

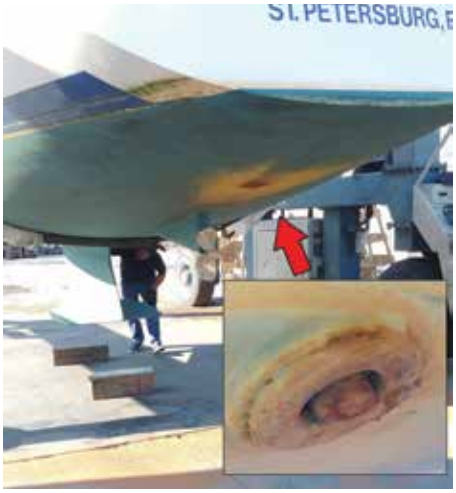
C350 Association Technical Editor Scott Monroe

This article is important for all sailors out there to read and prepare for. The proposition of losing steerage is scary. As Eric explains, he was very fortunate to be so close to safety when it happened, his story and the research he did is very enlightening. If you are interested in learning more about types of corrosion, BoatUS has a good introduction (www.boatus.com/BoatTech/articles/marine-corrosion.asp).

Everyone else, please keep those submissions coming. Your projects and experiences are benefit to all in the C350 family. **–Scott Monroe,** scott_monroe@verizon.net

How I Lost My Rudder – Corrosion

By Eric E. Ludin, *Free Spirit*, 2005 Catalina 350



Boat at haulout for surveyor

It was sunny with a 10 knot breeze and there was no way my wife and I could resist a day sail. We motored our boat out of the slip, made a turn to enter the marina fairway and heard a loud bang. The boat immediately went into a spin and I instantly realized I had no steering. I shifted from forward to reverse and back to avoid striking nearby yachts then noticed my rudder floating next to me.

Thankfully, a catamaran heading toward me witnessed the event and threw me lines to secure my position in the fairway. Someone else came by in his dingy to push me back into my slip. It was a miracle that my boat did not damage anything.



Ludin rudder

After tying my lines, I headed to the other side of the marina where someone had pulled my rudder out of the water. At this point, I was utterly confused and shaken. How did my rudder snap off? I did not strike anything.

When I recovered the rudder, I noticed on top of the rudder that there was a small foam like protrusion come from where the rudderstock would be. I did not see any metal that might make up the rudderstock. There was a rust color on the rudder near the foam remnants of the post. See figure 1

As I rolled the dock cart loaded with my errant rudder through the marina, I received multiple opinions from the dock "experts" on what had happened. As it turned out, not one was close to correct. Few boaters, even experienced ones, have the knowledge of what caused this to occur. I now know that what happened to my boat was foreseeable, avoidable and very dangerous.

You should know that Catalina boats have rudders attached to the rudder quadrant by stainless steel rudderstock. The hollow stock is filled with a foam material infused with resin to add strength. After hauling my boat, I learned that this stainless-steel rudderstock had completely disintegrated. See figure 2 (photo of the underside of my hull at rudder attachment point). All that was left were the remains of the foam insert.

I became determined to not only have the boat repaired, but also figure out exactly why this happened to make sure it would not happen again. I first reviewed what led up to this event.

About six (6) weeks earlier, my diver called concerned about a white substance that he noticed covering my propeller, zinc and shaft. He cleaned it off and everything looked fine. I decided to wait two more weeks until the next bottom cleaning to see if it returned. It did. My boat electronics installer hypothesized that a short circuit in my DC charger might be causing an underwater electrical problem. Based on this theory, I sent the charger off to the manufacturer to be tested. Two weeks later, the diver reported that there was no longer any white substance on the prop. I wrongly concluded that I found the source of the problem. I ignorantly assumed that a short in the DC charger was causing my boat to consume my neighbor's zincs (hence the "white stuff"). Bench testing by the battery charger manufacturer proved that the DC charger was working fine and had nothing to do with this episode.

I decided I needed to understand the theory of how underwater electrical current can damage a boat.

Galvanic Corrosion v. Stray Current Corrosion

All boaters are vaguely familiar with the concept of galvanic corrosion. Differing metals electrically connected, and immersed in seawater, will cause a transfer of ions through the water and electrons through metal-to-metal connection. This will occur over a relatively long time, and causes the least noble metal to deteriorate. We use sacrificial



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zinc anodes on our prop shafts and heat exchangers to prevent galvanic corrosion damage to important components. Galvanic corrosion had nothing to do with why I lost my rudder.

I later realized and proved that I lost the rudderpost because of stray current corrosion. This electrical model is both different and much more dangerous than galvanic corrosion. The type and quality of metal is irrelevant. Sacrificial anodes will not protect the metal from damage. For stray current corrosion to occur there has to be two separated underwater metals; one to act as an anode that will give up material, the other metal acting as a cathode which will receive protective current, both immersed in a common electrolyte, and a power source. The anode is in contact with the positive of a DC power source and the cathode will be connected to the negative of the same power source. As with galvanic corrosion, electrons flow through the metallic path and ions flow through the water path (electrolyte).

This power source can be a number of things, but it is most commonly a storage battery. With galvanic corrosion, the voltage difference from most active to the most noble metals on the galvanic series chart is less than two volts DC and anode wastage is slow. In the case of stray-current corrosion, the difference between anode and cathode could be as much as full battery voltage. The impact of this large voltage difference is huge in terms of the amount and rate of destruction of the anode.

I realized that somehow, my rudderstock became an anode and the prop, prop shaft and zinc became the cathode providing a pathway back to the negative terminal on the battery. As the cathode, the prop, prop shaft and zinc were protected. The only way for this circuit to be completed would be for the rudderstock to become positively charged.

Catalina yachts do not bond the rudderpost. This means that there is no ground connection to the rudderpost and it is not connected to any electrical circuit. So, how is it possible for the rudderstock to carry DC voltage?

The Cause of DC Leakage

While away from my boat, I have a habit of turning off the DC panel. I had left the boat plugged into the dock with the air conditioning and battery charger on. I also left the main battery switches on including one to my starter battery.

While laying in bed unable to sleep, it suddenly dawned on me that if there were a hot wire in my steering pedestal that somehow came in contact with the steering chain, it would be metallically/electrically connected to the rudder quadrant and rudderstock. Since I did not switch off the main battery switches, but did switch off the DC panel, my starter circuit would have electrical current all the time whereas the other DC circuits in the pedestal were off. The starter circuit has wires in the pedestal going to the key switch and starter button. Could a loose wire in the starter circuit have come in contact with the steering chain?

I hired Charlie Johnson, PE of JTB Marine Service to find the suspected voltage leak. Charlie is an electrical system specialist and ABYC Master Technician. He liked my theory about stray voltage and set out to test whether this is what caused the damage and find the source.

After the initial haulout for the insurance surveryor to see the extent of the damage, the boat was returned to the water for Charlie Johnson to do the electrical testing. See figure 2 photo showing condition of the hull after initial hauled for the surveyor to inspect. It was important that the source of the stray current testing be done before the new rudder was installed otherwise the new rudder could sustain damage.

First, he took a voltmeter and connected one lead to a silver/silver chloride metal that he lowered into the water next to the boat. The other lead was connected to the drive shaft. With the battery switches off, he measured -1015 mVDC representing a normal condition in Tampa Bay for a stainless steel shaft and bronze propeller protected by a zinc sacrificial anode. With the starter battery switch on, he measured -1717 mVDC representing a very significant increase in stray voltage. This test established that there was a voltage leak and it was from the starter circuit.

To find the source of the leak, he removed the instrument panel from the steering pedestal and observed a bundle of wires resting on top of the steering chain. When the wires were inspected, two positive wires, both running from the key switch, had chafed insulation. The steering chain had apparently rubbed the insulation away. The wires themselves were intact which is why the engine started without any difficulty. See blue box in figure 3.

Once the wires were removed from the chain, Charlie retested the shaft potential against the reference cell and found a normal reading. Charlie advised that this was a classic case of stray current corrosion. The white substance that my diver observed on my prop was carbonate created by the ions shed from my rudderstock. It had disappeared by the time of the third visit from my diver because, by then, the rudderstock had largely disintegrated.

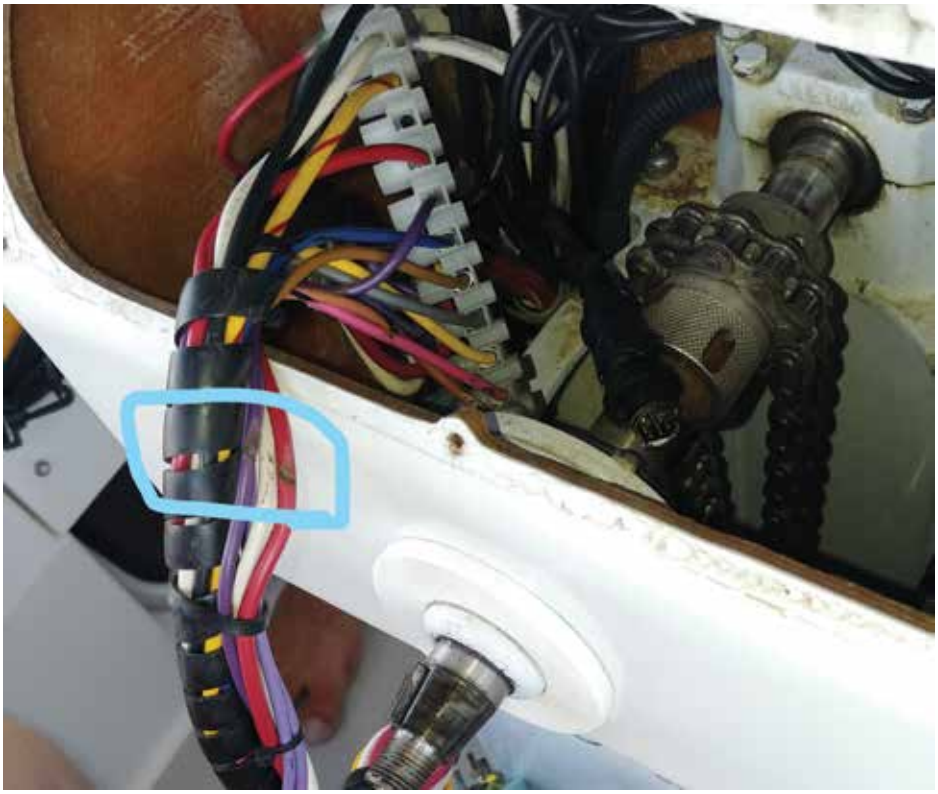
I have owned this boat for over ten years. During that time, I have had the electronics replaced and repairs made to the starting circuitry. Marine electricians have accessed the wires in the pedestal. I never removed the instrument panel myself for the purpose of checking the conditions of the wires. Clearly, whatever cable ties and "U" clamps that secured the wires had been cut and not adequately replaced. It is also possible that these plastic protective parts broke with time. But, before this episode, I would never have suspected that an unsecured wire could cause my rudder to snap off!

Rudder replacement

The rudderstock cannot be repaired since the rudder is molded around it. Catalina built me a new rudder from molds they have in their factory. I visited the factory to see how they would build my rudder. The rudderstock is actually a long stainless steel post with lateral flat plates welded to the post. See figure 4 showing examples of rudderstocks before going into the mold . The post with the plates attached goes into the mold. The mold is filled with high-density plastic foam core, which is wrapped in a fiberglass skin. This foam-core construction is relatively light with neutral buoyancy, which explains how I was able to recovery my errant rudder. Figure 5 shows my rudder at the factory after they completed construction.

Catalina is charging a little over $3,500 for the C 350 rudder. It took the factory eight (8) weeks to build mine, though they said it should typically take three (3) weeks depending on their schedule. I hit them at a bad time as they were busy finishing construction of the C 545 for the Annapolis boat show. After adding the cost of the haul out, labor, paint, etc., the total cost will be about $10,000.

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Chafed wires and steering chain



Rudderstocks before mold



New completed rudder

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What we need to know

110 volt AC voltage is very dangerous and can kill a person. 12 volt DC voltage might not kill you, but it can do serious damage to a boat. Owners must check their DC wiring. Any break in insulation can come in contact with underwater metal and create an anode/cathode relationship which will quickly disintegrate the anodic metal. Owners must be especially mindful of the wiring in your steering pedestal because of its proximity to the steering chain.

I realized that if I had discovered the problem the moment my diver called to tell me about the "white substance", I still would have needed to replace my rudder. There is no way to measure the amount of damage that had occurred by that time. At the very least, the rudderstock had been seriously weakened.

I questioned whether I made a mistake by leaving the boat with the battery in the on position. I realize now that this allowed me to discover the problem while docked. If I only turned the battery on when sailing, the rudder would have deteriorated over time whenever I was using the boat. If I went on a two-week cruise, the rudder might have snapped off while heading home.

This concern is not unique to Catalina yachts. It can happen to the most expensive boats on the market. If the rudder had been bonded, it would have been protected from this type of corrosion. Once the hot wire touched the chain, it would have caused a short circuit and likely blown a fuse. If the rudder were bonded, it would be subject to galvanic corrosion and would require placement of a nearby zinc anode which is extremely difficult to design. For this reason, I do not fault Catalina for not bonding the rudder.

The bottom line is that all boat owners must be aware of the dangers of stray current corrosion and take steps to avoid it. The best way to prevent this from occurring is to make certain your DC wires are secured and protected against chafe.

I made an insurance claim on my boat policy. Unfortunately, most boat policies have exclusions for corrosion. As of today, I still do not know whether this claim will be covered under the policy. It is my understanding that "yacht" policies may be available for a slightly higher premium which do not exclude corrosion. I would recommend you check the exclusions on your insurance policy.

Finally, if you have an underwater electrical issue, do not rely on so-called "experts" at your marina. If I had not educated myself about how such an event occurs and had not hired a qualified expert, I might not have found the true source of the stray current. It is very likely that I would have had to replace a second rudder. **–Eric E. Ludin**, Free Spirit, 2005 Catalina 350

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