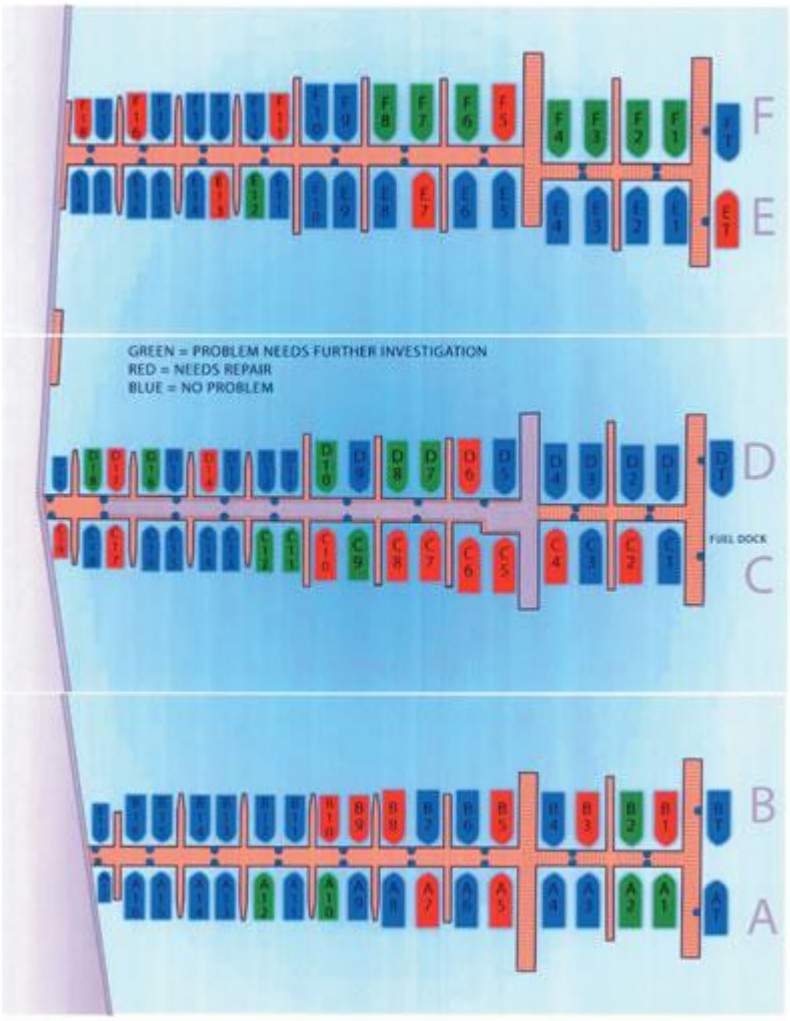
The Elements of a Galvanic Electrical Survey Success

By Captain Stanley G. Konz



THE CHALLENGE

Boat owners are inherently independent, drawn to the freedom and challenges of being on the water. Marinas, on the otherhand, not only protect and constrain a boat, but also obligate the boat owners to adhere to certain standards for the collectivegood of all the slip holders. Nowhere is this more important than balancing the freedom of the boat owners to outfit and maintain the systems on their boats and the need of the marina to minimize stray DC electric currents, which contribute to corrosion. Also, there is the problem of AC current leakage from the shore power source or from the vessels through the dock and on board the vessels to prevent potential shock and fire hazards.

When the complicated influences of a saltwater environment are added, a delicate balancing act develops between the boat owners' preferences, the other slip holders' expectations and the marina's management responsibilities. On the west coast of Florida, the Sarasota Yacht Club found the right balance as they strove to improve their marina's condition relative to galvanic corrosion and AC current leakage protection.

BACKGROUND

Located on Coon Key in Sarasota, Fla., the Sarasota Yacht Club (SYC) has embarked on a comprehensive program to assure its members that they have a safe and reliable electrical system in their marina. Th ere are power boats, sail boats, new boats and old boats in the SYC marina' s 104 boat slips. Acting with foresight, they addressed the electrical system in its totality by testing and then taking the necessary action to bring every element of the system up to code and the recommended ABYC (American Boat and Yacht Council) standards and NFPA (National Fire Protection Association) guidelines. Driven to succeed, the team included the SYC Board of Directors, management and members working with the surveyor and electricians.

THE PROCESS

First, we defined the marina electrical system to be from the shore based main distribution panel to every electrical element, including all pedestals, light fixtures, fuel pumps, the dock master' s office, all junction boxes, the TV cable system, all the shore power cord and all the boats in the marina. Then, a qualified electrical contractor, RAM Electric Inc., was selected to conduct a thorough inspection and correction of any necessary deficiencies of the entire dockside electric system. RAM Electric proceeded to:

- Check every wire and connection for evidence of corrosion or overheating
- Inspect all breakers
- Retorque all terminal nuts
- Replace all degraded components
- Check voltage drops and current availability throughout the system

Once convinced of the integrity of the electric system and assured that it met all codes, a contract was awarded to Captain Stanley G. Konz of Maritime Surveying, LLC. Th e fi rst task was to verify the integrity of the dockside electric system. Voltages and current availability were checked at every pedestal, receptacle, outlet, light fi xture and fuel pump system on the dock.

After it was determined that the dockside electrical system met the standards, the following detailed tests were performed. Included in the testing were:

- Every wire connected to every terminal in every dockside pedestal
- Every dock light fi xture
- Every cable TV outlet
- Every telephone outlet
- All the seawall fi xtures
- The hull potential on every boat in the marina

The readings that I took included:

- ACA (Alternating Current Amperage)
- ACV (Alternating Current Voltage)

- DCA (Direct Current Amperage)
- DCV (Direct Current Voltage)
- Hull potential
- Cable TV system grounding
- Telephone system grounding

The objective was to determine the presence of any AC current leakage and the degree of galvanic corrosion protection. The standards employed were the ABYC and NFPA guidelines. Th e following test apparatus was used throughout the process:

- A Hioki 3280-20 clamp on meter to test AC and DC voltages, current availability and for AC leakage determination
- An AW Sperry DM-4100 with a reference silver half cell in the water to determine hull potential
- I built six special adapters that allowed access to each wire independently:

1. On the pedestal side only of the circuit.
2. On the vessel side only of the circuit
3. On the vessel connected to the pedestal

For both 30 amp and 50 amp service

THE DETAILED TESTING

Comprehensive testing was done in a disciplined sequence to avoid any reading omissions or entry errors since so much data was recorded. For example, at the pedestal, the shore power cords were disconnected and:

1. AC and DC voltage(s) were recorded
2. Then the presence of AC and DC amperage(s) was recorded
3. Then the hull current potential was recorded
4. Then the neutral to ground connection was measured and recorded
5. Then the polarity was checked and recorded

When the tests were complete, the recordings were doublechecked to assure that the correct boat and slip number was recorded on the data sheet. Th e dock master assisted with the validation process to avoid the misassociation of test and slip designations. This testing also reconfi rmed that the dockside electric element readings were within acceptable ranges.

Next, the shore power cords were reconnected through a wire separation adapter, the power at the pedestal was turned on, and the clamp on meter was used to on the cord to determine if there was any current leakage. A reading of 0.00 AC amps indicated no leakage.

If leakage was detected, the hot – neutral wire pair AC amperage was recorded with the clamp on meter. Then, the bond wire AC and DC amperage was read. Since the other boats on the same circuit were connected to each other through the dockside ground (green) wire and the conductivity of the salt water, the readings

could have been aff ected by other boats on the same circuit and those in the vicinity of the boat undergoing the test. Therefore, if the readings of one or more boats on the same circuit or within a reasonable proximity of the boat being tested were outside of the ABYC recommended guidelines.

Some of the specific ABYC E-11 references are:
11.11 Ground fault protection-AC systems
11.11.1 An equipment leakage circuit interrupter with or in addition to the main shore power disconnect breaker, and
11.11.1.1 Trip level shall be a max. 30 ma with a trip time of 100 ms.
11.17.1.2 Neither the shore grounded or the ungrounded current carrying conductors shall be grounded on the boat, same as 11.5.5.2.1.

When the leakage is on the bond (ground) wire the shore power system is grounded on the boat. Any reading indicates there is a system ground on the boat.

All the boats were disconnected and then reconnected to test individually and in pairs to isolate the source of the stray current to an individual boat.

Next, the shore power cord was then disconnected, and an adapter was plugged into the shore power cord leading to the vessel. The wires were then tested for AC and DC voltage and amperage. Th en, the silver half cell was lowered about three feet into the water and connecting the meter to the adapter in the cord leading to the vessel reading the AC and DC amperage and voltage through the silver half cell and the water back to the meter the readings were recorded. Th is gave us an indication if the boat was within the ABYC recommended guidelines for galvanic corrosion for that hull type. If an isolation transformer was installed on the boat, the SYC would obtain permission from the boat owner to board the boat to test with the silver half cell on the other side of the isolation transformer through an available on board outlet. Following this process I was able to test the vessel by way of the shore power cord and back through the water for Hull Potential.

COMMUNICATION - EDUCATION – INVOLVEMENT

The next phase of the project was critical. To see real results, the confluence of data, people, an education program and corrective action encouragement was required. It was necessary for the boat owners to accept the responsibility and take the required corrective actions on their boats if the data indicated such a need. With the completion of data collection phase, the results were made available to the SYC members on an easy to decipher color coded chart on the SYC web site By clicking on the dock, the data recorded for that boat and slip pedestal is presented on a chart to aid the owner or an electrician to determine the specific cause of the out of guideline reading and to take corrective action. The survey showed that of the 112 boats, 28 had hull potential (galvanic corrosion) issues and 21 had current leakage (termed life safety) issues and since some had both, 42

boats had problems.
Once the data was made available on line, a Clubhouse Presentation was made to the members explaining the testing, the importance of correct hull potential (leading to corrosion in underwater metals resulting in component degradation, prop and rudder corrosion, bottom paint damage, and in the worse case- boat sinking) and the life safety issues associated with current leakage (over heated wires, electrical fires, electric shocks). Although there was a general familiarity with the galvanic corrosion issues, the current leakage results deserved additional emphasis. The effects of current through a human are:

Current	**Consequence**
1 milliamp	Threshold of perception
16 milliamps	Let-go current
30 milliamp	Irregular heart rhythm
50 milliamp	Pain, fainting, exhaustion
0.1 – 3 amps	2to Ventricular fibrillation

Although the SYC marina is a salt water marina and drownings/electrocutions associated with in-water currents are mainly associated with fresh water, there still remain life safety issues if there is current leakage on a boat. For example, current leakage coupled with resistance generates heat and can cause fires which could lead to the loss of life (or damage the boat). And, there have also been documented cases of on board electrocutions due to faulty wiring.
In addition to the Club House Presentation, a Dockside Presentation was given. A corrosion damaged prop, zinc and shaft was put on display. Dissimilar metals were placed in salt water taken from the SYC Marina and the generated electric current flow was demonstrated showing the corrosion process. Then a galvanic isolator and an isolation transformer were demonstrated showing how damaging DC current is blocked. The installation of those devices was recommended for members without such protection, and questions were fielded by equipment suppliers about costs and installations. The process to isolate on board faults was also answered. One-on-one discussions were also conducted.

WHAT WE FOUND

Specific problems that I personally saw were:
Ø Burnt and corroded shore power cords
Ø Improper AC Neutral to DC negative connections
Ø Reversed battery cables
Ø The failure of an automatic inverter ground switch
Ø Oversized breakers
Ø A battery charger inputting 110AC into the batteries

Ø Wire nuts used
Ø Undersized wire
Ø Hard (house type) untinned wires
One major fault was based on a manufacturer' s failure in their production line which led them to issue a letter to all the owners of their new 40 ft. model to correct the fault. One vessel had a shore power cord that was too hot to hold; luckily it hadn' t started a fire. Another vessel with an indicated AC leakage problem was resolved when the AC Neutral to DC Ground was properly rewired. A sailboat had experienced an overheated neutral wire that melted insulation causing AC leakage and was close to causing a fire.
As the boats owners used the survey data to pin point and correct anomalies on their boats, the following types of problems were discovered:

Area Anomalies Found

Galvanic Corrosion:

- Insufficient zincs
- Bonding wire corrosion at the terminals

Life Safety – current leakage:

- Salt bridges on shore power cables/boat receptacles
- Burnt/corroded but usable shore power cable ends
- Shore power cables with water intrusion
- Faulty wiring that burnt the insulation off
- New boats incorrectly wired at the factory
- Failed automatic switch in inverter/charger
- Air conditioner/refrigerator component faults
- Incorrect installation wiring of warranty replaced charger
- Improper AC Neutral to DC Negative

The feedback from the boat owners has generally been favorable about how the survey has been able to help them to correct problems on their boats before a more serious situation developed. As new boats come into the marina, they are tested to assure they meet the same standards that contribute to the safe marina environment at the SYC.

KEY POINTS TO REMEMBER

The program is showing solid progress. The Sarasota Yacht Club slip holders now have a cleaner, safer marina where they have confidence that their boats are less likely to suffer the effects of galvanic corrosion, that their neighbors are less likely to adversely affect their boats, and there is a lower probability of a marina fire or shocks caused by AC leakage. It took a well thought out plan, hard work and a team effort. The key elements of success were:

Ø A commitment by the Sarasota Yacht Club to conduct a thorough, comprehensive program
Ø The initial completion of the marina electrical system test, deficiency correction and validation program to assure the integrity of the system prior to the initiation of the detailed pedestal, shore power cord and boat electrical survey
Ø A detailed, disciplined data collection approach of every single element of the entire marina electrical system
Ø Easy access to the data for the members and their contractors
Ø A communication, education and program to initially promote boat owner involvement
Ø Periodic survey updates to stay current with boat slip reassignments, new boat owner slip assignments and to detect any future marina electrical system degradation
Ø A continuing communication program to maintain member awareness of the benefits of the program and their responsibility to be good marina neighbors

In addition, the SYC now has a well documented comprehensive baseline with a graphical and textual report that will aid the Club in the identification of marina or boat problems. The result is a safer marina that the members can enjoy with confidence due to the thoroughness, access and understanding of the survey.

As we move forward, SYC plans to continue to work for the members by making the SYC Marina the best and safest in the area. Maritime Surveying is proud to be part of that effort.

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An ABYC Perspective…

By Ed Sherman

In-water shock hazards have risen to the top of most electrical technicians' awareness at this point. Unfortunately this awareness needs to transcend to marina operators and boaters themselves, and it is our job as marine industry professionals to make sure this happens. Th e Sarasota Yacht Club and Mr. Konz should be congratulated on taking the important step to comprehensively survey and update their dock system to ensure that the membership boats were in a safe condition. The finding that approximately one-third of the boats docked at the club had dangerous levels of AC leakage current should be a reminder to all of the insidious nature of this problem. These leakage currents can go unnoticed

for years until a tragedy occurs. It’s my hope that more and more marinas and yacht clubs around North America will take this important step in the coming years. It really is a matter of life and death.