APLUXOR MARINE ELECTRICAL LIBRARY · SAFETY SIGNS

Safety Signs

One sign for each kind of hazard, and its rule in one place.

A sign marks one kind of hazard. In a chapter it stands once, at the start of the work it concerns, and leads here: when the rule applies, what to do and why. Where an entry sends you to an emergency card, the card holds the actions.



GASOLINE VAPOR Sparks near gasoline vapor

When: a meter or tester, a clamp, a switch, a power tool, a replacement or a crank in a compartment with a gasoline engine or tank; a heat gun, a flame or a soldering tool there or at a fuel tank, fill, vent or hose; a gasoline smell.

Do:

- Before you crank or start, run the bilge blower at least four minutes and check for no gasoline smell. CFR
- Do the same before a meter, a clamp, a switch, a power tool or a replacement there. PRACTICE
- No blower, or no power to it: open the compartment to the air and check for no smell first; with a gasoline engine in it, do not crank or start. PRACTICE
- A heat gun, a flame or a hot soldering tool: never in a compartment with a gasoline engine or tank, and never aimed at a fuel tank, fill, vent or fuel hose — the blower and the smell check do not make the space safe for them. Make the joint up outside it; a joint that can only be made inside: hire a pro. MFR
- If you smell gasoline: only the blower on, nothing else on or off, no engine start; open the hatches and find the leak. PRACTICE

Why: Vapor collects in a closed compartment and can explode; switch contacts (opening or closing), probes, clamps, power tools and the starter make sparks; a heat gun can blow air hotter than the temperature at which gasoline vapor ignites with no spark at all.



SHORT CIRCUIT Metal at a battery terminal

When: anything at a battery terminal, at a stud that stays live with every battery switch OFF, at the engine block, on a negative bus or at any other negative connection; a planned job on a battery — taking it out and putting it or a new one back in the same session, cleaning or tightening its terminals; a fuse at the battery, or at the panel on a circuit wired around the battery switch; a battery test or a portable charger's clamps.

Do:

- Take off metal jewelry (rings, watch, bracelets, necklace, belt buckle), wear eye protection, ventilate, and keep flame, sparks, smoking and loose metal away from the battery.
- Never let metal touch a live terminal and other metal at once — the other terminal, the engine block or any negative.
- A fuse at the panel on a circuit wired around the battery switch stays live with every switch OFF: jewelry off, that circuit's own switch OFF, the fuse out and in by hand — never a metal tool on the holder. PRACTICE
- A fuse at the battery in a holder that opens by hand comes out and goes back in with what it feeds off at its own switch, where it has one. A charging source's own fuse — a solar charge controller's or a wind generator's — comes out only after that source is off: the solar panels covered or their solar disconnect switch OFF, a wind generator stopped at the control its manual names; it goes back in before that source is turned back on. A fuse between two banks — a charging relay's, a DC-DC charger's, or a charger's on an output its manual does not call isolated — or one whose circuit you cannot tell: only with the engine stopped, every load off — so not under way,

and at anchor only by day — and every charging source off — the charger and any inverter/charger, a DC-DC charger, solar panels covered or their solar disconnect switch OFF, a wind generator stopped at the control its manual names, a generator stopped and its automatic start OFF — and the compartment open to the air at least 15 minutes. For such a fuse, a DC-DC charger is off at its own control — the remote on/off or the app its manual shows — or, with none, stopped by its maker's run conditions: the engine stopped and every other charging source off for the delay its manual gives; one that nothing but this fuse switches off: hire a pro. PRACTICE

- A portable charger's clamps or leads go on and come off only with its AC cord unplugged. MFR
- A wrench on a negative connection — the negative lug on the engine block, a negative bus, either stud of a battery monitor's shunt, a charger's, an inverter's or a DC-DC charger's DC negative terminal, or any other negative stud or terminal: engine stopped; meter on DC volts, black lead clipped to that negative, an insulated clip or a probe tip on one positive terminal alone — never bridging it and the negative. With the battery switch still ON, battery voltage to a positive you can identify — at the engine block, the starter stud. Then battery switch OFF — and a unit's positive terminal within reach made dead at the DC breaker or isolation switch that feeds it, or its own fuse at the battery out where its holder opens by hand — and 0 V from that negative to every positive terminal within reach of the wrench. Any voltage, or a terminal you cannot identify: hire a pro. Prove the meter again on a known live source before the wrench goes on; if it fails, the zeros proved nothing. PRACTICE
- A planned job on one 12 V lead-acid battery, or on one 12 V lithium battery with its BMS inside whose maker's manual addresses the owner (not one with an external BMS, nor one in a system its maker reserves to qualified personnel), or on one battery of a bank of such batteries joined in parallel — taking it out and putting it or a new one back in the same session (before you leave the boat), cleaning or tightening its terminals, but not a new cable or a new lug — is yours if the battery is not hot, swollen or gassing, water in the boat has not reached its terminals and no fuse is bolted to its positive

terminal: the compartment open to the air at least 15 minutes before any switch in it is turned; then every load off — so not under way, and at anchor only by day — and every charging source off — the charger and any inverter/charger, a DC-DC charger, solar panels covered or their solar disconnect switch OFF, a wind generator stopped at the control its manual names, a generator stopped and its automatic start OFF, the engine stopped; battery switch OFF; jewelry off, eye protection and insulating gloves on; one wrench at a time, with insulated handles, never touching two points at once. Note which cable goes where. The negative of the whole bank off first: the bank's main negative cable, then every other negative lead on every battery of the bank, and the same on every bank tied to it on the positive side by a switch at BOTH, ALL, 1+2 or COMBINE, a parallel switch, a charging relay whether or not it seems closed, a DC-DC charger, or a charger — except a charger with one output for each bank whose manual says its outputs are isolated from one another; each lug covered and tied back as it comes off. Then, on DC volts, with the meter proven on a known live source: 0 V from the bank's positive terminal to the negative bus — for a bank kept apart from the boat's other negatives, to the end of its own negative cable. The battery's own positive terminal reads 0 V the same way before a tool goes on it — on a lithium battery as well; a BMS that has disconnected it is no proof. Any voltage on any of these readings: no tool on any positive lug or terminal; every charging source stopped again by its own control; then every negative put back as below, those of the tied banks first and the bank's main negative cable last; hire a pro. A battery that joins a bank goes in only after it and the others have each been charged until the charger shows the charge complete — a lithium battery fully, as its manual says. A lithium battery joins a parallel bank only where its maker's manual and product specification allow parallel connection, and only with the batteries they allow with it. Back on: the positive first, with its boot or cover back on; then every negative of the bank and of the banks tied to it, the bank's main negative cable last; each nut to the torque its maker gives on the label or data sheet, set with a torque wrench with insulated handles — on a lead-acid battery, none given or no

such wrench: a small 6-inch wrench, as one battery maker advises; on a lithium battery, the terminal hardware of the type and each nut at the torque its manual gives, with that torque wrench; the hold-down fastened. A bank in series — 24 V, or 12 V from two 6 V batteries — and a battery whose bank is tied to a bank in series: hire a pro. A battery that cannot go back the same session: hire a pro — except on a boat out of the water, where it may stay out while every lug lifted stays covered and tied back, the battery switch stays OFF and every charging source stays stopped, and it goes back, by this same job from its first step, before the boat goes back in the water. PRACTICE

- A wrench on a stud or terminal that stays live with every battery switch OFF — at the battery, on the battery side of a battery switch, on a starter stud fed ahead of the switch, or on a bus or circuit wired around the switch — is a pro's job, whether it holds a fuse under a nut (even under a lift-off cover), a lug, a cable or a jumper, unless its own fuse at the battery, in a holder that opens by hand, has made it dead, or it is the planned job on a battery above. PRACTICE
- No pro available and the terminal work cannot wait: every load off and every charging source off — the charger and any inverter/charger, a DC-DC charger, solar panels covered or their solar disconnect switch OFF, a wind generator stopped at the control its manual names, a generator stopped and its automatic start OFF, the engine stopped; jewelry off, eye protection and insulating gloves on, ventilate; one wrench, with insulated handles, never touching two points at once; the negative of the whole bank off first and on last. PRACTICE

Why: Battery terminals, and the studs fed from them ahead of every switch, cannot be switched off: metal across one and other metal is a short that heats in an instant, and its spark can ignite battery gas.



METER LEADS Meter leads and jacks

When: the probes are about to touch anything powered; a current reading with the meter in series.

Do:

- Before the probes touch anything powered: red lead in the jack marked V, black lead in COM, dial on DC volts (or DC millivolts) — AC volts for the AC zero check (→ 3.7).
- A current reading in series — only for the draw with everything off (→ 7.3), and only into a negative connection opened under the SHORT CIRCUIT sign: the SYSTEM side of a battery monitor's shunt, a negative cable at the negative bus or, on a boat with no shunt, the battery's negative cable at the engine block; never at a battery terminal. Every charging source off; every bank that can be joined to the one you measure kept apart from it — a switch at BOTH, ALL, 1+2 or COMBINE on one bank alone, a parallel switch OFF, a charging relay at the position its maker gives for holding it open or with its own fuse at one bank out of a holder that opens by hand — a relay with neither counts as joining them, whatever they read; an inverter or inverter/charger OFF at its DC breaker or isolation switch. Not with a meter whose current jack has no fuse its manual names, or whose manual limits every reading on that jack to seconds; its current rating here is the largest current its manual lets that jack carry with no limit of seconds. Its fuses checked; black lead in COM, red lead in the A jack, dial on DC amps; the lifted cable end covered and clear of metal until a clip is on it; clips on the cable end and the stud — never across a battery, a fuse or any two points with voltage between them; then the battery switch ON. While the meter is in: no engine start and no load above the meter's current rating, and no reading longer than its manual allows on that jack; the mA jack only once the A reading is below that input's rating, with the cable end back on its stud while the lead moves. Stay with it: if its fuse opens, every load on that negative loses its power — the bilge pump, the high-water alarm and the CO alarm among them. Battery

switch OFF before the meter comes out and the cable goes back; then the red lead back in V. PRACTICE

Why: A lead in an amps jack (A or 10A), or the dial on amps, can turn the meter into a short circuit across whatever the probes touch; in series, the meter carries the whole current of everything on that negative, and only its fuse stops a starter's.



MOVING PARTS Cranking with leads or clamps on

When: you crank the engine for a measurement — key, button or remote starter; or for a jump start with a jump pack.

Do:

- Before each crank for a measurement: shift lever in neutral, probes clipped on, and leads, hands, hair and clothing clear of belts, pulleys, the flywheel and the propeller.
- For a measurement, the helper cranks and stops when you say so.
- Crank for a measurement only as often and as long as the reading needs, within the engine manual's crank time and rest.
- A jump start with a jump pack: only on a battery type the pack's manual names. Its cables laid away from belts, pulleys, a fan, the flywheel and the propeller; hands, hair and loose clothing kept clear of them while the engine cranks and runs, the clamps taken off included. The clamps go on and come off in the order the pack's manual gives. The negative clamp goes where that manual puts it: on the battery's negative terminal where it allows that; where it names only a chassis or an engine block, on a boat the engine block, away from the battery; never on the carburetor or a fuel line. Each crank, the rest between cranks and the number of tries within the pack's manual. PRACTICE
- Smoke, a burning smell, or a hot cable or terminal during a crank: the helper lets go of the key at once, without waiting; then engine stopped if it started, battery switch OFF unless you smell gasoline — while it stays OFF, the entries of the CARBON MONOXIDE and

BILGE PUMP signs apply — nothing hot touched until it cools, no cranking until the cause is found. Smoke goes on, a flame or a gasoline smell: the card "Smoke, a burning smell, or an overheated wire" (→ emergency card). PRACTICE

Why: These parts move the moment the starter does — with an outboard's cover off, in the open — and catch hands, hair and leads; a sticking solenoid can keep the starter turning after you let go.



MACHINERY A windlass, a thruster or a wind generator's blades

When: a windlass, a thruster or another machine runs as the load for a reading; someone goes near a wind generator's blades to reach or secure them.

Do:

- Its operator watches it — for a thruster, the water around it — and stops it when you say so. PRACTICE
- Keep hands, hair, clothing and leads clear of all it moves; nobody in the water near the anchor or the thruster; a thruster runs only in the water.
- The anchor stays secured except while you raise or lower it; never run a windlass against a stopper, a snubber or a secured anchor, or with its clutch handle in.
- Run it only as long as the reading needs and its manual allows; breaker or isolator OFF between runs, while you move the clips, and at smoke, a burning smell or heat until the cause is found.
- A wind generator: stop it at the control its manual names before anyone goes near its blades; reach the blades only once they stand still, and secure them the way that manual says — a blade tied to its pole, or the turbine lowered. A stopped wind generator can still turn slowly in a strong wind: work at it waits until its blades stand still. PRACTICE

Why: It pulls hard and catches whatever comes near, even when started by accident; a stalled windlass overheats with its circuit.



AC — PRO The AC side is a pro's job

When: any AC wiring work; unplugging shore power; a hand behind a panel with AC breakers on it or in bilge water; a probe on the bilge pump.

Do:

- Hire a pro for any AC wiring connection made, loosened or changed — even proven dead — and for probes or a clamp meter on live AC. Your one AC measurement is the zero check (→ 3.7). PRACTICE
- Before a hand goes behind a panel with AC breakers on it, into bilge water or onto the pump, every AC source is off. PRACTICE
- Shore power: panel and pedestal breakers OFF, the pedestal end unplugged first, every cord. ABYC
- Inverter OFF at its switch, plus its DC breaker or isolator, where you reach it without touching bilge water (none: hire a pro). Generator stopped, its automatic start OFF, and kept from starting at any station. PRACTICE
- Behind that panel: look, trace, read labels and measure; disconnect nothing. PRACTICE

Why: Several sources feed the AC side and some restart by themselves: a searching inverter reads 0 V until a load wakes it.



HOT BATTERY A hot, swollen or hissing battery

When: a battery is hot, swollen or hissing, smells, gasses violently or spews electrolyte; water in the boat has reached its terminals; a battery goes on charge; banks joined by a switch, a relay or a control.

Do:

- If it is hot, swollen or hissing, smells, gasses violently or spews electrolyte, go to the card "Battery smells, is swollen, or is hot" (→ emergency card).

- Never disconnect its cables or touch its terminals with metal — a tool, a probe or a clip: that is a pro's job. PRACTICE
- A lithium battery that is hot or swollen but does not hiss or vent: all charging stopped as the card says, and nothing used from it — its loads off at its battery switch; at anchor or under way, a bank that feeds the lights, the radio or what steers and navigates the boat stays ON until the boat no longer needs them, and its large loads — a refrigerator, an inverter — go off at their own switches; with its battery switch OFF, the entries of the BILGE PUMP and CARBON MONOXIDE signs apply; its terminals stay live whatever position its battery switch is in — no metal on them; not charged or used again until a pro has checked it; watch it from outside its compartment, and if it starts to hiss, vent or swell fast, the card's first action. PRACTICE
- Water in the boat at a battery's terminals: keep your hands out of that compartment; when the water is down, nothing charges that bank until a pro has checked it — shore power off, and every charging source off: the charger and any inverter/charger, a DC-DC charger, solar panels covered or their solar disconnect switch OFF, a wind generator stopped at the control its manual names, a generator stopped and its automatic start OFF, the engine stopped; the engine is not run unless you need it to reach safety. PRACTICE
- Never charge a frozen battery. One that has frozen and shows any crack in its case is not charged or used again; otherwise its maker's manual decides whether it is used again — one maker says never — and with no such manual it is not; where the manual allows it, it stands at room temperature for at least 24 hours before it goes on charge. PRACTICE
- A lithium battery charges only within its maker's charging temperature range, and at no more than the current its maker allows at that temperature. Its manual says whether its BMS stops a colder charge by itself; where it does not, each charging source has to be stopped or held to that current — by the BMS's signal or by its own low-temperature cut-off, where the source's manual says that cut-off is set up and reads the battery's temperature — and a source

that nothing stops or holds stays off while the battery is colder than the temperature below which its maker stops or limits the charge; the engine is still run if you need it to reach safety. Range unknown: no charge below 41 °F. PRACTICE

- A lithium bank is joined to a lead-acid bank — by a switch at BOTH, ALL, 1+2 or COMBINE, a parallel switch ON, a charging relay (ACR) or a relay's own combine control ON — only where the lithium battery's maker allows it, by the means that maker names; a bank whose chemistry neither the Boat Passport nor its label names counts as lithium. PRACTICE

Why: Batteries give off explosive gas: metal at a troubled battery's terminals makes the spark that sets it off, and a frozen battery can explode on charge; water across the terminals carries current between them, and a lithium battery that sat in salt water can overheat and catch fire. Joined to a lead-acid bank, a lithium bank pushes its current into it, or its BMS cuts off everything on that bank; charged below its maker's charging temperature range, a lithium battery can be damaged for good — one maker calls it unsafe.



CARBON MONOXIDE A CO alarm without power, or an engine run at rest

When: a CO alarm may lack power — a battery switch turned OFF, even for a moment, or left OFF, the breaker or fuse that feeds it left off or out, its negative opened (a negative cable lifted, a meter in series), a BMS disconnect, a battery at 0 V; an engine or generator you run for a reading or to charge the batteries.

Do:

- Until the alarm has power and its warm-up, if its manual gives one, is over — it sounds when you press its test button — nobody sleeps aboard, and nobody who has been drinking stays aboard. PRACTICE
- An engine or generator you run for a reading or to charge the batteries: nobody on the rear deck or the swim platform, or in the

water near its exhaust, while it runs; nothing blocks its exhaust outlets; where the boat has a CO alarm, it has power — it sounds when you press its test button — before the run. PRACTICE

- Anyone unwell — a headache, dizziness, nausea or vomiting, weakness, tiredness or drowsiness, confusion, chest pain, sore or watery eyes, what seems like seasickness — or impossible to wake: go to the card "CO alarm is sounding, or headache, nausea or drowsiness aboard" (→ emergency card).

Why: Without power the alarm cannot warn you, and the CDC warns that sleeping or drunk people can die from carbon monoxide before any symptoms.



SHOCK IN WATER Current in the water

When: swimming or going into the water near boats and docks; plugging in or resetting shore power; a lit reverse polarity light; someone in the water — salt, fresh or brackish.

Do:

- Never swim in a marina or near a dock or boat with AC power — shore power, dock outlets or lights, a lift. Unplugging your own boat does not make the water safe, and nobody goes in at a boat that is plugged in.
- Tingling: shout, stay upright and swim away from the source — never toward the dock or the boat, never to a metal ladder or rail; get out away from the dock, then get its power shut off and go to a hospital.
- Rescue: never go in. Pedestal breaker OFF, unplug every cord, have the marina shut off the dock; throw something that floats, touching neither water nor person; call 911 or VHF 16 — then the card "Someone got shocked — at the dock, in the water, or touching the boat" (→ emergency card).
- After water has reached the inlet, the cord or any AC equipment, nothing AC goes back on — shore power, inverter or generator —

until a pro has checked them. Plugging in: nobody in the water; both breakers OFF; boat end first; pedestal ON; panel ON only if the polarity light stays dark — if it lights, pedestal breaker OFF, unplug at the pedestal, and get a pro. ABYC

- After a trip: no swimmer, shock, smoke or hot case; big loads off; reset your own device once, never the pedestal's (tell the marina). Trips again, or anyone felt a shock: panel OFF, pedestal OFF, unplug every cord, until a pro finds the cause — the card "Shore power tripped and won't come back on" (→ emergency card). PRACTICE

Why: A fault on a boat or a dock can put AC into the water, where nobody can see it; in fresh water the current crowds into a swimmer's body.



BLOWN FUSE A blown fuse or a tripped breaker

When: a blown fuse or a tripped breaker — a branch, the panel's main breaker or a bank's main fuse or breaker near the battery; a lithium battery's BMS that disconnected its bank on a short circuit or an overcurrent; a positive wire with no fuse, one that carries more than its wire's ampacity, one with a connection that runs hot, or a fused one whose copper shows through its insulation.

Do:

- A blown fuse or tripped breaker has found a fault. Replace a fuse only after a first blow or with the cause found: the same rating and type — or, where the fuse that blew was below the rating the circuit takes (the device maker's rating within the wire's limit, → 4.3), that rating; never larger, never a wire, foil or anything else in its place. PRACTICE
- A branch breaker: no smoke, burning smell or hot case, and the device switched off — reset it once. If it trips again, do not reset it: leave the circuit off and label it. If it feeds a bilge pump, the boat has lost that pump and is not left without someone watching the water: stay aboard, or tell the marina or whoever watches the boat that it has no automatic pump; call a pro. PRACTICE

- The panel's main breaker: extra loads off, engine stopped, battery switch OFF; no smoke, burning smell or hot case — then reset it once and turn the battery switch back on. If it trips again, do not reset it; call a pro. PRACTICE
- A bank's main fuse or breaker near the battery: do not reset or replace it before a pro has found the cause. Until then the panel stays without power — engine stopped, battery switch OFF; watch the water and bail if it rises: the high-water alarm can be dead too, and the entry of the CARBON MONOXIDE sign applies. PRACTICE
- A lithium bank its BMS disconnected while not near empty — as a load came on or a cable was worked on, with a bang, a smell or smoke — or whose app or display names a short circuit or an overcurrent: engine stopped, battery switch OFF, every load off; no smoke or burning smell, and no battery case hot or swollen — then wake or reset it once, by the method its maker's manual gives the owner, and turn the battery switch back on. With smoke or a burning smell it is not reset: go to the card "Smoke, a burning smell, or an overheated wire" (→ emergency card). With a hot or swollen battery case it is not reset either: go to the card "Battery smells, is swollen, or is hot" (→ emergency card). If it disconnects again, do not reset it: battery switch OFF, call a pro — its BMS may switch it back on by itself. While the bank stays dark, the entries of the BILGE PUMP and CARBON MONOXIDE signs apply. Taking its cables off or putting another battery's clamps on its terminals is terminal work, a pro's job. PRACTICE
- Under way, get to safe water or anchor first: "engine stopped, battery switch OFF" applies once the boat is safe. PRACTICE
- Check that every positive wire that leaves a battery bank has its own fuse; the cables that join the batteries of one bank are part of it. The one exception is the starter cable — found by tracing it to the starter, not by its size; a wire taken off the starter's terminal is not exempt. Never load a positive without a fuse. PRACTICE
- Exception: a bilge pump on such a wire keeps running if the wire's insulation is intact and the wire neither chafes on metal nor lies in water. PRACTICE

- Exception: an alternator's output with no fuse where it lands at a battery — the engine may run if that cable's insulation is intact and it neither chafes on metal nor lies in water, until a pro fuses it at the battery. PRACTICE
- Under way, or at anchor after dark, a wire that feeds the navigation or anchor lights or what steers the boat — one with no fuse, one that carries more than its ampacity, one with a connection that runs hot, or a fused one whose copper shows through its insulation — stays in use until the boat is safe without it; watch it for heat, and at smoke or a burning smell, go to the card "Smoke, a burning smell, or an overheated wire" (→ emergency card). PRACTICE

Why: A larger fuse or a bypass lets the fault current heat the wire until it burns.



BILGE PUMP The bilge pump left ready

When: any step that turns a battery switch, a bilge pump breaker or the pump switch, or opens the negative the pump returns through; a BMS disconnect or a battery at 0 V on the bank that feeds the pump; leaving the boat.

Do:

- Before you leave the boat, the pump's automatic switch — a float, a sensor or one built into the pump — has power again, and no pump runs by hand: a three-position switch in AUTO, never OFF; a separate manual switch OFF. PRACTICE
- Never leave MAN unattended. A spring-return MAN is held by hand; when you let go, check that the switch is in AUTO. PRACTICE
- If the pump cannot have power again, the boat is not left without someone watching the water: stay aboard, or tell the marina or whoever watches the boat that it has no automatic pump. PRACTICE

Why: Water comes in when nobody is aboard, and on some panels a spring-return MAN drops back to OFF, not AUTO, when you let go.



PROVE IT DEAD Work on a wire that may still be live

When: you cut, strip, crimp, splice or loosen a wire, or replace a fuse, a lug or a part, on a circuit after the battery switch (on a boat with no battery switch, after the circuit's own breaker or fuse); an ohms or continuity reading; a connector, a fuse, a breaker or a terminal between a solar panel or a wind generator and its controller worked on.

Do:

- Engine stopped, meter on DC volts. With the battery switch still ON, prove the meter and your negative at the spot where you will work: battery voltage from a live positive there to the negative you will read against. Then battery switch OFF: 0 V on its panel-side terminal (at the panel: on the positive bus) and on every wire you will cut, strip or loosen, against that same negative; then battery voltage on the switch's battery-side terminal. MFR
- On a boat with no battery switch, the circuit's own breaker on a DC panel, or its own fuse in a holder that opens by hand, takes the switch's place in these readings: live with it ON, 0 V on every wire you will work on with it OFF, live again on its line side. PRACTICE
- On a negative wire, the 0 V readings go from that wire to its circuit's positive and to every other positive within reach of the tool. PRACTICE
- Any voltage on a wire you will work on: it has another feed — a circuit wired around the switch, a charger, solar, another bank, an electronics memory wire. No tool touches it until that feed is off and the wire reads 0 V. ABYC
- A wire on the battery side of the switch — the cable to the switch, a starter cable fed ahead of it, a circuit wired around it, or one fed both ways, after the switch and from its own fuse at the battery — stays live with every switch OFF. It is made dead only at its own fuse or at the battery, and the entry "Metal at a battery terminal" says which of that work is yours. PRACTICE
- Before a connector, a fuse, a breaker or a terminal between a solar panel or a wind generator and its controller is opened or worked on: every panel of that string covered completely with an opaque cover

— or its solar disconnect switch or PV breaker OFF, and then only the controller's side of it counts as off; a wind generator stopped at the control its manual names and its blades secured the way that manual says. Never open a panel's plug-in connector or a PV fuse while current flows through it. Then, with the meter proven on a known live source, 0 V between the wires you will work on — on DC volts, and on the wires between a wind generator and its controller also on AC volts. A string whose panels' printed open-circuit voltages add up to more than 60 V: its voltage is read on the controller's display, not with probes; no probe or tool goes on its wiring until every panel of it is covered completely; then 0 V is proven with the probes at its controller's PV terminals, the solar disconnect switch ON and the PV fuse in, before a tool goes on any of its wiring — otherwise hire a pro. PRACTICE

- Ohms and continuity readings only on a circuit proven dead this way. MFR

Why: A battery switch cuts only what is wired after it — memory feeds, safety equipment and chargers may be wired ahead of it — and a dead meter or an open negative also reads 0 V; a cutter or wrench across a live wire and a negative carries whatever the fuses upstream let through, and between the battery and its first fuse that is the bank's full short-circuit current; a lit panel and a turning wind generator are sources no switch turns off, and a connector pulled apart under current draws an arc.



BATTERY ACID Battery acid

When: a flooded battery's caps opened, water added, a hydrometer reading; a battery cleaned, moved or carried; a cracked or leaking battery; acid on skin or in the eyes.

Do:

- Goggles — and a face shield when the caps are open — and acid-resistant gloves; no flame, spark or smoking near the battery. PRACTICE

- Only distilled or deionized water, never acid; a flooded battery is carried upright. PRACTICE
- Acid in an eye: flood it at once with clean running water, eyelids held open, for at least 15 minutes, and get medical help at once. On skin: plenty of water for at least 15 minutes; medical help if it still hurts. MFR

Why: The electrolyte is sulfuric acid: it burns skin and eyes and destroys clothing, and an open cell gives off hydrogen.

Sources

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