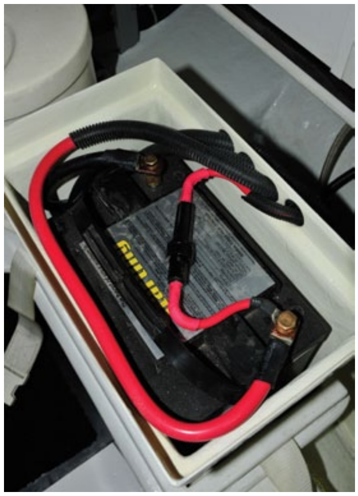
# Understanding overcurrent protection

STORY AND PHOTOS BY STEVE D'ANTONIO

Top right, overcurrent protection is generally designed to protect the wire, and the fuse or circuit breaker should be as close to the power source, like this battery, as possible. Far right, high resistance or poor connections, like the one shown here, do not increase current flow, and so OCP can't help with this type of fault.

The engine faltered, and with that a cloud of dense, white smoke erupted from under the small runabout's dashboard, enveloping the cockpit and its occupants … I vividly recall my first encounter with overcurrent protection, or more accurately the lack thereof. As a teenage would-be marine electrician, with little money to spend on professionals and more ambition than knowledge, I'd wired a light under the foredeck of the family boat. The wire passed adjacent to the steel fuel tank and the shelf on which it rested. After a summer's worth of use, the improperly secured wire worked its way under the tank, where a sharp metal edge chafed through the insulation.

Thankfully, it was over in just a few seconds. The wire was small and it quickly melted, breaking the circuit before it could plasma cut its way through the light-gauge sheet metal *gasoline* fuel tank. Knowing what I now know, I shudder at the potential consequences. While I quickly figured out what had happened, at that young age I assumed my error was in not properly routing or chafe-protecting the

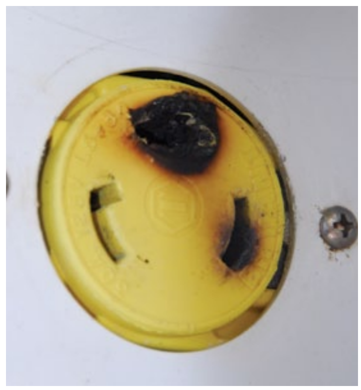


wire. I didn't know about the importance of overcurrent protection. That episode with its acrid smell, however, made an indelible impression on me.

## General requirements

Overcurrent protection (OCP) is simply a catchall phrase for fuses and circuit breakers. With just a few exceptions, which are detailed below, OCP protects wiring *and not the power consumer or appliance* from overheating and a potential fire.

In vessel inspections, I all too often encounter incorrectly installed or even an absence of OCP, which is an occurrence all savvy marine technicians — not just electricians — must understand and be able to identify. Additionally, there is a common misunderstanding about what OCP actually protects. A low-resistance fault, essentially a short circuit, can be dealt with by OCP. High-resistance faults cannot. Therefore, a poor, high-resistance connection (think of a corroded, salt-encrusted shore-power plug) can generate significant heat, leading to a fire without ever causing the OCP to react, trip or blow.



ABYC guidelines are clear. For DC systems, OCP must be installed within 7 inches of the source of power, measured by wire length. The exceptions to this mandate, which are critically important, are as follows (quoted from ABYC E-11.10.1.1):

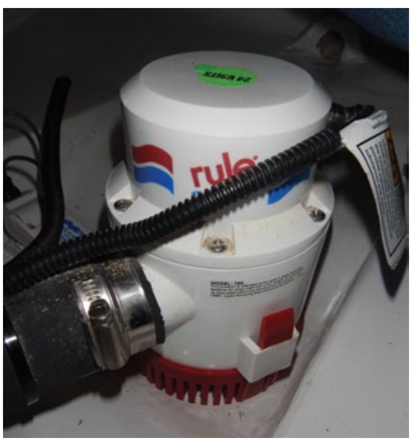
1. Cranking motor conductors. [Because no OCP is required, special care must be taken in routing the positive

cable. Among other things, it must not make contact with the engine other than at the point where it connects to the starter positive post.]

2. If the conductor is connected directly to the battery terminal and is contained throughout its entire distance in a sheath or enclosure such as a conduit, junction box, control box or enclosed panel, *the overcurrent protection shall be placed as close as practicable to the battery* but not to exceed 72 inches (1.83m).

3. If the conductor is connected to a source of power other than a battery terminal [this could be a battery switch, starter post or bus bar] and is contained throughout its entire distance in a sheath or enclosure such as a conduit, junction box, control box or enclosed panel, *the overcurrent protection shall be placed as close as practicable to the point of connection to the source of power* but not to exceed 40 inches (1.02m).

4. Overcurrent protection is not required in conductors from self-limiting alternators with integral regulators if the conductor is less than 40 inches (1.02m), is connected to a source of power other than the battery, and is contained throughout its entire distance in a sheath or enclosure.




Motor loads like bilge pumps have slightly different overcurrent protection needs. The OCP must also protect a motor that has locked, preventing overheating and a possible fire.

5. Overcurrent protection is not required at an alternator if the ampacity of the conductor is equal to or greater than the rated output of the alternator.

6. Pigtails less than 7 inches (178mm) in length are exempt from overcurrent protection requirements.

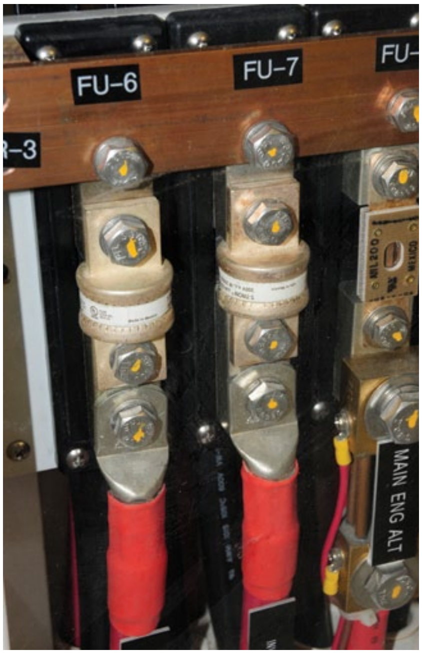
The italics are mine, emphasizing the need to place OCP as close as possible to the source, rather than at the maximum allowable distance. Each inch of wire between the power source and OCP is unprotected and, in a short circuit, could lead to a fire.

## Alternators

If the alternator's positive output cable leaves the engine, it must have overcurrent protection where it connects to the vessel's batteries or DC bus, following the standards detailed above. Furthermore, I don't fully agree with exception number five; if a high-output alternator's output cable shorts to a grounded structure (such as an engine block, shaft or fuel tank), regardless of whether the cable is capable of conveying the current, the ground source may not be able to convey it. Thus, the potential for arcing and substantial heat generation remains a significant concern for me. I recommend that OCP be installed at both ends of alternator positive output cables that leave the engine.

## Battery banks

Overcurrent protection is required




Class T fuses, like the cylindrical ones shown here, have a high amp interrupt capacity. These should be for power supplies from large battery banks and with most inverters.

for positive cables connected to battery banks used for purposes other than starting loads. Common ANL-style fuses are typical for comparatively small banks — i.e., 2,200 cold cranking amps (CCA) or 500 amp-hours or less. However, for banks that exceed this capacity, the ABYC Standards mandate a higher ampere interrupt capacity (AIC): It must be at least equal to the battery manufacturer's short-circuit rating (this could be up to five times the CCA rating). This level of OCP often calls for a Class T or equivalent fuse, as the interrupt capacity of the ANL fuse is woefully inadequate. In some cases of very large banks, even a Class T fuse may not be enough.

## Motors

Motor loads present yet another set of challenges for OCP. ABYC E-11.10.1.3.1 provides that motors "shall be protected internally" or "by branch circuit overcurrent protection devices suitable for motor current." The OCP should be able to prevent a fire hazard "for seven hours under any conditions of overload, including locked rotor."

To meet this requirement, the standard's guidance notes state that you may need to install thermal protection "if the motor is not capable of operating continuously at maximum possible loading." The notes also state that testing may be necessary to assure compliance with the locked rotor requirement: "Voltage drop, due to wire size, and delay characteristics of the overcurrent protection device may have to be adjusted to protect the motor."

Ultimately, unless a motor possesses the requisite internal thermal protection — and some do not — it may be necessary to install OCP at the motor, in addition to the OCP for the branch circuit serving the motor. Alternatively, there is no requirement to size OCP for a conductor's maximum current-carrying capability. The main OCP for a motor's branch circuit may, therefore, be sized to provide adequate protection for the motor itself, even if it's undersized per se for the wire size, as the wire size may be larger to reduce voltage drop. ■

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