



WORD TO THE WISE Electrical Hazard

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Important Information About Electrical Wiring, Connections and Equipment

ABYC, Boat U.S. and others have issued warnings to boaters about grounding problems on boats and docks. Several deaths were reported for fresh water swimmers near boats with the boats plugged into dock shore power. ABYC also recommends eliminating or restricting swimming at all marinas. They report that all swimming in marinas is dangerous not only for the electrical shock hazard but also for the hazard of injury from boats maneuvering in and around the marina, as well a possible contact with submerged structure and water contamination.

See information below that helps explain why swimmers can be electrocuted even when they are not physically touching docks, boats or submersible water pumps.

Information is also below that illustrates the serious safety hazard that occurs when the dock or boat neutral conductor is connected to the green grounding connector in a circuit breaker and junction boxes, outlets and on boats. Note that boats and boat docks can have electrical faults that cause in-water electrical fields. Non-marine electrical appliances installed on boathouses or boats often have grounding straps that connect the neutral to the green grounding terminal for onshore household use but must not be connected on a dock or boat.

The above types of safety hazards are significantly increased if the grounding pin is removed from an electric cord or if a separate green grounding conductor is not installed and isolated from the AC neutral conductor in the boat and/or boathouse.

Unqualified personnel sometimes remove or bypass Ground Fault Circuit Interrupter (GFCI) devices when they cannot correct the underlying cause for the GFCI tripping on the boat house or in the boat. This action seriously endangers the person and other unaware persons. They sometimes cut off the grounding pin on an extension cord to prevent the GFCI device from tripping or to use an ungrounded outlet.

Marine and onshore residential electrical standards and safety requirements have some very important differences that must be respected to prevent fires, injuries or worse. Moreover, floating structure and particularly boat AC electrical circuits and equipment should be installed, modified and maintained or at least inspected by qualified marine electrical personnel.

Swimmers Beware

Boatowner's Mechanical and Electrical Manual – Nigel Calder

Recently evidence has been mounting that some deaths around marinas that were classified as drowning were, in fact, caused by electric shocks. When improper or faulty grounding of either onboard or dockside wiring is combined with AC leaks to ground, enough current can be fed into the water to paralyze the muscles of a swimmer, resulting in a drowning that leaves no physical evidence of the causative shock.

When a person is in the water, it takes very little current to cause muscle spasms or seizure: Currents on the order of 50 milliamps (0.05 amps) sustained for 2 seconds, or 500 milliamps sustained for just 0.2 seconds, can, in certain circumstances, cause ventricular fibrillation; currents as low as 5 milliamps can cause muscle seizure. But for voltage present: Reports indicate that there has never been a documented case of electrocution on shore with a voltage much below 50 volts.

However, it seems a different criterion is needed to determine dangerous voltage levels when the current is flowing through the water. For the purposes of an illustration let us assume a boat this is connected to shore-side power using an extension cord from which the grounding pin has been cut off. A piece of onboard AC equipment, which is in some way or another grounded to the DC negative (as it should be if the boat is properly wired) develops a short. The fault current, denied a path to ground through the normal ground wire, runs to ground through a bonded underwater fitting.

The fault current will develop a field around the boat. At the fitting that is discharging the current into the water the voltage will be at the full fault voltage (as high as 240 volts). Resistance within the water will cause the voltage to decrease the further the distance from the boat until ground potential---i.e., 0 volts---is reached. Depending on the water's resistance and other factors, there will be a voltage gradient creating a declining voltage the farther on moves from the boat. This gradient can be measure in volts per foot (or meter)

A swimmer entering this field will have one part of his or her body at one voltage potential, and other parts at another potential. If the voltage differential that is bridged is great enough, current will pass through the body. A general rule of thumb it appears that if the voltage gradient is above 2 bolts per foot (6 volts per meter) the situation is potentially lethal. When this figure is looked at in combination with those given above for potentially dangerous current levels, it becomes immediately apparent that quite small leakage currents and voltages can be deadly.

AC leaks into fresh or brackish water are considered to be more dangerous than the less resistive salt water. (*Note Lake Texoma is considered Brackish*) Leaks into salt water tend to follow the shortest path to ground, directly to the bottom or to adjacent vessels with well-grounded systems, whereas leaks in fresh water radiate out into the surrounding water from the fitting that is feeding the current into the water. (Note that in salt water there could still be a severe shock hazard for someone cleaning a boat bottom or checking the propeller or other hardware.)

As stated in the text, the neutral and grounding wires of an AC circuit are connected to a driven ground rod at the power source. In the case of shore-side power, this is considered to be the dockside; with onboard generators and inverters it is the generator or inverter; with an isolation transformer it is the secondary winding of the transformer. There is never any connection between the neutral and grounding wires at any other point. This is important for a couple of reasons:

The neutral is a full current-carrying conductor. Were it to be grounded in more than one

place, small differences in ground potential, or perhaps undue resistance in the neutral circuit itself, might induce some of the return current to find a path to ground through the grounding circuit, creating a potential shock hazard (Figure 3-22).

In the case of a shore-power circuit, if the neutral is grounded on board and the boat is then connected with reverse polarity (either through improper wiring ashore or on board, or through inserting a two-pronged shore-power cord the wrong way around), any neutral to ground connection on board the boat will cause the grounding circuit to become hot (Figure 3-22). If this circuit is connected to the DC negative (as it should be – see the text), the entire DC negative circuit will become hot, creating a hazardous environment both on board and in the surrounding water. Fuses and circuit breakers will likely provide no protection against potential shocks since in most cases the resistance of the surrounding water will not allow the passage of sufficient current to blow a fuse or trip a circuit breaker. (If the total resistance of the path through the water is above 10 ohms, for example, this will limit the current flow from a 120-volt circuit to 12 amps, which is not enough to trip a typical 15-amp breaker but is more than enough to kill someone.)

Note that if a boat has two shore-power connections (as many powerboats and large yachts do) the two neutral circuits on board must also be isolated from each other. Should the neutrals be connected and one of the shore-power cords be plugged in with reverse polarity, all wires on the other circuit would be live!

It is worth repeating that shore-power based AC circuits never have the neutral grounded on board. Finally, it should be noted that for historical reasons some domestic electric clothes dryers and electric stoves do have a neutral-to-ground connection on the appliance frame. If such an appliance is used on board, this connection must be cut.

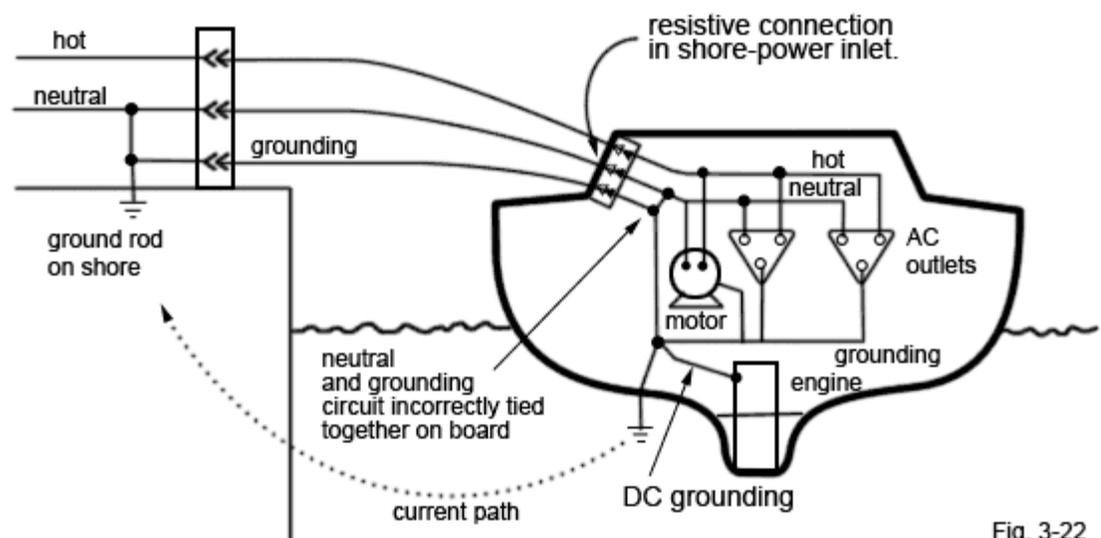


Fig. 3-22

In Fig. 3-22, the neutral and grounding circuits have been improperly wired together on this boat. There is a resistive connection in the neutral circuit. As a result, the return current from the appliances will now find an alternative (lower resistance) path to ground through the grounding circuit. Since this is (correctly) tied to the DC ground, it can create a shock hazard both on board and for swimmers. If the boat is connected to shore-power with reverse polarity, the entire grounding system will be "hot."