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By Stephen Sommer

Lightning Damage: Preventable?

Steve-
I am considering replacing a busted Raytheon ST50 depth sounder--it died as a result of a lightning strike--with an ST60 tridata instrument. Because you get all your information (speed, depth, log, water temp, etc.) from one instrument head, are you taking a chance that you'll lose a lot of necessary information by, figuratively speaking, putting all your eggs in one basket?

Your concern about "putting all your eggs in one basket" is a valid one. Unfortunately, in the case of a direct lightning strike, your eggs are all in one basket. Your "basket" is your boat, and all of your electronics may be destroyed. There are many other things that leave our important instruments non-operational, such as corroded connectors and moisture intrusion. These other failures occur more often than lightning, so your concern is valid and you should consider separate instruments.

The only sure bet for surviving a direct lightning strike with working instruments is to stow an emergency kit of isolated instruments in a conductive case. At a minimum, you should have a handheld GPS, handheld VHF and a lead line for depth sounding. Don't be tempted to think that you can incorporate a conductive case around your instrument panel to save it. To be protected, the emergency instruments must be isolated, without any wires penetrating the case. The case is only opened up after the strike to help you get home.

Sound like a lot of doom and gloom so far? That's the way direct strikes are, and it's certainly healthy to consider them that way. Fortunately, most lightning damage is the result of nearby strikes, especially if you spend a lot of time at docks with other taller masts around you. There is a lot that can be done to reduce the likelihood of damage to electronics from nearby strikes and to reduce the damage to your boat's structure from direct hits. There are many other benefits of designing your boat's systems to be resistant to lightning near- misses. If you can improve your resistance to Electro Magnetic Interference (EMI), your instruments will be affected less by lightning, your SSB, your inverter, and your first mate's hair dryer!

It helps to understand a little about the nature of lightning. Lightning is the result of the vertical motion of air in the column of a thundercloud that creates a very high voltage static charge. Eventually this voltage will increase to the point of being able to flow to ground without the help of wires. When it begins to flow, it ionizes air, which drastically reduces the air's resistance to the current flow. Once this happens the discharge occurs very quickly, allowing thousands to millions of amps to flow for a fraction of a second. This very rapid rise of current flow is essentially a very short-lived immensely powerful radio transmitter. This transmitted energy is called an Electro Magnet Pulse, EMP. You might recognize the term EMP from descriptions of one of the damaging effects of atomic bombs!

The first step in lightning protection is to protect the boat. The lightning will hit the boat simply to find a more conductive path to ground (the water). Unfortunately, the boat does not have to be a good conductor to encourage the lightning to hit it. If you want to survive the hit without extreme damage, you must provide a good path from the masthead to the water for the current surge. Obviously, you want to make sure that the path is not your electronics wiring. The path must be heavy duty AND direct. The surge of current rises so rapidly that it doesn't always follow the least-resistance path, as we normally expect. It can actually jump off a sharp bend in a wire, much like a racecar can fail to make a sharp turn in the road.

While the lightning's current surge is racing through your boat, it might not all be contained in the ground wires that you installed for the purpose. To give your electronics a chance of survival, you must keep them from becoming part of the path. For this reason, it is best to avoid uncontrolled connections to different parts of the boat. This is why modern electronic engine controls are not to be connected to any power sources or grounds at the helm station. They get power and a ground reference from the engine only. In your case, when you connect your instrument to ground, use a ground near the source of power, not just some nearby black or green wire.

Once lightning has successfully made it down your mast, or better yet, someone else's mast, and to the water, your next concern is the EMP. The most important concept to understand now is that the potentially damaging signal received in a conductor due to the EMP depends entirely on the physical position of the conductor, compared to the source of the EMP. The best defense is to bundle or twist the wires that connect to your instrument. This way, all the wires that go to the instrument are exposed to exactly the same field, so they receive the same EMI. Once all these identical EMI signals are presented to the instrument, there is no detectable difference in voltage to damage the instrument. This is called Common Mode Rejection.

Common Mode Rejection will work just as well to keep inverter noise out of your VHF, SSB out of your wind instrument, and hairdryer noise out of your TV. The beauty of designing your installation with minimum extraneous connections and bundled wiring for Common Mode Rejection is that it works to minimize the interfering field transmitted by devices as well as reducing the susceptibility of the receiving devices.

You will find it easier to install a separate depth sounder according to these guidelines, than a multifunction instrument that connects to so many different things in the boat.

Stephen Sommer is a degreed electrical engineer with extensive experience in electrical, mechanical, refrigeration and air conditioning systems and holds a USCG Masters license. He consults in all areas of yacht systems, which include all the equipment on board yachts beyond a basic hull and motor or sails.

Have a systems problem or question? Ask Stephen Sommer. Email: steve@boatek.com