

## Understanding Lightning Protection

by Bill Laudeman - reprinted with permission from

"Seaworthy, the Boat/U.S. Marine Insurance and Damage Avoidance Report"

Over the past couple of hundred years, as science has learned more about the nature of nature, lots of folks have tried to find ways to protect their homes and businesses against damage from lightning. But even after Ben Franklin's famous kite proved that lightning is an electrical force, and discoveries by such famous scientists as Volta, Ampere, Ohm, and others, lightning still remains something of a mystery. And we are still looking for ways to minimize damage.

Several years ago, while preparing an article on "Lightning Protection Systems" (*Practical Sailor*, December 1993), I interviewed one of the engineers responsible for preventing lightning damage to the U.S.'s largest power utility, the Tennessee Valley Authority, plus others at firms making lightning damage prevention systems for high-risk operations such as petroleum refineries and tank farms. The conclusions reached were fairly simple, and within a short time after the article was published, advertisements began to appear for devices called ion dissipators, like those previously offered only in high-tech industrial systems. These are stainless steel wire brushes, typically about two inches in diameter and about eight inches long. You can buy a similar brush for a few dollars from a supplier of dairy cleaning equipment; the ions probably can't tell the difference, but you will have to build your own mount.

Although there remains some controversy about how well the Lightning Protection Systems (LPS) function, there is little or no argument about the fundamentals of good lightning protection:

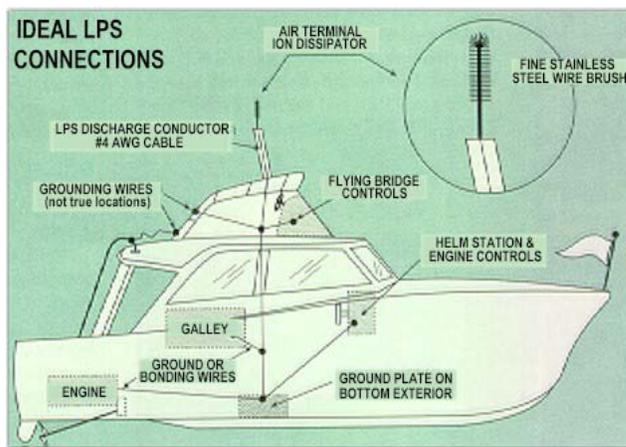
(1) It is better to avoid being struck in the first place, but

In practical terms, it comes down to this: If I were a boater in Florida's "lightning alley", I'd make sure the boat was well grounded. One way to do this is make a grounding plate from 1-1/2" to 2" wide bare copper grounding strap, as long as can be fitted below the waterline, epoxied to the hull exterior. As an alternative, make a "buss bar" using 1-1/2" - 2" copper strip under the boat running from the base of the mast to the engine or, another alternative, several square feet of copper sheet epoxied to the hull, with a substantial grounding lug extending into the bilges directly below the main LPS cable (which, in turn, leads straight to the air terminal). If it were not feasible to run this cable - 4 AWG is a good conductor - straight down the masthead to the bilge, I'd make up a jumper cable long enough to reach from the overhead to the bilge, to be clipped in place when a storm threatened. This means that access must be provided to the cable, where it enters the cabin overhead, and to the ground lug with sturdy (bare!) connection points to which you can clamp the jumper. Do you think that this is too much trouble? Ask someone whose boat has been struck.

damage if the strike is grounded as directly as possible. With these basics in mind, let's review and reiterate some general science that every boat owner can

**FACT: Lightning strikes are radio frequency (RF) events.** It is true that the build-up of energy is a direct current (DC) phenomenon, and the current flowing during a strike is unidirectional, but as each spark starts and stops, a great deal of high

An important note about the drawing.



ing. T

things are a bit different with a sailboat with a mast. The mast offers a cone of protection which basically protects occupants and offers more opportunity for a dissipation for the lightning down the rigging. Some experts feel a sailboat has about an equal chance with or without the described ground plate.

and should understand so that he or she can make the best use of the devices that are being sold. Armed with a few facts, you can better analyze your boat's lightning risk and make the best LPS installation or improve your present protection.

**FACT: It is better to avoid being struck so you do not want to "attract" a strike to any part of your boat.** The power of a direct strike is likely to heavily damage anything in its path and nearby electronics will suffer corollary damage from a side-effect of the strike, the magnetic pulse. Therefore, I suggest that the primary goal of an LPS must be to allow the accumulating "ground charge" (the buildup of energy in the earth or sea below a thunderstorm) to drain away at a low voltage level and to

frequency RF power is generated. This is why you can hear distant lightning storms on your AM radio-and when a strike does hit your boat, everything in the path of the strike becomes part of a wildly varying, enormously complex network of tuned RF elements. What you may find hard to believe is that a length of solid metal conductor is a perfect insulator at certain RF wavelengths. This may cause very high voltages to appear between two points (perhaps several feet apart) on a mast, a wire, or a length of metal trim. These voltages are the source of a sometimes deadly effect called "side flashes" that flicker between various parts of a boat - and its occupants.

To avoid becoming part of a side flash, you should understand the second purpose of the LPS; *martyrdom* (self-sacrifice).

When the LPS fails to prevent a strike

prevent the initiation of a strike. This is what the "ion discharge" or "dissipator" air terminals are designed to do. For these to be effective, however, they must be part of a well-designed system.

**FACT:** *No LPS is any better than its worst component.* Although the most obvious part of an LPS is the air terminal (or dissipator) mounted atop the rigging, it actually starts with the water beneath the boat. What is needed is the best possible ground so that the charge building up in the water can get to the air terminal. You can guarantee the best ground by having a bare metal hull.

Oh well, so much for the best. What's second best?

Second best is to have many square feet of metal wetted by the water. If this is still a problem, it is possible that connecting all underwater metal through-hull fittings to the LPS may be helpful, but you run the substantial risk of having a fitting blown apart in a strike, leaving a big hole in the hull of your boat.

*Bill Laudeman spent more than 30 years working as an industrial technologist and engineering project manager before becoming a marine surveyor. He has published his first book, Sailboat Wiring*

it must sacrifice itself in such a manner as to best prevent damage to the boat and its occupants. You encourage this vital role of the LPS by visualizing the path(s) that a lightning strike might take, then make the LPS conductor the one path that is as short, as straight and as low in resistance as possible. Then, during any lightning threat, you and your crew should stay as far away from this "favored" path as you can.

If you've done a good job on these basics, from ground plate to conductor to air terminal, and if you keep as far from the primary protection conductor as possible, then you've taken practical steps to guard against one of nature's mightiest forces.

Only one more suggestion: monitor weather reports and avoid being caught out in a thunderstorm!

*Copper straps, bars, and plates designed for lightning protection are available from Thompson Lightning Protection, (612)455-7661.*

**Cone of Protection from Lightning - Faraday's Cage**



This spring seems to have brought the most extreme weather in history. you will on the

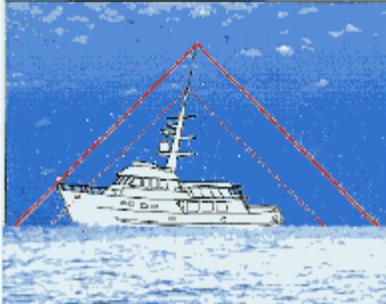
With heavy thunderstorms often find lightning. Lightning water can bring life-threatening circumstances. For your safety and the safety of others boating with you we have updated and are republishing this article on Lightning Protection.  
Capt. Matt

Even though the odds are in your favor that your boat may never be hit by lightning, if it happens it can have devastating effects. Don't take a chance, **protect yourself**. If you are in a small boat and close to shore when a thunderstorm approaches, get in and off the water immediately. Better yet, don't go out if thunderstorms are predicted. But what if you are miles offshore and a storm pops up? Hopefully, you have prepared in advance.

The voltages involved in lightning are so high that even materials that would normally be considered non-conductive become conductors, including the human body. The voltages are so massive that if they start to travel through a boat's structure - say through its mast - then meet with high resistance (for instance, the hull skin) the current discharge, in its attempt to reach ground, may simply blow a hole in the non-conductive barrier. The safety conscious Captain should make sure that his vessel is properly protected. Reference should be made in detail to the standards for lightning protection as set forth by the American Boat and Yacht Council (ABYC) and the job should be performed by a licensed marine electrician.

In theory, a lightning protection system is used to create what is know as a "Faraday's cage," so called after the late nineteenth-century scientist Michael Faraday. The principle of a Faraday's cage is to provide a surrounding, well-grounded, metal structure, in which all of parts are bonded together and carry the same electrical potential. Such a "cage" attracts and carries any lightning strike to ground much like lightning rods on buildings. In other words, you need to provide an unobstructed way for the lightning to dissipate its energy to ground (the water surrounding you). Faraday himself risked his own life to prove this theory. The additional benefit of a lightning protection system is that it tends to bleed off any charge build-up in the general vicinity, possibly averting a lightning strike in the first place.

So how does a lightning protection system work?  
In a boat, the "cage" is formed by bonding together, with heavy conductors, the vessel's mast and all other major metal masses. A marine electrician must tie in the engines, stoves, air conditioning compressors, railings, arches etc. with a low resistance wire which would ultimately provide a conductive path to ground (the water) usually via the engine and propeller shaft, keel



For wooden boats it is advantageous to have a mast or other conductive metal protrusion extending well above the vessel, creating what is known as a "cone" or zone of protection.

It is generally accepted that this cone of protection extends 45 degrees, all around, from the tip of the metal protrusion. This means that if the aluminum mast of the average sailing vessel is properly bonded to the vessel's other major metal

masses and is given a direct, low-resistance conductive path to ground, the entire boat should fall within the protected zone. If the vessel has a wooden or composite mast, a marine electrician can achieve the same effect by installing a 6 to 12 inch metal spike at the top and running a heavy conductor down the mast and as directly as possible to ground, usually through the engine and propeller shaft.

Again, refer to the ABYC standards and have a professional marine electrician install your lightning protection. **This is not a do-it-yourself project.**