water can carry current to whatever else your body touches. That is why the sign AC — PRO stands at the start of every route and procedure in this chapter that puts a hand into bilge water or at a sensor in the bilge, or a probe on the pump; its entry says which sources come off first and how. Unplugging shore power takes off one source only: an inverter/charger can switch its inverter on by itself when shore power is lost, and a generator can start on its automatic start (→ 1.7).

Water at the batteries is a hazard of its own. Once water reaches a battery's terminals, current flows through the water between them, and the battery switch, which sits after the terminals, cannot stop it; one lithium battery maker writes that a battery under water discharges through the water between its terminals. The battery keeps losing charge into the water, and with it the pump that it feeds. What happens to that bank after the water is down is the entry of the HOT BATTERY sign, which stands at the start of the route above. PRACTICE

The pump is not made for a leak in the hull

The 1986 and 2005 editions of ABYC H-22 cover bilge pumps meant for spray, rain water and the normal accumulation of water from seepage and spillage, and they do not cover pumps meant for damage control. Two pump makers write the same of their own pumps: not intended for damage control or for flooding from damage to the hull. ABYC MFR

> **WORKED EXAMPLE: A HOLE AGAINST A PUMP**
>
> Suppose a hole 2 in across sits 1 ft below the waterline. Water enters it at the speed it would reach falling 1 ft: the square root of 2 × 32.2 × 1, about 8 ft per second. The hole's area is 3.14 × (1/12)² = 0.0218 sq ft, so up to 0.175 cubic feet a second come in: 10.5 cubic feet a minute, or about 78 gal a minute — about 4,700 GPH. A real hole with sharp edges lets in less than this ideal figure, but of the same order.
>
> Suppose your pump is one maker's 1500 GPH model and its outlet sits 6.7 ft above it: by its maker's table it then moves 515 GPH (→ Table 12.3 · p. 31). The hole lets in about nine times that. What decides the outcome is not the pump: it is the bucket, the manual pump, finding the leak and calling for help — the card's actions (→ emergency card).

At the dock, water comes in at a few places. A boating safety foundation's course names stuffing boxes first, then outdrive or shift bellows, failed hoses or hose clamps, sea strainers and drain plugs, and adds through-hulls and the raw-water cooling system. Those are the places to look when the pump keeps running and the water keeps coming. PRACTICE

Why boats sink at the dock

A slow leak and a working pump together look like a dry bilge: the pump empties the water about as fast as it comes, and nobody sees either. The boat stays afloat until the pump stops — clogged by debris, held by a float that sticks, cut off by a blown fuse, or left with a discharged battery — and with nobody aboard, nothing else stops the water. A

boating safety foundation's course puts it in one sentence: by emptying the bilge, a pump can hide a problem until the pump clogs or the battery is discharged. The same course says why the dock is where it happens: a boat under way has someone aboard who can find the leak, and boats spend most of their time at the dock. The numbers PRACTICE are in → 1.6. What you can do about it is the rest of this chapter: a pump whose automatic switch has power while you are away (→ 12.2 · p. 9), an alarm that tells someone when the pump cannot keep up (→ 12.5 · p. 34), and a check that proves both by water (→ 12.7 · p. 38).

12.2. The pump circuit: anatomy and the "silent" route

Where does your pump take its power, what can cut it, and where do you look when the pump stays silent even in MAN? This section draws the circuit, sorts the pump switches you can meet on a US boat, gives the one check that shows its automatic switch has power, and follows a silent pump with a meter.

A pump circuit wired around the battery switch with a separate manual switch has these parts (→ Fig. 12.1 · p. 10); the other circuits of this section have the same points wherever they have the same parts (→ Fig. 12.2 · p. 13). It starts at the battery's positive terminal (point A) and goes through the pump's own fuse, whose output is point B. After the fuse it splits into two paths that meet again at the pump's positive splice (C): a manual path through the pump switch, which runs the pump when you choose, and an automatic path through the automatic switch — a float switch, an electronic water sensor, or one built into the pump — which runs it when water reaches its level. The automatic switch's input is point E and its output point F. The pump's negative splice (D) returns on the pump's negative wire to the negative bus (G), and one cable joins the bus to the battery's negative terminal (H).

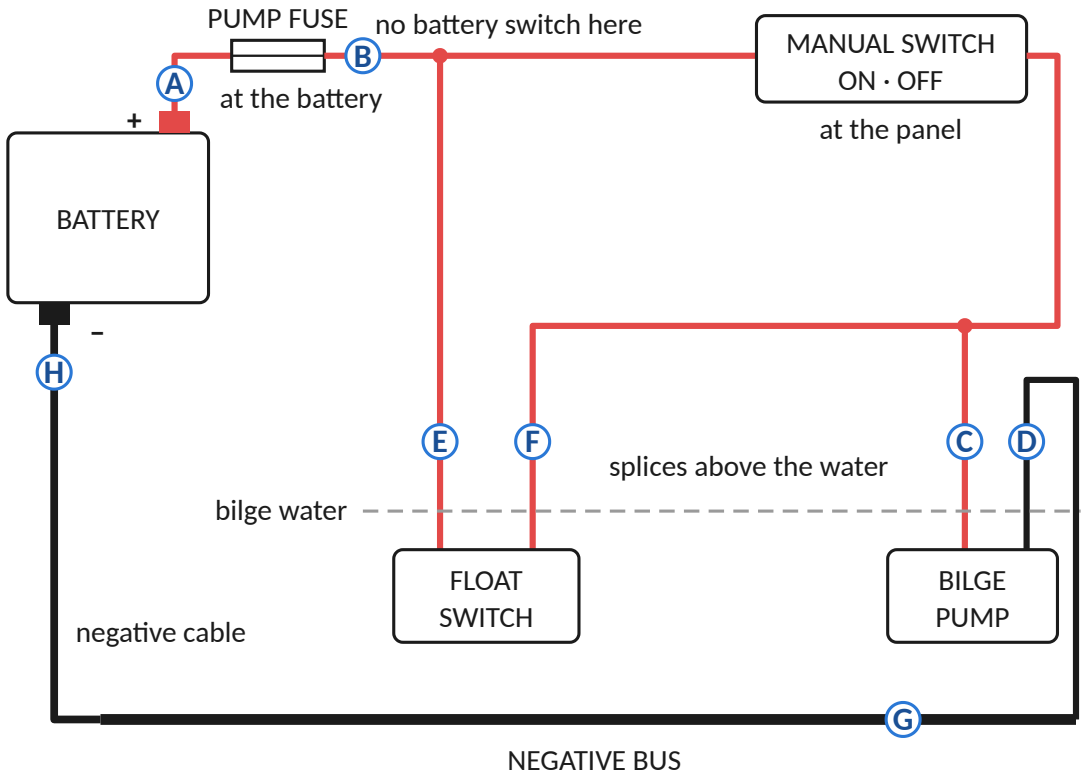


Fig. 12.1. Anatomy: the bilge pump circuit, with a separate manual switch and a float switch that has power of its own — switch (a) of → Table 12.1 · p. 11. A is the battery's positive terminal, B the output of the pump fuse at the battery, C and D the pump's positive and negative splices, E and F the float switch's input and output splices, G the negative bus, H the battery's negative terminal. Points A to H mean the same points everywhere in this chapter.

The pump's fuse can sit in several places, and your Boat Passport records where yours is (field 11). At the battery, in a holder that opens by hand; at the battery, under a nut on a stud, as a fuse that mounts on the terminal; along the wire, in an inline holder; or in the housing of the panel switch itself, where one maker puts a fuse holder that opens when you push and turn it. A fuse in the panel switch, or in an MFR inline holder along the wire, protects the wire after it; the wire from the battery to that holder is protected only by a fuse at the battery, within the distance of → 4.2, and without one that run is an unprotected positive (→ 12.8 · p. 41). On a boat whose pump is fed after the battery switch, its protection is a breaker or a fuse on the DC panel. And on

some boats the pump's wire has no fuse at all: that is an unprotected positive too (→ 12.8 · p. 41).

Which switch do you have

Pump switches on US boats come in several forms, and what each position does differs between them. Before any route in this chapter, find yours: look at the panel, read the markings on the switch, and follow its wires as far as you can see them. → Table 12.1 · p. 11 sorts them; your Boat Passport keeps the answer (field 11).

Table 12.1. Pump switches and what each position does

What you see	What feeds the automatic switch	What each position does
(a) A manual switch with two positions, ON and OFF, and an automatic switch — a float switch or a sensor — with power of its own	Its own wire from the fuse, which does not pass through the manual switch (E on → Fig. 12.1 · p. 10)	ON runs the pump by hand; OFF leaves the pump to its automatic switch, which keeps its power MFR
(b) A three-position panel switch marked AUTO · OFF · MAN (on some panels, ON for MAN)	The switch's AUTO terminal (E on → Fig. 12.2 · p. 13)	AUTO feeds the automatic switch; OFF feeds nothing — neither the pump nor its automatic switch; MAN runs the pump directly. On one maker's switch, MAN springs back to OFF when you let go MFR
(c) A pump with its automatic switch built in, with three wires: a manual lead, an automatic lead and a negative	Its automatic lead, from the fuse directly or from a switch's AUTO terminal (E on → Fig. 12.2 · p. 13); there is no point F	As switch (a) or (b), whichever feeds its manual lead MFR

What you see	What feeds the automatic switch	What each position does
An automatic switch with no pump switch at all, or a pump switch with no automatic switch	The fuse, directly; or nothing	The automatic switch alone runs the pump; or the pump runs only by hand MFR
You cannot tell	—	The check that the automatic switch has power (procedure in this section), taken in the position you found and then in each other position the switch stays in, shows in which position an automatic switch runs the pump: the one in which the pump stops by itself at its off level. A position in which the pump runs on is not that one, yet it can still be the automatic position, with its automatic switch held up or failed closed: step 1 of the check tells which

The difference matters most at OFF. On switch (b), OFF cuts the automatic switch as well as the pump, and a spring-return MAN that you let go lands in OFF, not in AUTO. On switch (a), OFF is the MFR manual switch's resting position: the automatic switch keeps its own power, and ON would run the pump without stop, dry, until the battery is discharged. The position you leave the switch in follows from this, and the entry of the BILGE PUMP sign gives it for each switch.

Many panel switches carry a light. On one maker's switch the light shows only that power is supplied to the pump, not that the pump is running. On that switch, a light lit in MAN with a silent pump puts MFR the open after the switch: in the wire, a splice, the pump or its negative. A dark light tells you nothing about the automatic switch, because a switch with no power at all is dark too; the check that the automatic switch has power, below, is what tells you.

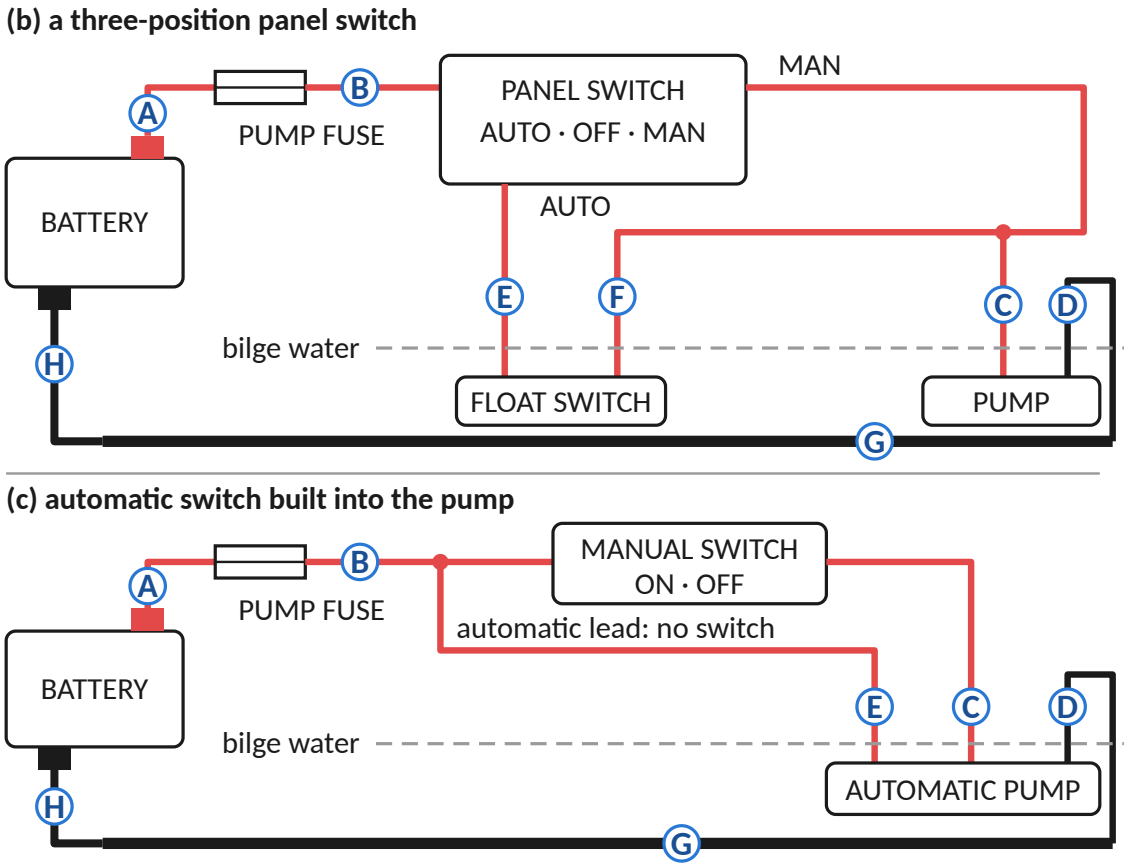


Fig. 12.2. Two more pump circuits, on the geometry and with the points of → Fig. 12.1 · p. 10. Top, switch (b): a three-position panel switch feeds the float switch from AUTO and the pump directly from MAN. Bottom, switch (c): a pump with its automatic switch built in; its automatic lead's splice is point E, fed with no switch on the way, and there is no point F.

CARBON MONOXIDE

A pump on a lithium bank needs the bank as much as it needs its wire. The bank's battery management system (BMS) can disconnect the bank from its terminals, and a pump wired around the battery switch on that bank goes dark with it, and so does a high-water alarm or a CO alarm fed there (→ 11.4). A pump fed from another bank, one that this BMS does not control, keeps working through such a disconnect; otherwise someone watches the water until the bank is back. One maker asks for at least 10.5 V at its 12 V pumps with an automatic switch built in, MFR so a discharging battery can leave such a pump short of what its maker asks long before the battery reads zero.

The pump's fuse is rated by the rule for every fuse (→ 4.3): its rating is at least the pump's current and at most the ampacity of the thinnest wire in its circuit, and where the pump's maker gives a rating smaller than that ampacity, the maker's rating is the one to use. The maker's number is in the pump's manual. One maker's 1100 GPH pump draws 3.7 A at 12 V and 4.7 A at 13.6 V and is fused at 7.5 A; its 1500 GPH pump draws 4.8 A and 7.0 A and is fused at 10 A. MFR

Why a fuse above the running current? A pump whose impeller jams draws far more than its running current — its locked-rotor current, the current of a motor that cannot turn — and the fuse has to open on that as well as on a short. The 1986 edition of ABYC H-22 asked that bilge pump circuits be protected against running overload and locked rotor, with the protection as close as practicable to the pump's rating at design voltage; the 2005 edition has the pump maker's instructions give the recommended protection. ABYC

The battery switch is not how you make the pump's circuit dead: a pump wired around it keeps its power in every position. Its own fuse is, as the procedure at the end of this section shows.

Every reading in the routes of this chapter is taken from a point to the battery's negative terminal (H), not across the pump from C to D. A pump whose negative is broken reads 0 V across C and D while C carries the full battery voltage: with no current flowing, both ends of the pump sit at the same voltage, whichever wire is open. Read against H, the same fault shows the battery's voltage at C and at D, and the open negative shows itself. The negative bus (G) does not take the place of H: with no current flowing, a bus whose cable to the battery makes a corroded, poor connection reads the same as H, and every reading after it would point to the wrong place. Where your meter's black lead does not reach from the pump to H, a clip lead — a wire with a clip at each end — on the black probe extends it.

Procedure: The check that the automatic switch has power

This check works on every switch and every kind of automatic switch, and it needs no hand in the bilge water. It is the check at the end of

every restore block in this chapter, and the one other chapters send you here for after a battery switch has been turned. Use water from a tap or from the water around the boat, not rain water: one maker's conductivity sensor can miss rain water (→ 12.3 · p. 23). You need a bucket and a watch, and, where you cannot see the outlet while you pour, a helper who watches it.

 **GASOLINE VAPOR**  **BILGE PUMP**

1. Set the pump switch to AUTO on switch (b), or the manual switch to OFF on switch (a), so that the automatic switch has power and nothing runs the pump by hand; with no pump switch, there is nothing to set. A switch you cannot identify: take the check first in the position you found it in and then, until one position passes, in each other position the switch stays in when you let go. The position that passes is the one in which the pump, once it has started, stops by itself at the automatic switch's off level, as step 4 describes. A position in which the pump goes on running after the stream at the outlet has stopped, longer than any delay in Table 12.2, is not the one to leave it in: it runs the pump by hand, or it feeds an automatic switch that is held up or has failed closed — move the switch on. If no position passes and a position ran the pump on, the automatic switch is the suspect when the switch also has a position that springs back, or when more than one position ran the pump on: take step 3 of the route in → 12.3 · p. 23 with the switch in a position that ran the pump on — with more than one, in each of them in turn, and read the outcome of its step 4 across all of them. One such position, on a switch with no position that springs back, runs the pump by hand, and step 5 sends you on from the silent positions. The position in which the pump stops by itself goes into the Boat Passport (field 11). The battery switches stay as they are.
2. Pour the water into the bilge at the pump, from above, without your hand in the water, until it stands above the level where the automatic switch starts: about 2 in on common float switches, about 2-3/4 in on one maker's pump with level sensing built in (→ Table 12.2 · p. 25). Keep pouring until the pump starts or the water

stands about 1 in above that level — this book's margin over levels that the makers give as approximate. If you do not know which automatic switch you have, pour to about 1 in above the highest starting level in Table 12.2.

3. Watch the outlet, and give the automatic switch its time: a sensor, or a float switch with a delay against false starts, waits some seconds before it starts the pump, and one maker's pumps with a load-sensing automatic switch test for water once every two and a half minutes, one of its models every 20 seconds. If you do not know which automatic switch you have, or its delay, wait two and a half minutes.
4. The pump starts by itself, water leaves at the outlet in a steady stream, and the pump stops when the water falls to the automatic switch's off level, with some water left in the bilge — or some seconds later, on a sensor that keeps the pump running for a set time after the water drops. The automatic switch has power and works.
5. The pump stays silent after that wait, with the water above its level: the automatic switch has no power, it has failed, or the pump itself does not run — run it in MAN (step 3 of the route in → 12.1 · p. 2). It moves water in MAN: the route "the pump does not come on by itself" (→ 12.3 · p. 23). Silent in MAN too, or a pump with no manual switch: the route "the pump is silent" (→ 12.2 · p. 9). It starts and no water leaves: step 4 of the route in → 12.1 · p. 2. It starts, water leaves, and the pump goes on running after the stream has stopped, longer than any delay in Table 12.2: the switch position first (→ Table 12.1 · p. 11), then the automatic switch, by step 3 of the route in → 12.3 · p. 23.

PUT THE BOAT BACK IN SERVICE

- The pump switch stays where step 1 set it, and step 4 has just shown the pump's automatic switch at work. The water you poured has left the boat, except what lies below the automatic switch's off level. If step 5 sent you on, the route it sent you to ends with this check.

Route: the pump is silent

WHAT CHANGED BEFORE THE PROBLEM?

- after you installed or changed a device → the pump's fuse and the wires you touched while installing it: step 3, then step 4
- after charging → a battery switch that the pump's wires pass through, set back after charging: step 2
- after rain or washing the boat → the splices at the pump, if water reaches them: step 1
- after the boat sat unused → the battery that feeds the pump: step 3
- after switching sources (shore power, generator, inverter) → the battery switches as you found them: step 2
- nothing you noticed → step 1

ROUTE: THE PUMP IS SILENT — POINTS A TO H ON → FIG. 12.1 · P. 10 AND → FIG. 12.2 · P. 13

For a pump that stays silent in MAN or, with no manual switch, with water above its automatic switch's starting level. Water rising, or at a battery's terminals: the card "Water in the boat — the pump can't keep up or is silent" comes first (→ emergency card). You need a meter on DC volts with a black lead that reaches from the pump's splices to H — a clip lead, a wire with a clip at each end, on the black probe extends it — and, with a switch that springs back, a helper who holds MAN at the panel while you read. Alone with such a switch, take steps 1 to 4, which need no MAN, and wait for a helper for steps 5 to 7.

GASOLINE VAPOR SHORT CIRCUIT METER LEADS AC — PRO
BLOWN FUSE CARBON MONOXIDE BILGE PUMP SHOCK IN WATER

1. Find on your boat the points you reach dry and without opening a panel: the battery that feeds the pump, with its positive terminal (A) and its negative terminal (H); the pump's fuse and its output (B); the pump's splices (C, D) where they sit above the bilge water; the negative bus (G). Follow the pump's wires from the pump toward the battery by looking,

and note any battery switch, breaker or isolator switch they pass through. If your Boat Passport is filled in, field 11 holds the answers.

You will see: Reading a splice that sits in the bilge water puts your hand in the water, and a splice in water is itself the first suspect (→ 12.8 · p. 41). The pump's only fuse sits in the panel switch or in an inline holder, with no fuse at the battery: the run from the battery to it is an unprotected positive (→ 12.8 · p. 41), and step 4 has no point B to read. A fuse you cannot find: the route goes on, and step 4 says what to do without it.

2. If the pump's wires pass through a battery switch that is at OFF: with the engine stopped, turn that switch to its working position, and run the pump in MAN again — with no manual switch, watch it with the water above its starting level.

   You will see: The pump runs: the switch was what stopped it, and with that switch at OFF the boat has no automatic pump — write it on the first line of the Boat Passport; moving the pump to a circuit wired around the switch is a pro's job (→ 12.8 · p. 41). Still silent, or no battery switch on the way: step 3. You cannot tell whether a battery switch is on the way: turn every battery switch to its working position, the engine stopped, before step 3.

3. Prove the meter at the battery that feeds the pump: the red lead on point A, its positive terminal, and the black lead on the battery negative terminal, point H.

   You will see: About the battery's normal voltage: the battery and the meter work — step 4. Well below its normal voltage, but not about 0 V: the battery is low, and → 3.5 says what it needs. Go on to step 4 with that reading written down; until the battery is back to its normal voltage, watch the water, and bail if it rises (→ emergency card). Step 6 says what a low battery changes for a pump with its automatic switch built in. About 0 V: prove the meter on another battery you know is charged (→ 3.7). Still about 0 V on this one: the battery has nothing to give — a lead-acid battery discharged, or a lithium battery whose BMS has disconnected it (→ 3.5, → 11.4) — and the pump has no power from it. Watch the water, and bail if it rises, until the pump has power again. A lithium battery can also read a normal voltage while its BMS has disconnected it (→ 3.5): with everything else on that bank dark too, the bank is the first suspect, not the pump's circuit (→ 11.4).

4. Take shore power, the inverter and the generator off the boat — shore power unplugged — as the entry of the AC — PRO sign says. Then read from the output of the pump's fuse at the

battery (B) to H; on a pump fed from a breaker on the DC panel, read that breaker's output in place of B. No fuse at the battery, or a fuse you could not find: step 5.

You will see: About 0 V at B, with A at the battery's voltage: the fuse at the battery, or its holder, is open — step 8. About 0 V at the output of a breaker on the DC panel: the open lies at the breaker or in the panel's own feed (→ 4.8). The battery's voltage at B: the fuse at the battery is sound — step 5.

5. Hold the pump switch in MAN, or have a helper hold it — on a pump with no manual switch, keep the water above its automatic switch's starting level instead — and put the red lead on point C, the pump's positive splice, and the black lead on point H. On a pump with its automatic switch built in and no manual switch, read its automatic lead's splice, E, in place of C.

   You will see: About the battery's voltage at C: power reaches the pump — step 6. Below it, but well above 0 V: a connection on the way loses volts under the pump's current, or a low battery cannot hold its voltage under it; the drop of each section, the battery's own included, read with the pump held in MAN, finds which (→ 3.4). About 0 V: power stops before C — step 7.

6. With MAN still held, or the water still above that level, read from the pump's negative splice (D) to H.

   You will see: About 0 V at D, with C at the battery's voltage: the open lies in the pump's own leads or its motor, or the motor is jammed — on a pump with no manual switch whose automatic switch is built in, that automatic switch as well — and the pump is replaced (→ 12.8 · p. 41). A pump with its automatic switch built in is replaced on this reading only with E at no less than the voltage its maker asks for — one maker asks for at least 10.5 V at its 12 V pumps of this kind; below it, the battery comes first (→ 3.5), and the route is taken again from step 3 when it reads its normal voltage. About the battery's voltage at D as well: the negative is open between D and H — read G to H. About 0 V there: the open is in the pump's negative wire or a splice between D and G. The battery's voltage there: it is in the cable between the bus and the battery, which carries the negatives of other circuits as well; a pro repairs it, with your readings.

7. C reads about 0 V, with B at the battery's voltage, or with no B to read — no fuse at the battery, or one you could not find: the open lies on the way to C — in the panel switch's own fuse, where the switch has one; in the switch or its contact; in

a breaker or an isolator switch on the way; in the wire; or in the splice at C; on a pump with no manual switch, in its automatic switch as well. Look at the fuse in the panel switch first. A broken link or a darkened glass: step 8. A fuse that looks whole proves nothing yet: open the panel the way it is built to open (→ 4.5) and read to H, first the terminal where the wire from B, or from the battery, comes into the switch or its fuse holder, then, with MAN held, the switch's MAN output terminal. On a pump with no manual switch, read its automatic switch instead, as steps 5 and 6 of the route in → 12.3 · p. 23 do.

You will see: About 0 V at the input: the open lies before the switch — in the wire from B or from the battery, in a splice or a terminal strip on its way, in a breaker or an isolator switch you noted in step 1, or in a fuse you could not find; follow that wire toward the battery by looking, and a wire you cannot follow goes to a pro with your readings. The battery's voltage at the input and about 0 V at the output: the open lies in the switch or in the fuse in its housing. The battery's voltage at the output as well: the open lies in the wire or the splice between the switch and C.

8 Replace the blown fuse: a fuse at the battery in a holder that opens by hand, and a fuse in the panel switch, come out and go in by hand; for a fuse under a nut on a stud, the entry of the SHORT CIRCUIT sign says who replaces it. Then run the pump in MAN.

You will see: The pump runs and water leaves at the outlet: the open was the fuse — and a fuse blows on a fault, so look for it (→ 12.8 · p. 41). The new fuse blows as well: with the holder empty the pump has no power at all, in MAN or by itself; look for the cause yourself first, as "A pump fuse that blows on a boat you are leaving" in → 12.8 · p. 41 says, and the entries of the BLOWN FUSE and BILGE PUMP signs say what to do meanwhile. The pump stays silent with a sound fuse: back to step 5.

PUT THE BOAT BACK IN SERVICE

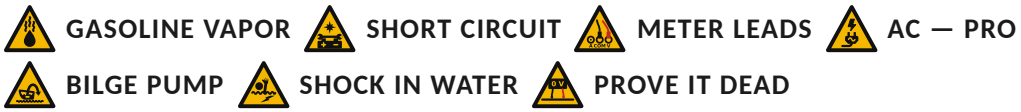
- The fuse holder closed, or the panel switch's fuse turned fully in; a panel you opened, closed; the meter's leads off and its dial at OFF.
- A battery switch you turned in step 2: if the pump ran only after you turned it, the pump is wired after that switch, and its automatic switch has power only while the switch stays in its working position — the entry of the BILGE PUMP sign decides where it stays when you leave the boat, and the first line of the Boat Passport records the wiring. If the pump did not run after the turn: back where you found it, with the engine stopped (→ 1.7).
- The AC sources you took off in step 4: the inverter's DC breaker or isolation switch and its own switch as you found them, the generator's automatic start as you found it, and shore power back last, in the order of → 17.2.
- The pump switch where its automatic switch has power and nothing runs the pump by hand — switch (b) at AUTO, switch (a) OFF; then the check that the automatic switch has power (the procedure in this section), with the battery switches as you will leave them. With a battery switch at OFF that the pump is wired after, the check cannot pass: the BILGE PUMP entry says what you do when the pump's automatic switch has no power.

Procedure: Making the pump's circuit dead before work

Before your hands go on the pump, its strainer, its wires, its splices or its automatic switch, the circuit is made dead at its own fuse and proven dead from the battery's negative terminal (H). The pump can start by itself while your hand is there — its automatic switch starts it when water reaches its level, and one maker's load-sensing pumps start themselves every two and a half minutes, one of its models every 20 seconds — and one pump maker asks for the power to be disconnected before its pump is serviced. The proof covers what lies after the fuse you take out: the pump, its automatic switch, and their wires and splices. A wire from the battery to a fuse that is not at the battery — in

MFR

the panel switch or in an inline holder — stays live, and it is not part of this work (→ 12.8 · p. 41). While the fuse is out the boat has no automatic pump. You need a meter on DC volts with a black lead that reaches from the pump's splices to H.



1. Find the pump's fuse and the points A, H, C and E (→ Fig. 12.1 · p. 10, → Fig. 12.2 · p. 13). The fuse that makes the circuit dead feeds both paths: on switch (a) and on a pump with its automatic switch built in, the fuse at the battery, because the automatic switch's wire leaves it ahead of the manual switch, so a fuse in the manual switch's housing leaves the automatic switch live; on switch (b), the fuse that feeds the panel switch. A fuse under a nut on a stud: this procedure stops here, and the entry of the SHORT CIRCUIT sign says who takes it out. A pump fed from a breaker on the DC panel: that breaker takes the place of the fuse in step 3. A pump wire with no fuse at all cannot be made dead this way: this procedure stops here (→ 12.8 · p. 41).
2. Prove the meter: the red lead on point A, the black lead on the battery negative terminal, point H. It reads the battery's voltage.
3. Take that fuse out of its holder by hand — at the battery, or in the panel switch — or turn the pump's breaker on the DC panel OFF.
4. Take shore power, the inverter and the generator off the boat — shore power unplugged — as the entry of the AC — PRO sign says. Hold the pump switch in MAN, or have a helper hold it, and put the red lead on point C, the black lead on point H; then set the switch where its automatic switch has power and move the red lead to point E. On a pump with its automatic switch built in, E is its automatic lead's splice. Both read about 0 V.
5. Prove the meter again, the red lead on point A and the black lead on point H: the battery's voltage. If it does not show it, the zeros of step 4 proved nothing: find why the meter failed (→ 3.7) and take steps 2 to 4 again.

6. Any voltage at C or E in step 4: something else still feeds it — the automatic switch's own wire from another fuse, a second switch, another battery. Follow the wire of the point that is live toward the battery, by looking, to the fuse that feeds it; take that fuse out as well, by step 3, and take steps 4 and 5 again. A wire you cannot follow, or one that reaches the battery with no fuse: the work waits, and a pro traces it (→ 12.8 · p. 41).

PUT THE BOAT BACK IN SERVICE

- With the work done: every fuse you took out back in its holder, closed — after a new pump, the fuse its maker gives, within the rule of → 4.3 — or the pump's breaker on the DC panel back ON.
- The AC sources as you found them: the inverter's DC breaker or isolation switch and its own switch, the generator's automatic start, and shore power back last, in the order of → 17.2.
- The pump switch where its automatic switch has power and nothing runs the pump by hand — switch (b) at AUTO, switch (a) OFF; then the check that the automatic switch has power (the procedure in this section).

12.3. Float switches and electronic water sensors

How does your pump's automatic switch know that water has come, and how does each kind fail? US boats carry three kinds — a float switch, an electronic water sensor, and an automatic switch built into the pump — and they differ in how they sense water, how long they wait, and what fools them.

A float switch has a float that rises with the water and closes a contact; the contact sits in series with the pump, so it carries the pump's whole current. That is why its rating matters: one maker rates its float switches at 14 A or 20 A at 12 V by model, and says not to use them on a pump that draws more. The same maker mounts the switch on a MFR flat surface, parallel to the waterline and 1/4 in above the bottom of the pump's strainer, and warns that a switch tilted beyond the angles of its diagrams works worse. Two makers' float switches start the pump MFR

at about 2 in of water and stop it at about 3/4 in. A float fails in plain ways: debris holds it down, a hose or a wire lies across it, it was mounted at an angle, or its contact wears out. A float held up runs the pump without stop until the battery is discharged. MFR

An electronic water sensor has no moving part. A conductivity sensor starts the pump when water bridges its sensors and closes a tiny circuit through the water. One maker's sensor of this kind starts the pump after the water has touched its lower sensor for 6–8 seconds, draws 0.006 A while it waits, and runs the pump for several seconds whenever power comes back to it, to calibrate itself. A field sensor senses water through its case by the change water makes in a small electric field. One maker's field sensor starts the pump at 2 in and stops it at 3/4 in, after a delay that one of its pages gives as three seconds and another as eight; a second maker's starts at 2 in, stops below 1/2 in, and on one model keeps the pump running for 30 seconds after the water drops. The maker of the conductivity sensor, and a maker of a pump with its sensor built in, ask for the sensor to be cleaned from time to time. MFR MFR

A pump with its automatic switch built in senses the water itself, in one of two ways. One maker's pumps with a load-sensing automatic switch turn on for about a second every two and a half minutes — one of its models every 20 seconds — and measure the load on the impeller: with water there, they keep running until it is gone. That short run is their normal work. The same maker's pump with level sensing built in starts at about 2-3/4 in and stops at about 5/8 in; it tests every two and a half minutes only in a fault — debris over its sensor, air in the pump, or more than 15 seconds of running without pumping. The same sign, a short run every two and a half minutes, means normal work on one of these pumps and a fault on the other: read your pump's manual before you call it either. MFR MFR

Table 12.2. Automatic switches, as each maker describes its own

Automatic switch	Starts · stops	Waits or tests	The maker's own test
Float switch, maker 1	2 in · 3/4 in	No delay given	On two models, a lever at the back, pressed down MFR
Float switch, maker 2	2 in · 3/4 in	A false-start delay, no time given	None given MFR
Conductivity sensor, maker 3	When water touches the lower sensor	6–8 s before it starts; a short run whenever power comes back	A wet rag across both sensors MFR
Field sensor, maker 2	2 in · 3/4 in	3 s on one page of the maker, 8 s on another	None given MFR
Field sensor, maker 4	2 in · below 1/2 in	One model keeps the pump running 30 s after the water drops	None given MFR
Pump with a load-sensing automatic switch, maker 1	Runs while it finds water	Runs about 1 s every 2-1/2 minutes, every 20 s on one model, to test for water — its normal work	None given MFR
Pump with level sensing built in, maker 1	About 2-3/4 in · about 5/8 in	Tests every 2-1/2 minutes only in a fault: sensor covered, air in the pump, more than 15 s running without pumping	— MFR

Rain water can fool one kind of sensor. The maker of that conductivity sensor writes that large amounts of rain water entering the bilge can dilute the bilge water out of its sensor's range, and that normal fresh water has enough minerals for it to work. So a test with rain MFR water can leave that sensor silent while it works on tap water, and a bilge filled by rain can do the same; the maker's answer for a diluted bilge is to run the pump in MAN. This is that maker's statement about its own sensor: the documents of the field sensors in this chapter's list of documents carry no such note.

When the pump starts, its circuit, its motor and the automatic switch's contact work. That does not prove that water leaves the boat: a clogged intake, air in the pump, a kinked hose or a stuck check valve let the

motor run and move nothing (→ 12.1 · p. 2, step 4). Every test of an automatic switch is judged at the outlet.

Route: the pump does not come on by itself

WHAT CHANGED BEFORE THE PROBLEM?

- after you installed or changed a device → the automatic switch's mounting and its wires, and anything new lying near it: step 3
- after charging → the pump switch, set back after charging: step 1
- after rain or washing the boat → the water itself — rain water on a conductivity sensor: step 2
- after the boat sat unused → debris and film on the automatic switch: step 3
- after switching sources (shore power, generator, inverter) → a battery switch the automatic switch is wired after, if it is: step 1
- nothing you noticed → step 1

ROUTE: THE PUMP DOES NOT COME ON BY ITSELF — POINTS E, F AND H ON → FIG. 12.1 · P. 10 AND → FIG. 12.2 · P. 13

For a pump that runs and moves water in MAN, but not by itself. You need a bucket, a dry wooden or plastic stick, and, for steps 5 and 6, a meter on DC volts with a black lead that reaches from the automatic switch's splices to H — a clip lead on the black probe extends it. In step 6 one hand holds the float up: the black lead stays on H by its clip, or a helper holds it.

GASOLINE VAPOR SHORT CIRCUIT METER LEADS AC — PRO BLOWN FUSE CARBON MONOXIDE BILGE PUMP SHOCK IN WATER PROVE IT DEAD

1. Set the pump switch to AUTO on switch (b), or the manual switch to OFF on switch (a), so that the automatic switch has power and nothing runs the pump by hand. A switch you cannot identify: take step 2 in each position it stays in when you let go. A position in which the pump goes on running after the stream at the outlet has stopped, longer than any delay in Table 12.2, is not one that shows the automatic switch

at work. With such a position, the automatic switch is held up or has failed closed if the switch also has a position that springs back, or if more than one position runs the pump on: go to step 3 with the switch in a position that runs it on — with more than one, in each of them in turn. Otherwise that position runs the pump by hand — not that one. If the pump's wires pass through a battery switch that is at OFF, turn that switch to its working position, with the engine stopped (→ 1.7).

You will see: Switch (b) was at OFF, or the pump is wired after a battery switch that was at OFF: its automatic switch had no power. Step 2 shows whether that was all.

2. Pour water from a tap or from the water around the boat — not rain water — into the bilge at the pump, without your hand in the water, until the pump starts or the water stands about 1 in above the automatic switch's starting level (→ Table 12.2 · p. 25; for an automatic switch you do not know, about 1 in above the highest level there), and give it two and a half minutes. If the bilge holds rain water and the automatic switch is a conductivity sensor, first empty the bilge with the pump in MAN (on some panels, ON) until the stream at the outlet stops, then set the switch back as step 1 set it, so that the sensor meets only the water you pour.

   You will see: It starts and water leaves at the outlet: the automatic switch works with this water. If step 1 found switch (b) at OFF or turned a battery switch, that was what held it: the restore block of this route says what follows. If the boat's own water was rain and the automatic switch is a conductivity sensor, that rain water is the cause its maker names, and the maker's answer is to empty a diluted bilge with the pump in MAN; on a boat you leave through heavy rain nobody is there to do it, while a float switch rises in rain water as in any other, so a second pump with a float switch (→ 12.6 · p. 36) covers that case. Otherwise, look for what held it, in step 3. Silent: step 3.

3. Look at the automatic switch without touching it: debris or a film on it or around it; a float held down, or held up, by a hose, a wire or a strap; a switch knocked off its mounting or tilted. Lift a float with a dry wooden or plastic stick from above the water and hold it up as long as step 3 of the check

that the automatic switch has power waits (→ 12.2 · p. 9), because some float switches wait before they start the pump (→ Table 12.2 · p. 25); then let it fall back.

You will see: The float moves and the pump starts: something held the float — step 4 cleans the space around it. A float held up, or debris or a film on a sensor, with the pump running and not stopping: what holds it is the cause — step 4. The float moves freely and the pump stays silent: step 5. A sensor, or an automatic switch built into the pump, has no float to lift: with debris or a film on it, step 4; clean to the eye, with the pump silent, step 5. The pump goes on running with no stream at the outlet and nothing you can see holding the automatic switch — a float that hangs free, a sensor or an automatic switch built into the pump clean to the eye: step 4, whose outcomes say what follows. A steady stream at the outlet, with the level not falling, is water coming in: the row "The pump runs and does not stop" of → Table 12.4 · p. 42.

4 Clean the automatic switch as its maker's manual says — debris away from the float and its guard, a sensor's face washed with a mild detergent where its maker asks for it. The pump can start by itself while your hand is there, so first make its circuit dead by the procedure "Making the pump's circuit dead before work" (→ 12.2 · p. 9); clean with your hand in the bilge water; then put the fuse and the AC sources back as the first two items of that procedure's restore say. Pour water again, as in step 2.

You will see: It starts, water leaves, and the pump stops at its off level: the dirt was holding it. On a switch you cannot identify that ran the pump on in more than one position, read this across those positions: one in which the pump now stops by itself is the position that feeds the automatic switch, and the cleaning was the cure; one in which it still runs on runs the pump by hand. Still silent: step 5. Still running without stop, with nothing left to hold it — on such a switch, in every one of those positions: the automatic switch has failed closed — step 7. Until it is replaced, stop the pump, which would otherwise run until its battery is discharged: switch (b) to OFF, and its MAN position still runs the pump by hand; on other switches, the fuse out again, by step 3 of that procedure. The entry of the BILGE PUMP sign says what you do while its automatic switch has no power. A pump that runs on with switch (b) at OFF, or with a new automatic switch, is fed past the automatic switch — through the pump switch or its wiring: its fuse out as well, and a pro traces it. You cannot reach the automatic switch: its cleaning goes to a pro (→ 12.8 · p. 41); a silent pump goes on to step 5, and one that runs without stop is stopped meanwhile as above.

5. Take shore power, the inverter and the generator off the boat — shore power unplugged — as the entry of the AC — PRO sign says. Read the automatic switch's feed, with the pump switch as step 1 set it — a switch you cannot identify, in each position it stays in when you let go: the red lead on point E, its input splice, and the black lead on the battery negative terminal, point H (→ 12.2 · p. 9). On a pump with its automatic switch built in, E is its automatic lead's splice.

   You will see: The battery's voltage at E: power reaches the automatic switch — step 6, in that position. About 0 V at E, in every position you read: power does not reach it, and the open lies on its own feed, which MAN does not use. On a switch you cannot identify, follow the wire from E by looking to where it comes from: a terminal of the panel switch is read as on switch (b), in each position the switch stays in, and about 0 V in all of them puts the open in the switch; a junction or a fuse, as on switch (a); a wire you cannot follow goes to a pro with your readings. On switch (b), open the panel the way it is built to open (→ 4.5) and, with the switch in AUTO, read its AUTO terminal to H: the battery's voltage there puts the open in the wire or a splice between that terminal and E; about 0 V puts it in the switch. On switch (a), or a pump fed as switch (a) is, follow the automatic switch's own wire from E toward the battery, by looking, to the junction or the fuse it leaves from, and read there: the battery's voltage at the junction, or at the output of its fuse, puts the open in the wire or a splice between there and E; about 0 V at the output of a fuse of its own, with the battery's voltage at its input, is that fuse open — replace it as step 8 of the route "the pump is silent" says (→ 12.2 · p. 9). A pump with its automatic switch built in, with E — read on the pump's side of the splice — at no less than the voltage its maker asks for (one maker: 10.5 V at a 12 V pump), and the pump still silent after two and a half minutes with the water above its starting level: the automatic switch inside the pump has failed, and the pump is replaced (→ 12.8 · p. 41). E below that voltage: the battery is low, and it comes first (→ 3.5).

6. Lift the float with the dry stick, or pour water from step 2 up to a sensor, and keep it there as long as in step 3; while the automatic switch should be closed, put the red lead on point F, its output splice, with the black lead still on point H.

   You will see: About 0 V at F: the automatic switch does not close. A float switch has failed. A sensor also needs its own negative wire: its splice reads about 0 V to H when the wire is sound; with a sound negative, the sensor has failed. The battery's voltage at F and the pump silent: the wire or the splice between F and C is open.

7 A failed automatic switch, or a pump with a failed automatic switch built in, is replaced: first the procedure “Making the pump’s circuit dead before work” (→ 12.2 · p. 9); the new part, where gasoline vapor can reach it, is ignition protected (below, and → 4.6); a new pump takes the fuse its own maker gives (→ 4.3); who does it → 12.8 · p. 41.

You will see: After the work: the check that the automatic switch has power passes, and the restore block of this route is done.

PUT THE BOAT BACK IN SERVICE

- A battery switch you turned in step 1: if the pump started by itself only after the turn, its automatic switch has power only while that battery switch stays in its working position — the entry of the BILGE PUMP sign decides where it stays when you leave the boat, and the first line of the Boat Passport records the wiring. Otherwise, back where you found it, with the engine stopped (→ 1.7).
- The AC sources you took off in step 5: the inverter’s DC breaker or isolation switch and its own switch as you found them, the generator’s automatic start as you found it, and shore power back last, in the order of → 17.2.
- A fuse holder you opened, closed; a panel you opened, closed; the meter’s leads off and its dial at OFF.
- The pump switch where its automatic switch has power and nothing runs the pump by hand — switch (b) at AUTO, switch (a) OFF; then the check that the automatic switch has power (→ 12.2 · p. 9), with the battery switches as you will leave them.

A pump, a float switch or a sensor that goes into a compartment with a gasoline engine, a gasoline tank or its fuel fittings has to be ignition protected, unless it is isolated from the fuel source in the ways → 4.6 describes. One pump maker prints that requirement in its pump manuals. MFR

ABYC E-11 (2008 edition) asks that an ignition-protected part be marked or identified by its maker, with a marking such as “SAE J1171 Marine”, “UL Marine-Ignition Protected” or “Ignition Protected”. One ABYC

maker's float switch sheet and another maker's sensor sheet in this chapter's list of documents say nothing about ignition protection: for such a part, the marking on it or its maker's document decides, and a part with neither is not identified as ignition protected, so it does not go into such a compartment.

12.4. Rated flow and real flow

How much water does your pump really move, and why is that less than the number on its label? The label gives a flow from its maker's test, under that test's own conditions: a voltage, a hose and a height. On your boat the voltage is what the battery and the wire deliver, the hose is longer and bends, and the outlet sits higher above the pump.

A bilge pump pushes water up from the bilge to the outlet. The height of the outlet above the pump is the head, and every foot of it takes flow away: the pump spends its work lifting the water instead of moving more of it. The hose adds friction, which the pump feels as more head. ABYC H-22 (2005) names four things in the discharge that reduce what the pump delivers as installed: the length of the hose, the number and the sharpness of its bends, the roughness of its inside wall, and any narrowing on the way, such as a check valve or a through-hull, and it asks for a discharge as free of restriction as practicable. ABYC

Table 12.3. One maker's pumps: GPH at three heads, with the share of the number on the label in parentheses MFR

Pump	At 0 ft	At about 3.3 ft	At 6.7 ft
500 GPH	572 (114 %)	470 (94 %)	270 (54 %)
1100 GPH	1,116 (101 %)	1,005 (91 %)	825 (75 %)
1500 GPH	1,050 (70 %)	950 (63 %)	515 (34 %)
2000 GPH	1,480 (74 %)	1,220 (61 %)	1,035 (52 %)

The maker's two manuals print their conditions differently. The manual for the 1500 and 2000 GPH pumps tests them at nominal voltage with fresh water at ambient temperature and prints the middle head as

3.35 ft; the manual for the 500 and 1100 GPH pumps prints it as 3.3 ft and gives no test voltage. MFR

So the number on the label is not a promise in either direction. At zero head this maker's 500 and 1100 GPH pumps move a little more than the numbers on their labels; at about 3.3 ft every pump in the table moves less; at 6.7 ft the 1500 GPH pump moves about a third of the number on its label.

Voltage changes the flow as well. A pump's motor turns slower on lower voltage, and both its flow and the height it can lift fall with it, as a boating safety foundation's pump tests showed. That is why PRACTICE two makers' tables cannot be compared without their voltages: one maker's manual for its 1500 and 2000 GPH pumps tests them at nominal voltage, while a second maker prints its capacities at 13.6 V — its 1250 GPH pump moves 1,250 GPH with no head and 800 GPH at 3 ft, both at 13.6 V. MFR

The 1986 edition of ABYC H-22 rated pumps at its design voltage, 113.3 % of nominal — 13.6 V for a 12 V pump — at 0 and 3 ft of head; the 2005 edition rates flow at three heads, starting at zero. ABYC

A battery at rest gives less than 13.6 V (→ 3.5), and the pump's own wire takes its drop on top of that while the pump runs (→ 3.4). This book holds a pump circuit to a 3 % drop (→ 3.5).

Procedure: Your pump's real flow

This uses the pump's own automatic switch and water that you pour, so it measures the whole system: the pump at the voltage it gets, through its own hose, up to its own outlet. You need a pump whose automatic switch works (→ 12.2 · p. 9), buckets of a known size, all filled before you start, a watch that shows seconds, and no water coming in by itself while you measure; where you cannot see the outlet from where you pour, a helper who watches it and calls the start and the end of the stream. No switch is touched.

GASOLINE VAPOR

1. Let the automatic switch empty the bilge to its off level, and wait until the pump has stopped.
2. Pour at least 10 gal of water from a tap or from the water around the boat into the bilge at the pump, bucket after bucket, faster than the pump can move it, and count the gallons. On a wide, flat bilge, 10 gal does not reach every automatic switch's starting level: pour until the pump starts, and count everything you poured.
3. Start the watch when water starts to leave at the outlet, and stop it when the stream ends — not when the motor stops, because a sensor can keep the pump running for some seconds. If the stream falters between buckets, the pump was waiting for your water, and the time measures your pouring, not the pump: take the measurement again with the buckets closer together.
4. Divide the gallons by the seconds, and multiply by 3,600: that is the pump's real flow on your boat, in GPH. The pump stops at the same off level it started from, so it has moved the water you poured, apart from what runs back from the hose.

WORKED EXAMPLE: A PUMP'S REAL FLOW

Suppose you pour three 5 gal buckets, 15 gal, and water leaves the outlet for 90 seconds. The pump moves 15 ÷ 90 = 0.167 gal a second; times 3,600, that is 600 GPH. Suppose the label says 1100 GPH: the pump moves about 55 % of the number on its label through your hose, at your outlet's height and your battery's voltage.

Suppose the bilge is flat, 24 in by 36 in, with straight sides, and the water stands at a float switch's off level of 3/4 in, as step 1 leaves it. A gallon is 231 cubic inches, so raising it to that switch's starting level of 2 in, 1-1/4 in higher, takes 24 × 36 × 1.25 ÷ 231 = 4.7 gal, and 10 gal raises it about 2.7 in. A bilge twice as long and twice as wide takes four times as much, 18.7 gal, to reach the same level.

LOOKS LIKE THE FIX	FIND OUT FIRST	WHAT FIXES IT
A pump with a bigger number on its label, because the one you have cannot keep up.	Where the water comes from, and how fast (→ 12.1 · p. 2); the real flow of the pump you have, by the procedure above; the hose — its length, its bends, a corrugated or a smooth inside wall, a check valve in it (→ 12.6 · p. 36); and the pump's voltage while it runs (→ 3.4).	The cause of the water first. Then the hose and the voltage the pump already has: one pump maker names smooth-bore hose as the best for flow. MFR A larger pump gains less than its label on the same hose and outlet, and it needs the fuse and the wire its own maker gives (→ 4.3) and, where gasoline vapor can reach it, ignition protection (→ 12.3 · p. 23); a second pump on its own circuit adds a second chance as well as flow (→ 12.6 · p. 36).

12.5. The high-water alarm

Why does a boat need an alarm when it already has an automatic pump, and how is that alarm powered and set? The pump cannot tell anyone that it has failed or cannot keep up. The alarm can: its sensor sits above the level where the pump's automatic switch starts the pump, so it sounds when the water has risen past the pump's level — because the pump is silent, cannot keep up, or moves no water.

The 2005 edition of ABYC H-22 requires an alarm, on a boat with an enclosed accommodation compartment, indicating that bilge water is approaching the maximum bilge water level. It defines that compartment as one contiguous space, surrounded by permanent ABYC

structure, that holds berths for sleeping, a galley area with a sink, and a head compartment; a cuddy meant for gear and an open cockpit, with or without a canvas enclosure, are not one. The maximum bilge water level is the level above which bilge water would harm electrical or mechanical systems, with the boat at rest or under way.

One pump maker's manuals print the same requirement and ask for an audible alarm. MFR

Two alarm makers place the sensor at the high-water level you want to detect, and one of them says where that is: above the level where the pump's automatic float switch starts the pump, and below the critical components, such as the starter. Mounted lower, the alarm sounds every time the pump does its normal work; mounted higher, it sounds after the water has reached what it was meant to protect. MFR

The alarm's power is a question of its own. It can be wired around the battery switch, after it, or on the pump's own fuse. Wired after the battery switch, it is silent whenever that switch is OFF. Sharing the pump's fuse, it goes silent with the pump when that fuse blows — the one failure it should report. On a lithium bank, it goes dark with the bank when the BMS disconnects it (→ 11.4). Trace yours, and write what feeds it in the Boat Passport (field 11).

An audible alarm on a boat with nobody aboard reaches only the people within earshot: a neighbor, or marina staff. Tell them what it sounds like and whom to call. Its sensor draws little while it waits: one maker's sensor uses 0.006 A, about 0.14 Ah a day, a small part of what a battery left alone has to give (→ 7.4). MFR



AC — PRO

Test it the way its maker says. One maker's sensor is tested with a wet rag across its two sensors — your hand at a sensor in the bilge, above the water; another maker's alarm panel has a switch with a test position. An alarm whose sensor has a float is tested by lifting that float with a dry wooden or plastic stick. The test belongs to the monthly check (→ 12.7 · p. 38). MFR

12.6. A second pump, the hose and the check valve

What happens to the water between the pump and the sea, and what keeps the sea from coming back the same way? The hose, its fittings and the outlet decide two things: how much water leaves (→ 12.4 · p. 31), and whether water can run back into the boat when the pump stops.

The impeller of a pump that sits in the bilge does not close the hose when the pump stops: water can pass through it either way. If the outlet goes under water — the boat heels, sits deep with a load, or a wave covers it — the hose fills, and once full it works as a siphon: the sea runs back down the hose, through the silent pump and into the bilge, for as long as the outlet stays below the surface. A loop in the hose, high above the waterline, with a vent at its top, lets air in at the top and breaks that siphon (→ Fig. 12.3 · p. 37).

The 2005 edition of ABYC H-22 puts the outlet above the maximum heeled waterline — the waterline with a powerboat heeled to 7°, or the sheer amidships on a sailboat. An outlet below it needs both a seacock and a vented loop or another means against siphoning, and a check valve is not that means. ABYC

One pump maker's manuals mount the outlet at least 8 in above the heeled waterline: the maker's own margin, written as advice. MFR

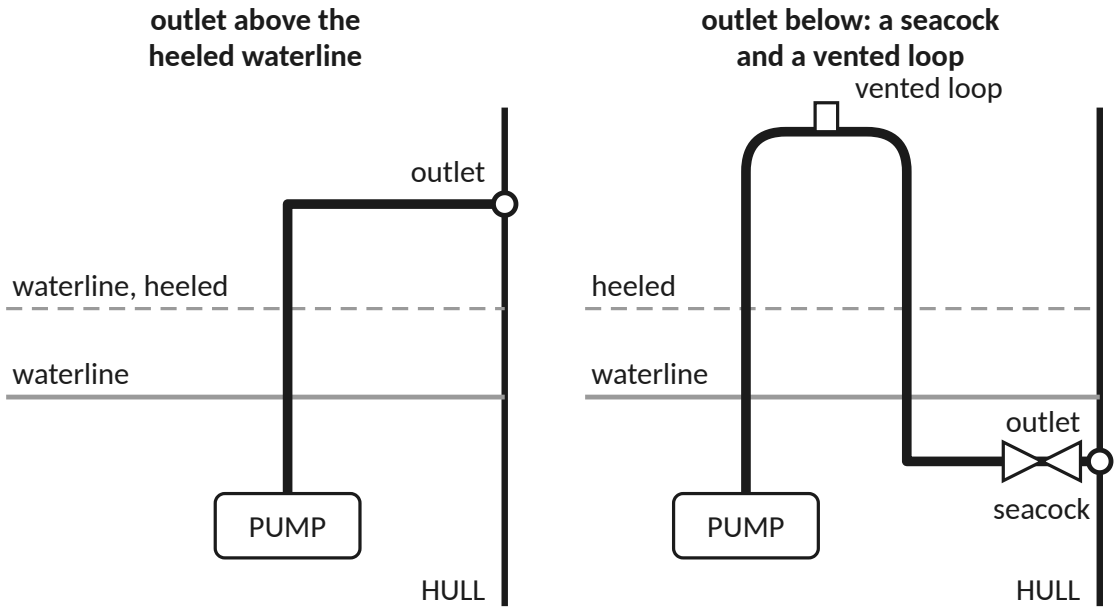


Fig. 12.3. Two ways the pump's hose leaves the boat. Left: an outlet above the waterline even with the boat heeled. Right: an outlet below the waterline, with a seacock at the hull and a vented loop high above the waterline (→ 12.6 · p. 36).

Why not a check valve against siphoning? A check valve lets water through one way and closes against the other — as long as its flap seals. A flap held open by debris lets the siphon through, a flap stuck shut stops the pump's own water, and even a sound valve narrows the hose and takes flow (→ 12.4 · p. 31). The 2005 edition of H-22 allows a check valve only where it is needed to stop an automatic pump from cycling on and off because of water running back from its discharge line. ABYC

That cycling has a plain cause. When a pump with a long hose rising to its outlet stops, the water left in the hose runs back into the bilge; if it lifts the level to the automatic switch's starting level again, the pump starts, pumps the same water up, and stops — again and again, each time from the battery. One pump maker ships a check valve with its pump for exactly that, to reduce cycling from back-flow. A pump that starts every few minutes with no new water in the bilge has this cause among others: a load-sensing automatic switch doing its normal test, or a level-sensing pump in its fault mode (→ 12.3 · p. 23), or water coming in slowly. MFR

Two or more pumps can share one outlet. The 2005 edition of H-22 then asks that one pump not feed back through another, that running them together not reduce what the system moves, and that no check valve stand in the shared line. ABYC

The same edition asks that hose connections be secured with clamps that do not corrode, or with fittings fixed permanently to the hose. One pump maker names smooth-bore hose as the best for flow; ABYC another gives each pump's hose size on its data sheet. MFR

A second pump, mounted higher than the first, with its own fuse at the battery, its own automatic switch and its own outlet, starts when the water has risen past the first pump. Each single part of the first circuit — its fuse, its float, its hose — can stop the first pump alone; the second circuit shares none of them. Neither the 2005 edition of ABYC H-22 nor one pump maker's manuals require a second pump; the reasoning for it is the single parts. When the second pump starts, the first has PRACTICE stopped or cannot keep up, and a high-water alarm at the second pump's level tells someone (→ 12.5 · p. 34).

12.7. The monthly check and acceptance by function

How do you know, while you are away, that the pump will work when water comes? By having watched it work the way it must then: by itself, with the switches as you leave them, moving water out of the boat. One pump maker's manuals ask for the function of every bilge pump to be checked at regular intervals, without naming an interval; this MFR book's interval is once a month, and before any absence longer than a month.

Procedure: The monthly check

The check is taken with the boat as you leave it: battery switches and pump switch as they stay while you are away. You need a bucket, a dry wooden or plastic stick, and the Boat Passport.

 GASOLINE VAPOR  AC — PRO  CARBON MONOXIDE  BILGE PUMP
 SHOCK IN WATER

1. Set the battery switches and the pump switch as they stay while you are away, with the engine stopped (→ 1.7).
2. Take the check that the automatic switch has power (→ 12.2 · p. 9): water from a tap or from the water around the boat, poured at the pump until the automatic switch starts it, and two and a half minutes of patience.
3. Watch the outlet from the boat or the dock: a steady stream, then the pump stops with water left at its off level. Note how long it ran. The pump stays silent, or no water leaves: the outcomes of step 5 of the check (→ 12.2 · p. 9) send you on.
4. Test the high-water alarm the way its maker says: its test position; a float lifted with the dry stick; or a wet rag across its sensor — your hand at the sensor in the bilge, with shore power, the inverter and the generator off the boat first, as the entry of the AC — PRO sign says. It sounds. It stays silent: what feeds it comes first (→ 12.5 · p. 34).
5. Look, without touching, along the pump's hose to its outlet — no kink, no crack, every clamp in place — and at the space around the automatic switch: no debris, no film.
6. Write the date, how long the pump ran and whether the alarm sounded into the Boat Passport.

PUT THE BOAT BACK IN SERVICE

- The AC sources, if you took them off for step 4: the inverter's DC breaker or isolation switch and its own switch as you found them, the generator's automatic start as you found it, and shore power back last, in the order of → 17.2.
- The high-water alarm's switch, if step 4 used its test position: back in the position in which the alarm sounds when water reaches its sensor — "armed", in the words of one maker whose rocker switch tests the alarm, turns it off or arms it MFR — and seen resting there.

- Leaving the boat: the switches stay as step 1 set them — a battery switch you leave OFF stays OFF — and step 2 has proven the pump's automatic switch in exactly that state.
- Staying aboard: the battery switches back to their working positions, with the engine stopped; then the check that the automatic switch has power once more (→ 12.2 · p. 9).

Acceptance by function

When a pro has worked on the pump, its switch or its wiring, accept the work by what it does, not by the sound of a motor. Seven signs:

- ☐ With the battery switches and the pump switch as you leave the boat, the pump starts by itself when water is poured in, and water leaves at the outlet in a steady stream.
- ☐ A float lifted with a dry stick starts the pump; a sensor starts it within the delay its maker gives.
- ☐ The high-water alarm sounds on its test.
- ☐ The pump's positive starts at the battery with its own fuse, within the distance of → 4.2; its rating passes the rule of → 4.3 and can be read on the fuse or its holder.
- ☐ The splices sit above the highest bilge water and are sealed: one pump maker asks for butt connectors and a marine-grade sealant, and two makers for every connection above the highest water level. MFR
- ☐ The outlet sits above the heeled waterline, or below it with a seacock and a vented loop (→ 12.6 · p. 36), and the Boat Passport says how the pump is fed (field 11).
- ☐ A new pump, float switch or sensor where gasoline vapor can reach it carries an ignition-protection marking, or its maker's document identifies it as ignition protected (→ 12.3 · p. 23).

The boat without you

While you are away, the battery that feeds the pump carries the automatic switch's standby current, the pump's runs, and everything

else that stays connected to it: every circuit wired around the battery switch (→ 1.7) and, with a battery switch left ON, everything after it as well. A charger on shore power keeps that battery charged only if the charger is wired to that battery and shore power stays on: trace which banks your charger is wired to (→ 1.7). The standby current of a sensor is small; a pump that tests for water by running draws more, and the pump's real work is set by the rain and the seepage.

> **NUMBERS**
>
> Suppose a sensor draws 0.006 A while it waits: 0.006 × 24 = 0.14 Ah a day. Suppose a pump with a load-sensing automatic switch draws 4 A for one second in every 150: that averages 4 ÷ 150 = 0.027 A, or 0.64 Ah a day, before it moves any water. Suppose rain and seepage make a pump that draws 4.8 A run 10 minutes a day: 4.8 × 10 ÷ 60 = 0.8 Ah a day.
>
> How many days your battery holds with these loads and the others is worked out in → 7.4.

12.8. On board

Your pump gives you a symptom: silence, a hum, a run every few minutes, a fuse that blows, an alarm. What do you check first, what can you repair yourself, and what goes to a pro? This section sends each symptom to its first check, draws the line between your work and a pro's, and ends with the pump on someone else's boat and the pump far from help.

> **ON BOARD: GOLDEN RULE**
>
> **Judge the pump by the water that leaves the boat, not by the sound of its motor. A motor can turn with a clogged intake, a kinked hose or a stuck check valve and move nothing; only a stream at the outlet shows that the pump, its hose and its outlet work together.**

What it means

Each first check below names the route or procedure that takes it; the signs at the start of that route or procedure go with it.

Table 12.4. What it means

What you notice	What is happening	First check	Yourself or a pro
The pump is silent in MAN and by itself	No power at the pump, an open negative, or the pump's motor	The route "the pump is silent" (→ 12.2 · p. 9)	**Do it yourself, if... you can take that route, with its signs**
The motor hums or runs, and no water leaves at the outlet	A clogged intake, air in the pump, a kinked hose, a closed seacock or a stuck check valve; or the outlet higher than the pump can lift	Step 4 of the route in → 12.1 · p. 2	**Do it yourself, if... you can take that step, with the route's signs; a failed pump: Hire a pro, or replace it (Do it yourself or hire a pro, below)**
The pump runs in MAN, never by itself	No power at the automatic switch; an automatic switch held by debris or failed; water below its starting level; rain water on a conductivity sensor	The route "the pump does not come on by itself" (→ 12.3 · p. 23)	**Do it yourself, if... you can take that route, with its signs**
The pump runs for a moment every few minutes, with a dry bilge	A pump with a load-sensing automatic switch doing its normal test; a level-sensing pump in its fault mode; water running back from the hose; water coming in slowly	Which automatic switch you have (its manual; → Table 12.2 · p. 25); then whether water leaves at the outlet each time, and whether the level rises between runs (→ 12.6 · p. 36)	**Do it yourself**

What you notice	What is happening	First check	Yourself or a pro
The pump runs and does not stop	Water coming in as fast as the pump moves it; a float held up; a MAN position that does not spring back, left on; a sensor fouled; an automatic switch failed closed	The level against a mark, and the outlet. A stream at the outlet and the level not falling: water is coming in — rising, the card "Water in the boat — the pump can't keep up or is silent" (→ emergency card); steady, where it comes in (→ 12.1 · p. 2). No stream, or the water already down at the pump's intake: the switch position (→ Table 12.1 · p. 11), then step 3 of the route in → 12.3 · p. 23	**Do it yourself; the water rising — the card**
The panel light is lit and the pump is silent	On one maker's lighted switch, the light shows power leaving the switch, and the open lies after it: in the wire, a splice, the pump or its negative	The route "the pump is silent" (→ 12.2 · p. 9), from step 3	**Do it yourself, if... you can take that route, with its signs**
A new pump fuse blows as well	A fault in the circuit — a jammed impeller, water in a splice, a chafed wire, among others — or a fuse rated below the pump maker's number	"A pump fuse that blows on a boat you are leaving", in this section	**Do it yourself, if... you find the cause; a cause you cannot find: Hire a pro**
The high-water alarm sounds	Water above the pump's level: the pump is silent, cannot keep up, or moves no water	The water against a mark: rising — the card (→ emergency card); standing — the route in → 12.1 · p. 2	**Do it yourself; the water rising — the card**

What you notice	What is happening	First check	Yourself or a pro
The pump goes silent when you turn a battery switch OFF	The pump is wired after that switch	The first line of the Boat Passport; the circuit in → 12.2 · p. 9	**Hire a pro: the pump moved to a circuit wired around the switch, with its own fuse at the battery**
The pump's positive leaves the battery with no fuse	An unprotected positive, also where the only fuse sits in the panel switch or along the wire: a fault in its insulation would draw the battery's full current	"A pump on a wire with no fuse", in this section	**Hire a pro to add the protection**

A pump on a wire with no fuse



A bilge pump whose positive leaves the battery with no fuse — none at all, or one only in the panel switch or along the wire (→ 12.2 · p. 9) — is the case of → 4.2 where both choices carry a risk: the wire can burn if its insulation fails, and a boat without its pump can sink. The entry of the BLOWN FUSE sign says when the pump keeps running on such a wire. Write the wire on the first line of the Boat Passport, and have a pro add its protection at the battery, rated to the pump maker's number and the wire (→ 4.3).

A pump fuse that blows on a boat you are leaving





A pump fuse that blows again has found a fault, and with its holder empty the pump has no power at all, in MAN or by itself. Look first for the causes you can find yourself: a fuse rated below the number in the

pump's manual, which can blow on the pump's own current — the rating the circuit takes is the rule of → 4.3; debris jamming the impeller, which makes the motor draw its locked-rotor current (→ 12.2 · p. 9), cleared as step 4 of the route in → 12.1 · p. 2 says; a splice or a connector that sits in the bilge water (step 1 of the route "the pump is silent", → 12.2 · p. 9). With the cause found and put right, the entry of the BLOWN FUSE sign says when a fuse goes back in, and of what rating. A cause you cannot find — a wire chafed through somewhere along its run, a motor that draws more than its maker's number — goes to a pro (What to tell the pro, in this section). Until the pump has power again, the entries of the two signs above say what you do when you leave the boat.

Do it yourself or hire a pro

DO IT YOURSELF OR HIRE A PRO · THE BILGE PUMP

STOP · Water rising in the boat, or at a battery's terminals: the pump is no longer the job.
What to do this minute: Go to the card "Water in the boat — the pump can't keep up or is silent" (→ emergency card).

HIRE A PRO · Moving a pump wired after the battery switch to a circuit wired around it, with its own fuse at the battery; protection at the battery for a pump positive that has none there; a fuse under a nut on a stud; a pump fuse that blows again with no cause you can find; a new outlet, seacock or vented loop; anything on the AC side in the bilge. Order it in trade words (What to tell the pro, below) and accept it by function (→ 12.7 · p. 38).
If no pro is available:  **BILGE PUMP**  **BLOWN FUSE** Each job leaves the boat as it is until it is done. A pump wired after the battery switch has its automatic switch only while that switch is in its working position; a blown fuse — under a nut on a stud, or one that blows again — leaves the pump with no power at all, in MAN or by itself; a positive with no fuse at the battery is the case of "A pump on a wire with no fuse", above. The entries of the two signs say what you do until then.

When a pro may do it differently: A pro may protect the pump's wire with a breaker or a fuse of another kind at the battery, or fit a pump with its automatic switch built in instead of a separate float switch — ignition

protected where gasoline vapor can reach it (→ 12.3 · p. 23). You see it in a rating you can read at the start of the wire, in the updated Boat Passport, and in the check that the automatic switch has power.

DO IT YOURSELF, IF…

- **AC — PRO** The strainer, the float or the sensor is within your reach — then clean it with your hand, the pump's circuit made dead first: the strainer by step 4 of the route in → 12.1 · p. 2, the float or the sensor by step 4 of the route in → 12.3 · p. 23.
- **SHORT CIRCUIT** **BLOWN FUSE** The pump's fuse sits in a holder that opens by hand, at the battery or in the panel switch — then replace a blown one by the route "the pump is silent" (→ 12.2 · p. 9).
- **GASOLINE VAPOR** **SHORT CIRCUIT** **AC — PRO** **PROVE IT DEAD** The new pump, float switch or sensor works the same way as the old one — the same kind of automatic switch, wired the same way — the splices sit above the highest bilge water, and the circuit can be made dead by the procedure in → 12.2 · p. 9 — then replace it, each splice made with a butt connector and a marine-grade sealant, as one pump maker asks; a new pump with the fuse its own maker gives, within the rule of → 4.3; and, where gasoline vapor can reach it, a part that is ignition protected (→ 12.3 · p. 23).

DO IT YOURSELF · With no tool: the check that the automatic switch has power (→ 12.2 · p. 9), the monthly check (→ 12.7 · p. 38), the pump's real flow (→ 12.4 · p. 31), the alarm's own test, and a look along the hose and at the outlet.

What to tell the pro

WHAT TO TELL THE PRO

Ask for this: "Trace the bilge pump circuit from the battery and write it down — what feeds the pump switch and the automatic switch, wired around the battery switch or after it, the fuse at the battery and its rating, the wire gauge, and where the splices are. If the pump is wired after the battery switch, move it to a circuit wired around the switch with its own fuse at the battery, rated to the pump maker's number and the wire. Make every splice above the highest bilge water and seal it." For

a fuse that blows: “Find why the pump’s fuse blows — the impeller, the motor’s current, the splices and the wire.” Accept the work by function (→ 12.7 · p. 38): with the switches as you leave the boat, the pump starts by itself when water is poured in, and water leaves at the outlet; the fuse’s rating can be read at the battery; and the Boat Passport says how the pump is fed (field 11).

ON SOMEONE ELSE’S BOAT

1. **Find:** the pump switch and which kind it is; the outlet; the high-water alarm and its test.
2. **Check:** the pump and the alarm by the 20-minute check of → 2.6; ask the base when the automatic switch was last tested.
3. **Don’t touch:** the pump’s fuse, its wires and its splices; a float in the bilge without the permission of the base or the owner.
4. **What to tell the base or the owner:** what the pump did in MAN and by itself, whether water left at the outlet, which fuse blew — on their boat you name it, you do not replace it — and whether the alarm sounded.

On someone else’s boat there are three levels, not four: switches and buttons — yes; tools — no; the gray zone — only with the permission of the charter base or the owner, by phone (→ 2.6).

 CARBON MONOXIDE  BILGE PUMP

AWAY FROM HELP

1. **What fails most often:** the pump clogged by debris, and its battery run down — the two causes a boating safety foundation names (→ 12.1 · p. 2); this chapter’s routes also find the pump’s fuse and a splice that sits in water.
2. **What you lose:** the automatic switch: the boat is pumped only while someone runs the pump by hand or bails; on a lithium bank whose BMS disconnects it, the high-water alarm and a CO alarm on that bank as well (→ 11.4).
3. **How to get to shore without it:** with the pump in MAN while someone watches the water, a bucket or a manual pump as well, and

the route of → 12.1 · p. 2 once the boat is safe; water rising — the card (→ emergency card).

4. **Spares to carry (with ratings):** fuses of the rating your pump's maker gives and of the type in its holder; a float switch or a sensor of the kind you have, rated for your pump's current and, for a place gasoline vapor can reach, ignition protected (→ 12.3 · p. 23); butt connectors and a marine-grade sealant; a manual pump and a bucket; a spare pump of the same size, ignition protected where the first one has to be, with its maker's fuse rating written on its box.
5. **What not to do at sea:** count on the pump against a leak in the hull — it is made for rain, spray and seepage (→ 12.1 · p. 2); judge it by the sound of its motor instead of the water at its outlet.

REMEMBER

- Judge the pump by the water at its outlet, not by its sound or its light.
- A pump wired around the battery switch keeps its power in every position of the battery switch and starts at the battery with its own fuse; a pump wired after the switch stops with it.
- Every reading of a pump circuit is taken against the battery's negative terminal; across the pump, a broken negative reads like no power at all.
- An automatic switch starts the pump at its own level after its own delay: too little water, rain water on a conductivity sensor or too short a wait makes a working automatic switch look dead.
- A short run every two and a half minutes is normal work on one maker's pumps and a fault on another of the same maker's pumps: the manual tells which.
- The flow on the label is a test result; your pump moves less through your hose, at your outlet's height and your battery's voltage.

- A high-water alarm is the pump's report: it sounds when the water has risen past the pump, if its own power survives the pump's failure.

Self-check

1. **Before you measure.** Suppose the pump is silent in MAN, and from point C to H the meter reads 12.6 V, and from D to H it also reads 12.6 V. Where is the open?
   Answer: in the negative path between D and H: with no current flowing, D sits at C's voltage through the pump's motor. Read G to H next: 12.6 V puts the open between the bus and the battery, about 0 V between D and the bus (→ 12.2 · p. 9).
2. **Before you measure.** In the same fault, what does the meter show across the pump, from C to D, and why is that the wrong place to read?
   Answer: about 0 V: both splices sit at the battery's voltage, so a pump with an open negative reads like a pump with no power at all (→ 12.2 · p. 9).
3. **Before you buy.** Suppose your pump is one maker's 1500 GPH model and its outlet sits 6.7 ft above it. About how much does it move, by its maker's table, and will it be more or less on your boat?
   Answer: about 515 GPH, a third of the number on its label, at the maker's test voltage; less through a long or corrugated hose, and less again at a voltage below the test's (→ 12.4 · p. 31).
4. **Two and a half minutes.** Your pump runs for about a second every two and a half minutes with a dry bilge. Fault or not?
   Answer: your pump's manual tells which. On one maker's pumps with a load-sensing automatic switch it is their normal test for water; on that maker's level-sensing pump it means debris on its sensor, air in it, or a run without pumping. Water running back from the hose and a slow leak give the same sign (→ 12.3 · p. 23, → 12.6 · p. 36).
5. **On your boat.** Find the pump switch, its kind — (a), (b) or (c) of → Table 12.1 · p. 11 — and the pump's fuse: where it sits and its rating. Write all three in the Boat Passport (field 11).
   Answer: with the three written, the route "the pump is silent" starts from your

own boat; a fuse you cannot find is traced next, by following the pump's positive wire toward the battery (→ 12.2 · p. 9).

6. **On your boat.** With the battery switches and the pump switch as you leave the boat, take the check that the automatic switch has power (→ 12.2 · p. 9). Does the pump start by itself, and does water leave at the outlet?

   Answer: yes to both — write "yes" on the line "Starts by itself with every battery switch OFF?" if your switches were all OFF. The pump stays silent: step 5 of the check says where to go on, and a pump wired after a battery switch shows itself in step 2 of the route "the pump is silent" (→ 12.2 · p. 9). It starts and no water leaves: step 4 of the route in → 12.1 · p. 2.

7. **On your boat.** Measure your pump's real flow by the procedure in → 12.4 · p. 31, and compare it with its label.

   Answer: the number is what your pump moves through your hose at your outlet's height; the label never was (→ 12.4 · p. 31).

Terms

circuit wired around the battery switch
A circuit connected on the battery side of the battery switch, so it stays live in every position of that switch.

automatic switch
The part that starts the bilge pump by itself when water reaches its level: a float switch, an electronic water sensor, or one built into the pump.

float switch
An automatic switch whose float rises with the water and closes the pump's circuit at one level and opens it at a lower one.

electronic water sensor
An automatic switch with no moving part that senses water by its conductivity or by an electric field and starts the pump after a delay its maker sets.

automatic switch built into the pump
A pump that senses water itself: by a short test run that measures the load on its impeller, or by a level sensor in its housing.

pump switch
The switch at the panel that runs the pump by hand; on a three-position switch, also the position that feeds its automatic switch.

open (in a circuit)
A break in a circuit's path — a blown fuse, a broken wire, a corroded splice, a contact that does not close — where no current can pass.

spring-return switch (momentary)
A switch position that holds only while your hand holds it; on some pump switches, MAN returns to OFF when you let go.

starting level · off level
The water levels at which an automatic switch starts and stops the pump.

locked-rotor current
The current a motor draws when its rotor cannot turn, as in a pump whose impeller is jammed; far above its running current.

head (pump head, lift)
The height a pump lifts water, from the pump to its outlet; the friction of the hose adds to it.

rated flow
The flow a pump's maker measured under the conditions printed with it: a voltage, a head, a hose.

high-water alarm
An alarm whose sensor sits above the pump's starting level and below the level where water harms the boat's systems.

enclosed accommodation compartment
In ABYC H-22 (2005), one contiguous space surrounded by permanent structure that holds berths, a galley area with a sink, and a head compartment.

maximum heeled waterline
In ABYC H-22 (2005), the waterline with a powerboat heeled to 7°, or the sheer amidships on a sailboat.

siphon
Water that keeps running through a full hose, over its high point, from the higher water level to the lower one.

vented loop
A loop in a discharge hose, high above the waterline, with a vent at its top that lets air in and breaks a siphon.

check valve
A valve that lets water through one way and closes against the other.

cycling
An automatic pump starting and stopping again and again on the same water, such as water running back from its hose.

ignition protected
Built so that, in its design operating conditions, it does not ignite the gasoline vapor around it.

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