

LIGHTNING

CONE OF PROTECTION

Department of Transportation
U.S. COAST GUARD

STUDY



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For additional copies and further information contact:

**Nearest Coast Guard Office
or
Michigan Sea Grant
Publications Office
2200 Bonisteel Blvd.
Ann Arbor, MI 48109**

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INTRODUCTION

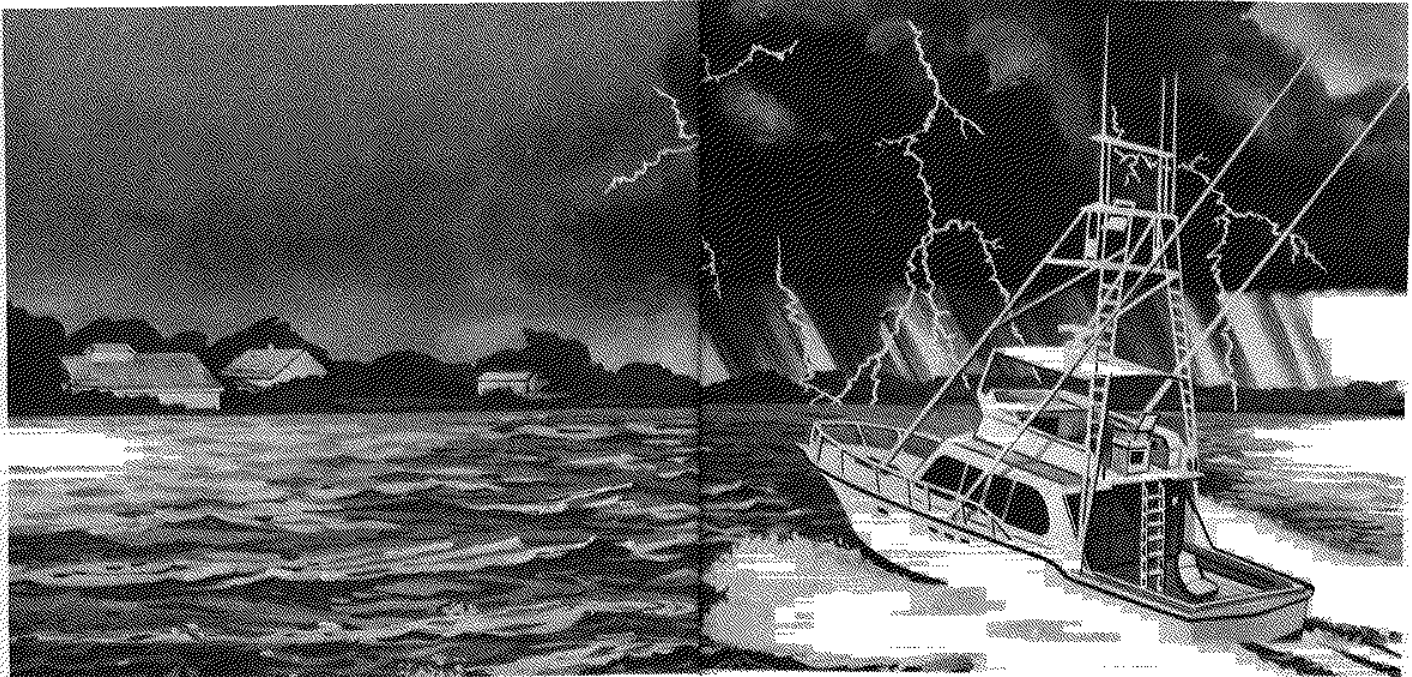
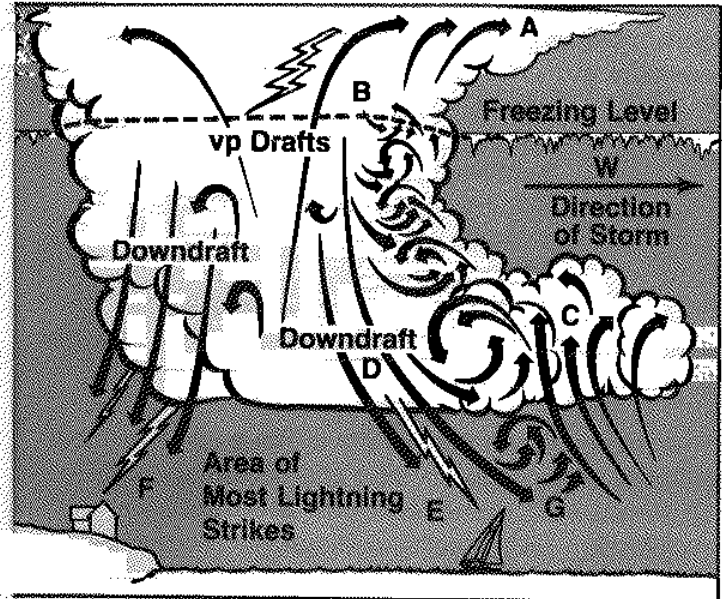
Thunderstorms may be experienced almost anytime, anywhere, but most occur during the summer boating season. Although lightning strikes on boats are rare, boats have been dismantled, holed, set afire and boaters have been severely burned and even killed by lightning. This pamphlet is designed to provide the information necessary to reduce the chance of damage or injury by lightning strikes.



THUNDERSTORMS AND LIGHTNING

Not all storms are thunderstorms, but all thunderstorms have lightning. They are most common in the summer months and are usually formed by air currents rising over locally warmed areas or the passage of a cold front which forces warm moist air aloft. Before a storm the winds are generally from the south and west and the air is warm and humid. The extreme vertical development which is characteristic of the cumulonimbus cloud is what creates a thunderstorm. Although cumulonimbus clouds may be obscured by other cloud layers, they can, if visible, be recognized by their characteristic shape. Starting at the top, often over 40,000 feet high, there is a layer of cirrus clouds that are shaped like an anvil. The top leans in the direction the wind is blowing and the direction the storm is moving. Below the "anvil head" is the main body of the storm. It is of great height and has "cauliflower" sides. At the front bottom is a roll cloud formed by the strong turbulent winds at the leading edge of the storm. Behind the roll cloud is a dark area which extends from the base to the earth where hail, rain or both are falling. Thunderstorms associated with cold fronts may develop any time, but local storms generally develop during the heat of the afternoon. Being able to recognize this type of cloud formation is an important warning of approaching thunderstorms.

- A—Anvil Top
- B—Main Part of the Cloud
- C—Roll Cloud
- D—Dark Area
- E—Primary Rain Area
- F—Secondary Rain Area
- G—Wind Turbulence



Whenever thunderstorms are in the area, boaters should head for shore to a safe mooring. Commercial AM radio and NOAA's continuous weather broadcast on VHF/FM channels WX1 (162.550 MHZ), WX2 (162.400 MHZ) and WX3 (162.475 MHZ) will provide up-to-date information on weather developments. If you do not have VHF/FM marine radio on your boat, inexpensive portable radios which include the continuous weather broadcast frequencies are available. Incidentally, static on the AM radio is also an indication of thunderstorm activity. Marine Weather Service Charts giving the locations and frequencies of weather broadcasts are available at most marinas or can be ordered directly from:

**National Ocean Survey
Distribution Center (C-4)
Riverdale, MD 20840**

Thunderstorms are dangerous because of lightning, but even more so because of the strong winds and the rough seas that accompany them.

The strong up and downdrafts within a cumulonimbus cloud generate huge electrical charges. After reaching a certain level, these charges are released in a multimillion volt electrical display which is called lightning. The rapid expansion and contraction of heated air in the lightning's path causes thunder. Lightning discharges take place between clouds, within clouds and between clouds and the ground.

It must be firmly understood that there are no guaranteed safeguards against lightning. It is very unpredictable and has immense power.

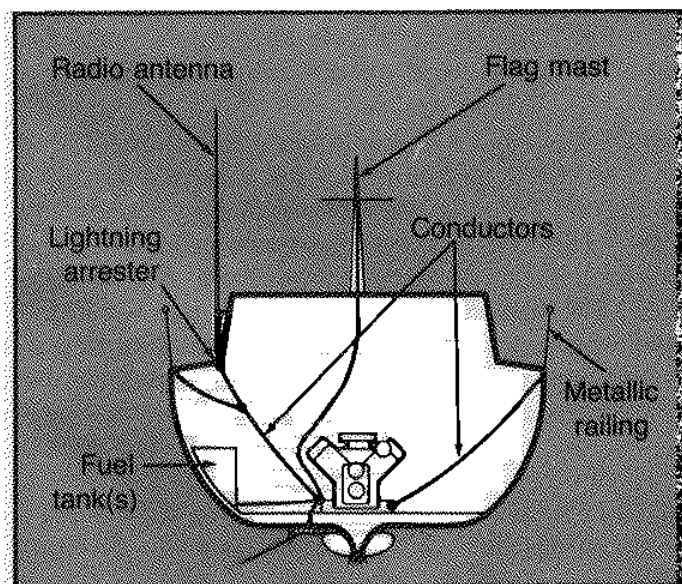
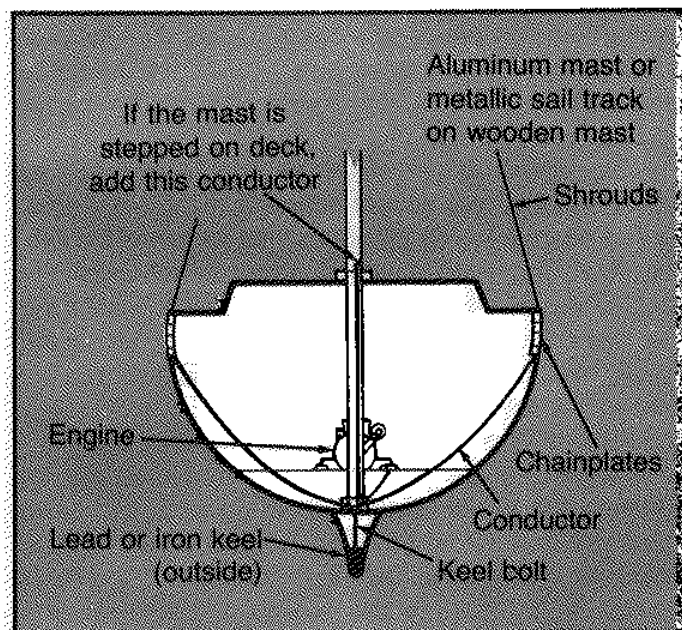
You can minimize the danger of having your boat struck by staying off the water during thunderstorms and by installing a grounding system on your boat similar to those found on buildings and other land structures. The grounding system provides lightning a path to reach ground without causing damage or injury.

THE GROUNDING SYSTEM

Most small craft are not constructed with a proper grounding system, therefore it is up to the owner to have one installed. If you are handy with tools and "do it yourself" project. All it takes are a few basic hand

tools, some common hardware store items and following the principles described in this pamphlet. If you are not sure of yourself, let the electrical contractor at the local boat yard do the job for you.

The grounding or bonding system, requires a straight, high capacity electrical conductor from the highest point on the boat to a submerged ground plate, or to an exposed metallic keel. In addition, large metallic masses, such as engines and fuel tanks, should be included in the grounding system to eliminate the possibility of side flashes of lightning within the vessel.



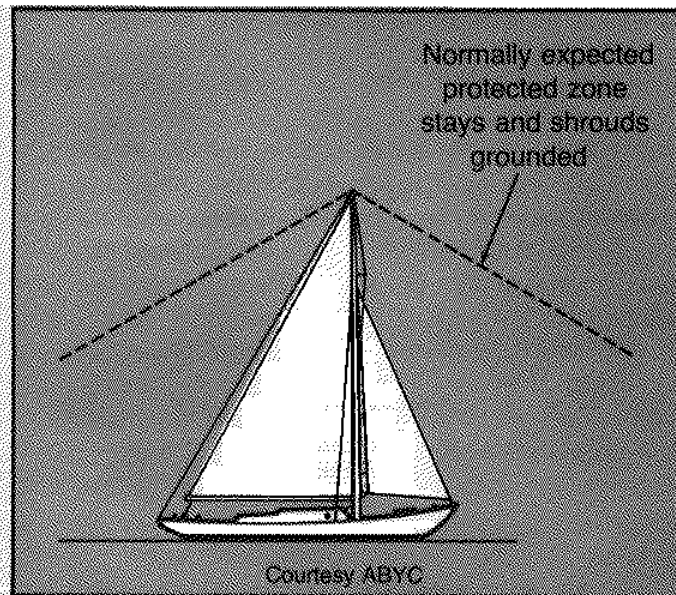
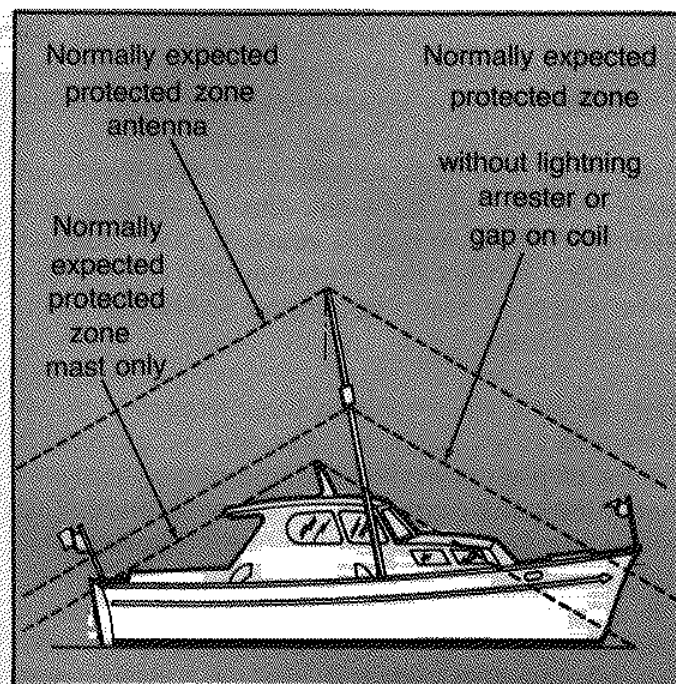
ZONES OF PROTECTION

The wire used to bond masts, engines and shrouds to the keel or ground plate should have a conductivity equal to or greater than #8 AWG copper wire. Since a boat vibrates, it is recommended that the bonding wire be tin stranded copper which resists metal fatigue better than solid, single conductors. Copper tubing or strips can also be used as long as the thickness of the material is .032 inch thick or greater. All electrical connections should be made with corrosion resistant hardware and mechanically strong. Solder must not be used as it may melt during a lightning strike. The wire should be firmly attached to a bolt that goes through the hull to the grounding plate or a metallic keel, both of which must be exposed to the water. On some boats the metallic rudder, propeller and shaft can provide an adequate ground if they form a relatively straight grounding path.

The "lightning rod" should extend at least 6 inches above any other equipment attached to the masthead, such as anemometers, antennas, flagstuffs and the like. The "lightning rod" must be firmly attached to the grounding wire running to the keel or ground plate. If the boat has an aluminum mast, the rod can be connected directly to the mast head and the grounding wire to the base of the mast.

To insure that a vessel is adequately protected against lightning, the entire vessel should be enclosed in an imaginary cone formed by a 60° angle from the highest grounded point on the vessel. If the grounded mast is too low in relation to the length of the boat, the extremities of the vessel are not protected. In such a case, the lightning rod should be extended until the entire vessel lies within the 60° "cone of protection."

In many instances, the radio antenna is the highest point on a boat. An antenna can be used for lightning protection if it is equipped with a lightning arrester in the lead-in cable. The lightning arrester allows normal operation of the radio, but in the event of a lightning strike, the high voltage jumps a small gap within the lightning arrester and is shunted to ground. This not only provides protection for the vessel, but also reduces the chance of damage to the radio equipment.



Courtesy ABYC

Please note that fiberglass antennas with spiral wound wire are **not** suitable for lightning protection. Antennas with loading coils offer protection only to the height of the loading coil.

If you are not sure how your antenna is made, consult the dealer or manufacturer about its suitability for use as lightning protection.

OTHER ELECTRICAL HAZARDS

Powerlines at launch ramps are also a hazard to boaters, specially sailors. To expedite the launching, many sailors step the mast while the boat is still on the trailer. Before stepping the mast, it is important to check for any overhead wires nearby or between the boat and the launching ramp. In recent years, a small number of sailors have been electrocuted when their metal spars or standing rigging contacted uninsulated wiring.

High tension transmission lines crossing reservoirs and other boating areas are dangerous. If the tip of the mast should come close to one of these lines, the current may be strong enough to bridge the gap and strike the boat. The fact that you have gone under the lines at other times may not mean that they are safe. The reservoir level may change and, on hot days, the lines may expand and sag from the heat. A watchful eye upwards as well in other directions is needed.

For more information on Boating Safety, contact the nearest Coast Guard Office:

USCG BOSTEAM 1
427 Commercial Street
BOSTON, MA. 02109

USCG BOSTEAM 2
1430 Olive St.
ST. LOUIS, MO. 63103

USCG BOSTEAM 3
Governor's Island
NEW YORK, NY 10004

USCG BOSTEAM 5
431 Crawford Street
PORTSMOUTH, VA. 23705

USCG BOSTEAM 7
FOB Rm. 1018
51 S.W. 1st Ave.
MIAMI, FL. 33130

USCG BOSTEAM 8
P.O. Box 6248
NEW ORLEANS, LA. 70114

OR, U.S. Coast Guard Director of Auxilliary:

150 Causeway St.
BOSTON, MA. 02114

Otis Air Force Base
FALMOUTH, MA. 02542

FOB Rm. 668
ST. PAUL, MN. 55111

550 Main Street
CINCINNATI, OH. 45202

1430 Olive Street
ST. LOUIS, MO. 63103

210 N. 12th St.
ST. LOUIS, MO. 63101

110 9th Avenue S.
NASHVILLE, TN. 37203

Governors Island
NEW YORK, NY. 10004

Bldg. 2, GSA Depot
SCOTIA, NY. 12303

King and Cumberland Sts.
GLOUCESTER CITY, NJ. 08030

P.O. Box 782
HARRISBURG, PA. 17108

431 Crawford Street
PORTSMOUTH, VA. 23705

USCG BOSTEAM 9
110 Wall Street
HURON, OH. 44839

USCG BOSTEAM 11
Coast Guard Base Terminal Is.
Building 6
SAN PEDRO, CA. 90731

USCG BOSTEAM 12
U.S. Navy Communication Sta.
STOCKTON, CA. 95203

USCG BOSTEAM 13
NSA Sand Point
SEATTLE, WA. 98115

USCG BOSTEAM 14
300 Ala Moana Blvd.
HONOLULU, HI. 96850

USCG BOSTEAM 17
P.O. Box 2471
ANCHORAGE, AK. 99510

51 SW First Ave.
MIAMI, FL. 33130

Hale Boggs FOB
NEW ORLEANS, LA. 70130

1240 E. 9th St.
CLEVELAND, OH. 44199

Building 401
Niagara Falls International Airport
NIAGARA FALLS, NY 14304

Box 480 Castle Station
Warren & E. Genesee Sts.
SAGINAW, MI. 48606

2420 S. Lincoln Memorial Dr.
MILWAUKEE, WI. 53207

400 Ocean Gate Blvd.
LONG BEACH, CA. 90822

2721 N. Central Ave.
PHOENIX, AZ. 85004

830 Sansome St.
SAN FRANCISCO, CA. 94126

350 Main St.
SALT LAKE CITY, UT. 84101

915 Second Avenue
SEATTLE, WA. 98174

300 Ala Moana Blvd.
HONOLULU, HI. 96813

Federal Bldg.
P.O. Box 3-5000
JUNEAU, AK. 99801