MERCURY MerCruiser

Service Bulletin

Bulletin No. 2013-02

Circulate to: ☐ Sales Manager ☐ Accounting ☑ Service Manager ☑ Technician ☑ Parts Manager

Corrosion Prevention and Maintenance

NOTICE
This March 2013 bulletin supersedes the previous bulletin number 2002-06 April 2002.

Models

All Mercury MerCruiser products.

Marine Corrosion Introduction

The prevention of marine corrosion can be a challenge for boat owners; however, corrosion is almost always controllable. To protect the product, all that is required is to know what causes corrosion and to perform the proper maintenance.

Mercury has published several guides to educate dealers and boat owners about corrosion and the steps that should be taken to help prevent corrosion damage to submerged drive components. All Mercury dealers should be familiar with these publications, understand the primary causes of corrosion, and understand what to do to help prevent marine corrosion in all types of boating environments.

During the predelivery inspection process, you and the boat owner should review the proper maintenance needed to ensure that the boat and sterndrive are protected from corrosion. We also encourage you to review the contents of the **Marine Corrosion Protection Guide** with the owner, and give them a copy to take home. This guide is available to you at no charge by ordering 90-881813 01 (Mercury branding) or 90-809844 01 (Quicksilver branding).

If a boat owner has a complaint about corrosion damage, perform the necessary inspection and testing procedures to identify the source of the corrosion. Record the findings in the included **Corrosion Test Data Sheet**.

The Mercury dealer technical support team is available to provide technical assistance in the diagnosis and correction of corrosion. Contact Mercury technical support at 920-929-5884.

Galvanic Corrosion

Galvanic corrosion occurs when dissimilar metals are immersed in an electrolyte, an electrically conductive solution. This is an electrochemical reaction where the weaker, more chemically active metal acts as an anode and the stronger, more stable metal acts as a cathode. Electrical current flows between the metals, causing the weaker, less stable metal (the anode) to be eaten away or corrode.

In the case of the galvanic corrosion of marine sterndrive components, the electrolyte is water. While chemically pure water will not conduct electricity, the water in which boats operate is not chemically pure and will conduct electricity. Typically, the less pure the water is, the more conductive it is. Salt water, fresh water with high mineral content, and polluted water have high conductivity.

NOTE: *Temperature also affects the conductivity of water: the higher the water's temperature, the higher its conductivity. This is one reason why boats in Florida experience more corrosion than boats in Maine.*

One example of dissimilar metals used on a sterndrive is an aluminum lower unit with a stainless steel propeller. The aluminum is more chemically active, and the stainless steel is less chemically active. If no preventive measures are taken, the lower unit will eventually corrode due to the flow of electrons from the lower unit to the propeller.

Stray Current Corrosion

⚠ WARNING

Stray alternating current in the water presents a potentially lethal electrical shock hazard to anyone in contact with the water. If you suspect the presence of stray current, immediately disconnect any source of alternating current, including shore power, and contact a certified, licensed electrician for evaluation of your AC power systems.

Stray current is the passing of electrical current through the metal drive components and then through the water on its way to ground. Stray current typically results from improperly grounded shore power, but may also originate from a faulty onboard AC power source. Stray current present in the water in which a boat is operating or moored can itself cause corrosion. When combined with the current already passing between dissimilar metals, stray current greatly accelerates normal galvanic corrosion. For more information, refer to page 4 of the **Marine Corrosion Protection Guide** (90-881813 01).

Testing Procedures

The following step-by-step procedures guide you through checking a boat for a corrosion problem at the location where the boat is normally moored. A copy of the **Corrosion Test Data Sheet** included in this bulletin should be completed and returned to MerCruiser Service (fax: 800-842-4550).

Test Equipment

The dealer must perform a hull potential check by using a digital multimeter, such as the Mercury DMT2000A (91-854009A3) along with the Quicksilver reference electrode (91-76675T1).

Tools Required

Description	Part Number
Digital multimeter	854009A 3
Quicksilver reference electrode tester	76675T1

Before Performing Any Test

1. If the boat is connected to shore power, unplug the shore power.
2. Check the fuse in the positive (+) battery lead.
3. Check the battery voltage and record the value in the **Corrosion Test Data Sheet**. The voltage must be at least 12.6 volts.
4. Check for loose connections at the controller and at the battery. All connections must be tight.
5. Check the ground connection between the drive and the controller.

Before Performing Corrosion Testing

The boat should be moored (without being operated) for at least eight hours before performing the test. This will allow the MerCathode system and the sacrificial anodes to polarize the water molecules that are in direct contact with the drive. Be careful not to rock the boat excessively while performing the test, as this will alter the test readings.

Step 1: Check for Conductivity

This check tests the conductivity of the sterndrive's grounding circuit. The boat must be moored when performing this test.

1. Set a digital multimeter to its 0–2 V (0–2000 mV) DC scale.
2. Connect the meter’s negative (–) lead to the negative (–) battery terminal.
3. Suspend the meter’s positive (+) lead in the water within 15 cm (6.0 in.) of the aft end of the drive unit. Do not allow the lead to make contact with the drive unit or the propeller.
4. Record the voltage in the **Corrosion Test Data Sheet**. The reading should be above 3 mV.
5. Connect the end of the positive meter lead to each metallic component on the drive and transom, making sure that there is good electrical contact to each surface.
6. For each component:
   - If the reading is below 2 mV, then the grounding circuit has good conductivity.
   - If the reading is higher than 2 mV, then there is an improper grounding circuit. Perform the following additional steps:
     i. Record the component name and the measured voltage for that component in the **Corrosion Test Data Sheet**.
     ii. Investigate the cause of the high reading, and note it on the **Corrosion Test Data Sheet**.

iii. Perform the out-of-water resistance check of all drive components. Refer to **Out-of-Water Resistance Check** and the **Marine Corrosion Protection Guide**.

Step 2: Measure the Hull Potential

This test measures the potential of the boat's hull with respect to the water in which it is normally moored. Moor the boat in the testing location for at least eight hours without operation prior to beginning the test.

1. Set a digital multimeter to its 0–2 V (0–2000 mV) DC scale.
2. Connect the meter's negative (–) lead to the negative (–) battery terminal or the engine ground stud on the flywheel housing.
3. Connect the reference electrode tester to the multimeter.
4. Suspend the end of the reference electrode in the water within 15 cm (6.0 in.) of the aft end of the drive unit behind the propeller. Do not allow the electrode to make contact with either the drive unit or the propeller.
5. Record the measured hull potential in the **Corrosion Test Data Sheet**.

Step 3: Interpret the Hull Potential Readings

Water Type	Hull Potential	Interpretation
Salt	< 850 mV	The hull potential is too low, and corrosion is occurring.
	850 – 1100 mV	The hull potential is at the proper amount to protect the drive.
	> 1100 mV	The hull potential is too high, and the drive is over-protected
Fresh	< 750 mV	The hull potential is too low, and corrosion is occurring.
	750 – 1050 mV	The hull potential is at the proper amount to protect the drive.
	> 1050 mV	The hull potential is too high, and the drive is over-protected

Possible causes of a hull potential that is too low:

1. The hull or drive is too cathodic, such as having a high stainless steel content.
2. There is a loss of continuity between the drive components and the system ground.
3. The sacrificial anodes are more than 50% consumed, painted, or inactive.
4. The MerCathode reference wire or anode plate is painted over.
5. There is no power to the MerCathode controller due to:
   a. A fuse is open.
   b. The MerCathode power is shut off at the battery switch or it is wired to the wrong side of the switch.
6. There is a poor connection of the reference electrode lead (brown) or the anode lead (orange) at the MerCathode controller.
7. The MerCathode reference electrode is faulty. To test it:
   a. Disconnect the reference electrode lead (brown) from the "R" terminal on the controller.
   b. Connect the brown lead to the positive (+) lead from the digital multimeter (set on the 0–2000 mV scale).
   c. Connect the negative (–) lead of the multimeter to either the negative battery lead or the engine grounding stud at the flywheel housing. Note the meter reading.
   d. Repeat the test with the Quicksilver reference electrode held 15 cm (6.0 in.) behind the propeller.
   e. The same reading should be obtained with both tests. If not, replace the MerCathode unit on the transom gimbal housing or transom.
8. The MerCathode controller is faulty. To test the MerCathode controller:
   a. Ensure that the anode and the reference electrode leads are connected to the controller.
   b. Connect a jumper wire between the "R" terminal and the negative (–) terminal on the controller.
   c. Set the multimeter to the 0–20 VDC scale.
   d. Connect the multimeter positive (+) lead to the "A" terminal on the controller.
   e. Connect the multimeter negative (–) lead to the negative terminal on the controller.
   f. The voltage should be at least 11.5 V in fresh water and 3.55 V in salt water.
   g. If the reading is low, replace the controller.

Possible symptoms of a hull potential that is too high:

1. Paint is blistering and falling off of the drive components.
2. There is pitting of the aluminum on the drive.

NOTE: Excessive voltage causes hydrogen to form at the surface of the metal, "blowing" the paint off and creating an alkaline condition at the surface, which dissolves the aluminum and causes pitting.

Possible causes of a hull potential that is too high:

1. Stray current is increasing the hull potential.

   NOTE: Any electrical current flowing along or through a metal conductor that leaves the metal for a water path to ground will cause ionization of the metal and an area of rapid corrosion.

   - To determine if the source is internal, observe the hull potential with a meter while disconnecting the electrical components (one at a time) until the high reading is eliminated. That component is the immediate source of the stray current.
   - If the source is external, install a galvanic isolator.
2. There is a poor connection between the MerCathode reference electrode lead (brown) and the controller's "R" terminal.
   a. Clean and tighten the connections, and repair wiring as required.
   b. Remove all salt deposits.
3. The MerCathode reference electrode is faulty. To test it:
   a. Disconnect the reference electrode lead (brown) from the "R" terminal on the controller.
   b. Connect the brown lead to the positive (+) lead from the digital multimeter set on the 0–2000 mV scale.
   c. Connect the negative (–) lead of the multimeter to either the negative battery lead or the engine grounding stud at the flywheel housing. Note the meter reading.
   d. Repeat the test with the Quicksilver reference electrode held 15 cm (6.0 in.) behind the propeller.
   e. The same reading should be obtained with both tests. If not, replace the MerCathode unit on the transom gimbal housing or transom.
4. The MerCathode controller is faulty.
   - Check the output of the controller.
   - If the hull potential indicates overprotection, remove the reference electrode lead from the controller. If the controller is off, the voltage between the controller's negative (black) lead and the anode should be less than 1 V. With the reference electrode disconnected, the amperage between the negative on the controller and the anode terminal should be less than 1 mA.
   - Measure the output of the MerCathode as described in **Step 4: Check the MerCathode Anode Output**. If you disconnect the brown reference electrode lead during the test, the output should drop to zero. If there is any current output with the brown reference lead disconnected, the controller is faulty and should be replaced.

Step 4: Check the MerCathode Anode Output

This test measures the current output of the MerCathode.

1. Disconnect the orange anode lead from the controller.
2. Set your multimeter to the 2000 mA scale.
3. Connect the meter between the orange anode lead and the anode terminal.
4. Note the reading and record it in the **Corrosion Test Data Sheet**.
   a. If the MerCathode is fully on, the output should be about 200 mA in salt water or 20–25 mA in fresh water.
   b. If the reading is zero, the MerCathode assembly on the gimbal housing must be replaced.

Out-of-Water Resistance Check

IMPORTANT: The boat must be out of the water to perform this check.

A digital multimeter, such as the Mercury DMT2000A (91-854009A 3) or equivalent, must be used for this test.

1. Set the meter to its low resistance range (~2 ohm). Ensure that the red meter lead is plugged into the meter's OHM jack.
2. Connect the black meter lead to the drive unit trim tab or the driveshaft housing cavitation plate anode.
3. Connect the red meter lead to an exposed area of any component of the power package to be tested. For all components, the reading should be no higher than 150 milliohms (0.15 ohms). If any component has a resistance higher than 150 milliohms, record the value in the **Corrosion Test Data Sheet**.

4. Connect the black meter lead to the battery negative terminal or a good ground on the engine, such as the ground stud at the flywheel housing.
5. Connect the red meter lead to the ground strap on the inner transom plate.
   - Record the resistance in the **Corrosion Test Data Sheet**.
   - The reading should be no higher than 150 milliohms (0.15 ohms).
   - If the reading is higher than specified, poor continuity is indicated. The high resistance area must be located and its cause must be corrected.

Galvanic Isolator Testing

Use a multimeter that has diode testing capability, such as the Mercury DMT2000A (91-854009A 3) or equivalent.

1. Connect the meter leads between the ends of the green leads on the galvanic isolator.
2. The meter reading should start at the low end of the scale, gradually increase, and settle on a single value. Record this value in the **Corrosion Test Data Sheet**.
3. Reverse the leads from end to end. The reading should again start low and rise to a point to where it levels out. Record this value in the **Corrosion Test Data Sheet**.
4. The two readings should be about the same.
   - If the readings are not close to the same (one reading levels out high, while the other reading stays at zero), the diode is bad and the galvanic isolator requires replacement.
   - If either reading is infinite, the diode is shorted and the galvanic isolator requires replacement.

Mercury-Offered Corrosion Protection

Mercury Marine offers the following items to combat galvanic and stray current corrosion:

1. Sacrificial anodes – Available in aluminum (for use in fresh, brackish, or saltwater) and magnesium (for use in fresh water only).
   - For fresh water conditions, the hull potential should be between 750 and 1050 mV. With a hull potential of 600 mV, for example, magnesium anodes can be used to increase the potential to 750 to 900 mV, but not to exceed 1050 mV.
   - After the installation of magnesium anodes, return the boat to the dock or slip where the boat is normally moored. The boat should be in the water for a minimum of 24 hours before retesting the hull potential. Readings must not exceed 1050 mV in fresh water conditions.
   - If the hull potential is already above the 750 mV minimum and magnesium anodes are used, the hull potential may raise above the maximum of 1050 mV. This higher hull potential can cause the drive unit and transom paint to blister.
2. MerCathode – Comes standard on all Bravo products and is available in a kit for Alpha product.
3. Transom-mounted button anode – Connected to the current MerCathode for additional anodic protection.
4. Transom-mounted MerCathode kit – For use with non-current MerCruiser product where the transom gimbal housing has no access for mounting a current style MerCathode system.
5. Defender anode – Connects to either the negative terminal on the battery or a good engine ground, for additional protection while the boat is moored.
6. Galvanic isolator – This device is connected in series into the boat's green safety grounding lead ahead of all grounding connections on the boat. 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.

Recommended Protection for Sterndrive Product

Based on the water conditions and the boat's hull potential, the following protection is recommended for sterndrive product.

Fresh-Water Conditions

Hull Potential	Sterndrive Type		
	Alpha	Bravo I, Bravo II	Bravo III
750 – 1050 mV	Standard aluminum anodes are sufficient.	The factory installed MerCathode system is normally sufficient.	
< 750 mV (in heavily silted water)	Additional anodes and/or a MerCathode system are recommended.	The factory installed MerCathode system plus additional anodes and/or two transom-mounted button anodes may be required.	

Brackish or Salt-Water Conditions

Hull Potential	Sterndrive Type		
	Alpha	Bravo I, Bravo II	Bravo III
850 – 1100 mV	Standard aluminum anodes are sufficient.	The factory installed MerCathode system is normally sufficient.	
< 850 mV	Additional anodes are recommended.	The factory installed MerCathode system plus additional anodes are required.	The factory installed MerCathode system and two transom-mounted anodes are required.

New Anode Kits for Current MerCruiser Sterndrives

The following kits include all anodes required to replace every anode on an Alpha or Bravo drive and transom:

- 888756A 1 Alpha aluminum anode kit
- 888755A 1 Alpha magnesium anode kit
- 888758A 1 Bravo I aluminum anode kit
- 888757A 1 Bravo I magnesium anode kit
- 888761A 1 Bravo II/III aluminum anode kit
- 888760A 1 Bravo II/III magnesium anode kit

Additional Information

The following information on corrosion is available in a variety of Mercury Marine publications:

- Corrosion protection, testing, and troubleshooting.
- Drive unit continuity test
- Hull potential testing
- Stray current corrosion
- Crevice corrosion
- The effect of water velocity on corrosion rates
- Methods of increasing the protection provided by a MerCathode system
- Anti-fouling paints on drives

The publications containing this information include:

- Marine Corrosion Protection Guide (90-881813 01)
- MerCruiser service manual 6, section 7
- MerCruiser service manual 11, section 7
- MerCruiser service manual 14, section 7
- MerCruiser service manual 28, section 7
- MerCruiser service manual 39, section 1D
- Owner’s manuals (All)

Corrosion Test Data Sheet

Date of test: _____

Dealer name: _____ Dealer number: _____

Customer name: _____

Address: _____

_____

Telephone number: (_____)_____

Address where the boat is moored: _____

Vessel Information

Boat manufacturer: _____ Boat model: _____

Type of installation: ( ) Single ( ) Dual ( ) Triple ( ) Quad

Engine package model: _____

Serial numbers:

Starboard engine:	_____	Starboard inner/ center engine:	_____
Starboard transom:	_____	Starboard inner/ center transom:	_____
Starboard drive:	_____	Starboard inner/ center drive:	_____
Port engine:	_____	Port inner engine:	_____
Port transom:	_____	Port inner transom:	_____
Port drive:	_____	Port inner drive:	_____

MerCathode system type:	( ) Transom mounted	( ) Gimbal housing mounted
Propeller type:		( ) Aluminum ( ) Stainless steel
Is the boat equipped with trim tabs?		( ) Yes ( ) No
If so what type?		( ) Aluminum ( ) Stainless steel
If yes, are the trim tabs grounded to the power package?		( ) Yes ( ) No
Does the boat have an attached swim platform with mounting hardware?		( ) Yes ( ) No
If so what type of mounting hardware is used?		( ) Aluminum ( ) Stainless steel
If yes, is the swim platform grounded to the power package?		( ) Yes ( ) No
Is there a battery switch in use?		( ) Yes ( ) No
If yes, can the switch turn off the power to the MerCathode controller?		( ) Yes ( ) No
Is there shore power to the boat?		( ) Yes ( ) No
If yes, does the boat have a shore power isolator or an isolation transformer installed?		( ) Yes ( ) No
If yes, what brand?	_____	
Does the hull potential voltage rise with the shore power unplugged?		( ) Yes ( ) No
Has an antifouling paint been applied to:	The drive?	( ) Yes ( ) No
	The transom?	( ) Yes ( ) No

If yes, list the type of antifouling fouling paint used:_____

If applied to the boat hull, is there 2.5–3.8 cm (1.0–1.5 in.) of unpainted boat transom around the gimbal housing? ( ) Yes ( ) No

Name of technical service representative: _____

Dock/Mooring Description

Dock construction/type:	Metal?	( ) Yes	( ) No
	Wood?	( ) Yes	( ) No
Shore line type:	_____		
Water type:	( ) Fresh	( ) Brackish	( ) Salt
Water velocity (speed of movement):	_____ mph		
Docking area:	Number of boats: _____		
	Type of boats: _____		
	Is shore power present on other boats?	( ) Yes	( ) No

Has a stray current check been done? ( ) Yes ( ) No

If so, what was the reading? _____

Test Results

Battery voltage: _____ V

Conductivity

Positive Lead Location		Measured voltage
Suspended aft of drive		_____ mV
List any component with a measured potential greater than 2 mV		
Component 1:	_____	_____ mV
Component 2:	_____	_____ mV
Component 3:	_____	_____ mV
Component 4:	_____	_____ mV
Component 5:	_____	_____ mV

If the conductivity test reading was too high, what was the cause of the high reading?

_____

_____

_____

_____

Hull potential: _____ mV

Anode output: _____ mA

Out-of-Water Resistance Check

Gear housing:	_____ mΩ	Driveshaft housing:	_____ mΩ
Bell housing:	_____ mΩ	Gimbal ring:	_____ mΩ
Trim cylinders:	_____ mΩ	Propeller:	_____ mΩ

Resistance between engine ground and the ground strap on the inner transom plate: _____ mΩ

Galvanic Isolator

Initial reading: _____

Reading with leads reversed: _____

Description of the Corrosion

Have pictures been taken of the corrosion? ( ) Yes ( ) No

Where is the corrosion? ( ) All underwater power package components

( ) Gear housing ( ) Driveshaft housing ( ) Bell housing

( ) Gimbal ring ( ) Gimbal housing ( ) Trim cylinders

( ) Propeller ( ) All anodes ( ) Other _____

If the unit has paint blistering, where? ( ) All underwater power package components

( ) Gear housing ( ) Driveshaft housing ( ) Bell housing

( ) Gimbal ring ( ) Gimbal housing ( ) Trim cylinders

( ) Propeller ( ) All anodes ( ) Other _____

What is the severity of the paint blistering? ( ) None ( ) Slight ( ) Moderate ( ) Severe

What is the severity of the corrosion? ( ) None ( ) Slight ( ) Moderate ( ) Severe

What is the condition of the boat hull?

_____

_____

_____

_____

_____

Inspection performed by: _____