Preview A boat is a most inhospitable home for all things electrical and electronic. Temperatures are usually uncontrolled and equipment is often exposed to direct solar radiation. Humidity can be high enough to cause condensation. Rain, sometimes buckets of it, even the occasional splash of fresh and salt water or maybe total immersion challenge the water resistance of equipment. The quality and stability of electrical power can be questionable. Sensitive receivers may be exposed to nearby sources of radio frequency energy, and everything is subject to long periods of vibration plus the occasional mechanical shock. Regardless, boat owners expect the electrical and electronic equipment we install on their boats to work reliably year after year.

BY CHUCK HUSICK

Hostile Environment

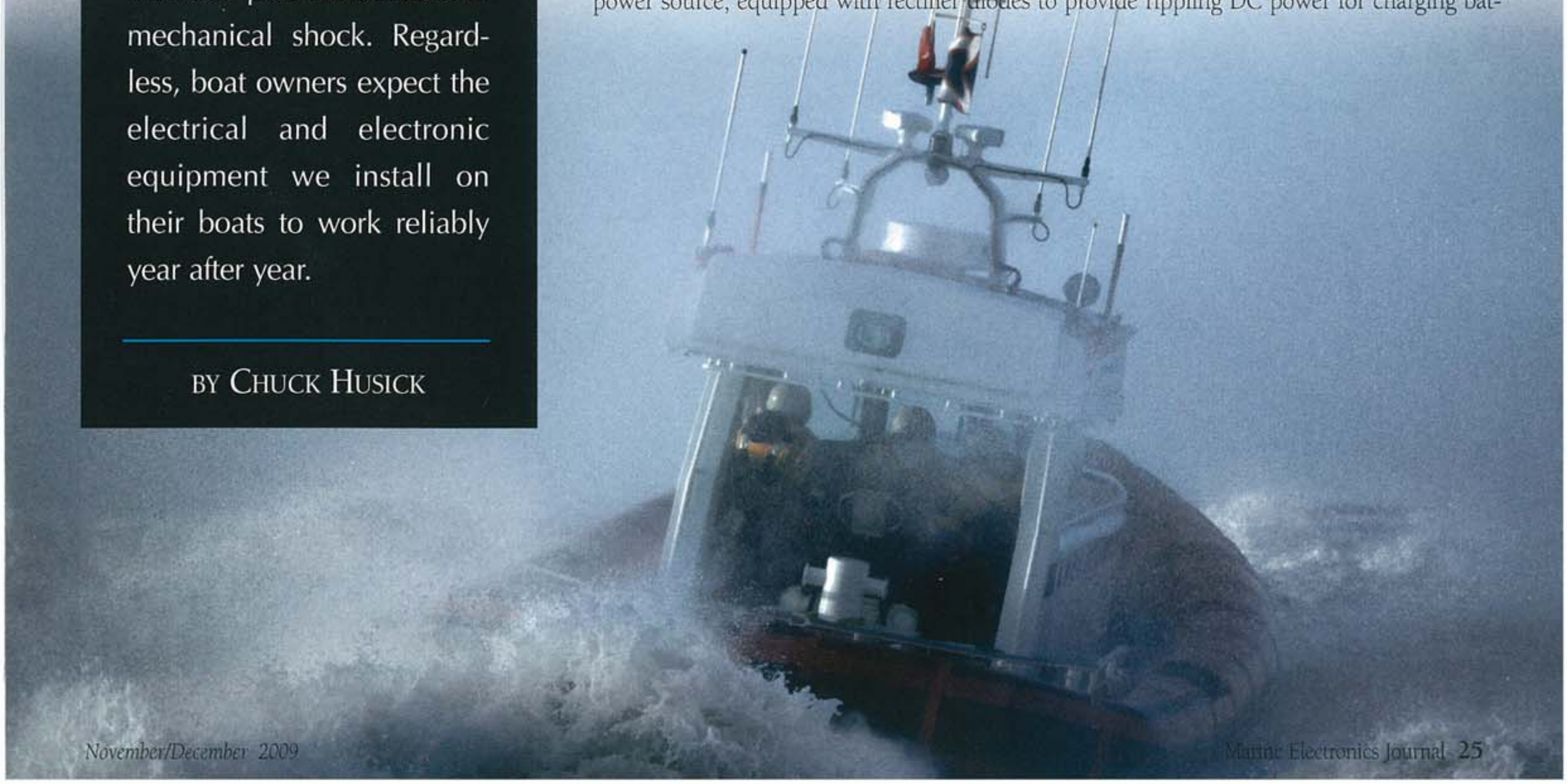
Keeping electronics ticking despite heat, moisture & more

The hostile environment in which marine electrical and electronic equipment must work demands that we do what we can to improve their "living quarters." It's not just the flat screen TV in the saloon that has to work in an inhospitable environment, it's everything, including today's engines. Deprive a common rail diesel engine of its electrons and unlike a mechanically fuel-injected engine that would continue to operate until it ran out of fuel, air or oil, it will quit. Like the electronically controlled engine, many of today's mariners will become exceedingly unhappy (unable to continue a voyage—quit) if the chartplotter goes dark or the autopilot fails.

Fortunately, the inherent reliability of today's electronics has more than kept pace with the intensity of our addiction to their proper operation. The gear generally works very well for very long periods of time if we take proper care of it—a process that begins with providing a reliable source of clean electrical power.

Battery Basics

It may appear that the battery bank's lead-acid batteries will always provide electrically "quiet" power. However, the presence of a corroded terminal connection can degrade the quality of the DC power, and it's worth considering that the engine-mounted alternator is an AC power source, equipped with rectifier diodes to provide rippling DC power for charging bat-



teries. A bad diode, combined with a high-impedance connection to the battery or a power feed to an electronic unit taken directly from the alternator's "S" terminal, can create RFI and EMI problems. AC-powered battery chargers and some DC/AC inverters can create RF noise that will interfere with electronics.

Other installation-related problems include use of wire that's "heavy" enough to deal with the average current demand of a consumer but inadequate when it has to deal with high current pulse demands. A common example is a VHF radio that becomes unusable when the fishfinder is operating. Low-quality DC power connectors and cheap coax connectors are a common source of poor equipment performance and can create drawn-out and therefore costly troubleshooting efforts.

Batteries that appear to be in good condition when checked with a voltmeter but are beyond their useful life can create a variety of problems, including shut-down of navigation equipment on engine start. Owners of boats whose engines can be successfully started from a single battery should be encouraged to routinely use only one battery at a time to start the engine. Doing so will provide a load test that will disclose the real health of the battery and the connecting cables; paralleling batteries will "hide" the fact that one of the batteries is beyond its useful life.

Lightning Strikes

Boats are unavoidably exposed to external forces over which we have no effective control, including direct lightning strikes and the high-gradient electrical fields created by a nearby cloud-to-ground or ground-to-cloud discharge. A nearby strike can create a voltage gradient sufficient to damage or destroy sensitive electronic equipment, including navigation receivers, communication radios, radar and just about anything on board that contains transistors, integrated circuits and microprocessors. A direct lightning strike on a vessel will most likely destroy all of the electronic equipment, most if not all of the electrical gear and may cause significant mechanical damage to machinery and the structure of the vessel. I know of no totally effective way to protect against the energy delivered by a direct hit.

Fortunately, the electronics used to control modern diesel and gasoline engines are generally protected within metal cases carefully designed to minimize the risk of damage from local voltage gradient fields. For the rest it's mostly a matter of making certain that the ground connections are made correctly—wires run as directly as possible to a central ground terminal to minimize ground loops.

If you suspect that a boat has been exposed to a nearby strike don't assume that a piece of equipment that is still operational has not been harmed. Experience shows that damage may not show up for some days. (When my home was struck by lightning some years ago, my ham radio receiver appeared to be unharmed, until the power transformer shorted out two days later. The overvoltage pulse had damaged the insulation on the primary winding.)

There have been numerous attempts to minimize the chance of damage from nearby lightning strikes, including the installation of static dissipaters on mastheads. The idea is to "bleed-off" the increasing charge on the vessel, thereby reducing the boat's attraction to a lightning strike. I have seen no convincing evidence that this tactic has any significant value in preventing a direct lighting strike. Static dissipaters—"static wicks"—are required on aircraft where they successfully bleed off the static charge that accumulates on the airframe as a result of flight (especially flight in dry snow which creates a very rapid increase in static charge), preventing an unmanaged discharge from interfering with radio communication. A static wick or brush at the masthead might reduce the incidence of St. Elmo's Fire, the visible blue plasma that's often seen when sail-

Stay Cool

Temperature Sensitivity

Those who worked in marine and aircraft electronics in the now distant days of the transition from vacuum tubes to transistors may recall the initial design reaction to the new "solid-state" boxes. They did not contain hot vacuum tubes, therefore the carefully carried out cooling provisions needed to keep the radios from incinerating themselves were no longer needed.

The temperature sensitivity of germanium transistors soon made itself known; the solid-state boxes were failing at a totally unacceptable rate. Ventilation came back into vogue. Fortunately, the very much more temperature-tolerant silicon transistor became available (or we might still be using vacuum tubes) and before long equally tolerant ICs. Boxes were again made smaller and tightly sealed, greatly improving their resistance to the elements.

However, before long microprocessors were finding their way into all kinds of electronic equipment including what we use on our boats. Moving the heat created by jamming millions of transistor junctions onto a micro size sliver of silicon became a necessity, demonstrated by the relatively high failure rate of some early products. At about the same time, the liquid crystal display panel replaced the CRT in the radar or chartplotter. Since it was a "display" panel the early LCDs told us of their dislike for temperature extremes by either going all black or simply stopping to show us anything when they got too hot or cold.

Most of the above is now history, or is it? The microprocessors used in today's chartplotters, multifunction displays, radar sets, SSB radios and in the control systems for engines have benefited from the work required to make similar devices operate reliably in laptop computers. Automatic cooling systems can keep things running even when the processor is highly stressed. All of the associated electronic components that surround and support the processor have been temperature "hardened," just as the components in old TV sets had to withstand continuous operation at more than 85°C.

LCD panels are much better able to withstand both high and low temperatures, although they still have limits beyond which it is not wise to go. The high-brightness LCD panels used in many of today's chartplotters and MFDs have typical operating temperature specifications that range from about -15°C to 55°C with storage temperatures from perhaps -30-40°C to a maximum of 70-80°C. However, the original lesson from the earliest days of electronics still apply—cooler is better, cold is best!

Shading electronics from direct sunlight can reduce temperatures significantly. In an experiment similar to the one above, a simple white paper shade reduced surface temperature by 18 degrees.

ing at night. However, don't count on a static dissipater to protect the boat against being hit by lightning.

The physical environment on a vessel presents challenges that include wide temperature changes, moisture varying from high humidity to rain, direct splashes of seawater and occasional immersion. Keeping electronics dry is an obvious requirement; therefore many devices are designed to resist exposure to the flow of water from a hose or total immersion. However, although the device itself may meet the test, connectors can be problematic. The rubber boots that protect the connector pins and sockets may work well when new, however a few months of exposure to the elements can cause deterioration. If possible, protect all connectors from direct exposure to the sun and water. Packing the connector with a water-excluding grease can minimize the chance for water to accumulate in the mated connector.

Cool It

Electrical equipment and electronics (other than arc welders and the filament in the magnetron's vacuum tube) work best when cold. Heat is the greatest threat to electronic equipment reliability. The relatively low power dissipation in transistors, integrated circuits and microprocessors allow some equipment such as VHF radios to be built in virtually sealed enclosures. Cooling fins on the back of VHF radios are not there to make the device look more impressive. Adequate cooling air must pass over the fins of the heat sink if the unit is to operate properly.

Cooling provisions are especially important for large LCD screen equipment, including chartplotters and radar. The cold cathode LCD illumination lamp and the system's circuitry (and especially the microprocessor) create a substantial amount of heat within the enclosure. Some displays will automatically dim the backlight if the internal temperature becomes excessive. Boat owners should be instructed to operate the display at the lowest brightness consistent with visibility to extend the life of the panel. While the larger, black box systems include provisions for cooling air flow through the unit, many self-contained chartplotters rely entirely on cooling air flow across the external heat transfer fins.

Cooling provisions for equipment installed where it will be exposed to direct sunlight or in an instrument panel that is exposed to direct sunlight, including through a windscreen, are especially critical. Although we may think of the effect of temperature on electronic equipment primarily in terms of high temperatures within solid-state devices—transistors, ICs and microprocessors—it is the accumulated mechanical stress imposed on conductive circuit board traces and connectors that eventually causes many reliability problems. While there's not much we can do to minimize the number of on/off cycles, we can reduce the magnitude of the temperature extremes, both by removing the heat generated within the device and by minimizing the heat load created by solar exposure.

Simply shading a device from direct exposure to sunlight can create a significant, perhaps surprising difference. We exposed a black plastic-cased portable radio to direct sunlight in an ambient temperature of 72.5°F. The surface temperature of the radio stabilized at 110°F. We then covered the radio with a sheet of white, 80 pound paper, providing a 1 inch free-air space between the radio and the underside of the paper shield (which was open at both ends). The radio case temperature rapidly decreased to 92°F (despite the fact that the paving bricks on which the radio was resting were at a temperature of 104°F). Lesson learned: a little bit of shade will go a long way toward reducing temperature related stress in exposed electronics. The color of a solar shield can make a substantial difference. The temperature of the silver-painted hood of a nearby car was 120°F, the temperature of the adjacent black plastic fender was 151°F.

Although the electronics on the average boat do not experience very high levels of vibration and shock there can be situations where

(Continued on page 50)

Feeling the heat

High temperatures increase failures

While the comparison between the temperature-driven failure rate of a transistor or IC cannot be directly translated into the failure rate for a complete device such as a radio, radar or chartplotter, the component data does provide a useful insight into the importance of keeping things cool. A 30°C increase in the temperature of the junction in a transistor or IC from 130°C to 160°C (23%) increases the failure rate by a factor of 10:1! The lesson: keep it cool to keep it working.

Cooling fins are an important component in keeping electronics operating properly. Make sure adequate cooling air passes over them.

Hostile Environment

(Continued from page 28)

a piece of equipment that is improperly secured may vibrate in resonance with an external excitation frequency, imposing unwanted strain on the unit and the connectors. The shock loading that can occur on a fast boat in rough seas can be significant and must be taken into account when making installations, especially of equipment located on flybridges or on tuna towers.

The bottom line is quite clear: the most benign place for marine electronic equipment is in the vessel's freezer. Short of meeting that rather challenging goal, we need to ensure that all equipment is properly mounted, grounded, supplied with clean power, protected from excess heat, water of any kind and operated by people who know what they are doing. A truly challenging task list, but you knew that when we started.

About the author

Chuck Husick's current business activities include technical journalism, consulting in marine and aviation projects and participation in organizations such as the Radio Technical Committee for Marine Services on behalf of recreational boating. Following his service as an officer in the Corps of Engineers, his work as an electronics engineer included designing analog computers, program management for the Gemini Space Program telemetry system and senior management positions in companies in non-destructive testing, marine and aircraft electronics and two major aircraft companies. His marine experience includes serving as chairman and president of the Chris Craft Boat Co.

New Members

(Continued from page 10)

Installation, consultation, survey and repair of marine electronics since 1982. MacDonald holds FCC GROL and GMDSS maintainers license with radar endorsement.

Associate

Joseph Derie
Southwest Passage Marine Surveys
1205 S.E. 57th Ave., Portland, OR 97215
Phone: 503-236-6818, Fax: 503-961-1128
Email: joederie@earthlink.net
Website: www.swpassagemarinesurveys.com

Michael Slater
MWS Project Management
5704 Morningside Ave., Dallas, TX 75206
Phone: 214-368-2411, Email: verado02@airmail.com

Grahame Shannon
Avia Design Group Inc., 2101 Philip Ave.
N. Vancouver, BC V7P 2W5 CANADA
Phone: 604-980-0646
Email: support@aviadesign.com
Website: www.aviadesign.com
Yacht design firm with over 100 successful designs from Walker Bay 8 dinghy to Grand Alaskan 55, and the Amazon series of sailboats. Also a software developer specializing in virtual instrumentation for sailing and power yachts. Begun in 2009, already 27 dealers in nine countries have signed on.

INDEX TO ADVERTISERS

Tech Update

(Continued from page 14)

Despite the slowdown of new products into the marketplace, NMEA 2000® continues its strong acceptance in the marketplace. The "OPEN" industry standard continues to see new product development from existing NMEA 2000® manufacturers as well as new manufacturers implementing NMEA 2000®.

Class B PGNs (message database) and technical updates to Class A PGNs have been published. These can be found on www.nmea.org. The Class B PGNs can be found in the new Appendix B 1.300. All current PGNs can be found on the NMEA website. It will be a requirement that all manufacturers publish their PGNs either in operators' manuals or on their respective websites. The NMEA 2000® Technical Standards Committee, which is comprised of a diverse group of manufacturers, is working on the following

- Alarms and Faults
- Distributed Power
- Power Generation
- E-Loran
- 24 Volt
- Galileo

Currently, there is a consumer-oriented NMEA 2000® PowerPoint presentation template on the web for dealers to utilize at boat shows or in their showroom. You can find this at: www.nmea.org/content/nmea_members/nmea_member_new.asp

Please don't forget this is your organization. Get involved. We have plenty of room for more volunteers. Don't hesitate to contact me at sspitzer@nmea.org.

Directors' Report

Manufacturer Director

Lou Rota, FLIR Systems

(Continued from page 11)

dealer cruise. Last but not least, you missed the chance for some well-deserved fun and relaxation at the beautiful Sanibel Harbour Resort & Spa.

In these difficult and challenging economic times, it's more important than ever to support the NMEA and its annual convention. I'm proud to be a part of the NMEA as it continues to strengthen its emphasis on education, training and standards.

Next year's convention promises to be bigger and better than ever. Please plan now to join us next year in Seattle. I'll look forward to seeing you there.