QUICKSILVER®

# Everything you need to know about marine corrosion.

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# Preface

No matter what their dollar value, your boat and motor are pretty precious to you. You go to great lengths to protect them. You protect them from theft with locks, you protect them from the elements with covers and shelter, and you protect them from premature wear with regular maintenance.

But there's an insidious force attacking your boat and motor right now that you may not be adequately protected from. You can't see it, or any evidence of it, until it's too late. It's corrosion.

In the most extreme conditions, corrosion can destroy your drive unit, motor, prop, accessories and fittings in a matter of weeks—sometimes even days.

At its best, corrosion is expensive and inconvenient. A corroded prop or lower unit is very inefficient, resulting in lower top speed, lower fuel efficiency and increased wear on the engine. At its worst, corrosion can be potentially unsafe. Imagine being on the water when corrosion damage starts causing equipment or parts to malfunction.

When it comes to corrosion, what you don't know can hurt your equipment. That's the reason we wrote this book. Like *Everything You Need To Know About Propellers*, this book has been compiled from engineering data and factual metallurgy, stress and corrosion tests performed by Mercury Marine. Our laboratory (which we humbly believe is one of the best in the world) has accelerated-atmosphere bath tanks that can simulate years of corrosion in just a few weeks. We also real-world test, in all parts of the world.

This book will give you an understanding of the basics of corrosion—the signs, the causes, the remedies and the preventions. And while these are only the basics, some of the information is very technical. If you have any questions or need assistance in corrosion protection, contact your Mercury, Mariner, or Force Outboard, MerCruiser Stern Drive and Inboard, and Sport-Jet dealer. Because when you come right down to it, you don't really have a choice. Every minute your boat and motor are in and on the water, corrosion is at work . . . until you stop it.

Quicksilver Marine Parts & Accessories

*The term "drive unit" refers to all product lines, MerCruiser stern drives and Mercury, Mariner and Force outboards except where specified.*

*All photos and illustrations are representative and may not apply to every year of production of every model.*

CHAPTER 1

# What Is Corrosion?

There is nothing mysterious about corrosion. We've all experienced it. It is simply any metal naturally changing. The processes it goes through in changing are slightly complicated, but not especially complex.

## High School Chemistry Revisited

To best describe corrosion, let's start with the most common type, rust. We all know rust, but to *understand* rust, we have to go back to the very beginning.

Iron ore has a chemical composition of two iron atoms bonded with three oxygen atoms ($Fe_2O_3$). As it is mined out of the ground, it's a brownish-red powder that's useless to us. But by refining, purifying and smelting, we create iron, which *is* useful to us. We can use it as plain iron, or we can process it further and combine it with other elements to get different kinds of steel.

Let's say the iron is made into hinges for your backyard fence. Everyone knows that if you leave iron (or steel, which is mostly iron) out in the rain, it rusts. If it rusts long and badly enough, the metal disappears and you're left with a pile of brownish-red powder—rust, or iron oxide, both of which have a chemical composition of $Fe_2O_3$. Yes, rust—or iron oxide—has the same composition as iron ore.

Here's why. Iron atoms want to return to their natural state as iron ore, iron oxide or rust, which are all the same thing. That's the state in which iron is most comfortable and most stable. Left alone, it won't turn into anything else. And most metals used in manufactured products want to do the same—return to their natural states.

## Electrochemical Reactions

Iron left out in the rain results in a specific kind of corrosion. It's called an "electrochemical reaction," meaning there is an electrical change along with a chemical change. Here's how that mouthful works:

For two iron atoms to really interlock with three oxygen atoms (and make $Fe_2O_3$), they have to share some electrons (the little particles orbiting the atom). That releases a few electrons. And since electricity is just a flow of electrons, those free electrons become a little bit of electricity when the chemical change takes place.

Remember, the iron wants to corrode into iron oxide because that's its natural, most stable state. And all it needs for this to take place is oxygen. Water is a supply of oxygen, so iron rusts fastest when it gets wet. You knew that already, but now you know *why*. And that same exact scenario applies to aluminum and aluminum oxide.

So those are the deep, dark secrets of corrosion as they apply to metals. Those are also the basics of an electrochemical reaction, which is also known as *galvanic corrosion*. (All galvanic corrosion is an electrochemical reaction. Not all electrochemical reactions, however, are galvanic corrosion.)

## Types of Marine Corrosion

Metal parts under water are primarily subjected to two basic types of corrosion: 1) galvanic corrosion and 2) stray current corrosion.

Galvanic corrosion is an electrochemical reaction between two or more different (or "dissimilar") metals. The metals must be different because one must be more chemically active (or less stable) than the other(s) for a reaction to take place. When we talk about galvanic corrosion, we're talking about electrical exchange. All metals have *electrical potential* because all atoms have electrons, which are electricity.

**Corrosion Table**

| | |
|---|---|
| Gold | *Least Active* |
| Stainless Steel | |
| Bronze | |
| Copper | |
| Brass | |
| Steel | |
| Iron | |
| Aluminum | |
| Zinc | |
| Magnesium | *Most Active* |

Galvanic corrosion of the more chemically active metal can occur whenever two or more dissimilar metals that are "grounded" (connected either by actually touching each other, or through a wire or metal part) are immersed in a conductive solution (any liquid that can transfer electricity). Anything but pure water is conductive. Salt water, fresh water with high mineral content, and polluted fresh water are *very* conductive, and conductivity goes up with water temperature. (That's one reason why boats in Florida experience more corrosion than boats in Maine.)

The simplest example of galvanic corrosion, and the most applicable, is an aluminum lower unit with a stainless steel propeller. The aluminum is the more chemically active metal (the "anode"), and the stainless steel is the less chemically active metal (the "cathode"). Several things happen at the same time (Figure 1-1):

1. At the anode
   a) Electrons flow from the anode, the metal that is more chemically active (the aluminum drive unit), via the external conducting path to the cathode, the metal that is less chemically active (the stainless steel prop), as in the reaction $Al \rightarrow Al^{+++} + 3e$.
   b) When this happens, the more chemically active metal atoms become ions (an atom with one or more electrons either missing or added) and break away into the water, where they can bond to oxygen ions, with which they can share electrons and produce aluminum oxide. (This is the identical process iron ions go through when combining with oxygen ions in water to form iron oxide).
   c) The newly formed aluminum oxide molecules either drift away in the water or settle on the surface of the aluminum. Your lower unit is literally dissolving through galvanic corrosion.
2. At the cathode
   a) Electrons are accepted from the anode; however, they cannot simply accumulate, but react with ions in the electrolyte.
   b) The most common reaction is (as in Fig. 1-1): $1\ 1/2\ O_2 + 3\ H_2O + 6e \rightarrow 6\ OH^-$.
   c) The hydroxide ion ($OH^-$) is alkaline, and makes the electrolyte alkaline in the area of the cathode. This detail is particularly important for wooden boats, as an alkaline solution will attack cellulose.

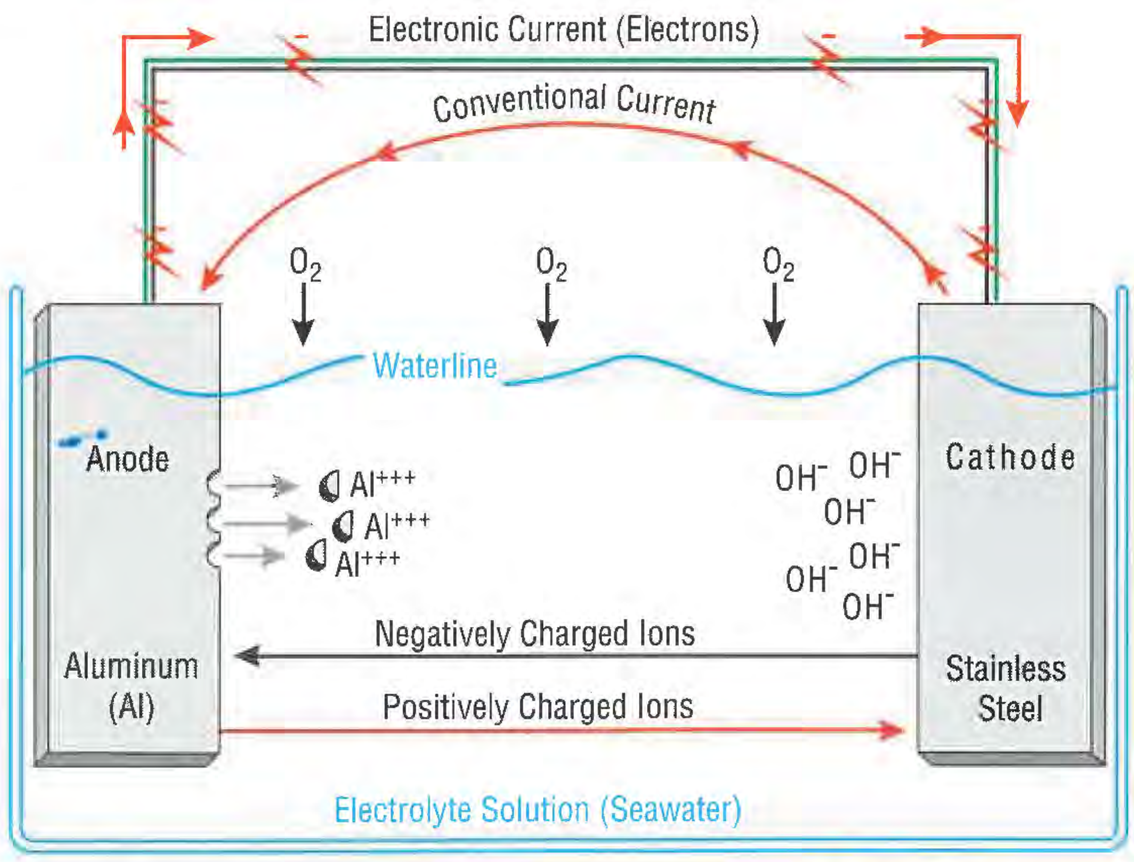



*Figure 1-1*
*A basic corrosion cell*

It is important to understand that for each positive metallic ion released at the anode, electrons in the cathode react to form a negative ion in the electrolyte. Electrically the anodic and cathodic reactions must be equivalent. Increases or decreases in the rate of the cathodic reaction will have a corresponding increase or decrease on the anodic reaction. This is a basic fact in understanding and controlling corrosion. This fact can also be demonstrated by the effect of size ratios between anodes and cathodes. If there is a very large anode connected to a small cathode the anode will corrode very slowly. However, if a very large cathode is connected to a small anode the anode will corrode very rapidly.

Marine drive components have *many* aluminum parts. If you do not control galvanic corrosion, over time the aluminum will corrode away.

Galvanic corrosion can also occur without any stainless steel components on your boat. For example, you have an aluminum drive unit and an aluminum propeller, but you dock at a pier with steel pilings or at a steel seawall, then plug into shore power. The ground wire, which is grounded, connects your aluminum components with the submerged steel because the steel is also grounded (Figure 1-2). Considering the mass of a seawall or even a single piling, your drive and propeller can sustain serious damage. (This damage can be prevented with a galvanic isolator, mentioned later.)

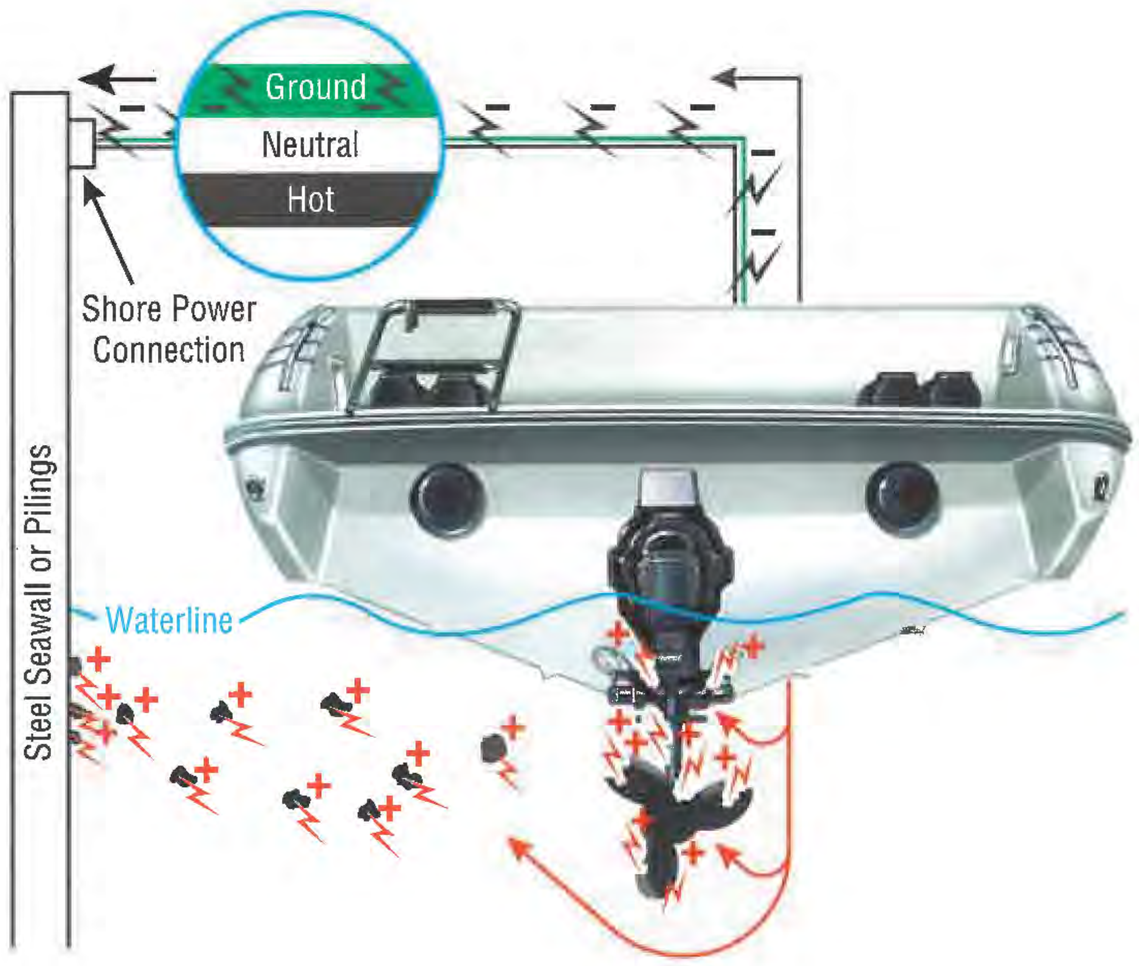



*Figure 1-2*
*Galvanic corrosion caused by nearby grounded steel structures*

## What to look for

The first sign of galvanic corrosion is paint blistering (starting on sharp edges) below the waterline, with a white powdery substance forming on the exposed metal areas. As the corrosion continues, the exposed metal areas will become deeply pitted, the metal actually being eaten away (Figure 1-3).

*Figure 1-3*
*Corrosion on aluminum lower unit and propeller*

Galvanic corrosion of aluminum drive units—or any underwater aluminum on your boat—is accelerated by attaching stainless steel components like propellers, trim planes (if connected to engine ground) and after-market steering aids. In doing this, you have introduced a dissimilar metal to which electrons from your drive unit will flow. Another condition that will increase the speed or intensity of galvanic corrosion is removal or reduction in surface area of sacrificial anodes. (Much more about sacrificial anodes later.) But you don't need stainless steel components for galvanic corrosion to take place. Galvanic corrosion continually affects all underwater aluminum, but at a reduced rate when no dissimilar metals are connected to your aluminum parts. When in contact with an electrolyte, most metals form small anodes and cathodes on their surfaces due to such things as alloy segregation, impurities, or cold working.

## What Is Corrosion?

We have used stainless steel (cathode) and aluminum (anode) in this discussion as an example; however, other metals coupled with aluminum also produce galvanic corrosion cells. For example, zinc connected to aluminum will form a corrosion cell, but in this case, the aluminum becomes the cathode and the zinc (anode) corrodes. One of the worst couples with an aluminum drive would be connecting it with copper or a copper alloy (bronze).

Another cause of galvanic corrosion is the shore power hookup. When you plug in, you tie your aluminum drive unit to other boats using shore power through the green grounding lead. Your aluminum drive unit is now part of a large galvanic cell (a battery) interconnected with onshore metal that is in the water—as well as other boats—and corrosion may be greatly accelerated.

## Stray Current Corrosion

We've discussed what galvanic corrosion can do, using just the electrical *potential* in metals. Imagine what happens if you add *more* electricity. That's exactly the basis for stray current corrosion.

Stray current corrosion occurs when metal with an electrical current flowing into it is immersed in water that is grounded (such as in any lake, river or ocean). The current can leave the metal and flow through the water to ground. This will cause rapid corrosion of the metal at the point where the current leaves. Stray direct current (or battery current) is particularly destructive. Stray current corrosion can cause *rapid* deterioration of the metal. If the metal in question happens to be an aluminum part like your drive unit, it can be destroyed in a matter of *days*.

Stray current corrosion is different from galvanic corrosion in that galvanic corrosion is caused by connections between dissimilar metals of your boat's drive components, and utilizes the electrical *potential* of those dissimilar metals. Electrons flow from one dissimilar metal (the anode) to another dissimilar metal (the cathode). In stray current corrosion, electricity *from an outside source* flows into your boat's metal components and out through the water for a ground.

For example, your boat may be sitting between a boat leaking DC current and the best ground for that current. Rather than the DC current moving exclusively through the water to ground, your boat could provide a path of lower resistance. The DC current could enter a thru-hull fitting, travel through the bonding system, and leave via your drive to ground. Remember that corrosion occurs at the location where DC current leaves metal and enters water.

Stray current can come from an outside source either internal or external to your boat. Internal sources involve a short in your boat's wiring system, such as a poorly insulated wire in the bilge, any electrical accessory that may be improperly wired, or a wire with weak or broken insulation that is intermittently wet.

External sources are almost always related to shore power connections. A boat with internal stray current problems can cause accelerated corrosion to other boats plugged into the same shore power line if they provide a better ground. The stray current would be transmitted to other boats through the common ground wire, but can (and *should*) be blocked by installing a galvanic "isolator" (discussed later).

A much more subtle—but potentially more damaging—cause of stray current corrosion can occur without any electrical problems. Suppose you cruise back to your marina after a weekend on the water, and plug in to shore power to recharge batteries using your automatic trickle charger. Then you go to work for the week. On Monday, a large steel-hulled boat (with scratched and scraped paint) ties up next to your boat. He also plugs into shore power and goes visiting onshore for a few days. A battery has just been formed—the large steel hull and your small aluminum drive connected by the shore power ground wire. Depending on the proximity, relative sizes and how long your neighbor is ashore, when you try to go out the next weekend you may find your drive highly deteriorated. This unfortunate scenario can also be prevented by the installation of a galvanic isolator.

## Crevice Corrosion

There is a form of corrosion that affects many metals, particularly stainless steel, called crevice corrosion. A crevice may be formed under a deposit (such as sand or silt), under a plastic washer, under a fibrous gasket, under tightly wrapped fishing line or anywhere moisture can get in and not get back out, and form a stagnant zone. Stainless steel is an iron-based alloy containing chrome and nickel. The quality that causes it to be stainless (non-rusting) is its formation of a thin, tightly adhering surface layer of chrome oxide. If this surface is deprived of oxygen, the oxide layer breaks down and the stainless steel will rust just like plain steel. In other words, stainless steel is only stainless when it has access to oxygen. In a crevice where there is moisture depleted of oxygen, stainless steel rusts. The simplest prevention for this condition is to seal out the moisture or clean off any deposits.

CHAPTER 2

# Corrosion Protection

## Mercury Marine Metals

Some metals are more resistant to corrosion than others. Gold is the most resistant of all, but solid gold isn't very appropriate for use in drive units due to its extreme softness and, of course, cost. The fact is, to build an outstanding drive unit with maximum performance and durability, a variety of metals and alloys must be used. Therefore, a variety of special measures must be taken to protect them against corrosion.

The most common metal used in Mercury Marine drive units is a strong, lightweight aluminum alloy. High-stress parts are made of hardened steel. The moving parts exposed to water—drive shaft, shift shaft, and prop shaft—are made from corrosion-resistant stainless steel.

XK-360 aluminum alloy is one of the most corrosion-resistant aluminum alloys on the market today, and it's a Mercury Marine exclusive. No other manufacturer offers this special corrosion-resistant alloy. Developed specifically for Mercury Marine products by Mercury Marine engineers, this unique, lightweight alloy is used to cast gearcases, drive shaft housings, outboard cylinder blocks, and other components exposed to corrosion.

## Mercury Marine Multi-Step Metal Finishing Process

How Mercury Marine finishes metal parts depends on what metal the part is made of, and where the finished part is going to be used. Aluminum alloys are the primary material of construction, but there are many steel parts. In the early steps of the finishing process, these parts are treated differently for enhanced protection.

All aluminum alloy parts are completely cleaned in a chemical bath (Figure 2-1). Then they are *chromate-converted*. This involves immersing them in a solution containing chromate ions. The chromate ions react with the aluminum alloy to form a surface layer of aluminum and chromate. This aluminum-chromate surface provides an excellent base for later coatings to adhere to, as well as a layer of corrosion protection. If the paint and primer are scratched completely through, the chromate will offer a last line of defense against corrosion.

Steel parts, including some stainless steel parts, are cleaned, then coated with electro-deposited paint (EDP). In this process, the object being painted receives an electrical charge, and the paint particles receive an opposing charge. The paint particles are electrostatically drawn to the object being painted, resulting in more complete coverage (Figure 2-2). The EDP serves as a primer, or base, for an acrylic finish coating.

*Figure 2-1*
*Aluminum alloy parts being chemically cleaned*

*Figure 2-2*
*Aluminum alloy parts receiving electro-deposited paint (EDP)*

*Figure 2-3*
*Epoxy primer being applied to aluminum alloy parts*

All parts, whether chromate-converted or coated with electro-deposited paint, are then painted with a chromate-enriched epoxy primer (Figure 2-3), followed by a high-solids acrylic enamel. Both the epoxy primer and acrylic enamel are thermally cured by baking at a high temperature. Through the entire process, the paint equipment is computer-controlled to provide uniform coverage. Also, all the parts for each individual motor are painted at the same time in order to ensure color matching.

All of the paints used are formulated to provide a hard, chip-resistant elastic finish.

One note: from the viewpoint of corrosion, all the stainless steel parts in the water connected to the drive should be painted, and the aluminum unpainted. This may sound like a crazy statement, but think back to the discussion of anodes and cathodes. With a very large anode (aluminum) and a very small cathode (stainless steel), corrosion is greatly reduced. If the aluminum is painted and the stainless unpainted, the aluminum is protected by the paint—as long as the paint surface is perfectly intact. In the real world of sandbars, rocks and logs, the paint will get scratched, and that scratched bare aluminum is now a very small anode. As in most cases, aesthetics wins over science, so the aluminum is painted and the stainless steel is polished.

## Sacrificial Anodes

For additional protection from galvanic corrosion, Mercury Marine drive units are equipped with inexpensive and easy-to-replace sacrificial anodes (Figure 2-4). These anodes are galvanically very active and, therefore, corrode first, protecting the other more expensive drive components. But because they are self-sacrificing, the anodes must be inspected often and, when 50% consumed, replaced.

In the past, a special zinc alloy was the only anode material in use (in fact, anodes are often referred to as "zincs"), but zinc must be processed in virtually sterile conditions to avoid contamination. Contamination will eliminate all of zinc's sacrificial properties.

Mercury Marine has developed a new aluminum alloy that provides better protection (a higher galvanic potential) and lasts longer than zinc. But, as in most changes, there is a compromise, and in the case of aluminum anodes, higher galvanic potential comes with lower mechanical strength. This means that for some designs where the anode bears a load or serves some structural purpose, zinc is still the preferable material.

*Figure 2-4*
*Sacrificial anodes*

The anodes that are included as standard equipment on a drive unit will provide adequate protection under light to moderate service conditions. For many moderate to heavy conditions, additional anodes can be used to achieve adequate protection. For severe conditions, such as when using underwater stainless steel components, Mercury Marine recommends that a Quicksilver MerCathode System or a Transom-Mounted Anode Kit be installed. If the boat is equipped with shore power, we strongly recommend that a Quicksilver Galvanic Isolator be installed.

Sacrificial trim tabs help compensate for propeller torque and also act as sacrificial anodes (Figure 2-5). Sacrificial trim cylinder anodes and sacrificial drive-mounted anodes provide protection when stainless steel components are installed (Figures 2-6 and 2-7).

To determine if your boat needs additional corrosion protection, a hull-potential test should be performed (refer to Corrosion Protection Testing, starting on page 16). On dual drive installations, or on boats with considerable amounts of metal immersed below the waterline, more than one MerCathode System or Anode Kit may be necessary.

*Figure 2-5*
*Sacrificial trim tab anode on lower unit*

*Figure 2-6*
*Sacrificial trim cylinder anode on trim cylinder*

## Transom-Mounted Anode Kit

The Transom-Mounted Anode Kit (Figure 2-8) is an inexpensive means of providing additional corrosion protection. A large anode is included in the kit, along with the necessary mounting hardware to attach it and ground it to the drive unit. *The anode must be grounded (making good electrical contact) to the drive unit* in order for the anode to provide corrosion protection. Because they are self-sacrificing, the anodes must be inspected periodically and replaced when 50% or less remains.

*Figure 2-7*
*Drive-mounted sacrificial anode (MerCruiser anodic block on drive)*

*Figure 2-8*
*Quicksilver Transom-Mounted Anode Kit*

### CAUTION!

- Due to the location of the sacrificial trim tab, the drive unit MUST BE kept in the "In" position when the boat is moored. If the drive unit is raised, the trim tab may be out of the water and, therefore, unable to act as a galvanic corrosion inhibitor.
- DO NOT paint anodes. Painting will render them inoperative.
- When replacing anodes, be sure to scrape the anode mounting surface down to bare metal and to tighten anodes securely. Anodes MUST make good electrical contact with the drive in order to provide protection.
- The anodes will not provide corrosion protection when the boat is removed from the water; therefore, the drive unit should be flushed with fresh water to remove salt water or pollutants prior to placing the boat in storage. For example, dried salt deposits can react with moisture in the air to create a cell, and corrode metal.

*Figure 2-9*
*New Quicksilver Magnesium Sacrificial Anodes*

*Figure 2-10*
*New Quicksilver Prop Nut Sacrificial Anode*

*Figure 2-11*
*New Quicksilver Quick'Defender Sacrificial Anode*

## The Newest in Corrosion Protection from the Folks Who Wrote the Book

New from Quicksilver is a magnesium sacrificial anode (Figure 2-9), developed specifically to provide more protection in fresh water than zinc or aluminum anodes. In fact, this new magnesium alloy is so effective it even offers protection in moving fresh water.

Also new is the Quicksilver Prop Nut Anode and the Quick'Defender Anode. The Prop Nut Anode (Figure 2-10) is offered in Quicksilver's exclusive lightweight aluminum. It attaches to the engine's propshaft and offers an added measure of protection.

The Quick'Defender Anode (Figure 2-11) is designed to attract galvanic corrosion away from your engine or drive *when your boat is moored*. The Quick'Defender is the only port or starboard hanging anode offered in lightweight aluminum.

**WARNING!**

DO NOT ATTEMPT TO USE MAGNESIUM ANODES IN SALT WATER. They will provide overprotection. Overprotection will result in a different electrochemical reaction that will create hydrogen on the metal surface of the drive, under the paint. The paint will blister and peel completely off the surfaces of the overprotected drive.

There is a common misconception that you can overprotect your drive by using too many zinc or sacrificial aluminum anodes. This is not true. The corrosion potential of any metal is a voltage that can be measured by a reference electrode. Such measurements in water commonly are made with a silver/silver chloride reference electrode. The corrosion potential of a sacrificial anode is a characteristic value for that metal, and it does not matter if you have one piece of the metal or 100 pieces. The corrosion potential stays the same. Of course, 100 anodes would be expensive, heavy and a considerable drag under water. Only by increasing the corrosion potential by using a different anode material (such as magnesium in seawater) can you overprotect your drive.

# Additional Corrosion Protection

**CAUTION!**

Mercury Marine recommends a MerCathode System or Anti-Corrosion Anode Kit be installed **whenever using a stainless steel propeller,** or if a boat is equipped with stainless steel components (immersed below the waterline) that are connected into the engine ground system. If a boat is equipped with stainless steel after-planes, a large anode should be installed on **each** to handle the increased galvanic corrosion potential.

## MerCathode System

The Quicksilver MerCathode System provides automatic, permanent protection against galvanic corrosion. A solid-state device that operates off a boat's 12-volt battery, the MerCathode System provides protection by impressing a reverse blocking current that stops the destructive flow of galvanic currents.

Once again, this mouthful has a simple translation. In the first chapter we learned that the process of galvanic corrosion occurs when two dissimilar metals are grounded (connected) and immersed in a conductive liquid. Electrons flow from the more chemically active metal directly to the less chemically active metal through the external connection. Positively charged ions (as $Al^{+++}$) move from the anode and negatively charged ions (as $OH^{-}$) move from the cathode through the electrolyte. The result of this process is the dissolving of the anode. But by sending an opposing current through the conductive liquid, the MerCathode System basically blocks the ions from leaving the more chemically active metal.

The MerCathode System consists of a controller, reference electrode and anode. The reference electrode senses the corrosion potential of the drive in the water, and regulates the controller to keep the protective current within a prescribed range for optimum blocking and, hence, optimum corrosion protection. The protective current (from the battery) is emitted into the water via the controller and anode. The surface of the anode is platinum-coated so that it will not corrode due to the current flow, like sacrificial anodes. The MerCathode System automatically adjusts itself to compensate for changes in corrosion potential caused by variations in water temperature, velocity and conductivity (such as salt content). It even compensates for changes in the condition of the paint on the drive unit.

The MerCathode System is extremely economical to operate. Even under the most severe corrosion conditions and in continuous use, an average battery will last three weeks or more before recharging is necessary. The system automatically shuts off when the boat is removed from the water.

There are two types of MerCathode Systems available. Figure 2-12 shows a transom-mounted two "button" system. This system is mounted with the anode and reference electrode on (and through) the transom of the boat on opposite sides of the drive. The *black* controller is mounted inside the boat as high as possible (Figure 2-13). *Do not* mount the controller so that the terminals can be exposed to water.


*Figure 2-12*
*Quicksilver MerCathode System for all inboards and outboards*


*Figure 2-13*
*Quicksilver MerCathode System installation*


*Figure 2-14*
*Quicksilver MerCruiser MerCathode System designed specifically for MerCruiser Stern Drives*


*Figure 2-15*
*Quicksilver MerCathode System installation*

When using a MerCathode, all underwater metal parts to be protected *must be* connected to the negative (–) battery terminal (ground). Although the MerCathode System provides protection to all the exposed metal surfaces that are grounded (electrically connected) to the drive, it does not protect internal surfaces which pocket moisture and dirt. We recommend that the drive unit be flushed with fresh water before storage to remove salt water or other pollutants. (Dried salt can absorb moisture from the air and create an active cell.)

We also strongly recommend that the MerCathode System be tested at least once a year to ensure that it is providing adequate corrosion protection. (Refer to Corrosion Protection Testing, following.) *The test should be conducted in the water where the boat is moored.*

## MerCruiser MerCathode System

Quicksilver has developed a second type of MerCathode System specifically for MerCruiser stern drives. It features an integrated one-piece anode and reference electrode as shown in Figure 2-14. This anode/reference electrode is mounted directly on the drive unit (gimbal housing) of a MerCruiser stern drive, eliminating the need to drill holes through the transom as with the old system. The *blue* controller is mounted in the engine compartment, usually on top of the engine (Figure 2-15). Installation is very quick and easy. Again, *do not* mount the controller so that the terminals can be exposed to water.

For proper operation of the Quicksilver MerCruiser MerCathode System, the following information *must be* observed.

- *Do not* paint the electrode assembly. This will render the system inoperative.
- *Do not* replace plastic caps (Figure 2-16) with zinc anode heads. (Newer models do not have external gimbal housing caps. See Figure 2-17.) If you do, the anode caps will be too close to the MerCathode reference electrode and will cause it to incorrectly gauge the corrosion potential of the drive in water and, therefore, cause the controller to think that the drive is protected, and shut off. Sacrificial anodes should not be installed within ten inches of the reference electrode. (Sacrificial anodes may be installed as long as they are further away from the reference electrode than the gimbal housing caps.)
- The power supply for the MerCathode System is provided by the engine wiring harness. If your boat is equipped with a battery switch, the switch *must be* left in the "On" position when the boat is moored in order for the system to provide protection.

  *Note*: To allow the battery switch to be placed in the "Off" position while boat is moored, remove and discard the red-purple power supply lead from the "+" terminal of controller

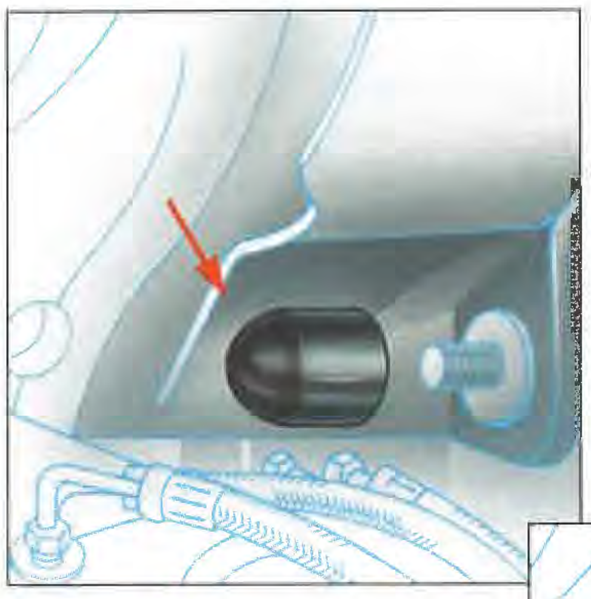


Figure 2-16
Gimbal housing plastic caps (on older MerCruiser models)

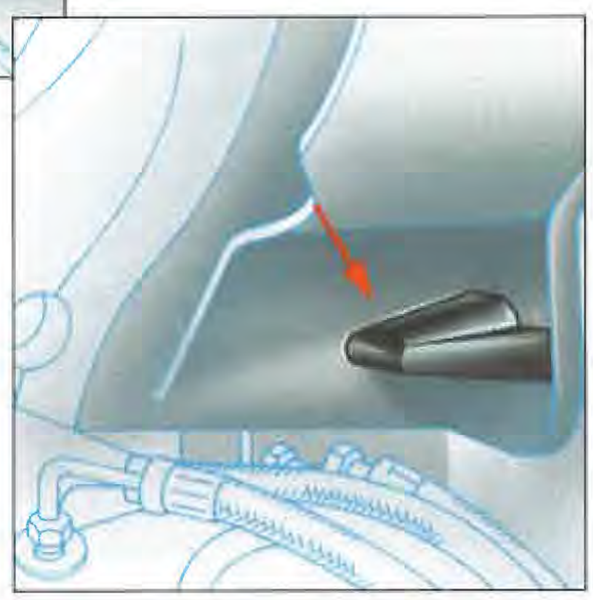


Figure 2-17
Newer MerCruiser models do not have external gimbal housing caps

and connect a separate wire between the "+" terminal on the controller and the positive (+) battery terminal. This lead must be fitted with a three-amp fuse, placed within six inches (15 cm) of the positive battery terminal.

- *Do not* substitute a black controller for a blue controller or vice-versa. They are *not* interchangeable.
- We recommend testing your MerCathode System at least once each year to ensure it is providing the proper corrosion protection. Refer to Corrosion Protection Testing on the following pages.

**CAUTION!**

- Never exchange the blue and the black controllers.
- Never paint the MerCathode System reference electrode or anode. This will prevent the system from functioning properly.
- Never use abrasives or sharp tools to clean the anode. This could break through the platinum plating and corrosion of the anode will result.
- MerCathode System should be attached directly to boat battery with no switches that could possibly deactivate the system.
- Protect the reference electrode if a power washer is used to clean the boat and/or drive.


Figure 2-18
MerCathode Monitor

## MerCathode Monitor

The optional MerCathode Monitor (Figure 2-18) allows you to check the operation of the MerCathode System with the push of a button.

## MerCathode Monitor Operation and Testing

When a MerCathode System and a MerCathode Monitor are both installed on a boat equipped with a *new* stern drive, the Monitor may *initially* indicate the protective current is not being supplied through the MerCathode anode. This condition is normal and, in such a case, the green light will not illuminate when the red button is depressed. This is only a temporary situation caused by the sacrificial anodes and/or new paint on the drive unit providing complete protection.

After the boat has been in the water for a while, scratches and abrasions expose aluminum surfaces to the water. Water can also work its way into direct contact with the aluminum in seams and joints.

This is when the MerCathode System begins protecting the drive. The green light on the Monitor will begin to glow when the red button is pushed, but during this transition period the green light may only flicker. The green light will become steady as soon as the MerCathode is called upon to provide continuous automatic protection. If the stern drive is equipped with a stainless steel propeller, the MerCathode System will usually be activated immediately and there won't be a "waiting period" before the Monitor shows a steady green light.

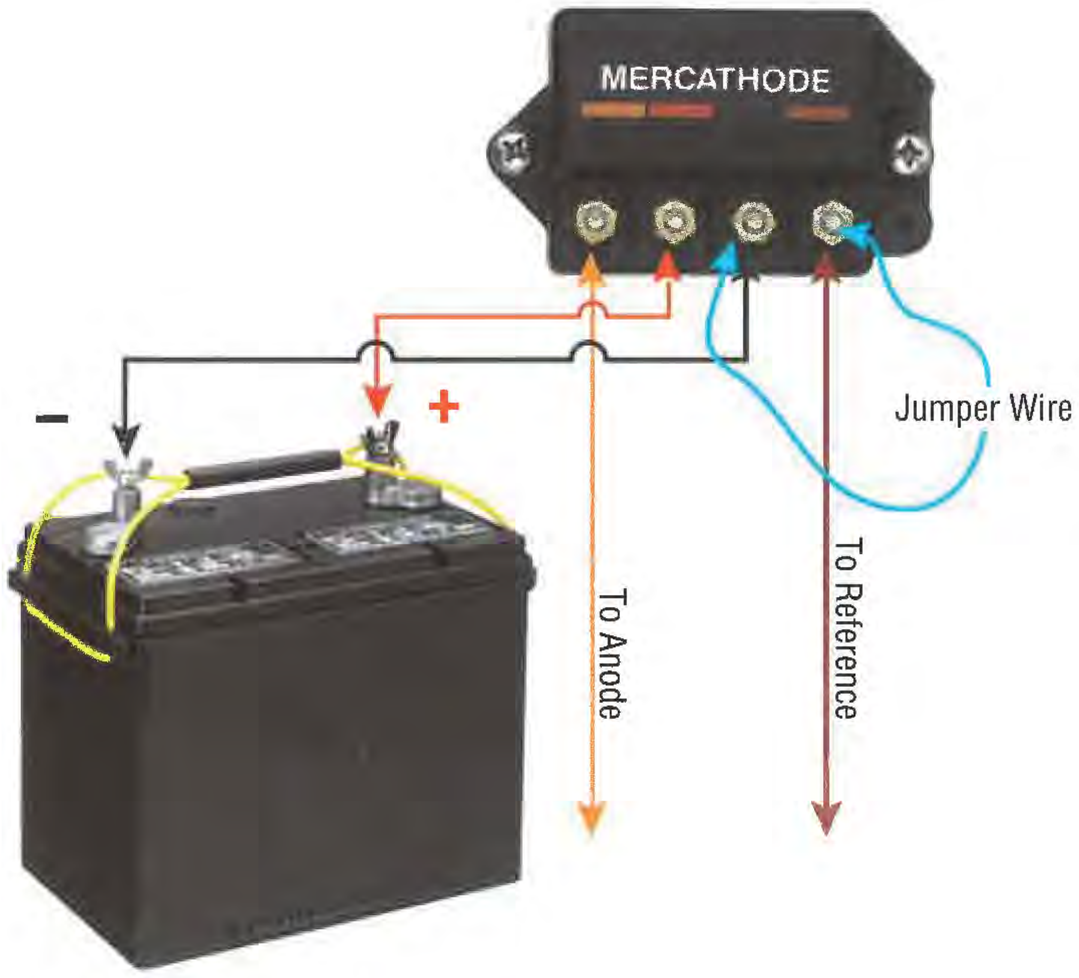



*Figure 2-19*
*MerCathode controller check test #1*

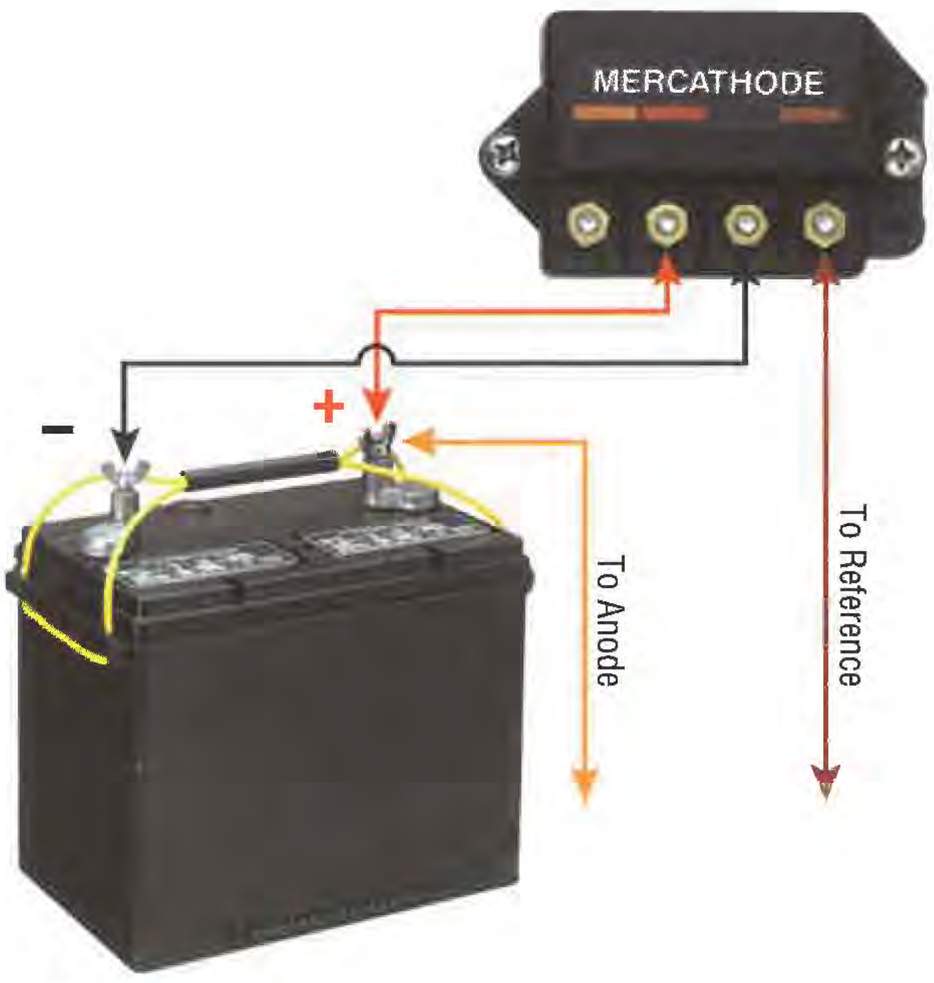



*Figure 2-20*
*MerCathode controller check test #2*

The following test can be used to check the MerCathode Monitor for proper operation.

1. Connect a jumper wire between the "R" and "–" terminals on the MerCathode controller (Figure 2-19).
2. If the Monitor light illuminates, the Monitor is in good condition, but the MerCathode System may or may not be providing protective current. Perform the MerCathode test procedure, on pages 18-19, to determine if the MerCathode is operational.
3. If the light does not come on, disconnect the Monitor lead from the "A" terminal on the MerCathode controller and connect the lead to a 12-volt source (Figure 2-20).

   *If the light now illuminates*, the Monitor is operating properly, but the MerCathode System may or may not be providing protection current. Again, perform the MerCathode test procedure, on pages 18-19, to determine if the MerCathode is operational.

   *If the light does not illuminate*, check the Monitor wiring for damage or loose connections. If the wiring is good, the Monitor is faulty and must be replaced.
4. Disconnect the Monitor lead from the 12-volt source immediately after performing the test and reattach to the "A" terminal to prevent corrosion damage.
5. Remove the jumper wire from the MerCathode controller.

## The Effect of Water Velocity on Corrosion Rates

In general, an increase in water velocity through currents or tides increases the corrosion rate of metals. This is because the flowing water puts more water in contact with the metal and, therefore, more oxygen in contact with the metal. For example, the corrosion rate of zinc in still salt water is less than one mil (0.001 in.) per year. In the same salt water with a velocity of six ft. per second (just four miles per hour), the same zinc has a corrosion rate of over eight mils per year.

It is also more difficult to provide corrosion protection in flowing water. If sacrificial anodes are used, adding more anodes and distributing them on the drive is necessary. If an impressed current system (MerCathode) is used, increased output is necessary. In the case of a MerCathode System, the output is limited by the controller to prevent draining the battery; in some cases (depending on both water velocity and conductivity), the output may not be enough to provide protection. For example, if it takes 45 milliamps per square inch to provide protection in still water, it can take 370 milliamps per square inch in water moving at ten ft. per sec (approx. seven mph).

## Methods of Increasing the Protection Provided by a MerCathode System

*Background:*

1. The MerCathode controller output is limited, by design, to approximately 200 mA to avoid a rapid drain of the boat's battery.
2. The MerCathode can put out the full 200 mA in salt water.
3. In fresh water, the output is limited by the area of the anode and the conductivity of the water, usually to less than 25 mA.
4. If the boat is equipped with a gimbal ring MerCathode (blue controller), adding a transom mount MerCathode (black controller) will not add much to the protection level. When the blue controller turns on, it will shut off the black controller.

*Solutions:*

**In Fresh Water:** Two or more additional MerCathode anodes can be installed and connected to the anode terminal of the controller (Figure 2-21).

Put the anode lead (orange wire) on the anode terminal of the blue controller. Attach the second anode lead wire (orange) to the anode terminal on the blue controller. Attach additional anodes. This results in extra anodes operating off the terminal. If the boat happens into salt water there will not be a problem, as the controller is limited to 200 mA.

The black controller and transom reference can also be used.

**CAUTION!**

Do not place the anodes near the reference.

**In Salt Water:** Add another MerCathode System controller, wired in parallel (Figure 2-22). (The additional MerCathode controller must be of the same type as the original one; i.e., black plus black or blue plus blue.) This will double your protection to 400 mA. (Keep in mind that this will also increase the drain on your battery.) If you take your boat into fresh water, the conductivity of the water will limit the output of your MerCathode Systems.

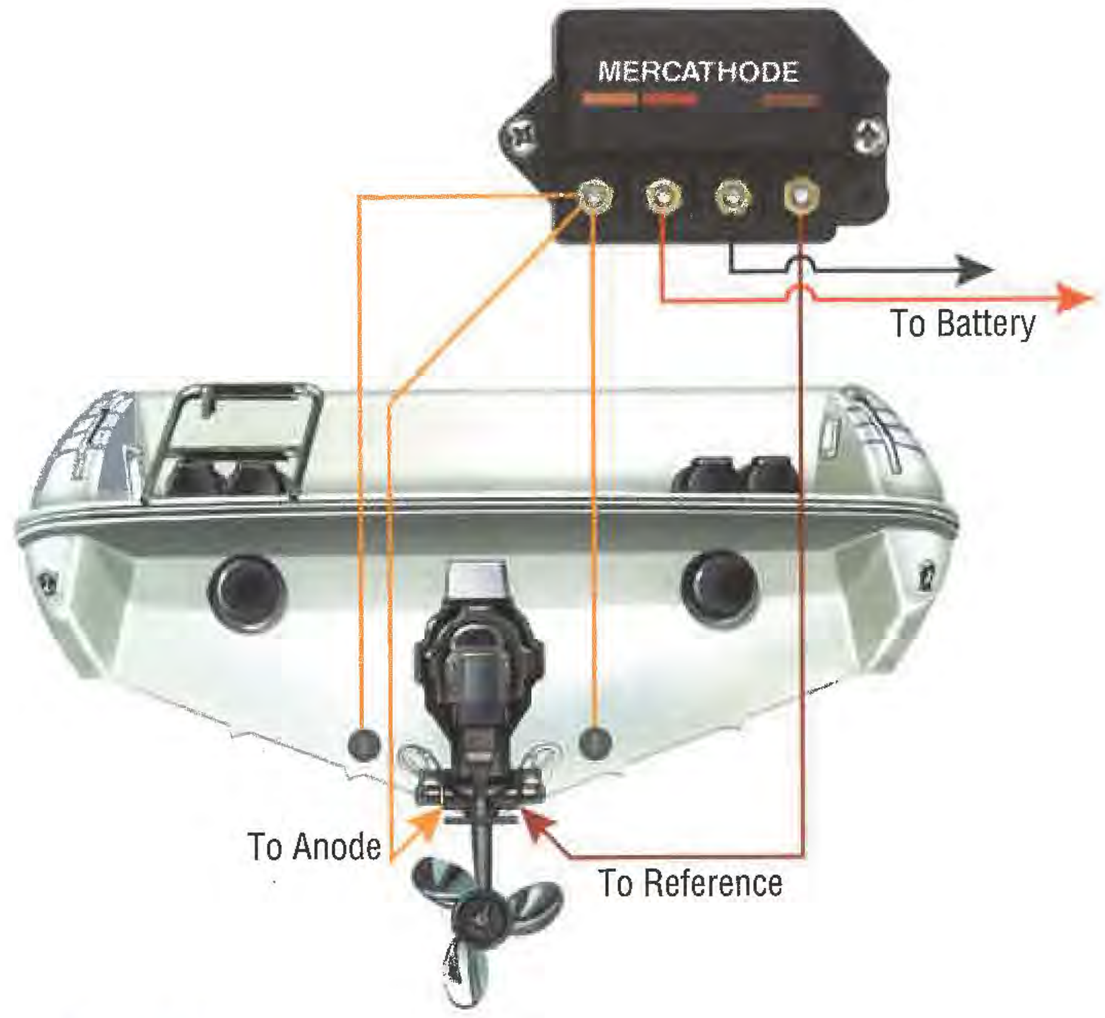



*Figure 2-21*
*Increasing MerCathode protection in fresh water*

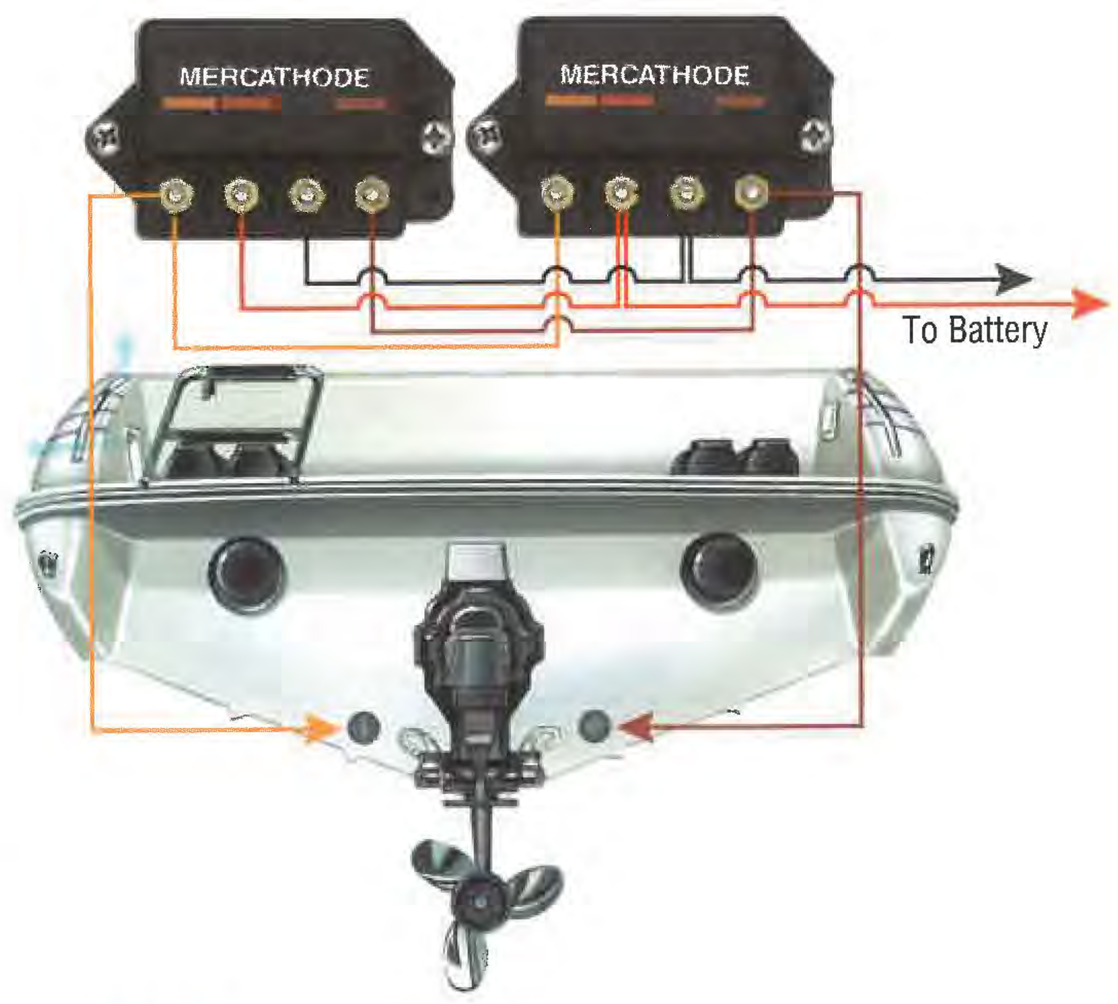



*Figure 2-22*
*Increasing MerCathode protection in salt water*

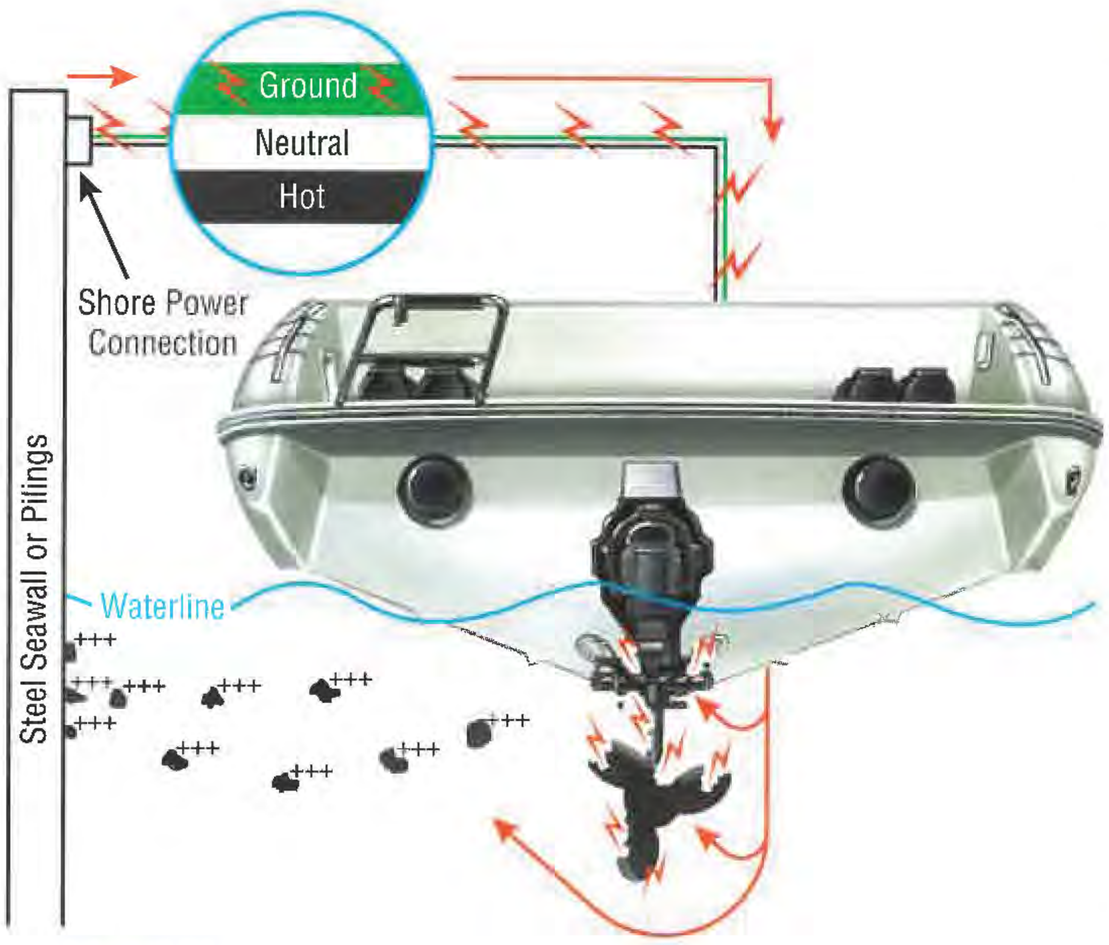



*Figure 2-23*
*Galvanic current flow without isolator*


*Figure 2-24*
*Quicksilver Galvanic Isolator*


*Figure 2-25*
*Isolator installation*

## Stray Current Corrosion

There is a greater danger for boats that connect to AC shore power: destructive, low-voltage galvanic currents (DC) passing through the shore power ground wire (Figure 2-23). Normally, AC is not a corrosion problem, but because the boat, pier and wire are all connected, or due to a leakage, there can be a direct current (DC) also present. This is potentially very damaging and requires additional protection.

**WARNING!**

Never disconnect or place a switch in the shore power green safety grounding lead, as this could create an electrical shock hazard.

Safety regulations require a three-wire cable for carrying shore power aboard any boat, and that one of these leads (the green lead) grounds all electrical and propulsion equipment to shore. This safety procedure reduces the danger of shock, but also connects the underwater metal components on your boat with metal parts on neighboring boats using shore power, steel piers and metal objects on shore that are grounded and extend into the water. This interconnecting of dissimilar metals allows destructive galvanic currents to flow between them. If these currents are allowed to continue, your drive unit will experience severe corrosion damage in a very short time (as little as days).

In most cases, sacrificial anodes and even the MerCathode System (if equipped) *will not* be able to control or counteract the increased corrosion potential.

The Quicksilver Galvanic Isolator (Figure 2-24) or an isolation transformer can be used to galvanically isolate the AC shore power ground from the boat.

## Quicksilver Galvanic Isolator

The Quicksilver Galvanic Isolator is a solid-state device that is *series connected* in line into the boat's green safety grounding lead *ahead of all grounding connections on the boat* (Figure 2-25). This device functions as a filter, blocking the flow of destructive low voltage galvanic (DC) currents, but still maintaining the integrity of the safety grounding circuit (Figure 2-26).

The Quicksilver Galvanic Isolator provides inexpensive protection when compared to a similarly rated 120-volt AC, 50-amp isolation transformer. The Quicksilver Galvanic Isolator measures just 8" x 4" x 3" and weighs less than 10 lbs. It's much smaller and lighter than a transformer, which is about four times the size and six-to-eight-times the weight. (A 220-volt AC, 50-amp transformer is 18- to 24-times the size, weight and cost.)

Isolator installation is easy, requiring only four mounting screws. The isolator is designed for use in 120- and 240-volt AC, 60-Hertz circuits with up to a 60-amp rating and is *ABYC-certified and UL-approved. The Quicksilver Galvanic Isolator is the only product of this type approved by Underwriters Laboratories at the time of this publication.*

***An important performance note**: The Quicksilver Galvanic Isolator contains both diodes and a large capacitor, whereas most competitive products contain only diodes. If there is even the smallest AC current leakage through the ground circuit, diodes can be "biased," becoming conductive and allowing the destructive galvanic current (DC) to pass along with the AC. Any AC current leakage renders useless any isolators with only diodes. An isolator with a capacitor, like the Quicksilver Galvanic Isolator, solves this problem.*


*Figure 2-26*
*Galvanic current flow with isolator*

## Anti-Fouling Paint on Drives

Fouling is a major concern in many situations. Marine animals (barnacles, mussels, etc.) and vegetation can make life miserable for boaters. There are anti-fouling paints available, but some can affect corrosion protection or even accelerate corrosion.

In the past, tributyltin- (sometimes referred to as "TBT" or "organotin") based anti-fouling paints controlled fouling and did not cause corrosion problems for aluminum drives (Figure 2-27). Recently, environmental concerns and legislation have restricted or prohibited the use of tributyltin paints. Presently, tributyltin-based paints must be applied by a state-licensed repair shop. In the U.S. and Canada, tributyltin is prohibited for vessels less than 25 meters with an exemption for aluminum hulls, fittings and drives. If TBT paint can be obtained, it is still recommended for drives.

Other anti-fouling formulations (tin-free) are being tested. Copper and copper oxide formulations that are electrically non-conducting have had minimal effect on drive corrosion. If this type of paint is used on the hull, an unpainted gap of at least 1.5 in. should be left around the drive. We will continue to test further developments of tin-free anti-fouling paints and we will announce successful formulations in service bulletins.

*Figure 2-27*
*Marine fouling on boat hull and drive units*

CHAPTER 3

# Corrosion Protection Testing & Troubleshooting


*Figure 3-1*
*Reference electrode tester positioned properly*

## Testing

For diagnostic tests, a simple digital volt/ohm meter (multimeter) is necessary. An analog version may be used, but it must be a high-impedance model. (Even the most inexpensive digital volt/ohm meter has high impedance.)

One of the most useful methods for determining if corrosion below the waterline is occurring is through the measurement of the "hull potential" (Figure 3-1). This is done by immersing a reference electrode, usually silver/silver chloride (a silver wire with a coating of silver chloride), into the water about six inches behind the drive. This electrode is connected to the positive (red) terminal of a digital volt/ohm meter. The negative (black) lead from the meter is attached to the battery (or system) ground. With the meter set on a two-volt DC scale (if using a silver/silver chloride reference), the "hull potential" is displayed.

The values displayed will be discussed in the charts later in this chapter. However, please note that the values given do not indicate a line, one side of which is "protected" and another side of which is "corroding." From an "ideal" potential to "active" corrosion is a graduated scale. Local water conditions may also cause a lower or higher potential to be "ideal."

### IMPORTANT!

Be sure to observe the following when performing tests:

- If the unit is equipped with a MerCathode System, make sure that the battery is fully charged (12.6 volts or above).
- New boats will usually produce higher readings than normal. This is because the drive unit is being protected by a new finish and new sacrificial anodes. To obtain an accurate diagnosis, the test should be performed after the boat has been used at least one or two weeks. This will give the paint a chance to "soak" and acquire minor abrasions and scratches, which will result in a more accurate reading.
- Boats should be moored (without being operated) for at least eight hours before performing the test. This is necessary to allow the MerCathode System and/or sacrificial anodes to polarize the water molecules in direct contact with the drive. Be careful not to rock the boat excessively while boarding to perform the test, as this will alter the test reading.

## Troubleshooting Corrosion

The first signs of corrosion below the waterline are paint blistering, usually on sharp edges, and the formation of powdery white corrosion material on exposed aluminum surfaces. If the corrosion is allowed to continue, pitting of the aluminum will occur. The charts included later in this chapter may help you determine the cause of the corrosion and the corrective action needed to prevent its continuance.

First, some basic observations on corrosion and corrosion prevention must be considered.

- Loosely adhering, powdery white material that forms on sharp edges or near fasteners should not be confused with hard, tough, white or off-white calcareous (calcium carbonate) deposits, which form uniformly on well-protected surfaces (painted or unpainted). These deposits are primarily a result of the calcium and magnesium in the water, and heat in the area of the deposit.
- There must be electrical continuity from the battery (or system) ground through all parts of the outboard or drive.

## Inactive Sacrificial Anodes

If the underwater portion of the drive unit shows signs of corrosion but the sacrificial anodes are not being consumed, the problem may be due to the following:

- The sacrificial anodes may not be making good electrical contact with the drive unit. Remove the anode, scrape the mounting surfaces on the part to be protected down to bare metal, and reinstall anodes.
- Zinc sacrificial anodes may have a protective coating of a very dense oxide film on their surface (which usually has a charcoal-gray appearance). This condition usually occurs in fresh water, but it can also happen in saltwater areas.

To confirm this condition, test for continuity between the anode and the drive using a multi-meter set to "ohms" on the R x 1 scale. If the anode must be scraped with a knife in order to get a conductive reading, the anode is oxidized and should be replaced. Sanding the surface with coarse sandpaper provides a temporary solution, but the oxide will form again.

## Corrosion on Underwater Parts (without MerCathode or impressed current protection)

| Cause or Observed Condition | Corrective Action |
|---|---|
| Sacrificial anode(s) consumed | Replace anode(s) when 50% consumed |
| Stainless steel prop installed | Add MerCathode (impressed current protection) or additional sacrificial anodes |
| Sacrificial anode(s) not grounded to drive | Remove anode(s), clean *contact* surface, reinstall, check continuity |
| Loss of continuity between underwater parts & ground | Provide good ground connections |
| Shore power causing overload of anode(s) and/or MerCathode | Disconnect shore power or install Quicksilver Galvanic Isolator |
| Paint on drive heavily worn (exposing more metal) | Prime and repaint, and/or install additional anode(s) |
| Sacrificial anode(s) painted | Remove paint or replace anode(s) |
| Drive tilted so far that anode(s) are out of water | Leave drive down, install additional anode (below waterline), or transom mount a MerCathode System |
| Power trim cylinders *only* corroded | Provide good ground to drive. All parts *must* be grounded. |
| Corrosion in area of exhaust outlets<br>Exhaust deposits can cause corrosion | Remove deposits with marine or auto wax |
| Corrosion occurring after unit is removed from salt water | Wash exterior and flush interior with fresh water |
| Corrosion and/or salt buildup between mating parts | Exclude moisture from between mating parts with Quicksilver 2-4-C with Teflon® |
| Stainless steel parts corroding:<br>1. Tightly wrapped fishline or foreign material excludes oxygen, causing corrosion<br>2. Iron particles, such as from a wire brush, cause rusting<br>3. Propeller pitting can occur if electrical continuity is lost | Clean parts, remove foreign material, insure continuity |

# Corrosion on Underwater Parts (with MerCathode or impressed current protection)

Unplug shore power

Check fuse in hot lead

Check battery

Check for loose connections at controller and battery

Check ground between drive and controller

Measure hull potential with silver/silver chloride reference electrode and digital volt/ohm meter

**Potential below**
850 millivolts for salt water
750 millivolts for fresh water

Drive is corroding

Too much cathode (such as stainless steel)

Even a MerCathode can be overpowered by a large quantity of stainless below the waterline. Add additional sacrificial anodes or more MerCathodes (for fresh water, MerCathode anodes).

Loss of continuity between drive components & ground

Insure continuity

Sacrificial anodes consumed, or painted or inactive

Replace anodes

MerCathode reference or anode painted

Remove paint or replace

No power to MerCathode controller

Connect positive (+) lead of volt meter (set on 0–20 volt scale) to "+" terminal on controller and negative (–) volt meter lead to "–" terminal. Meter should indicate battery voltage. Check for blown fuse (if so equipped) on Standard MerCathode System. Clean connection or repair wiring as required.

Poor connection between reference electrode (brown) lead or anode (orange) lead and MerCathode controller

Clean and/or tighten connection. Repair wiring. Clean off salt deposits.

Faulty MerCathode reference electrode

Disconnect reference electrode (brown) lead from "R" terminal on controller. Connect lead to positive (+) terminal of digital multimeter (set on 0–2000 millivolt scale). Connect negative (–) meter lead to negative (–) battery terminal. Note meter reading, then repeat test with a test silver/silver chloride reference electrode held behind drive. The same reading should be obtained in both cases. If not, replace reference electrode.

Faulty MerCathode controller

With anode and reference electrode leads connected to controller, connect a jumper wire between "R" and "–" terminals on controller. Connect positive (+) lead of volt meter (set on 0–20V scale) to "A" terminal on controller. Connect negative (–) meter lead to negative "–" controller terminal. Reading should be as follows:
- Fresh water areas = 11.5 volts minimum
- Salt water areas = 3.55 volts minimum

If reading is low, replace controller.

**Potential between**
850 to 1100 millivolts for salt water or
750 to 1050 millivolts for fresh water

Drive is protected

**Potential above**
1100 millivolts for salt water
1050 millivolts for fresh water

Drive is overprotected

Symptoms: Paint blistering and falling off, pitting of the aluminum drive

Reason: Excessive voltage causes hydrogen to be formed at surface of metal, literally "blowing" the paint off. This also creates an alkaline condition at the surface which dissolves aluminum.

Stray current corrosion. If an electrical current flowing along a metal conductor leaves the metal for a water path, it will cause ionization of the metal, and an area of rapid corrosion.

If the source is internal, observe reading while disconnecting electrical components (one at a time) until high reading is eliminated. That is the immediate source of stray current. If external, install a galvanic isolator.

Poor connection between MerCathode reference electrode (brown) lead and "R" terminal on controller

Clean and/or tighten connection. Repair wiring as required. Clean off salt deposits.

Faulty MerCathode reference electrode

Disconnect reference electrode (brown) lead from "R" terminal on controller. Connect lead to positive (+) terminal of digital multimeter (set on 0–2000 millivolt scale). Connect negative (–) meter lead to negative (–) battery terminal. Note meter reading, then repeat test with a test silver/silver chloride reference electrode held behind drive. The same reading should be obtained in both cases. If not, replace reference electrode.

Faulty MerCathode controller

Replace controller. (see corrosion column)

A second check is the output of the controller. If the hull potential indicates overprotection, remove the reference electrode lead from the controller. If the controller is "off" (no impressed current called for) the voltage between the negative (black) and the anode should be less than one volt. If your digital volt meter can measure amperage, with the reference electrode disconnected, the amperage between the negative on the controller and the anode terminal should be less than one milliamp.

If your multimeter can measure amperage, you can measure the output of the MerCathode. Disconnect the anode lead from the controller, set your multimeter to a 2000 milliamp scale and connect between the anode lead and the anode terminal. If the MerCathode is fully on, the output should be about 200 milliamps in seawater or 20-25 milliamps in fresh water. If you now disconnect the reference electrode lead the output should drop to zero. If there is any anode current output with the reference disconnected, the controller is faulty and should be replaced.





Corrosion Protection Testing & Troubleshooting

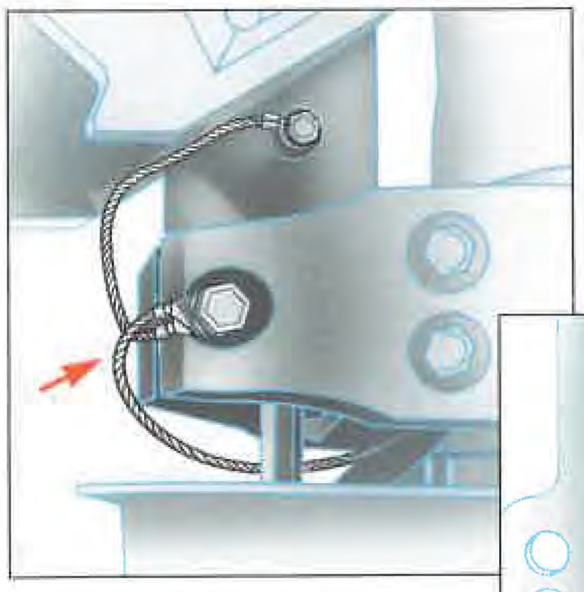


*Figure 3-2*
*Continuity ground strap between drive shaft housing and swivel bracket*

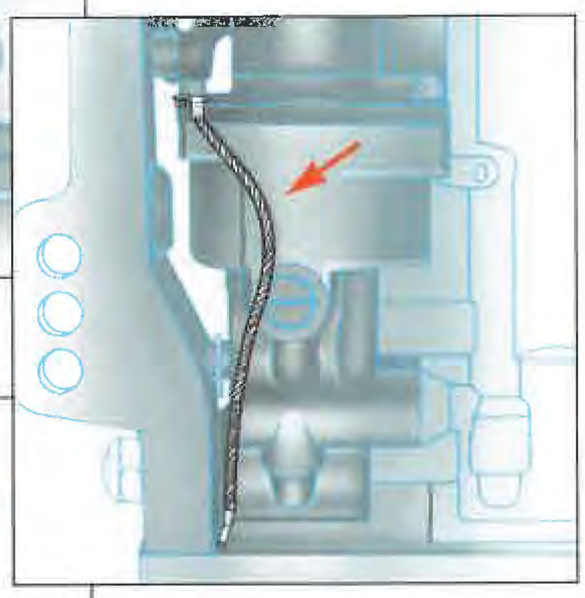


*Figure 3-3*
*Continuity ground strap between hydraulic system and mid-section of outboards*

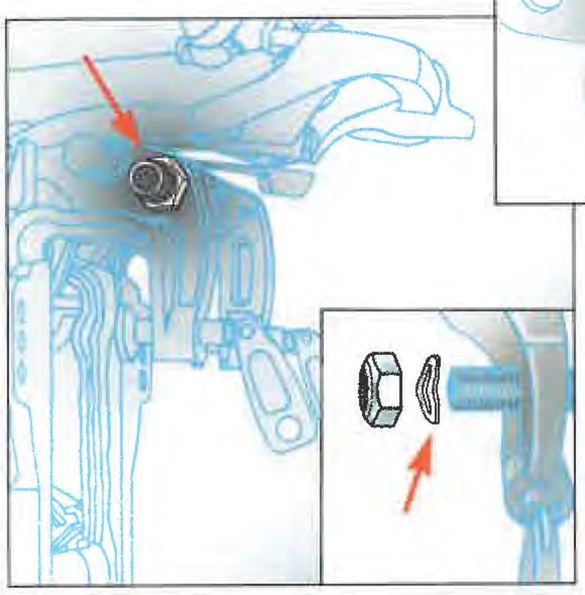


*Figure 3-4*
*Wave washers*

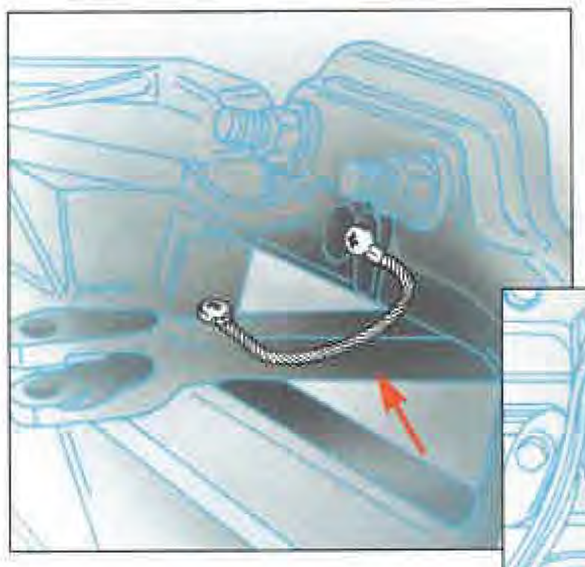
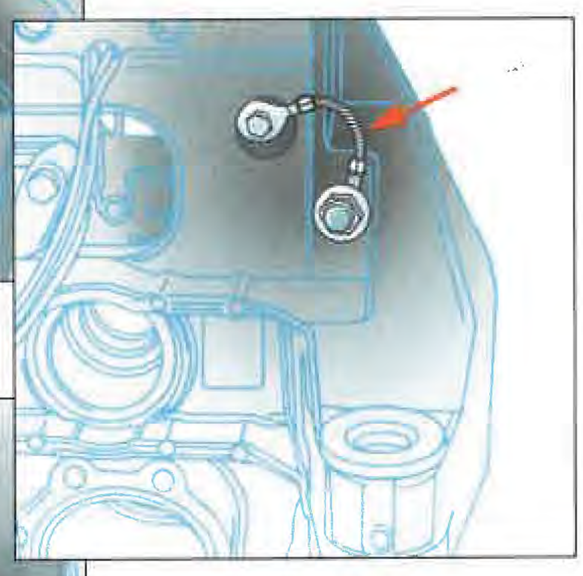


*Figure 3-6*
*Steering lever ground wire*



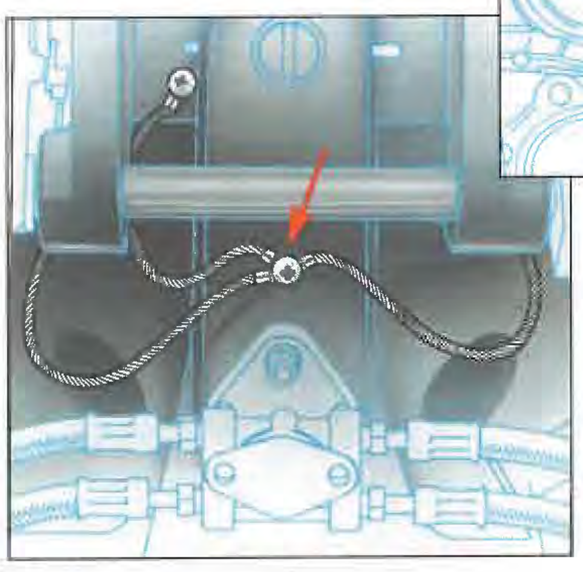


*Figure 3-7*
*Ground wire between inner transom plate and gimbal housing*

*Figure 3-8*
*Ground wire between gimbal housing and gimbal ring*

## Continuity Devices

Galvanic corrosion, as we've discussed, is an *electro*chemical reaction. Being such, all underwater metal components on the drive unit can *only* be protected if they maintain electrical continuity. Several different methods are used on outboards and stern drives.

### Outboard Continuity Devices

Outboards 35-horsepower and above use braided stainless steel continuity straps between drive shaft housing and swivel bracket (Figure 3-2).

It was found that a ground strap was required between the hydraulic system and the mid-section of the outboard (Figure 3-3).

Outboards 75-horsepower and above also use wave washers between clamp brackets and swivel bracket (Figure 3-4) and another wave washer between swivel bracket and bottom yoke to ensure electrical continuity.

### MerCruiser Stern Drive Continuity Devices

Stainless steel trim hoses (Figure 3-5) help ensure continuity to trim cylinders. (Hoses on older MerCruiser models were also equipped with star-washers under hydraulic connector attaching nuts. Trim cylinders on older MerCruiser models were also equipped with spiral springs.)

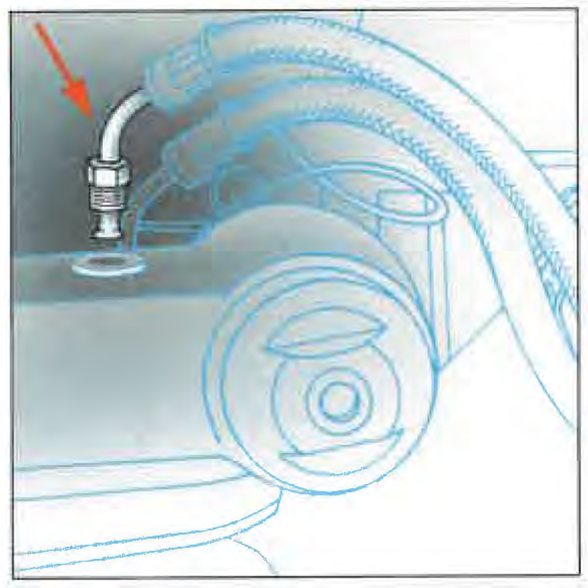


*Figure 3-5*
*Stainless steel trim hoses*

The transom assembly and stern drive unit are equipped with a continuity circuit to ensure good electrical continuity between engine, transom assembly and stern drive components. Good electrical continuity is essential for the anodic trim tab and MerCathode System to function effectively.

A Continuity Circuit Kit is also available to retrofit older MerCruiser I, TR and TRS models with this system. The continuity circuit should be periodically inspected to ensure that there are no loose connections or damaged wires. Isolated corrosion on only one or two components on the drive unit could indicate improper grounding of those components (see Figures 3-6 through 3-14).

## Drive Unit Continuity Test

For all underwater components on the drive unit to be effectively protected by the MerCathode System and/or sacrificial anodes, electrical continuity must be maintained. If the unit is equipped with a MerCathode System, all underwater components *must* be electrically grounded to the negative (–) battery terminal to be protected.

To help ensure proper grounding of underwater components, current MerCruiser models are equipped with a continuity circuit.

The following test can be used to check if the drive unit is properly grounded (see Figure 3-15).

1. Boat must be in the water when performing this test.
2. Set DC volt meter on 0–2 volt (0–2000 millivolt) scale.
3. Connect negative (black) meter lead to negative (–) battery terminal.
4. Suspend end of positive (red) meter lead in the water within 6" (15 cm) of drive unit. Do not allow it to contact drive unit. Reading should be above 3 millivolts.
5. Connect end of positive meter lead to each metallic component on stern drive. Be sure there is good electrical contact to each metal surface. Reading should drop below 2 millivolts.
6. A reading higher than 2 millivolts indicates improper grounding.

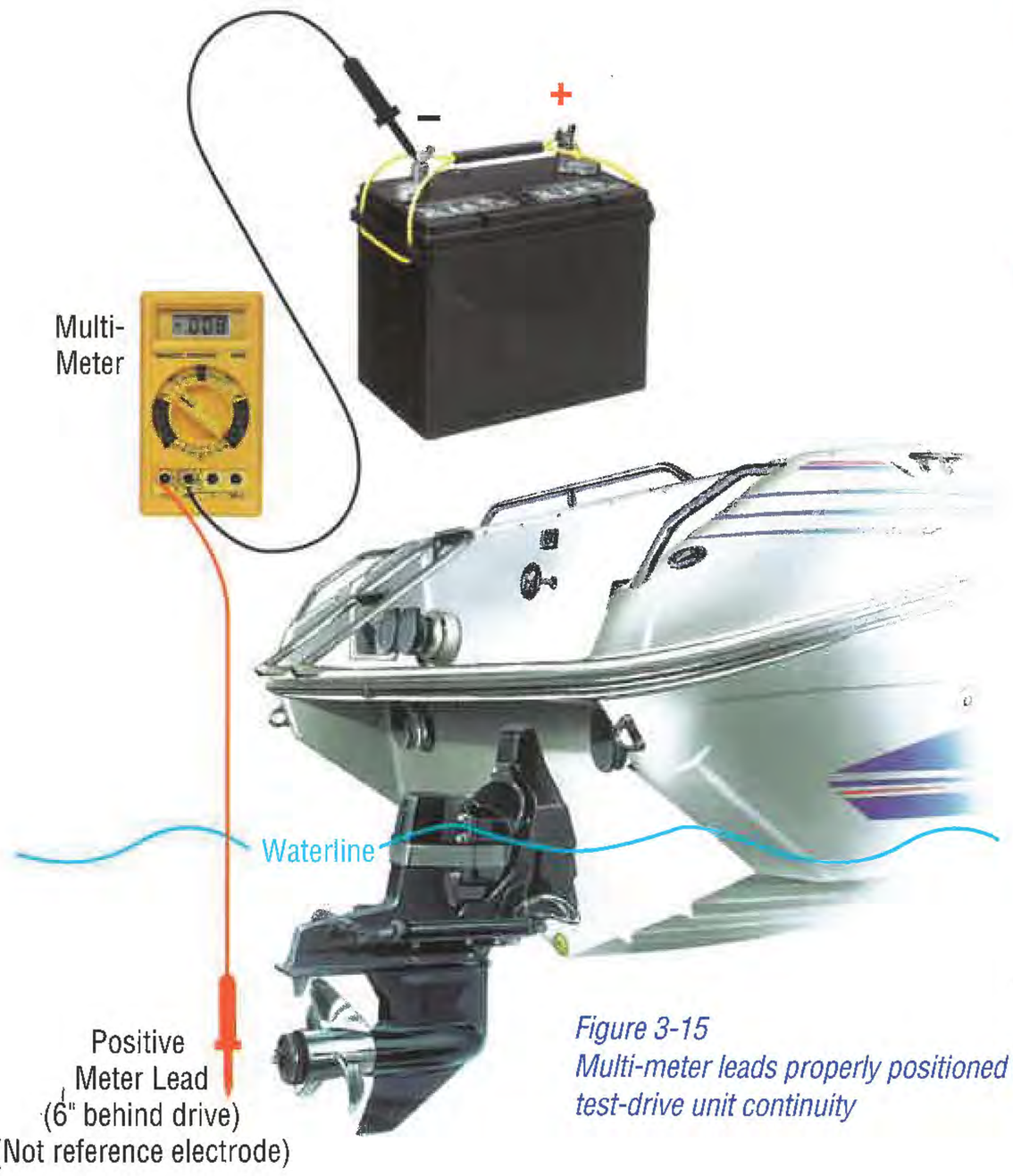



*Figure 3-15*
*Multi-meter leads properly positioned to test-drive unit continuity*

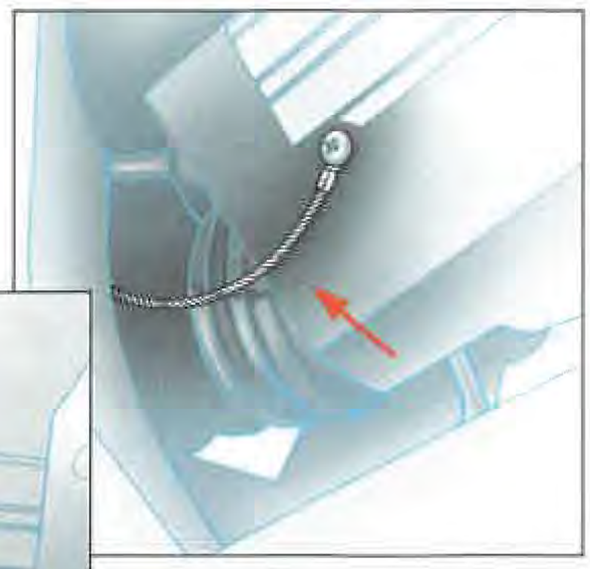


*Figure 3-9*
*Ground wire between gimbal ring and bell housing*

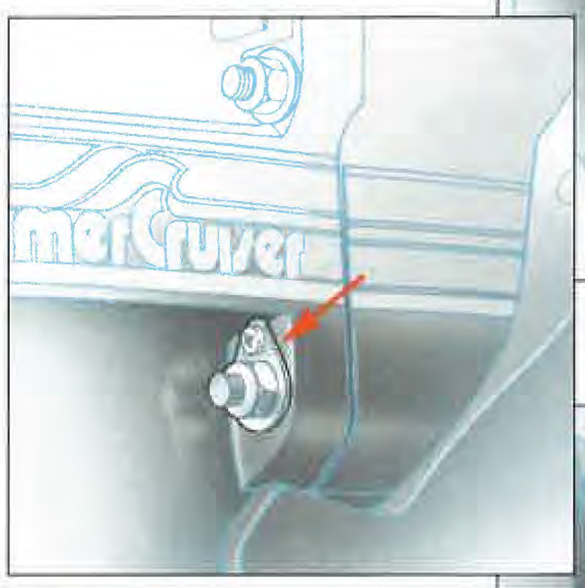



*Figure 3-10*
*Ground plate between drive unit and bell housing*

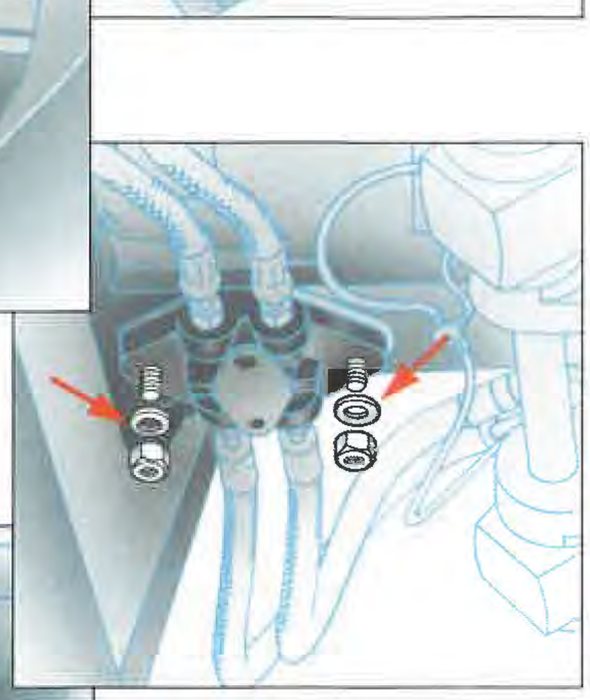


*Figure 3-11*
*Continuity washers between hydraulic manifold block and gimbal housing*

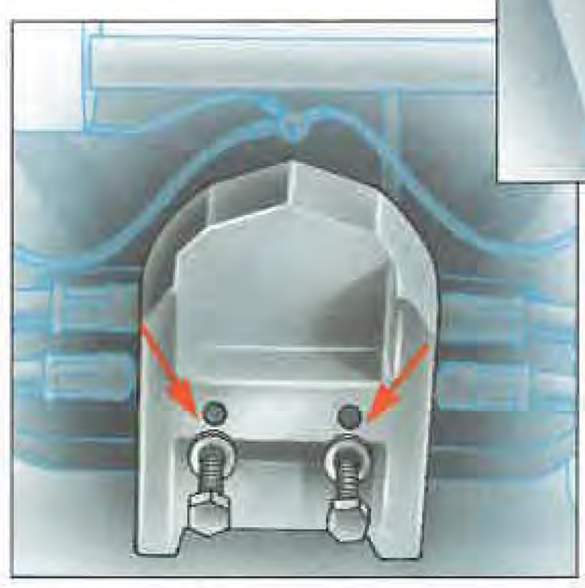


*Figure 3-12*
*Ground washers (beneath screws) between anodic block and hydraulic manifold*

*Figure 3-13*
*U-joint bellows ground clip*

*Figure 3-14*
*Exhaust bellows ground clip*


Figure 3-6
Steering lever ground wire

Figure 3-7
Ground wire between inner transom plate and gimbal housing

Figure 2-16
Gimbal housing caps; die cast on newer models, plastic caps on older models

Figure 3-13
U-joint bellows ground clip

Figure 3-10
Ground plate between drive unit and bell housing

Figure 2-6
Sacrificial trim cylinder anode

Figure 2-5
Sacrificial anode

Figure 3-11
Continuity washers between hydraulic manifold block and gimbal ring

Figure 3-12
Ground washers (beneath screws) between anodic block and hydraulic manifold

Figure 2-7
Drive-mounted sacrifical anode

Figure 3-8
Ground wire between gimbal housing and gimbal ring

Figure 3-5
Stainless steel trim hoses

Figure 3-14
Exhaust bellows ground clip

Figure 3-9
Ground wire between gimbal ring and bell housing


Figure 3-4
Wave washers between clamp brackets and swivel bracket

Figure 3-3
Continuity ground strap between hydraulic system and outboard mid-section

Figure 2-9
Sacrificial anode

Figure 2-4
Sacrificial anode

Figure 3-2
Continuity ground strap between drive shaft housing and swivel bracket

## Corrosion of Stainless Steel Propellers

Good continuity must be maintained between a stainless steel propeller and propeller shaft to prevent corrosion damage to the propeller. The corrosion damage will appear in the form of deep pits or holes in the metal (Figure 3-16).

To help ensure good continuity, the propeller should be removed periodically and all mating surfaces on propeller, propeller-attaching parts and propeller shaft should be cleaned. A liberal coat of Quicksilver 2-4-C with Teflon, Special Lubricant 101, or Perfect Seal should be applied to propeller shaft before reinstalling the propeller. Be sure to retorque the propeller nut to 55 lbs.ft. (75 N.m.).

On MC-I, Black Max and TRS Cleaver Propellers (with square rubber drive hub), a continuity washer can be installed between the spline washer and the propeller to help ensure continuity (Figure 3-17). This washer is included as standard equipment with these propellers.

Other Mercury Marine propellers with Flo-Torq® molded rubber hubs or plastic hubs have continuity devices built in.

*Figure 3-16*
*Propeller corrosion from loss of continuity*

*Figure 3-17*
*Continuity washer installation*

CHAPTER 4

# Preventative Maintenance



Figure 4-1
Maintain paint coverage on lower unit

Figure 4-2
Spray powerhead and all electrical connections with Quicksilver Corrosion Guard

Figure 4-3
Inspect sacrificial anodes regularly and replace when 50% consumed

Figure 4-4
Flush motor with fresh water after each salt-water excursion

There are several simple service procedures you can perform to maintain the quality of corrosion resistance built into your Mercury Drive Unit. A little patience, some simple hand tools, and a few Quicksilver products are all you need.

## Maintain

Maintain a complete paint covering on the lower unit (Figure 4-1). Check the finish regularly, and prime and paint nicks and scratches. If any bare metal is exposed, sacrificial anodes will be eaten away rapidly and corrosion of the drive unit will quickly occur. Use only tin anti-fouling paint on or near aluminum surfaces below the waterline. Never use paints containing copper or mercury. It's a good idea to check the lower unit frequently for sand abrasion, nicks and scratches. If bare metal is showing, apply two coats of paint to prevent corrosion.

## Spray

Spray the entire powerhead, all electrical connections, and everything under the cowl with Quicksilver Corrosion Guard (Figure 4-2).

## Inspect

Inspect the sacrificial trim tab at regular intervals and replace it before it's half gone (Figure 4-3). Never paint trim tabs or the mounting surface on the gearcase. Additional anodes or a MerCathode System will be required if a stainless steel prop is installed.

## Flush

Flush the motor with fresh water after each saltwater excursion, and wash down exterior of motor with fresh water as well (Figure 4-4). Attachments for flushing are available for all Mercury Drive Units and are designed for easy use. Use them!

## Check

Check the prop shaft for fish line (Figure 4-5). If a stainless steel shaft is wrapped with line, oxygen is eliminated from the surface, allowing corrosion. Remove the fish line. Fish line cutters are standard on all MerCruiser Stern Drives and Mercury and Mariner Outboards, 9.9- to 125-horsepower.

*Figure 4-5*
*Check prop for fish line*

## Lubricate

Lubricate everything according to your owner's manual (Figure 4-6). In salt water, more frequent lubrication is required. Do not use lubricants that contain graphite on or near aluminum. Graphite causes rapid corrosion to aluminum when the two are combined in salt water. Additional grease fittings have recently been added to many Mercury Drive Units in a variety of areas. The more lubrication, the better performance and corrosion resistance you'll get. Remember, saltwater operation requires lubrication much more often!

*Figure 4-6*
*Lubricate everything according to your owner's manual*

## Propellers

The propeller should be removed every 60 days and Quicksilver 2-4-C with Teflon, Special Lubricant 101, Anti-Corrosion Grease or Perfect Seal applied to the prop shaft (Figure 4-7). When re-installing the prop, be sure the prop nut is tightened sufficiently (see your owner's manual). Have an authorized dealer lubricate the cover nut and bearing carrier spool at least once each season.

## More Lubrication

Other lubrication points are: thumbscrews, starter motor pinion shaft, upper shift shaft, swivel tube, steering tube, throttle and shift linkages, reverse lock lever and cam, and tiller handle hinges. The lower unit must be checked and lubrication added as necessary (Figure 4-8).

*By following these simple maintenance steps, your Mercury Drive Unit will remain corrosion free . . . just as it was designed!*

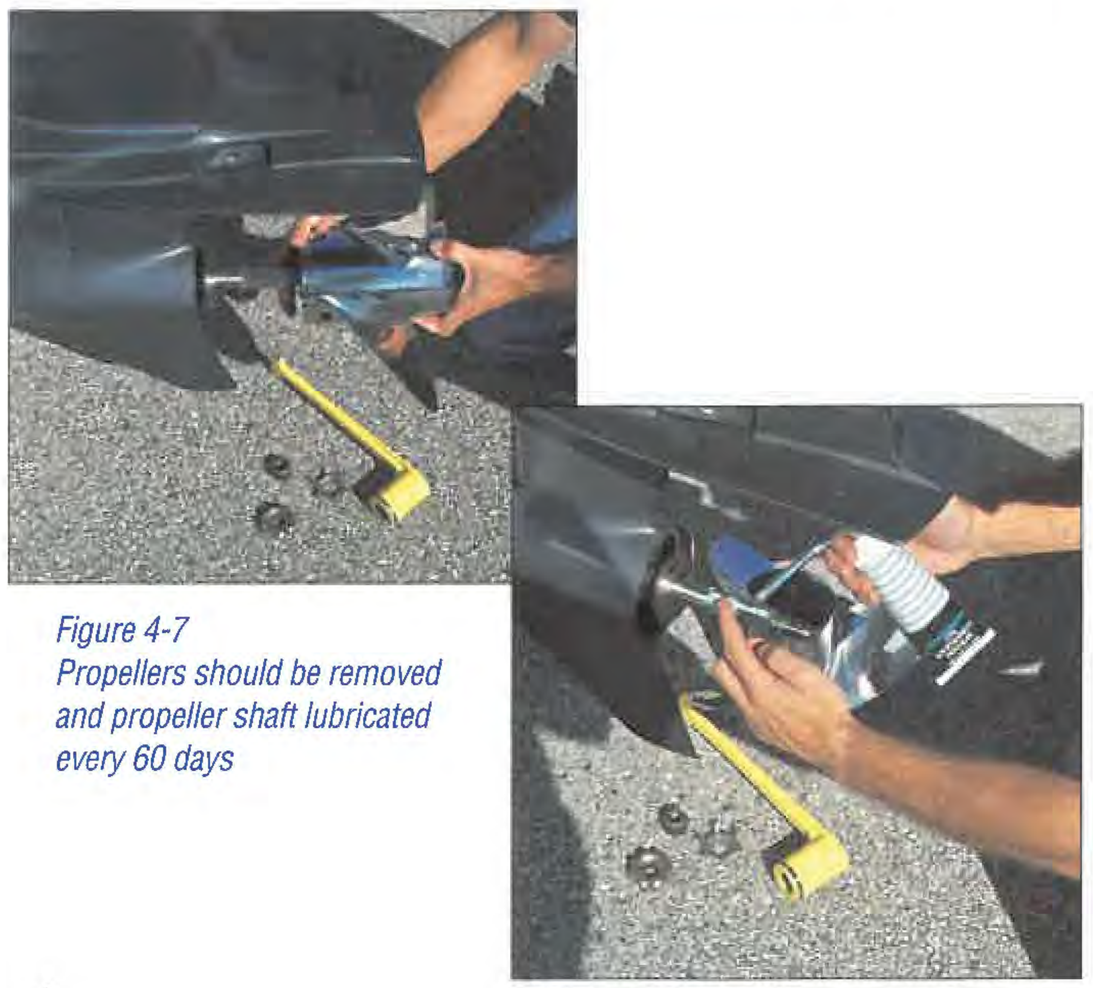


*Figure 4-7*
*Propellers should be removed and propeller shaft lubricated every 60 days*


*Figure 4-8*
*Lubricate other points such as starter motor pinion shaft*

CHAPTER 5

# Other Corrosion Protection

Remember, the outside of your engine or drive unit is not the only area susceptible to corrosion. It can happen inside, where you can't see it. But if you follow a good maintenance schedule, you can prevent and fight corrosion everywhere. Take care of your investment!

## Quicksilver Maintenance Products Schedule Guide

| Location<br>1. Outboards<br>2. Stern Drives | Fresh Water Lubrication Intervals (Whichever comes first) | Salt Water Lubrication Intervals (Whichever comes first) | Recommended Quicksilver Product |
|---|---|---|---|
| Steering Systems/Cable and Linkages (1 & 2)* | 100 hrs./at least once a year | 50 hrs./at least once a year | **2-4-C Marine Lubricant with Teflon** |
| Throttle and Shift Cables and Linkages (1 & 2)* | 100 hrs. | 50 hrs. | **OR** |
| Remote Controls (1 & 2) | 100 hrs./at least once a year | 50 hrs./at least once a year | |
| Grease Fittings (1 & 2) | 100 hrs./60 days | 50 hrs./30 days | **Special Lube 101 (Special Lube 101 contains Teflon and is designed to withstand extremely high friction loads)** |
| Prop Shaft (1 & 2) | 100 hrs./120 days | 50 hrs./60 days | |
| Swivel Pin (1 & 2) | 100 hrs./120 days | 50 hrs./60 days | |
| Drive Shaft Splines (1 & 2) | 100 hrs./at least once a year | 50 hrs./at least once a year | |
| Tilt Lock Mechanism (1) | 100 days | 50 days | |
| Tilt Tube (1)<br>Hinge Pins (2) | 100 days<br>100 hrs./at least once a year | 50 days<br>50 hrs./at least once a year | |

*continued on page 27*

# Quicksilver Maintenance Products Schedule Guide (continued)

| Location<br>1. Outboards<br>2. Stern Drives | Fresh Water Lubrication Intervals<br>(Whichever comes first) | Salt Water Lubrication Intervals<br>(Whichever comes first) | Recommended Quicksilver Product |
|---|---|---|---|
| Universal Joints (2)<br>Gimbal Bearing (2) | 100 hrs./at least once a year(2)<br>100 hrs./at least once a year | 50 hrs./at least once a year(2)<br>50 hrs./at least once a year | **U-Joint and Gimbal Bearing Lubricant** |
| Engine Coupler Splines (2) | 100 hrs./at least once a year<br>(300 hrs./at least once every 2 years for 1993 Alpha One models) | 50 hrs./at least once a year<br>(300 hrs./at least once a year for 1993 Alpha One models) | **Engine Coupler Spline Grease**** |
| Prop Shaft (1 & 2) | 100 hrs./120 days | 50 hrs./60 days | **Anti-Corrosion Grease, 2-4-C Marine Lubricant with Teflon, Perfect Seal and Special Lube 101** |
| Gear Housing (1) | Drain and refill after first 25 hrs., then after every 100 hrs., and once a year before storing.<br>Check and fill (if required) after first 10 days, then every 30 days. | Drain and refill after first 25 hrs., then after every 100 hrs., and once a year before storing.<br>Check and fill (if required) after first 10 days, then every 30 days. | **Gear Lube-Premium Blend** |
| Drive Unit (2) | Check after first 20 hrs., then weekly. Fill if needed. Replace every 100 hrs. or once a year (at end of season). | Check after first 20 hrs., then weekly. Fill if needed. Replace every 100 hrs. or once a year (at end of season). | **High-Performance Gear Lube** |
| 4-Cycle Stern Drive/ Inboard Engines | Check weekly. Fill if needed. Change after first 20 hrs., then every 100 hrs., or at least once a year. | Check weekly. Fill if needed. Change after first 20 hrs., then every 100 hrs., or at least once a year. | **4-Cycle Oil** |
| 4-Cycle Stern Drive/ Inboard Engines | Change after first 20 hrs., then every 100 hrs., or at least once a year. | Change after first 20 hrs., then every 100 hrs., or at least once a year. | **Oil Filter** |
| 2- & 4-Cycle Engines | Replace once a year (more often if clogged or excessive water is present in fuel). | | **Water Separating Fuel Filter** |
| 2- & 4-Cycle Engines | As required, to help clean combustion chamber (at tune-up time, and for a smoother idle). | | **Power Tune Engine Cleaner** |
| 2- & 4-Cycle Engines | As required on powerhead to protect electrical connections and exposed metal surfaces from corrosion. | | **Corrosion Guard** |
| 2- & 4-Cycle Engines | At winterization time (or before, if planning not to use the engine for longer than 30 days). | | **Storage Seal Rust Inhibitor** |
| Power Trim Reservoir (1)<br>Power Trim/Steering Pump/Reservoir (2) | Check and fill (if needed) every 100 hours or once a season.<br>Check weekly and fill as needed. | | **Power Trim & Steering Fluid** |
| 2- & 4-Cycle Engines and Drives | As needed to protect bare metal from effects of corrosive marine environment or for aesthetics. | | **Touch-Up Paints** |

*Use Quicksilver 4-Cycle Marine Engine Oil on linkages per Owner's Manual. 1) This chart is a general maintenance guide. Maintenance schedules for specific models are included in each engine's Owner's Manual and should be followed as such. 2) 1993 Alpha One models have a Perma-Lube U-joint which requires no lubrication. **See your dealer for information and service application.

# Application Guide for Outboard Maintenance Products

Spray ***Power Tune*** into carburetor to rid engine of carbon deposits.

Use ***2-4-C with Teflon*** or ***Special Lube 101*** on tilt tube.

Use ***2-4-C with Teflon*** or ***Special Lube 101*** on tilt lock mechanism (if so equipped).

Use ***2-4-C with Teflon*** or ***Special Lube 101*** on drive shaft splines.

Use Quicksilver ***Power Trim and Steering Fluid*** to top off reservoirs and pumps.

Use ***2-4-C with Teflon*** or ***Special Lube 101*** on swivel pin.

Use Quicksilver ***Gear Lube Premium Blend*** in the gear case.

Use ***Anti-Corrosion Grease***, ***2-4-C with Teflon***, ***Perfect Seal*** or ***Special Lube 101*** on prop shaft.

Spray ***Touch-Up Paint*** on external metal surface nicks and scratches to protect from corrosion.

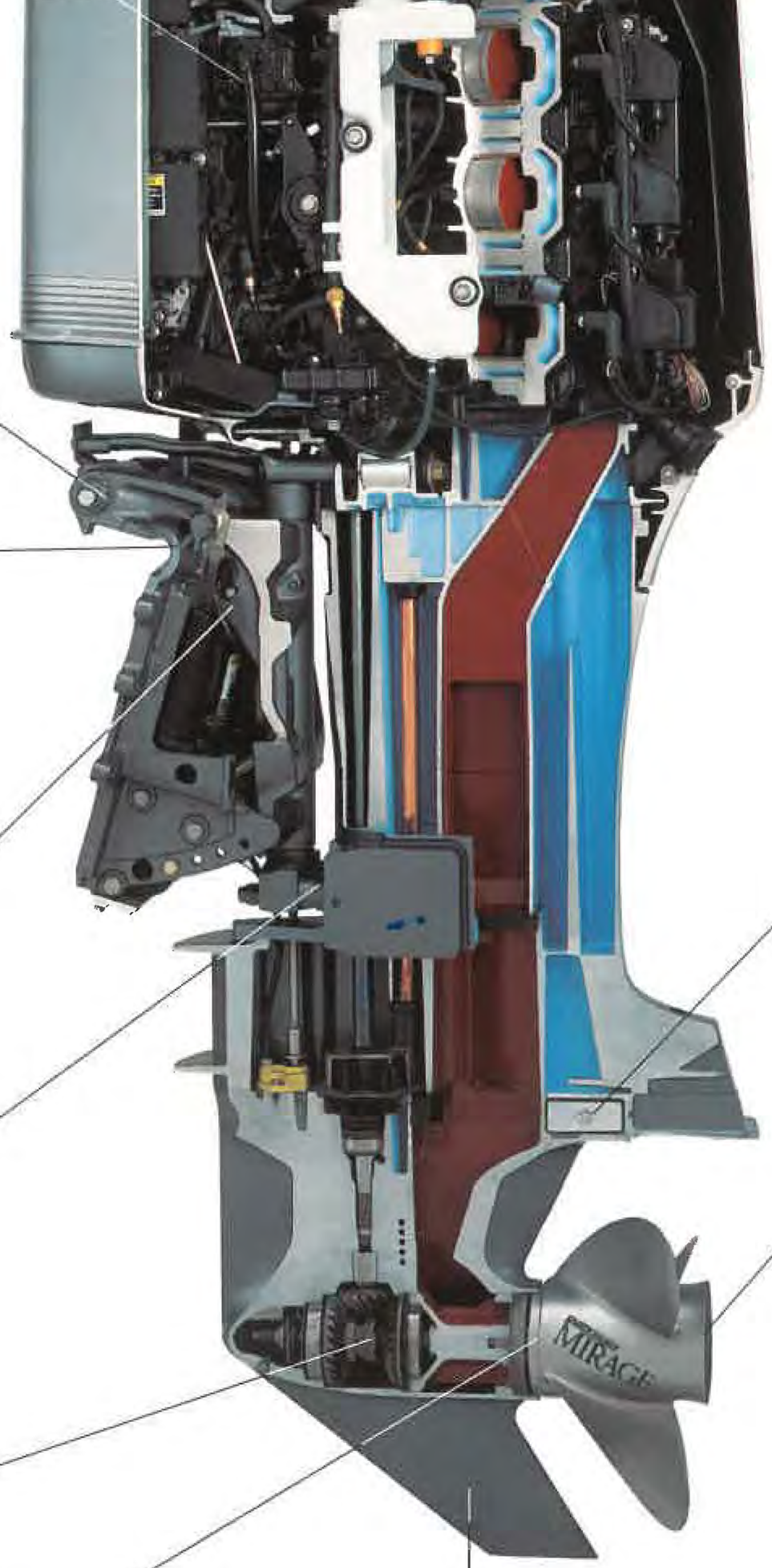
Fog internal components with ***Storage Seal Rust Inhibitor*** to protect from corrosion during storage.

Spray ***Corrosion Guard*** on external electrical connections and painted surfaces to protect from corrosion.

Use ***2-4-C with Teflon*** or ***Special Lube 101*** or Quicksilver ***4-Cycle Marine Engine Oil*** on throttle linkages (see Owner's Manual).

Use Quicksilver ***trim tabs*** and ***anodes*** for greater protection from galvanic corrosion.

Replace damaged propellers with Mercury Marine ***finished aluminum*** or Mercury Marine ***stainless steel propellers***.




*Keep your engine running longer and stronger with Quicksilver Marine Parts and Accessories. Use this chart as reference only. See your Engine Owner's Manual for specific applications.*

# Application Guide for Stern Drive Maintenance Products

Use Quicksilver ***Power Trim and Steering Fluid*** to top off reservoirs and pumps.

Spray ***Power Tune Engine Cleaner*** into carburetor to rid engine of carbon deposits.

Fog internal components with ***Storage Seal Rust Inhibitor*** to protect from corrosion during storage.

Use ***2-4-C with Teflon*** or ***Special Lube 101*** on steering system and cables.

Spray ***Corrosion Guard*** on external electrical connections and painted surfaces to protect from corrosion.

Use only Quicksilver ***oil filter*** replacement elements.

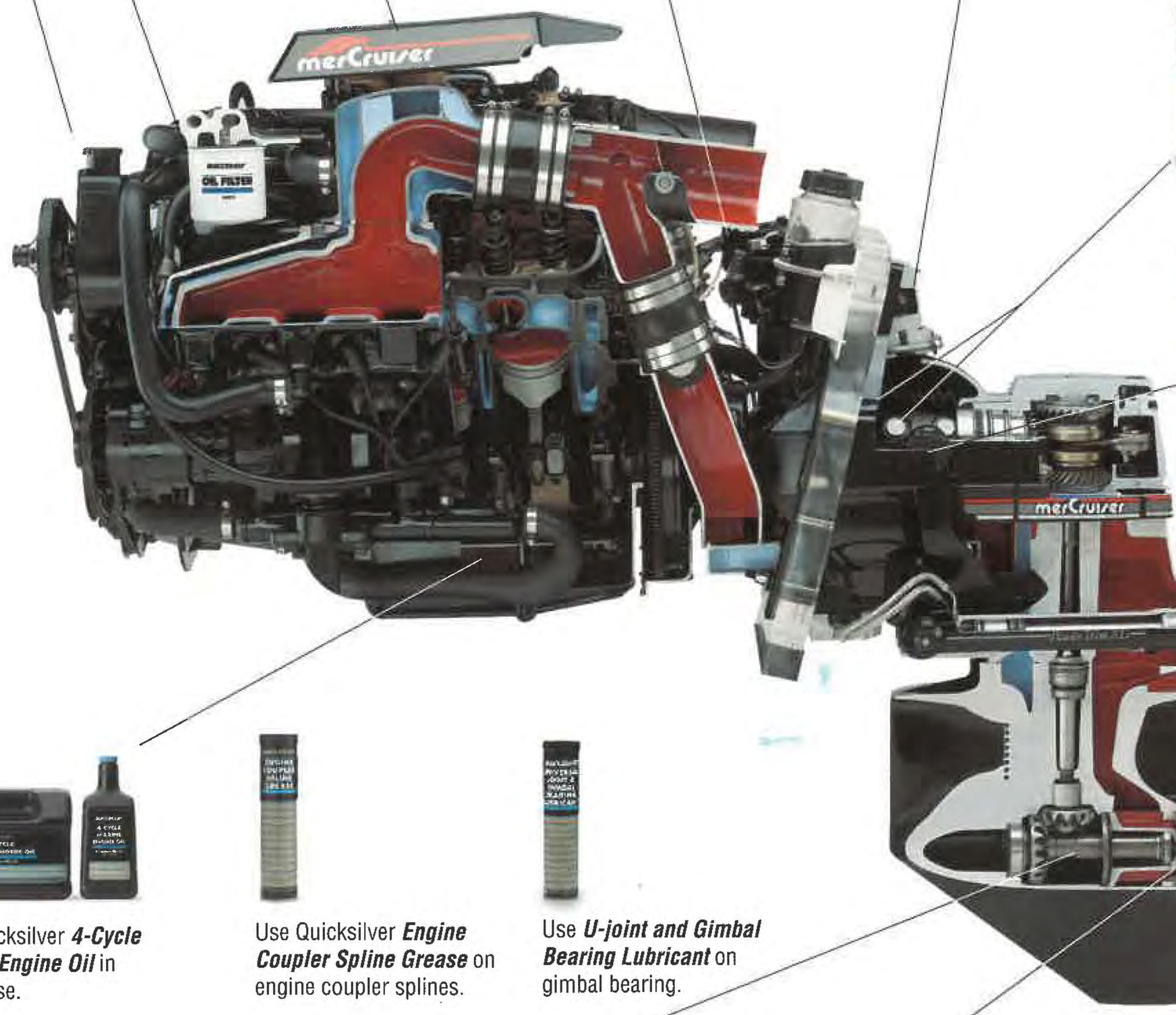
Use ***Special Lube 101*** on steering cable end.

Use ***2-4-C with Teflon*** or ***Special Lube 101*** on grease fittings of upper swivel pin.

Spray ***Touch-Up Paint*** on external metal surface nicks and scratches to protect from corrosion.

Use ***U-joint and Gimbal Bearing Lubricant*** on U-joints.

Use ***2-4-C with Teflon*** or ***Special Lube 101*** on hinge pins.






Use Quicksilver ***4-Cycle Marine Engine Oil*** in crankcase.



Use Quicksilver ***Engine Coupler Spline Grease*** on engine coupler splines.



Use ***U-joint and Gimbal Bearing Lubricant*** on gimbal bearing.


Use ***High Performance Gear Lube*** in the gear lube monitor and gear case.

Use ***Anti-Corrosion Grease***, ***2-4-C with Teflon***, ***Perfect Seal*** or ***Special Lube 101*** on prop shaft.

Replace damaged propellers with Mercury Marine ***EDP finished aluminum*** or Mercury Marine ***stainless steel propellers***.

Use Quicksilver ***trim tabs*** and ***anodes*** for greater protection from galvanic corrosion.


Figure 5-1
Anti-Corrosion Grease


Figure 5-2
2-4-C Marine Lubricant with Teflon


Figure 5-3
Special Lubricant 101


Figure 5-4
Silicone Dielectric Compound


Figure 5-5
Storage Seal Rust Inhibitor


Figure 5-6
Corrosion Guard

## Quicksilver Anti-Corrosion Product Guide

Quicksilver is a recognized authority in fighting marine corrosion. The following products were specially formulated for specific purposes, and will go a long way in protecting your equipment. If you have any questions about their usage, ask your Mercury, Mariner, Force, Sport-Jet or MerCruiser dealer. He'll steer you right.

**Anti-Corrosion Grease:** 8-oz. tube (227 g) (Figure 5-1). Improves adhesion and provides a protective lubricating film on metal surfaces exposed to the elements. Apply to prop shaft to make propeller installation and removal easier.

**2-4-C Marine Lubricant with Teflon:** 8-oz. tube (227 g) (Figure 5-2). Now with Teflon, an anti-galling additive. For lubricating linkages and external moving parts on both 2- and 4-cycle engines, drive units, steering cables and trailer wheel bearings. Not for ball, roller or needle bearings inside outboard power-heads or gearcases.

**Special Lubricant 101:** 8-oz. tube (227 g) (Figure 5-3). Specially formulated to lubricate the extension rod and guide tube of MerCruiser transom-mounted power steering units. Excellent for lubricating prop shaft. Contains Teflon and is designed to withstand extreme friction loads.

**Silicone Dielectric Compound:** 8-oz. tube (227 g) (Figure 5-4). Use on spark plug boots and electrical connections. Prevents breakdown on high-tension leads and prevents corrosion in electrical connections.

**Storage Seal Rust Inhibitor:** 12-oz. spray can (340 g) (Figure 5-5). Protects internal engine surfaces from corrosion during extended storage periods.

**Corrosion Guard:** 11-oz. spray can (312 g) (Figure 5-6). Increased corrosion protection for external metal surfaces, including engine powerhead and electrical connections. Clear film coating dries to touch in 24 hours.

## Quicksilver Anti-Corrosion Systems

When paint and treatments aren't enough, turn to a Quicksilver anti-corrosion system. All are designed to stop corrosion and keep it from coming back!

**Flush Kits:** (Figure 5-7). Help remove harmful deposits from engine and drive unit cooling system after running in salt- or silt-laden water. See dealer for correct application.

**MerCathode® System:** (Figure 5-8). A Quicksilver exclusive! Provides permanent protection against galvanic corrosion. 12-volt, push-button MerCathode Monitor also available. Protects all makes of outboards and stern drives. See your dealer for applications.

**Galvanic Isolator:** (Figure 5-9). Light and compact, protects aluminum drives, hull and anodes from grounding-accelerated galvanic corrosion when boat is plugged into shoreside AC power. Installs easily with no special tools.

## Quicksilver Anodes

See the new Quicksilver Anode Reference book (Figure 5-10), which provides quick-reference charts listing the proper Quicksilver anodes for Mercury, Mariner, Force, Sport-Jet and MerCruiser products from 1960 to 1995.

**Trim Tabs and Anodic Plates:** Anodic plates serve as sacrificial anodes to protect underwater aluminum parts from galvanic corrosion. Trim tabs help compensate for propeller torque and act as sacrificial anodes.

*New!* Introducing the Quicksilver Prop Nut Anode, offered in Quicksilver's exclusive lightweight aluminum. It attaches to the engine's propshaft and offers an added measure of protection.

*New!* Introducing the Quick'Defender Anode, designed to attract galvanic corrosion away from your engine or drive *when your boat is moored*. The Quick'Defender is the only port or starboard hanging anode offered in lightweight aluminum.

**Drive-Mounted Anodes:** Anodes can be mounted on such points as power trim systems and bearing carriers for extra corrosion protection.

**Transom-Mounted Anode:** For extra protection against galvanic corrosion when using a stainless steel propeller.

*For more information regarding sacrificial anodes, see pages 5–7.*


*Figure 5-7*
*Flush kits*

*Figure 5-8*
*Quicksilver MerCathode System*

*Quicksilver MerCruiser*
*MerCathode System*


*Figure 5-9*
*Galvanic Isolator*

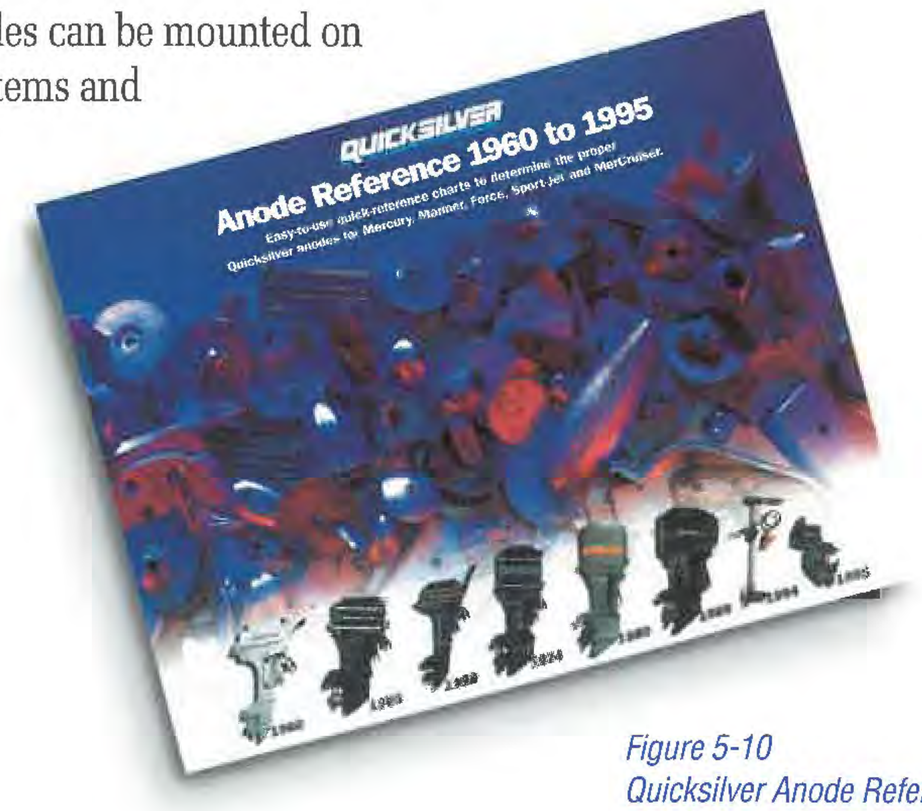



*Figure 5-10*
*Quicksilver Anode Reference book*


*Figure 5-11*
*Quicksilver touch-up paints are available in a variety of colors.*

*Phantom Black*

*Mariner Silver*

*Nickel Gray*

*Mariner Light Gray*

*Mariner Gray*

*Graphite Gray*

*Force White*

*Force Blue*

*Force Black*

*1989 Bayliner Blue*

## Quicksilver Paints

Nicks and scratches are where corrosion will start, eventually destroying your precious boat or motor. Touch up any nicks and scratches regularly with Quicksilver Touch-Up Paint and repaint larger areas with Quicksilver Spray Paint, all formulated to protect and match your equipment (Figure 5-11).

**Phantom Black:** 12-oz. (340 g) and .5-oz. bottle with applicator brush. Matches MerCruiser Stern Drives and Inboards and Mercury Outboards.

**Mariner Silver:** 12-oz. (340 g) and .5-oz. bottle with applicator brush. For 1994 and newer Mariner Top Cowl.

**Nickel Gray:** 12-oz. (340 g) and .5-oz. bottle with applicator brush. For Mariner Outboards (lower cowls) 8, 9.9, 15, 75 and larger hp, 1994 and newer.

**Mariner Light Gray:** 12-oz. (340 g) and .5-oz. bottle with applicator brush. For 1994 and newer models (except top cowl of 1985 model) and lower cowls of 8. 9.9, 15, 75 and larger hp, 1994 and newer.

**Mariner Gray:** 12-oz. (340 g) and .5-oz. bottle with applicator brush. Matches 1984 and earlier dark gray Mariner Outboards.

**Graphite Gray:** 12-oz. (340 g) and .5-oz. bottle with applicator brush. For 1989–94 Force and 1994 Tracker Nitro.

**Light Gray Primer:** 12 oz. (340 g) Provides better adhesion for touch-up painting.

**Clear Coat:** 12 oz. (340 g) Use to protect painted surfaces.

**EDP Propeller Black:** 12 oz. (340 g) The perfect match for all Mercury Marine aluminum props. Touches up scratches to combat corrosion. Also good for touch-ups on majority of powerheads on 1989 and newer Mercury and Mariner Outboards.

**Force White:** 12-3/4 oz. (361 g) For all 1984 and later models.

**Force Blue:** 12-3/4 oz. (361 g) For all 1988 models.

**Force Black:** 12-3/4 oz. (361 g)

**1989 Bayliner Blue:** 12-3/4 oz. (361 g)

**Leveler:** 12 oz. (340 g) Use at time of touch-up painting for a smooth finish.

# Glossary

**Anode:** The electrode of an electrolyte cell at which oxidation is the principle reaction. (Electrons flow away from the anode in the external circuit. It is usually the electrode where corrosion occurs and metal ions enter solution.) 2) See "Sacrificial Anode."

**Cathode:** The electrode of an electrolyte cell at which reduction is the principle reaction. (Electrons flow toward the cathode in the external circuit.)

**Chromate:** An ion of chromium oxide.

**Conductivity:** The degree of ability of a substance to transmit electricity. Any water that is not completely pure is conductive to a degree. Minerals, salt, pollution and higher temperatures make water more conductive.

**Continuity:** Electrical contact. Two pieces maintain continuity if electricity can pass from one to another.

**Electrochemical Reaction:** A reaction in which an electrical change in the metal causes a chemical change in the metal and results in corrosion.

**EDP:** The process of electro-depositing, wherein an object is electrically charged and a substance, such as paint, is oppositely charged. When the paint is sprayed toward the oppositely charged object, the paint droplets are magnetically attracted by the object. EDP results in complete and uniform coverage.

**Galvanic Corrosion:** An electrochemical reaction caused whenever two or more dissimilar metals that are connected electrically are immersed in a conductive solution.

**Galvanic Potential:** (also "Electrochemical Potential") A statement of the relative stability of a metal. The more chemically active, more anodic and less stable a metal is, the more galvanic potential it has.

**Ground:** 1) In boating, the negative (–) pole of the battery. 2) The zero potential level, or the potential of the earth. 3) The English equivalent to our "ground" in electrical wiring is called "Earth Return," and that's all it is—any route for an electrical charge or current to get back to the earth.

**Ion:** An electrically charged atom or molecule. For example, an oxidized atom of aluminum (the anode) is noted as $Al^{+++}$. The plus signs indicate it has lost three electrons. At the cathode, the hydroxide ion is noted $OH^{-}$. The minus sign indicates it has gained one electron.

**Organotin:** See "Tributyltin."

**Sacrificial Anode:** (Sometimes referred to as a "zinc," for the alloy they are usually made of.) A galvanically active piece of metal attached to an outboard motor, lower unit or other submersed metal part. Anodes are more active than the more expensive drive components, thus protecting them from corrosion. Anodes are generally made of zinc, aluminum alloys and magnesium alloys.

**Stray Current Corrosion:** Galvanic corrosion caused by a leakage of current into and through the metal drive components, exiting for a water path to ground. Stray current corrosion is commonly a result of connecting a boat to shore power, and has much more potential to damage parts, as it is regular galvanic corrosion greatly accelerated by the addition of electricity.

**TBT:** See "Tributyltin."

**Tributyltin:** (Also known as TBT and Organotin.) An organic form of tin that allows it to be mixed and suspended in paint, allowing it to be applied to boat hulls as an anti-fouling agent.

# Index

# Index



In our continuing efforts to offer the finest products available, we must reserve the right to change models, specifications, and part numbers without notice.

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