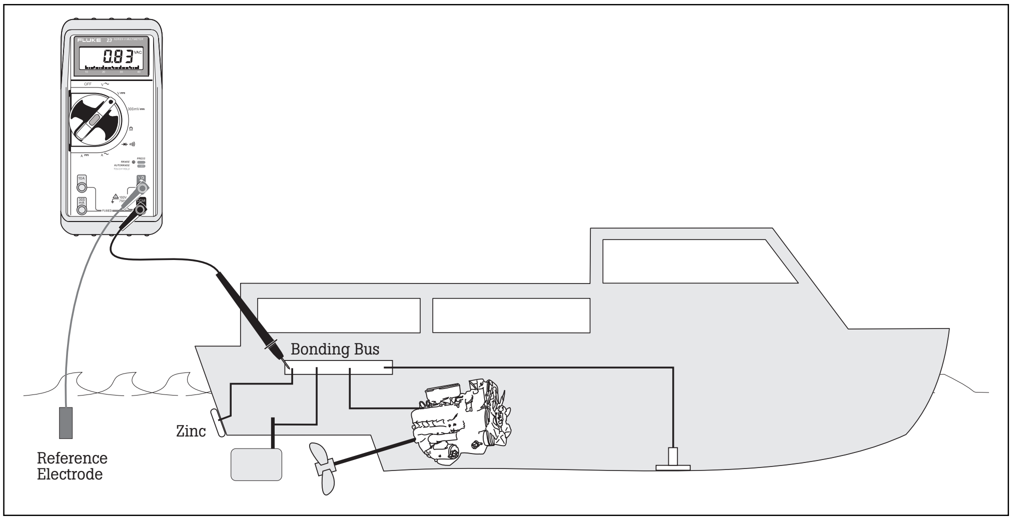
# Testing Corrosion Protection Systems

## Application Note




### Introduction

The corrosion protection system on your boat should be checked at regular intervals. Failure to do so can lead to costly and time consuming repairs. The tools you'll need for the job include a high quality digital multimeter and a reference electrode. Fluke multimeters are ideal for corrosion system testing for several reasons. They are accurate, rugged, reliable, and most important, they have 10 Megohm input impedance in the DC volts function. The high input impedance will allow you to test your boat in either fresh water or salt water with repeatable results.

This application note will help you understand some basic corrosion mechanisms and the methods used by professionals to test corrosion protection systems. At the end of the application note, you'll find a list of references for further reading on the subject.

### Basic corrosion mechanisms

In general, the term "corrosion" refers to the unwanted loss of metal from the hull and/or under-water metal fittings of the vessel. There are two main types of corrosion – mechanical and electrical. Under the electrical category, there are three common subcategories: galvanic corrosion, stray current corrosion, and crevice corrosion.

Galvanic corrosion occurs when two dissimilar metals are connected together electrically in the presence of a conductive electrolyte. Atoms in the less noble metal give up their electrons to the more noble metal and are released to flow (corrode) into the electrolyte in the form of positively charged ions.

Stray current corrosion occurs when a foreign voltage source pulls electrons out of the metal allowing the ions to flow as previously described.

Crevice corrosion is actually a form of galvanic corrosion but involves only one metal. A portion of the metal (in the crevice) becomes active (less noble) due to loss of oxygen while the remainder stays passive. If electrolyte is present, a galvanic couple is formed and the active metal is converted to ions and enters the electrolyte solution.

### Principles of galvanic corrosion

Materials used in the construction of marine vessels are chosen using various criteria including cost, mechanical strength, workability and corrosion resistance. When we want to compare metals according to their corrosion resistance, we refer to a ranking list called the "Galvanic Series of Metals" often referred to as the "noble scale". This scale indicates the relative affinity that each metal has for its electrons, i.e., it ranks the metals according to their electron bonding strength.

Metals at the active (less noble) end of the scale will give up their electrons and corrode more easily than metals on the passive (more noble) end of the scale.

**Galvanic Series of Metals**
(alloys may vary according to composition)

**Active** (least noble)

| | | |
|---|---|---|
| Magnesium | Iron | Lead |
| Zinc | Brass | Titanium |
| Aluminum | Tin | Silver |
| Cadmium | Copper | Platinum |
| Steel | Bronze | |

**Passive** (most noble)
Gold

Underwater metals can be protected if they are supplied with extra electrons. Active metals like zinc are commonly used to protect more noble metals. If the two metals are immersed in the same electrolyte and deliberately connected by an electrical "bonding" system, the zinc will give up its electrons to protect the more noble metal. In this configuration the zinc is called an anode and the protected metal is called the cathode.

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## Testing with a reference electrode

When a metal is in contact with an electrolyte such as sea water, the metal will establish a natural potential or voltage with respect to the electrolyte. This natural potential (or “freely existing” potential) is the value that exists when no extra electrons are being supplied or removed by an outside voltage source. We can measure this potential with a digital multimeter and a reference electrode. The reference electrode allows us to make an electrical connection to the sea water with a known, repeatable value, i.e., a reference value.

Reference electrodes are often called “half cells” because they contain a metal and a metal compound. Popular types are Copper-Copper Sulfate and Silver-Silver Chloride. Marine system tests are often conducted with a Silver-Silver Chloride electrode (see description in reference 1).

The principle of the test is straightforward: We want to establish that the corrosion protection system is supplying enough electrons to raise the potential of the protected metal 250 mV ($^1/_4$ Volt) above the freely existing value. The test procedure is as follows: (Refer to drawing on page 1).

1. Set the multimeter function to DC volts.
2. Connect the reference electrode to the volts input jack and place the electrode in the water. Best results are obtained when the electrode is located away from the anode.
3. Connect the multimeter common jack to a probe that will be used to contact each piece of underwater metal.
4. Touch the common probe to each underwater metal fitting and record the millivolt value as displayed on the meter. If all underwater metal fittings are connected together with a “bonding” system as shown on page 1, then all readings should be identical. Some typical values for several metals are listed in Table 1.

| Metal | Free Unprotected* | Protected* | Over Protected* |
|---|---|---|---|
| Steel | 0.50V | 0.75V | 1.00V |
| Bronze | 0.30V | 0.55V | 0.80V |
| Aluminum | 0.65V | 0.90V | 1.05V |

* Voltages given in this table are typical values obtained using a silver/silver-chloride reference electrode. Values may vary according to alloy and type of coating.

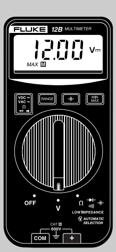
Overprotection can cause paint to peel from a metal hull, or chemical damage to a wooden hull. Refer to references 1 & 2 for more information on the dangers of over protection and details about bonding systems.

## References for additional information


1. Boat and Yacht Corrosion Control; by Yacht Corrosion Consultants 2970 Seaborg Avenue Ventura, CA 93003
2. Boatowner’s Illustrated Handbook of Wiring; by Charlie Wing International Marine Camden Marine
3. Your Boat’s Electrical System; by C. Miller and E.S. Maloney Hearst Marine Books


## Fluke Multimeters for Marine Applications

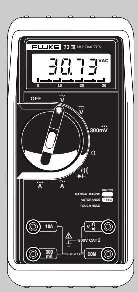
The following Fluke Digital Multimeters are recommended for use in marine applications.



**Fluke 12B**

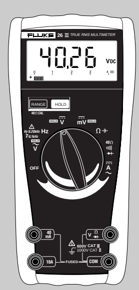
**Put basic tests on automatic**

- VCheck™ automatically switches from measuring ohms/continuity to ac or dc volts
- Capacitance, to 10k microfarads
- Continuity capture locates intermittent opens and shorts
- Min/Max recording with relative time stamp



**Fluke 73 Series III**

- Touch Hold® captures stable readings
- Auto and manual ranging
- Holster with Flex-Stand™ included
- Volts ac and dc
- Resistance
- Diode test/continuity beeper
- AC/DC current with ranges from 32 mA to 10A



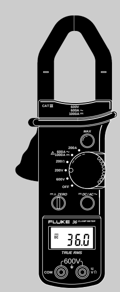
**Fluke 26 Series III**

**Same features as Fluke 73 Series III, plus:**

- Rugged, overmolded case
- Tough, electrical test lead set with silicone insulation and alligator clip
- True-rms ac voltage
- AC/DC current with ranges from 4.0 mA to 10A
- Lo Ohms

**Fluke 27**

- Fully sealed, waterproof case
- Touch Hold® captures stable readings
- Volts, ohms, amps, continuity, diode test
- Current with ranges from 320 μA to 10A



**Fluke 36 ClampMeter**

- True-rms responding
- AC current to 600A
- DC current to 1000A
- AC and DC voltage to 600 Volts
- Max Hold
- Continuity beeper

## Other marine application notes available from Fluke:

- Troubleshooting Marine Engine Electrical Systems
- Troubleshooting Outboard Motor Magneto Ignitions

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