BoatZincs.com

America's Superstore for Marine Anodes

As part of our commitment to providing product knowledge and technical expertise, we source quality content that informs, educates, and benefits our customers.

This article originally appeared in the Marine Trawler Owners Association (MTOA) quarterly magazine *Turtle Times* in June, 2023 and is reprinted here with permission from MTOA and the author, Mike Bell.

MIKE BELL, ABYC Certified Advisor
MTOA Board Member • DeFever Cruisers Member

Author Mike Bell graduated with honors in Electrical Engineering from Columbia University, is an ABYC certified technical advisor for marine electrical systems and has lived aboard his DeFever 48 for six years along with his wife Marilou and her ferocious dog Sinbad. Marine Trawler Owners Association is a technical resource for cruisers and trawler owners, largely through the efforts of members like Mike who continue the tradition of helping cruisers understand the systems on their boats and enable them to maintain and upgrade their systems in a safe and effective manner.

– MTOA Engineering Corner –

ALL ABOUT GALVANIC ISOLATORS

Submitted by: Mike Bell

This article will discuss the purpose of galvanic isolators, their proper installation, and methods to test the isolator with commonly available equipment.

Galvanic Isolators (GI) are used to prevent corrosion in boat systems. They are not needed for boats operated solely in freshwater, nor boats with isolation transformers, but a GI should be used if a polarization transformer is installed. The GI is installed in the ground circuit between the shorepower ground entering the boat and the ship's grounding system. A GI blocks low level DC currents from galvanic couples within the boat systems. To explain this further it is necessary to first discuss galvanic couples as these are the reason GI's are needed, and diodes as they are the key to how a GI works.

GALVANIC COUPLES

All metals, when immersed in an electrolyte such as seawater, have characteristic electric potentials (voltages). Table 1 is an excerpt from the ABYC standard on cathodic protection, and it contains many of the most common metals used on our boats. Because these metals have differing electric potentials current can flow between two different metals through the electrolyte. This is the underlying science that also enables lead-acid batteries. The differing metals and their differing electric potentials are termed "galvanic couples", and the voltages in Table 1 are referenced to a silver, silver-chloride reference cell (Ag/AgCl).

continued on next page >

Galvanic Series in Sea Water

	Ag/AgCl Reference Cell Potential (mVDC)
ANODIC OR LEAST NOBLE	
Magnesium and Magnesium Alloy	-1600 to -1630
Zinc	-980 to -1030
Aluminum Alloys	-760 to -1000
Mild Steel	-600 to -710
18-8 Stainless Steel, Type 304	-460 to -580
18-8, 3% Mo Stainless Steel, Type 316	-430 to -540
Copper	-300 to -570
Silicone Bronze	-260 to -290
Bronze ASTM B62	-240 to -310
Copper Nickel	-180 to -230
Stainless Steel Propeller Shaft (ASTM 630: #17 & ASTM 564: #19)	-30 to +130
Graphite	+200 to +300
CATHODIC OR MOST NOBLE	

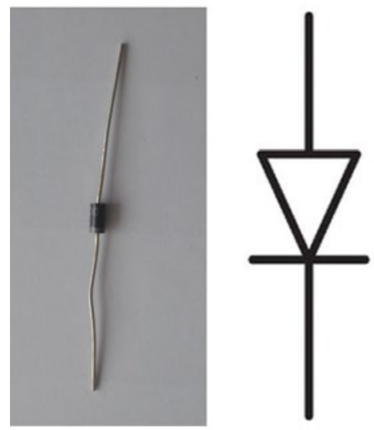
While galvanic currents are the basis of lead-acid batteries, they are not helpful for the metals of our boats. The galvanic currents are actually a stream of ions which can deplete the underwater metals on a boat in seawater. This is why we use metals such as zinc and magnesium as donor metals to protect other underwater metals on the boat. These "anodic metals" sacrifice themselves to protect the rest of our boat systems.

The largest voltage difference between dissimilar metals in common use is between Type 304 stainless steel (-580 mVDC) and stainless steel propeller shafts (+130mVDC), or a difference of 710 mVDC. Thus to block galvanic currents the blocking mechanism must overcome a voltage of 0.71 volts. It is not necessary to overcome the voltage difference to magnesium or zinc anodes as these are purposely intended to be donor metals.

BACKGROUND ON DIODES

Diodes are semiconductor devices that are available with a wide variety of uses, and which we commonly use every day. For purposes of this discussion we will exclude specialty diodes such as Zener, Schottky, tunnel and light emitting diodes (LED's) and focus on their basic function as a power rectifier. A common diode and its circuit symbol are shown in Figure 1. It is hard to see in the photo in Figure 1, but the diode has a stripe around one end to identify the diode's polarity.

Figure 1. Common Diode and Circuit Symbol



Diodes are the electrical equivalent of check valves in plumbing. They permit electric current to flow in one direction and not the other. All diodes have a forward bias voltage which has to be reached before current will begin to flow. The forward bias voltage is dependent on the semiconductor material used. The most common material, silicon, has a forward bias voltage of 0.5-0.7 volts, and once this voltage across the diode is reached an unlimited amount of current can flow through the diode. Unlimited, that is, until the diode is damaged by the heat generated by the current flow. Power diodes have a high reverse breakdown voltage, and when this is exceeded the diode will be damaged and unusable. Reverse breakdown voltages are seldom exceeded in normal operation, but that can happen with nearby lightning strikes. Diodes can fail in various ways, and can exhibit an open circuit (no current flow) or a complete short circuit (unlimited current flow).

Many volt-ohm meters (VOM) and digital volt meters (DVM) have a diode test function built in. The photo in Figure 2 shows one of my VOMs with an arrow pointing to the diode test setting. When the test leads are applied across the diode so it is forward biased the meter reads the forward bias voltage, and when the leads are reversed the meter shows the maximum voltage it can generate with its internal battery, usually an indication like 'OL' or '1'. This indicates no current flow. Figure 3 shows a diode being tested, with the forward bias shown on the left side of the photo and the reverse bias on the right. Note that the VOM wire connections are reversed between the forward bias and reverse bias configurations, and the forward bias voltage is consistent with a silicon diode.

continued on next page >

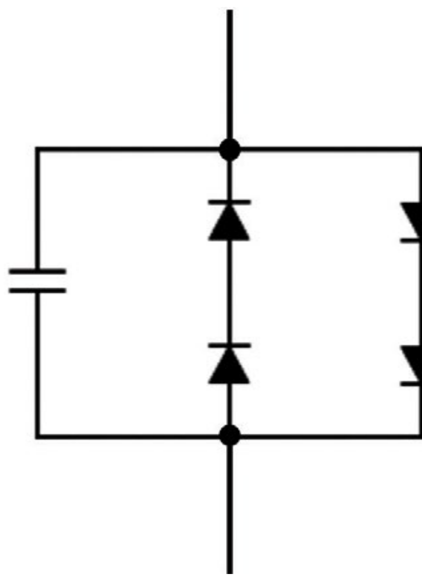
Figure 2.VOM with Diode Test Setting

Figure 3.VOM Testing a Diode

GALVANIC ISOLATOR INTERNAL CIRCUITRY

The basic galvanic isolator internal circuitry is a combination of diodes and a capacitor as shown in Figure 4. This shows two sets of diodes in parallel, with each set having two diodes in series. The two sets of diodes are oriented in opposite directions, and the capacitor is in parallel to this arrangement. The purpose of the diodes in series is that the forward bias voltage across the unit is the sum of two individual diodes (1.0-1.4 volts for silicon diodes), and the opposed sets of diodes limit current flow for low DC voltages in both directions. The parallel capacitor aids in passing AC voltages, but will block DC voltage. This arrangement has little effect on 120VAC power but it effectively blocks low DC voltages and currents which are typical of galvanic couples.

Figure 4. Simplified Galvanic Isolator Circuit



Galvanic isolators are wired between the shorepower ground and the ship's AC ground, and they maintain the AC ground connection while blocking low level DC galvanic currents. A typical GI installation is shown in Figures 5 and 6. GI's have had three product cycles in their history. The earliest ones were simple units but they could fail leaving the AC ground lost. This was a safety problem. Technicians reported about 5% of the fielded units (1 in 20) had failed. Then units became available which had a detector circuit to test the unit. They were expensive and the detector circuit was a problem with the new NEC shorepower pedestal requirements. This type is no longer available. Finally Dairyland Electric developed a FAILSAFE unit that meets ABYC requirements. If this unit fails it

continued on next page >

maintains the AC ground, but galvanic isolation can be lost. Promariner also provides an excellent FAILSAFE unit. A boat with 50 amp shorepower needs a 50 amp GI. Boats with a single 30 amp shorepower connection need a 30 amp GI, and boats with dual 30 amp shorepower connections need a 60 amp GI.

Figure 5.Galvanic Isolator Installation, 50 Amp Power

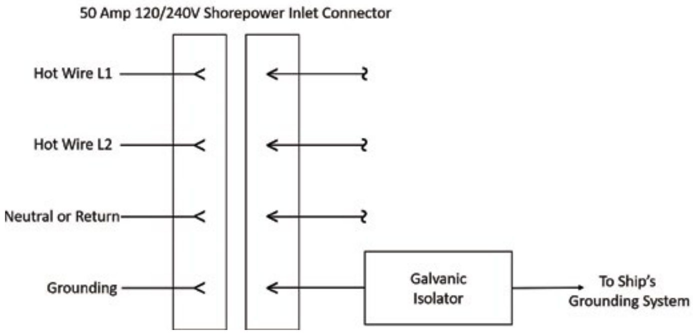
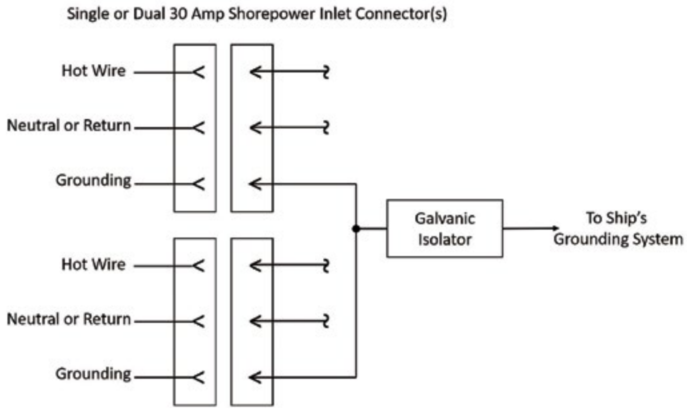


Figure 6. Galvanic Isolator Installation, Single or Dual 30 Amp Power



TESTING GALVANIC ISOLATORS

To test a galvanic isolator first disconnect shore power and disable any inverter. Use a VOM or DVM in the AC voltage setting to verify no AC voltage is present on the boat. Then disconnect the wire from one side of the galvanic isolator—it doesn't matter which side of the GI is disconnected. Use the meter in the diode test setting, and place the test leads across the two connections of the GI. You should see the display ramp up to a voltage, and then stabilize. The voltage ramp-up is the capacitor charging inside the GI. Then reverse the leads, and again the voltage should ramp up and stabilize. The stable voltage should be between 0.9 and 1.5 volts with the test leads connected one way, and also when they are reversed. Figure 7 is a composite photo showing a GI test with the leads in both configurations, and the diode test voltage in each case. The GI is the black unit with heat dissipation fins behind the VOM. As you can see in the photos, the voltage across the galvanic isolator is 1.08V with the test leads in one position, and 1.063V with the test leads reversed. This is a normally functioning galvanic isolator. If the voltage is zero, or if it reaches the maximum setting (OL) then the GI is faulty and must be replaced. Unfortunately galvanic isolators are not repairable.

Figure 7. Testing a Galvanic Isolator

Galvanic Isolators are important devices for protecting our boats from corrosion. They are relatively simple devices, but are commonly misunderstood. I recommend periodically testing an installed galvanic isolator, and especially after significant lightning events near your boat or unexpected, sudden lost power events affecting the dock or docking facility.

Article courtesy of Mike Bell, BoatZincs.com, and Marine Trawler Owners Association (MTOA).