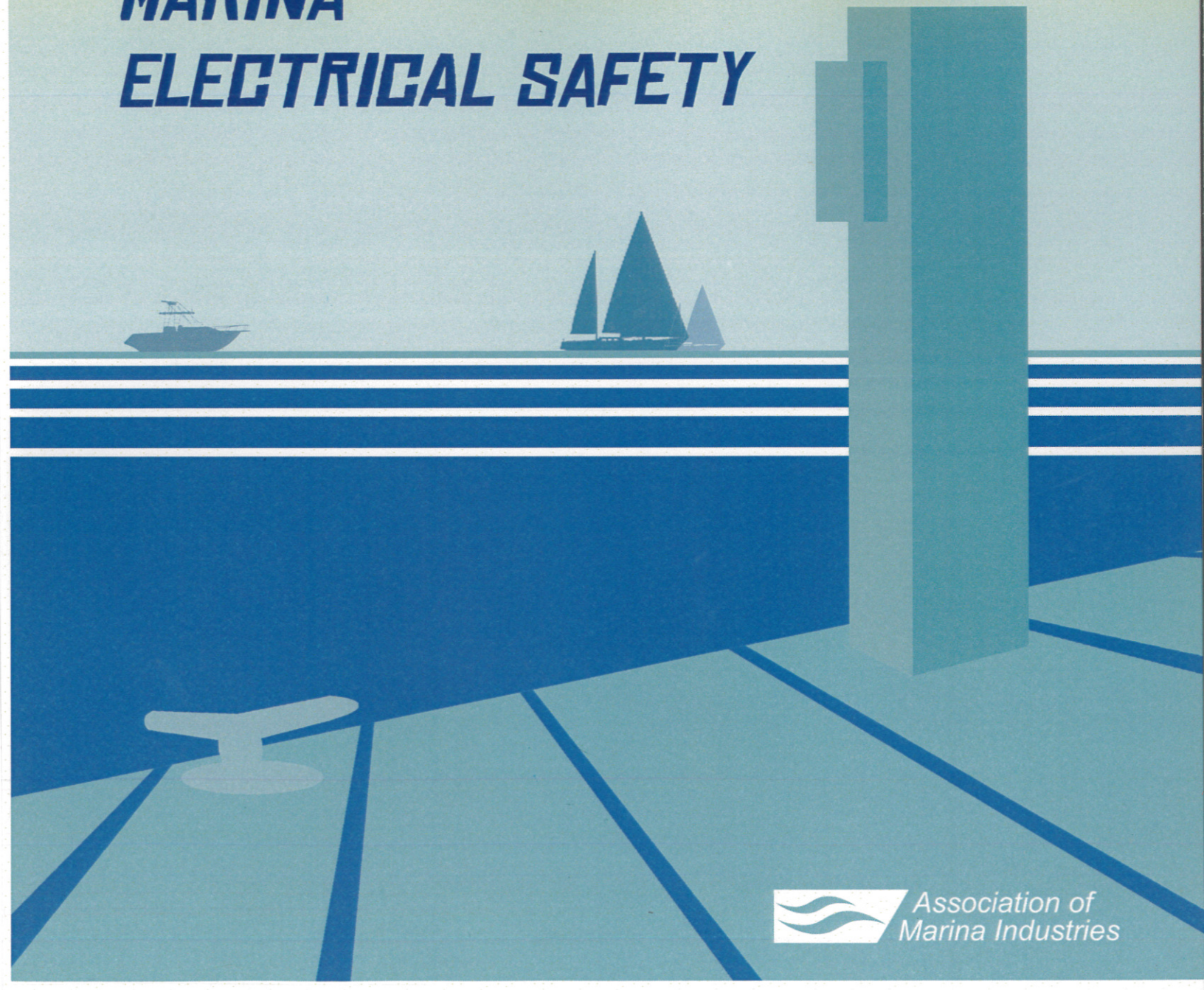
BEST MANAGEMENT PRACTICES

FOR

MARINA ELECTRICAL SAFETY



Association of Marina Industries

INTRODUCTION

The intent of this document is to provide an overview of the electricity encountered at a marina, what tools of the trade a marina should have for dealing with electrical components, how a marina operator can use regular observation and inspection to avoid most electrical hazards, and how to best educate boaters on what they need to do while in a marina. While regulations pertaining to electrical systems at marinas will be included here, the guidelines within this document are not intended as a means to ensure your marina is meeting your local, state, and/or federal regulations.

Marina electrical system design and construction are specialized crafts requiring knowledge and skills that are unique to these types of facilities. Only knowledgeable, experienced, competent contractors and technicians should undertake marina electrical-system projects, repairs, and maintenance. However, marina personnel should be taught how to safely handle electrical components and how to properly respond to emergency situations, in addition to learning how to visually identify electrical hazards.

This guidebook was prepared as an industry service by the Association of Marina Industries. The recommended practices in this document constitute a synthesis of literature published by equipment manufacturers, regulatory requirements, and the extensive knowledge and experience of the following professionals:

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GLOSSARY

Alternating Current (AC) Electric—Marina power pedestals or vessels' onboard generators and inverters are the source. Marine voltages are normally 120 and/or 240 volts; amperages are normally 30 and 50 amp with smaller amperages aboard the boat.

Bonding System—A system connecting underwater metals on board a boat. This is tied into the DC negative and the AC ground (if AC is present) to minimize stray-current corrosion.

Direct Current (DC) Electric—Batteries aboard boats are usually the source. Marine voltages are normally 12 and/or 24 volts.

Electric Shock Drowning (ESD)—Typically occurs in fresh water and is caused by a small amount of stray AC electricity that has entered into the water from a fault aboard a boat or on the dock. Immobilizes the victim. (See Bonding System.)

Electrical Datum Plane—A horizontal plane 2 feet above the highest high-tide level for the area under normal circumstances or 2 feet above the highest water level in non-tidal areas under normal circumstances.

Grounding—Green wires paired with all AC circuits (and occasionally DC circuits). Returns stray currents to the source of power.

Ground Fault Protection Devices--- AC devices that disconnect a circuit when it detects that the electrical current is not balanced between the energized or hot (black) conductor and the neutral or grounded (white) conductor. Types of devices include:

- Equipment Leakage Circuit Interrupter (ELCI)—A residual current device installed in the internal main shorepower conductor of a boat. An ELCI de-energizes the whole boat when a fault current is over 30mA (mA=milliampere).
- Ground Fault Circuit Interrupter (GFCI)—A residual current device installed in heads, galleys, engine rooms, and deck spaces. GFCI de⊠energizes a circuit when an imbalance or fault current is over 5mA. GFCI can be configured in an outlet as we see in kitchens, bathrooms, and other places where electricity is used near water. Ground fault circuit protection can also be configured as in-line devices installed in electric-carrying conductors (wires).
- Residual-current device (RCD), or residual-current circuit breaker (RCCB) is an electrical device that disconnects a circuit whenever it detects that the electric current is not balanced between the energized conductor and the return neutral conductor. Vessels built in other countries will typically be equipped with RCDs or RCCBs

Leakage Grouping—Multiple vessels producing stray current on the same piece of ground fault protection or ground fault monitoring device.

Standard Circuit Breaker—A device that de⊠energizes a circuit when the amperage exceeds its rated current (e.g., a 15-amp breaker trips when current exceeds 15 amps).

National Fire Protection Association (NFPA)—An international nonprofit organization established in 1896 to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. www.NFPA.org

Nuisance Tripping—Common phrase used by boaters to deflect blame for faulty boat wiring and/or repairs. If a circuit breaker is in good working condition and trips, there is a problem present.

Over-Current Circuit Breaker (or Fuse)—An AC (or DC) electrical device that turns itself off (trips) to interrupt the flow of electricity if the current exceeds a preset limit.

BASIC ELECTRICAL THEORY

Electricity and Boats

Boats, like recreational vehicles, can be equipped with both AC and DC systems. Like a home, the ground system is used to prevent a shock hazard. The AC and DC systems are tied together through a common grounding point in the boat, making sure combination appliances, such as battery chargers, are protected from faults on either system.

Additional grounding systems may be installed on boats. These systems are called "bonding systems" and consist of green wires or green wires with yellow stripes connecting all the metal components in contact with water. While this system is extremely useful in combatting corrosion, it is also the system that could allow deadly stray AC current to enter the water in the event of an onboard fault that does not trip a circuit breaker.

There are strategies to deal with faults such as these. The American Boat & Yacht Council (ABYC) requires GFCI outlets in galleys, heads, deck spaces, and engine compartments. These are the same outlets in your home's kitchen and bathroom. A recent version of ABYC's electrical standard now includes whole-boat protection through a similar device called an Equipment Leakage Circuit Interrupter (ELCI), which is recommended on boats manufactured in 2013 and newer.

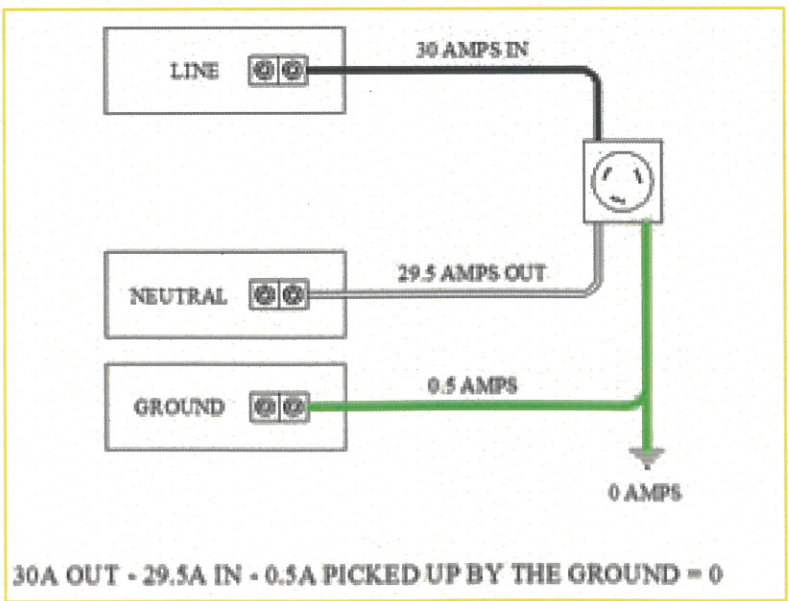
Electricity and Marinas

Marinas have many types of electric sources both on land and on the water. The electricity powering buildings and equipment used on land is "traditional" and should be installed following published and acceptable safety codes. Those electric sources will not be covered here. This document will focus on the electricity that provides power to the docks and, in turn, the boats. This is where the risk of mixing electric and water is highest.

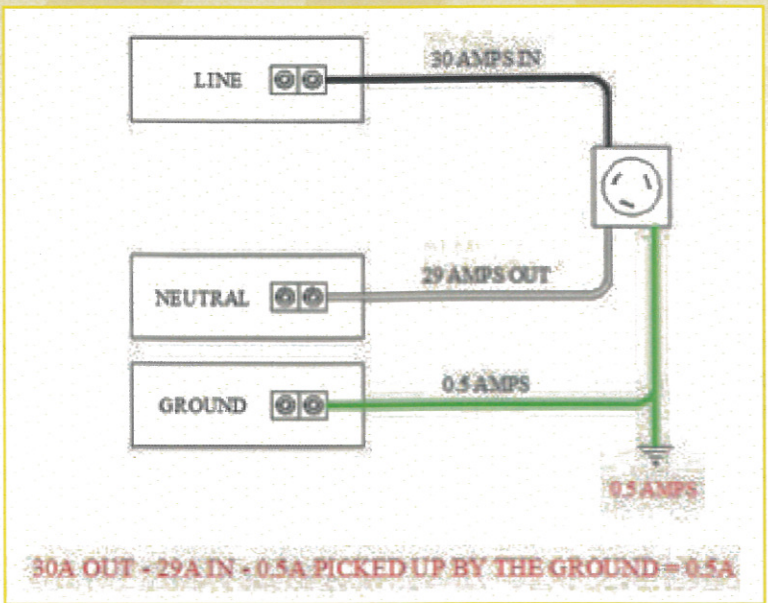
Generally, electricity flows from a main source through wires encased in waterproof conduit under docks and out to power sources on the docks, such as utility stands, or to powered objects like lighting. In addition, power from land can also be transferred down the dock to fuel pumps and dock houses. With all of these power sources running in such close proximity to the water, you and your staff must recognize, understand, and minimize the hazard risk.

Recognized safety standards for marinas require that electrical equipment be installed a specific distance above the Electrical Datum Plane in order to keep electrical equipment away from the water (normal and above normal).

Diagrams: ***Adequate and Inadequate Electrical Circuits***



Above is an example of an adequate electrical circuit. Below is an example of an inadequate electrical circuit.



Above in this example .5 amps of electric are being released to the surrounding waters creating a potential hazard.

Electrical Problems

Wiring problems, component failures, or the use of improper equipment to bring AC shorepower onboard boats can lead to dangerous situations. Electricity cannot be detected without the use of specialized testing equipment. Stray currents on land or in a boat can lead to sparks and subsequent fires or electrical shock.

Also note, electricity in water can lead to Electric Shock Drowning (ESD). ESD can occur when faulty wiring on a boat or in marina causes underwater metals, such as boat props or dock frames, to become energized, creating an electrical field in the water. A swimmer entering the charged water becomes a target for the electrical current leakage because the human body is a better conductor of electricity than water. Depending on the amount of current, the swimmer can experience just a tingling feeling or they can lose complete muscle control and/or suffer a heart attack and drown.

Diagram: ***Electrical Current in Water***

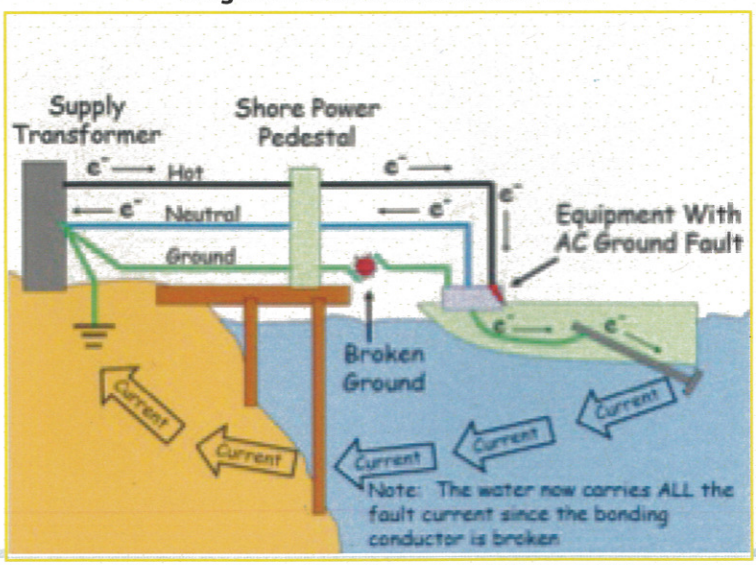


Diagram courtesy of Captain Dave Rifkin

Electricity at Fuel Docks

Fuel pumps carry two electrical risks. First, the electrical connections are in close proximity to water so they present a shock risk both on the dock and in the water. Second, the long lengths of hose needed to get the fuel from tanks to the dock favor the build-up of static electricity, which can cause sparks and present a fire risk.

While the fuel system installer must follow electrical and fire codes, it is still wise for a marina operator to know what to look for after the installation is complete. To be protected a marina operator must ensure proper grounding and the use of corrosion-resistant or corrosion-protected materials on electrical conduit and fittings.

Crucial to safety at fuel docks is to have an easily identified emergency shutoff button that, when pushed, shuts down power to all pumps, fuel-dispensing devices, solenoid valves, and electrical circuits. The switch should be located where it is readily accessible—no closer than 20 feet and no farther than 100 feet from each dispensing device. Each shutoff switch should be identified with a clearly legible sign reading EMERGENCY PUMP SHUT OFF.

Please see NFPA 30A: Code for Motor Fuel Dispensing Facilities and Repair Garages, Chapter 11: Marine Fueling.

TOOLS OF THE TRADE

As a marina professional, you should be familiar with and have access to the following tools and devices that are both for testing electric and for protecting the marina from dangers of faulty electric systems. There are many types of these devices on the market and the brand used by a marina is completely up to the discretion of the person who purchases the device. We do not offer recommendations or endorsements of any specific product brand.

Ground Fault Protection Devices can be located in several areas, which varies the cost and effectiveness of the system. Trip rates vary typically from 5mA to 100mA depending on the installation. You can place protection:

- at the utility entrance where incoming power enters the facility from the utility company. This is the most economical placement but it also makes it difficult to pinpoint the cause of any current leakage.
- at the head of each dock within a disconnect or distribution panel. This is still a fairly economical solution. The ability to locate current leakage depends on how the system is wired.
- on each dock within a distribution panel or through a ground fault monitoring system with shunt trip circuit breakers. This location is more costly but makes it much easier to identify the location of current leakage.
- at each power pedestal through ground fault circuit breakers. This is the most costly placement, but also the most effective to identify the cause of current leakage. If the circuit breaker trips, the boat or piece of equipment plugged into that pedestal is experiencing a problem.

Image: ***Ground Fault Protection***

An **Overcurrent Circuit Breaker** (or fuse) is an AC (or DC) electrical device that turns itself off (trips) to interrupt flow of electricity, if the current exceeds a preset limit.

Ground Fault Monitors, consisting of a control module and current transformer(s) with wires run through the current transformer(s) to measure the electrical cycle, are available in single source and multiple source options depending on whether there is one major power source or multiple power sources. See below.

Diagram: Single Source Ground Fault Monitor

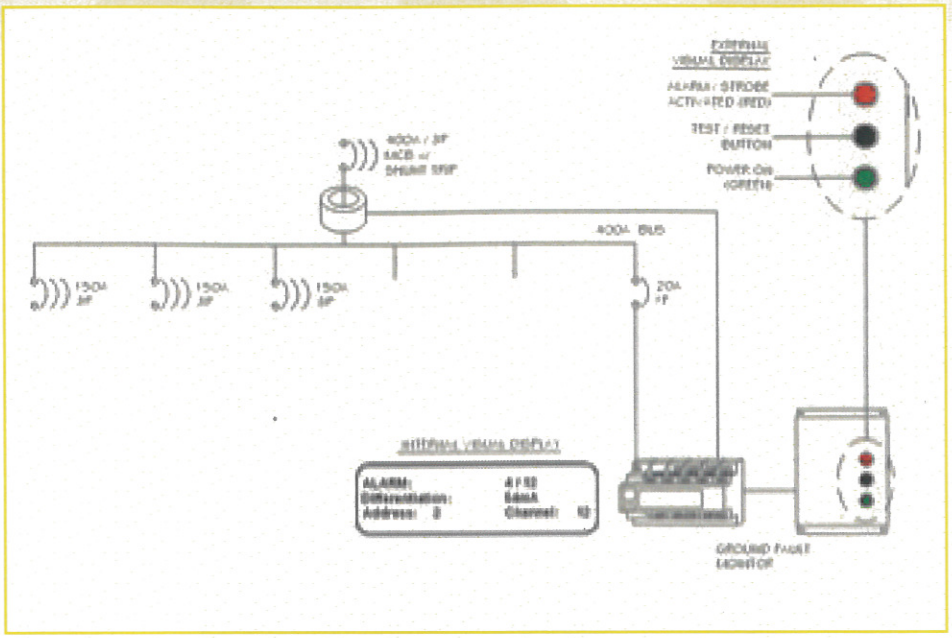
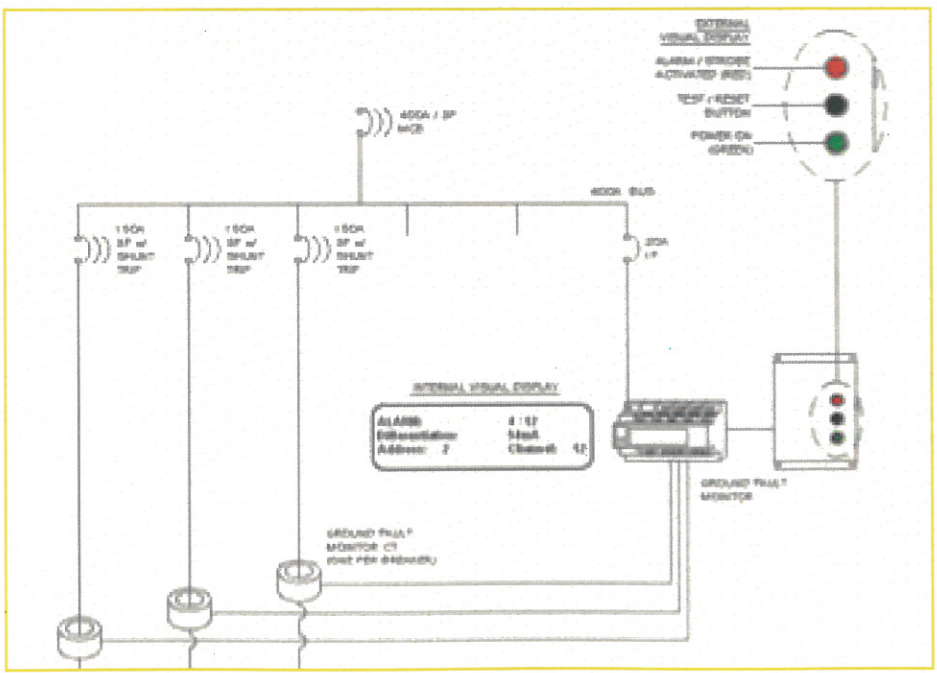


Diagram: Multiple Source Ground Fault Monitor



Digital Multimeter measures voltage, current, and resistance. It can range from a basic tool (e.g., volts, amps, DC, AC) to a complex diagnostic tool (e.g., fault-sensing, tracking over time).

Inductive Amp Meters can range from simple to complex. This device can read amperage (current) without being connected into the circuit you are reading. It can be used to read a vessel's AC and/or DC leakage current by clamping around the shorepower cord. In a properly working boat, the reading should be zero. If readings are not zero, you must investigate further.

Images: Inductive Amp Meters

AC Circuit Analyzer displays important AC electrical conditions including voltage, frequency, polarity, voltage drop, and the absence of a properly working ground. These devices are equipped with 20A household connections. 30A and 50A adapters will be necessary for testing marina shore power. Different types are available as shown here.

Images: AC Circuit Analyzers

REGULATIONS & STANDARDS

Marinas

The National Fire Protection Association (NFPA) is a nonprofit organization that publishes a number of safety-related codes and standards. These regulations are used by the fire service, industry, and state and local government as well as insurance and legal parties. Here, we will discuss NFPA standards that are relevant to marinas. For more information and access to these codes and standards, visit www.nfpa.org.

NFPA 303: Standard for Marinas and Boatyards has been published since 1940 and includes a number of important topics. Chapter 5 covers Electrical Wiring and Equipment. All marina and boatyard owners and operators should be familiar with and have access to this document.

NFPA 70: National Electrical Code (NEC) is a very comprehensive electrical standard that is recognized and used throughout the United States. Section 555 of the NEC covers specific electrical requirements for marinas and boatyards. Section 553 covers the specifics for floating buildings, such as floating fuel docks, small marina offices, etc. Electricians who perform work in marinas and boatyards should be familiar with the requirements of these two sections and marina owners and managers should discuss the specifics when contracting for their services.

Some or all of NFPA 303 and NFPA 70 have been adopted as law by a number of states and are not merely recommendations. Some states have recently adopted their own legislation for marinas and boatyards. Most of these new laws reference NFPA 303 and NFPA 70.

The NFPA and NEC are continually being revised. New in 2011, the NEC has a requirement under **NEC 555.3 Ground Fault Protection** that states, "The main overcurrent protective device that feeds the marina shall have ground fault protection not exceeding 100mA. Ground protection of each individual circuit breaker or feeder circuit shall be permitted as a suitable alternative."

Additionally, current NEC requires 100mA protection somewhere within the electrical system for all new installations.

NFPA 303–5.20 Maintenance of Electrical Wiring and Equipment states, "An inspection of all electrical wiring, ground connections, conduit, hangers, supports, connections, outlets, appliances, devices, and portable cables installed or used in a marina, boatyard, boat basin, or similar establishment shall be made at regular intervals to ensure complete inspection at least annually."

Furthermore, the inspection required in 5.20.1 shall include a test of the ground integrity and polarity. The use of grounding-type portable electrical equipment that is not properly and adequately grounded shall be identified and removed from use or repaired.

Marinas should have these rules on hand as a reference at their facilities.

To purchase the NFPA standards and NEC visit http://marinaassociation.org/publications/other-resources

Or go directly to the NFPA catalog: http://www.nfpa.org/catalog/

Codes and standards can be viewed for free here (not available for download or printing):
http://www.nfpa.org/aboutthecodes/list_of_codes_and_standards.asp

Or contact NFPA Customer Service at custserv@nfpa.org, (800) 344-3555.

Boats:

The Code of Federal Regulations (CFR), Title 33, are the only "laws" for pleasure boats and they apply only to inboard engine-powered boats. There is minimal information and regulation in the CFRs regarding the installation of AC electricity aboard boats. ABYC publishes comprehensive but voluntary standards for all types of boats, including **ABYC E–11 AC & DC Electrical Systems on Boats**. The NFPA also publishes **NFPA 302: Pleasure and Commercial Motor Craft** up to 300 tons but it is not as comprehensive as the ABYC Standards.

In 2006, ABYC entered a requirement for an Equipment Leakage Circuit Interrupter (ELCI) that provides GFCI-type protection for the entire boat, to be installed in the internal shorepower conductor aboard all new boats made after December 2012. Since this is for new construction only, it will be a long time until all boats meet this standard.

For more information about ABYC standards and recommendations, please visit www.abycinc.org.

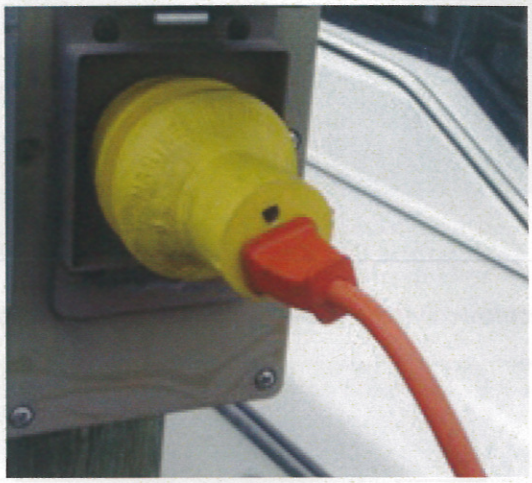
IDENTIFYING PROBLEMS & POTENTIAL HAZARDS

There are many areas in a marina where electricity flows and consequently many areas that need to be regularly inspected and tested for potential damage or misuse. Utility stations, light fixtures, fuel pumps, and dockmaster's house all can pose electrical hazards if they are not up to code.

Regularly inspect all areas of the marina's electrical systems for hazards. Daily, weekly, monthly, and annual examinations should be performed in order to ensure the facility is operating safely.

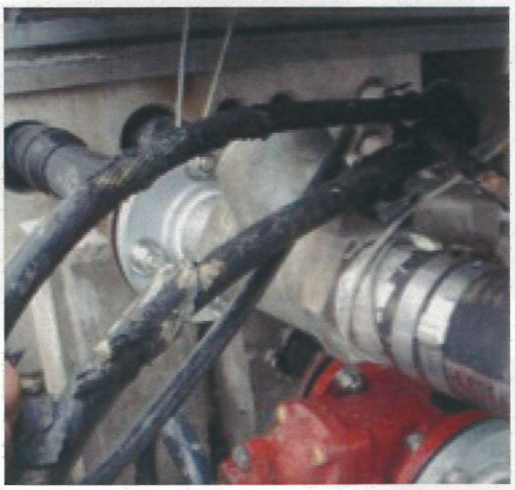
In many cases a visual inspection can quickly and efficiently identify where there are electrical problems. Following are photographs showing areas of potential electrical problems and hazards.

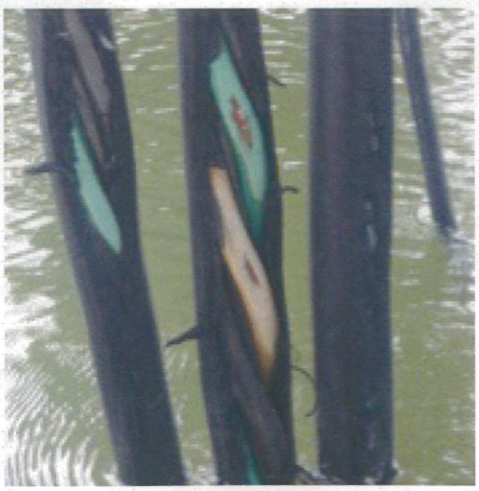
All marine cords should have grounding. This does not.



Damaged wire and exposed conductors can lead to oxidation (rusting) and potential overheating and/or fire.

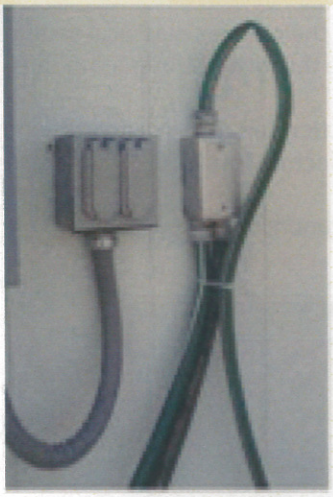
If electricity is turned on, exposed conductors can be potential safety hazards.





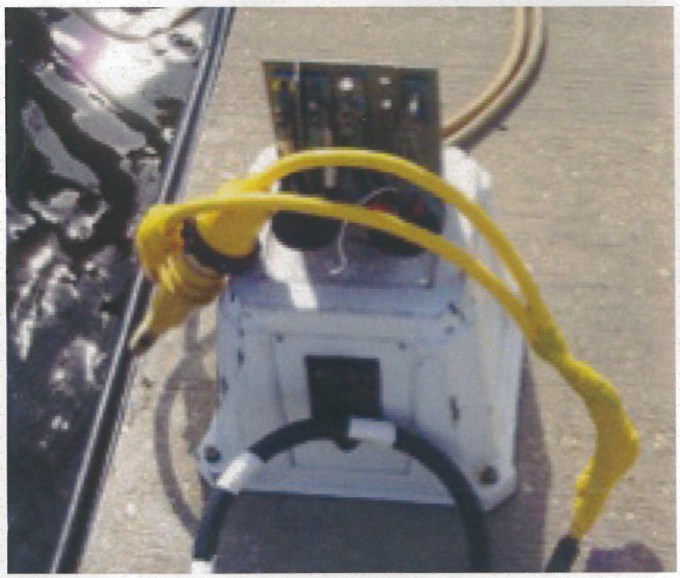
If electricity is turned on, exposed conductors can be potential safety hazards.

Garden hose cannot be used for electrical piping.



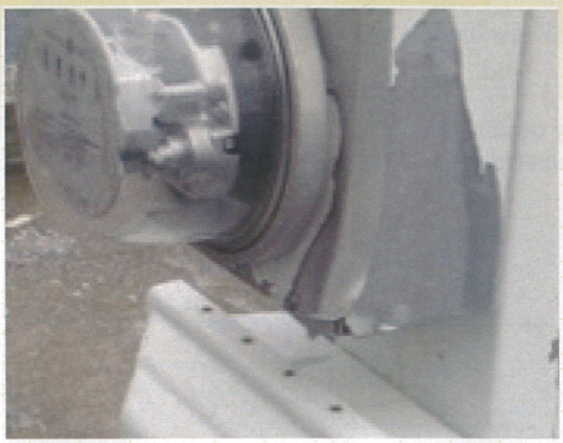
Exposed cables or electrical boxes should be closed.

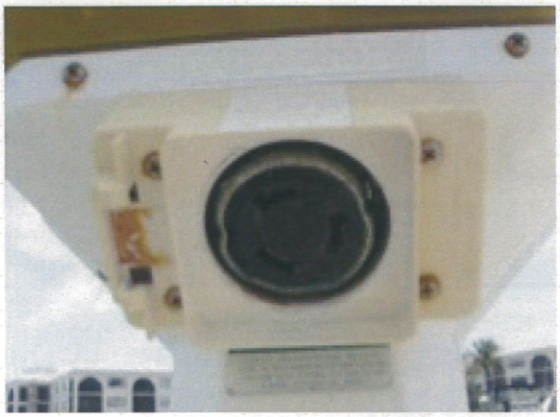
Exposed electrical connections can lead to a potential safety hazard.



Circuit breaker should not be taped in the on position. This eliminates the safety feature of the product.

Examples of damaged products. All of these should be fixed or replaced immediately.





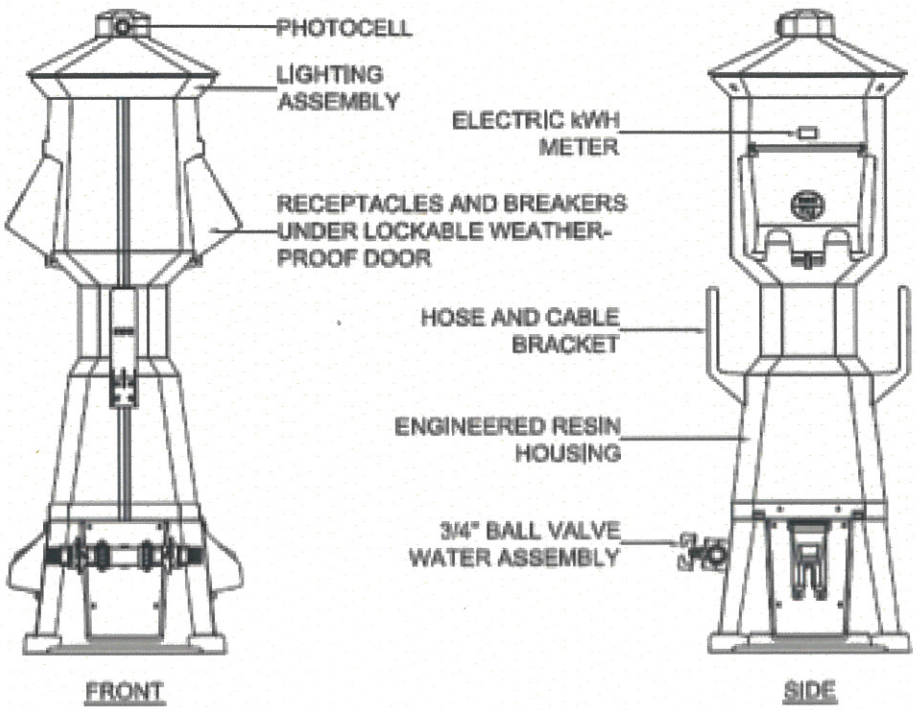
Product shows signs of burning indicating a problem

Product shows signs of burning indicating a problem

Having a checklist in hand when walking through a marina will ensure every type of electrical system is completely inspected. Different areas and utilities at a marina will necessitate daily, weekly, monthly, or annual inspections as indicated on the checklist below. These are suggested inspection schedules. Each marina is different and will need to determine how often inspections should be conducted based on their own needs and use of electric.

Also, the following checklist is based on the shown type of power pedestal. Utility centers generally have the same components and would require similar if not the same inspection. To be sure you are inspecting all parts, include a diagram from your particular utility center with the inspection sheets.

Product Features



Daily Inspection	YES	NO
Are all lights working properly on power pedestals		
Are there any non-approved marine electrical cables		
Is there any non-approved marine electrical lighting		
Are there electrical cords or is there equipment in the water		
Are any electrical cords in contact with sharp edges that may produce chafing		
Are any electrical components exposed anywhere among the marina's electrical equipment		
Is there charring at any powerpost outlets		
Is there charring at any powerpost outlets		
For Power Pedestals:		
Are there any signs of melting around the terminations		
Are all plates holding terminations in good working condition		
Are all doors and door springs in good working condition		
Are all cable brackets in good working condition		
Are all water connections in good working condition		
Are all units mounted securely		
Are there any signs of arcing under receptacle doors		
Are all receptacle plates and breaker covers in good working condition		
Are there any signs of arcing around the terminations		
Are there any signs of melting around the terminations		
Are all plates holding terminations in good working condition		
Monthly Inspection		
For Power Pedestals:		
Are all cables supported properly to avoid damage/chafing		
Are equipment housings in good working condition		
Are all doors in good working condition		
Are all locking mechanisms operational		
Are all units mounted securely		
Are there any signs of cracking at mounting locations		
Are equipment housings in good working condition		
Are all meters working properly		
Are all counters visible		
Are there fogging issues with counters		
Are all communication connections and weatherproof covers in good condition		
Are there any signs of cracking at mounting locations		
Are there any signs of rust around the receptacles or breakers		
Do you signs posted at Fuel Dock instructing boaters to turn off all power while fueling		
Annual Inspection		
For Power Pedestals:		
Are all cables approved for installation in a wet location		
Is the electrical wiring in good working condition		
Are grounds installed properly		
Are emergency electrical disconnects readily accessible and clearly identified		
Such disconnects have a sign stating EMERGENCY PUMP SHUTOFF in 50 mm (2 in.) red capital letters		

HOW TO WORK WITH YOUR SLIP HOLDERS TO BEST PROTECT YOUR MARINA

Sources of electrical hazards can be from boats or from a marina's power equipment. A marina operator can take precautions and steps to ensure all marina power sources are safe, but a marina operator cannot ensure a boat is free from hazards. While it may seem logical for a marina to require electrical inspections or conduct inspections on boats, there is a great risk of liability in undertaking such actions. One way to avoid liability would be to have a third party, not related to the marina or the boater, conduct an annual electrical fitness test for slip holders. The slip holder could be required to pay for such a test as a contractual obligation. The test would use either a "pigtail" device with an ELCI installed to detect a fault over a period of time, or a test with a clamp-on meter on a shore cord with all boat systems energized. While customers might balk at an added cost to have this test performed they can be reminded the test provides a value in knowing a boat's electric systems are sound.

Another simpler and free means for a marina operator to help prevent electrical problems from boats is to supply slip holders with a list of best management practices and suggestions on how a boater can best protect a vessel from the risk of fire or leaching stray currents. While providing the list is not as reliable as requiring testing, it may make the most sense for a particular facility and its customers.

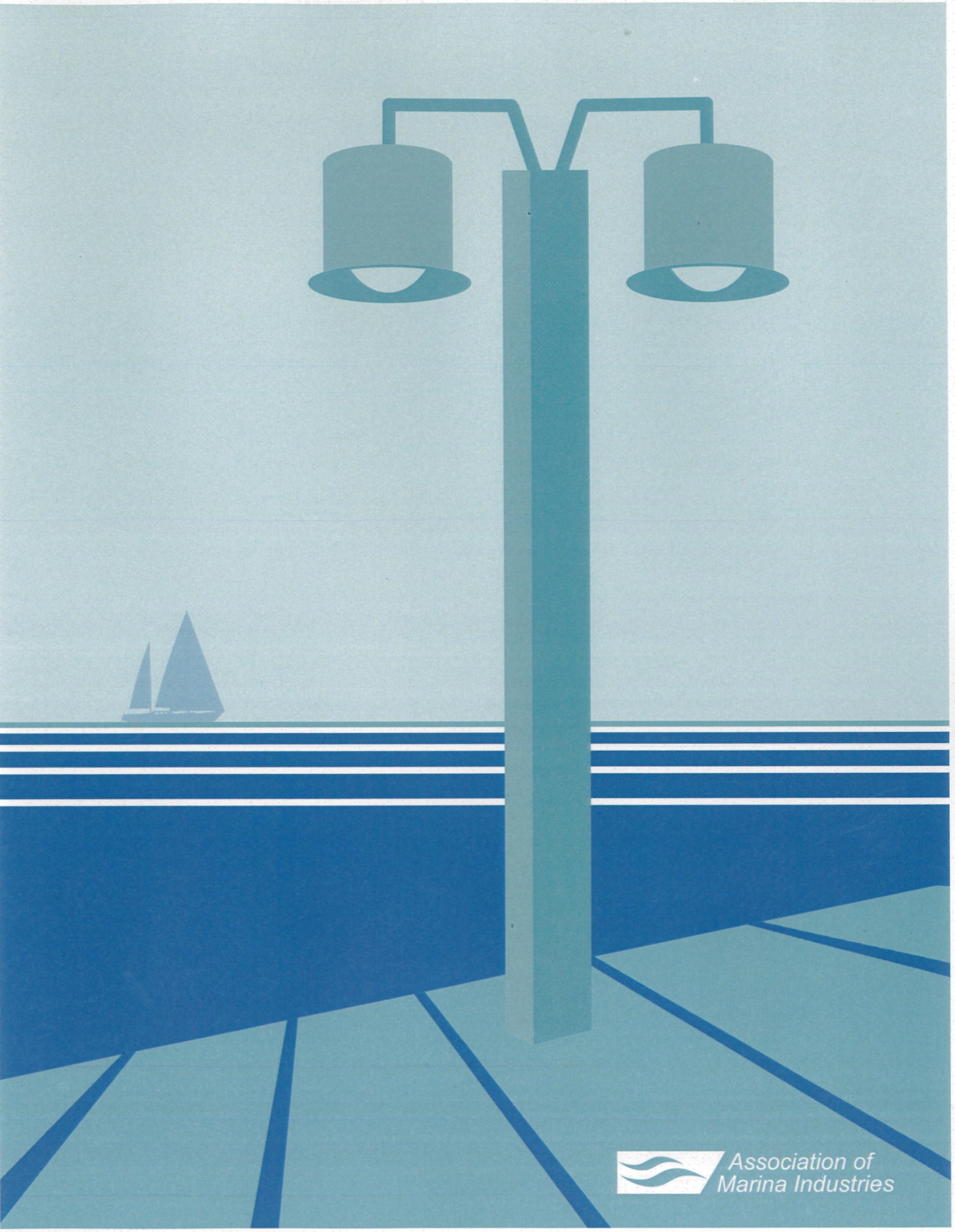
Marina operators should distribute the following responsibility code and onboard safety message to all customers annually to remind them of the importance of electrical safety and encourage them to take steps to ensure their boats are safely connected.

Boaters' Electrical Responsibility Code
PLUGGING IN:

1. Use only shorepower cords and adapters that are in good condition. Common problems include cuts, loose blades, burned ends, or melted plastic around the connections. When in doubt, replace them or have them repaired by an ABYC Certified Marine Electrician.
2. Use the right cord for the right application, 30 amp 110 volt or 50 amp 110/220 volt. Adapters must be approved by the marina management.
3. Purchase and use only products that are "factory assembled" by a recognized manufacturer and have the UL listing mark. Read and follow the manufacturer's instructions and warnings. Do not use "homemade" adapters or shorepower cords.
4. Support the shorepower cord adequately to prevent damage during wind, wave, and tide action. Make sure any locking rings are fully engaged and in good condition.
5. If an appliance has a 3-prong grounded plug, never eliminate the ground pin by either removing it or using an adapter. If the ground pin is missing or has been modified, discontinue use of the device immediately.

Onboard Safety

1. Know where your main breaker(s) are located on both the boat and the shorepower source.
2. Do not use any plug-in battery chargers that are not UL rated for marine use.
3. When using "straight blade" portable tools or extension cords always ensure these tools are connected to a Ground Fault Circuit Interrupter (GFCI) protected receptacle.
4. Test any Ground Fault outlets on board monthly and consider converting traditional outlets to Ground Fault.
5. Leave non-essential AC equipment OFF when not on the boat, this includes water heaters, outlets, lighting, etc.
6. All electrical installations and repairs must be performed by an ABYC Certified Marine Electrician or must follow the ABYC Electrical Standards with the use of products designed for marine use.
7. Do not alter the AC electrical system in any way.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