Technical BULLETIN

OX66 EFI MODELS

O_2 Sensor Operation, Testing and Cleaning

INTRODUCTION

The Oxygen Density Sensor (O_2 Sensor) is a vital link in the operation of Yamaha's OX66 EFI engines. The O_2 sensor is connected to the #1 cylinder and measures the amount of oxygen in the exhaust gases within the combustion chamber. The sensor supplies this information to the CDI, which changes the fuel injection map to achieve optimum combustion.

The O_2 sensor is very sensitive and can be fouled or permanently damaged by contamination. A malfunctioning sensor can result in poor performance or engine damage. This bulletin provides information about the causes of sensor fouling, and how to test and service if it is not working correctly.

SERVICE PROCEDURES

Avoiding O_2 Sensor Contamination

An O_2 sensor can be fouled by internal or external sources. Be sure your customer is aware of these possible contamination sources and how to avoid them.

Fuel

- *Poor quality* - Stale or lower quality fuel can contaminate the fuel system and the O_2 sensor. Choose brand-name fuel from a supplier who has good turnaround of the product - fuel blends used now do not have long shelf life. Also, use the correct octane. Yamaha recommends 86 octane (R+M/2), or mid-grade fuel. Today's engines do not require high-octane fuel.
- *Lead Additives* - Lead can permanently damage the O2 sensor, requiring it to be replaced. Although leaded fuel is not for sale in the U.S., it can be a problem for customers who purchase fuel in some other countries (e.g., Canada). Do not use fuel containing lead, even "low lead" blends, unless no other fuel is available.
- *Alcohol* - Excessive alcohol in the fuel can cause problems. Do not exceed the recommended maximum of 10% ethanol. Do not use fuel which contains methanol.
- *Additives* - If an additive is needed, such as to boost octane or condition fuel, the appropriate Yamaha maintenance product or a high-quality equivalent. Some aftermarket additives can harm Yamaha engines or fuel systems, as well as contaminate the O_2 sensor.

Using Yamaha's **Ring Free®** fuel additive on a continuous basis is highly recommended, regardless of the fuel type used.

Oil Additives
The base oil stock is a very low percentage. Different additives are added to help inhibit friction, rust preventers, detergents, carbon inhibitors and ash-less compounds. Remember the old saying, "You get what you pay for." This is very true when it comes to oils. Some additives (whether in small or excessive amounts) could affect the O_2 sensor and require it to be replaced. Phosphates and some synthetic additives could directly affect the sensor and its operation. Today's engines require a 2-stroke oil rating of TC-W3. This is a minimum specification set by the NMMA. Most oils on the market meet this requirement, but Yamalube far exceeds this specification. Yamaha has a vested interest to provide their customers with a reliable product for repeat business. **Yamaha strongly recommends the use of Yamalube 2-M® in all 2-stroke outboard engines**. Refer to the *1999 Outboard Accessory Catalog* for part numbers on the available container sizes for the Yamalube 2M oil.

External Contamination
A common cause for external contamination is the improper use of external engine protection. **The use of silicone engine protection is highly recommended on all Yamaha engines**. However, there is a proper procedure for application. These sprays are not to be ingested into the internal components of the engine. Also, they are not to be sprayed on or around the O_2 sensor cover. Remember, the O_2 sensor uses atmospheric oxygen and compares it to the exhaust gas oxygen levels which determines its signal to the CDI. Even if the cover was sprayed, the protective spray could drip into the internal part of the cover. The internal part of this cover gets very hot. The heat will vaporize the protectant resulting in a contaminated oxygen supply to the internal section of the O_2 sensor. This also holds true if the gasket for the O_2 sensor was leaking oil into the cover. Also, advise customers who wash down their engines with fresh water that water inside the cover will have the same affect.

Set-up and Break-in
Set-up and break-in procedures are very critical for all engines. This information is found in several places (e.g., Owner's Manual, Technical Bulletins, Rigging Specs book and the Marine Technical Update Guide). All of the steps need to be followed. This helps ensure customer satisfaction and confidence in the product and the dealership.

Some acceptable methods with older technology could adversely affect new technology regarding the O_2 sensor. There are two older technology methods that have very adverse affects on the O_2 sensor, they are:

- The use of too much oil mixed into the fuel during break-in.
- Disconnecting the oil link arm when bleeding the oil pump.

Always follow the most current procedures for break-in and engine set-up. **Do not disconnect the oil link arm** when bleeding the oil pump.

Engine Damage from A Contaminated or Fouled O_2 Sensor
An O_2 sensor that is not operating properly has the following affects on an engine's performance:

- Rough idle
- Poor mid-range operation
- Loss of WOT rpm
- Surging
- Unable to obtain WOT operation
- Increased fuel consumption
- Dropping cylinders
- Excessive smoking

O_2 Sensor Pre-testing
Perform the following basic checks on the engine before testing the O_2 sensor:

1. Perform a compression and spark check to ensure the engine does not have any other problems.
2. Install the indicator light (YB-06444) available from Kent-Moore Tools.
3. Check the codes. If a code flashes for a specific failure, repair the problem. If the codes are normal (e.g., "1") but a problem exists, determine what is affecting the engine. Isolate the cylinder or cylinders affected.

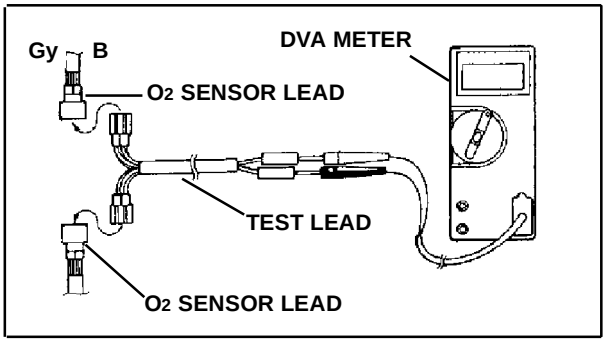
NOTE: It is easier to repair an engine when the affected cylinder is located.

O_2 Sensor Testing
If the O_2 sensor is suspected as the source of a problem, perform the following test:

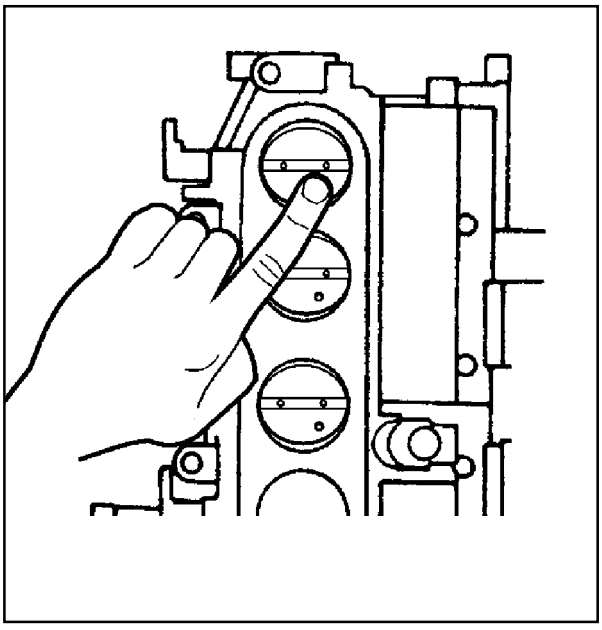
1. Make sure the engine is not running.
2. Remove the air box on the front of the throttle plates.
3. Locate the O_2 sensor wire leads.

NOTE: There are two leads - one will have two white wires. These wires are for a heater that is built into the O_2 sensor. The other lead has a gray and black wire where the test lead is to be connected.

4. Trace the gray and black wire back to the 2-pin connector. Unplug the connector.
5. Install the O_2 sensor test lead (Kent-Moore Number: YB-06767) between the connectors.
6. Hook up a DVA meter to the 2 pig tails on the test harness. Your negative will go in one bullet connector and the positive in the other connector (see illustration at the top of the next column).
7. Set the meter to DCV.



8. Start the engine and ensure it is running at operating temperature (118~126°F or 48~52°C) before performing this test.
9. Watch the meter. The operating range for an O_2 sensor is 0.2~0.9 millivolts. A normal reading is 0.3~0.6 millivolts. The reading itself should be constantly changing. If the reading is changing slowly or staying about the same, the O_2 sensor is likely contaminated.
10. Verify the O_2 sensor operation by covering the hole in the #1 cylinder throttle plate with a finger while the engine is running at idle.

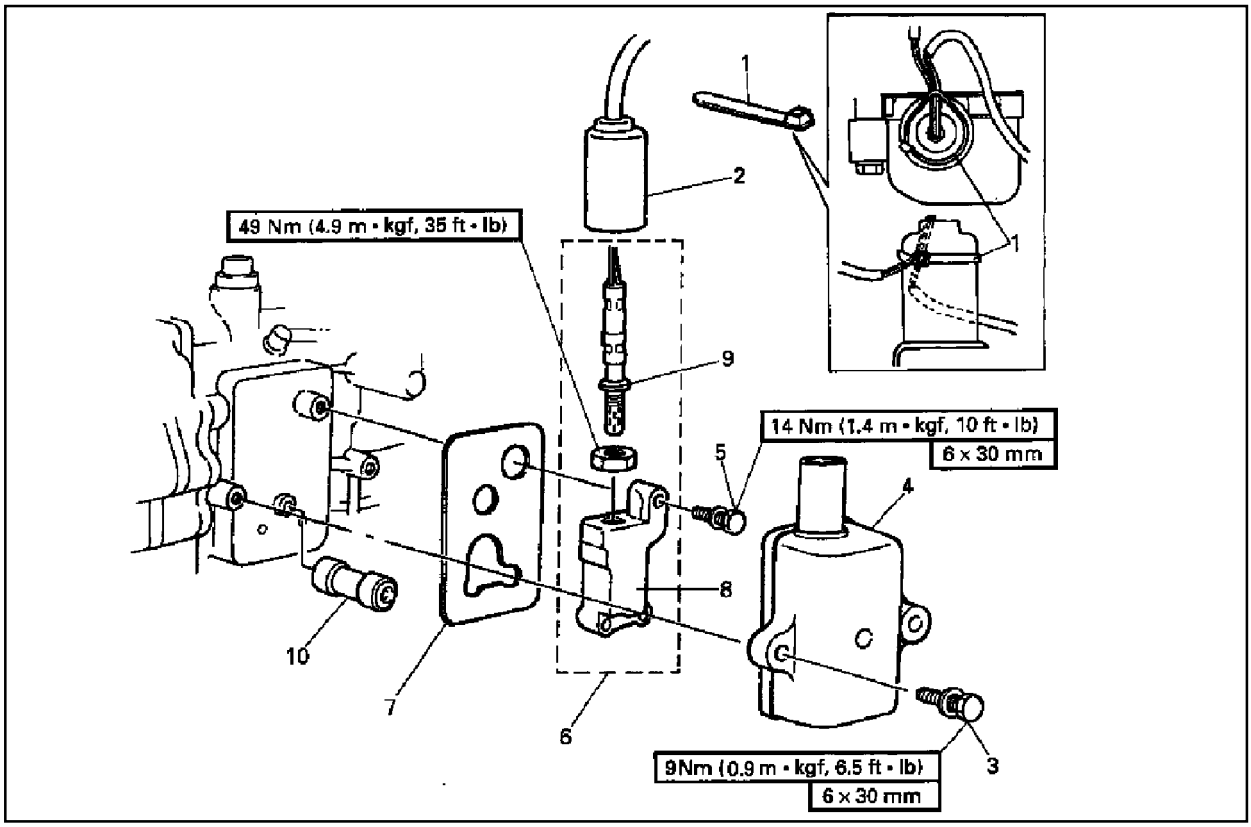


11. Observe the reading. In normal operation, the voltage will first go high then come down. If the finger blocking the #1 cylinder throttle plate hole is removed, the reading should go low and then come back. The sensor should be reacting quickly.

When the engine is running too rich, the O_2 sensor voltage goes higher, which causes the CDI to reduce fuel injection duration. When the engine is running lean, the O_2 sensor voltage goes lower, and the CDI will increase fuel injection duration. **If a change in voltage is not seen or it is slow to react, the O_2 sensor needs cleaning.**

O_2 Sensor Removal

The O_2 sensor may be removed as follows:



1. Remove the tie strap (1) that holds the wires and top boot of the O_2 sensor secured to the cover assembly.
2. Remove the rubber boot (2) by lifting the bottom lip and rolling it up to the top. Be careful not to pull on the sensor wires, because they could be pulled out of the sensor.
3. Remove the two cover bolts (3) and cover (4).
4. Inspect the internal insulation material located in the cover (4). Make sure this material is clean and dry. If it is contaminated, it must be replaced along with the O_2 sensor to avoid re-contaminating the sensor.

5. Use a 22mm wrench to loosen the O2 sensor nut from the holder.
6. Remove the 3 bolts (5) that secure the O2 holder to the block.
7. Remove the holder (8) from the engine block and unscrew it from the O2 sensor. Remove the O2 sensor (9) from the engine and place it on its side. Cleaning and retesting will be covered later.
8. At this point, remove the drawtube (10) from the engine block.
9. Inspect the internal bore of the drawtube. It should be clear without any internal carbon build up.

NOTE: It is normal to have external carbon build-up. Be sure to inspect inside the drawtube hole in the block and check the hole in the cylinder sleeve to make sure this hole is not clogged with carbon. Clean out any blockages and remove carbon from the components. (Combustion Chamber Cleaner, Ring Free, or Contact Cleaner work well for cleaning.) **Do not use any cleaners that contain silicone**.

O2 Sensor Cleaning

When the O2 sensor is removed, inspect the tip. It should be a light brown in color without any carbon deposits or oil. If not, it will need to be cleaned before retesting.

There are several ways to clean the O2 sensor. The sensor could be either soaked or sprayed with a cleaner. The only solvents recommended for cleaning are Combustion Chamber Cleaner, Ring Free, or Contact Cleaner which are available from Yamaha.

CAUTION:

Do not let any silicon anticorrosion solvent touch the O2 sensor or its accuracy will be affected.

If soaking the O2 sensor is intended, use the Combustion Chamber Cleaner or Ring Free. When soaking, soak only the tip of the sensor from the threads down. **Do not soak the sensor from the threads up or the neck**. If the neck is soaked, the sensor will become contaminated internally and will need to be replaced.

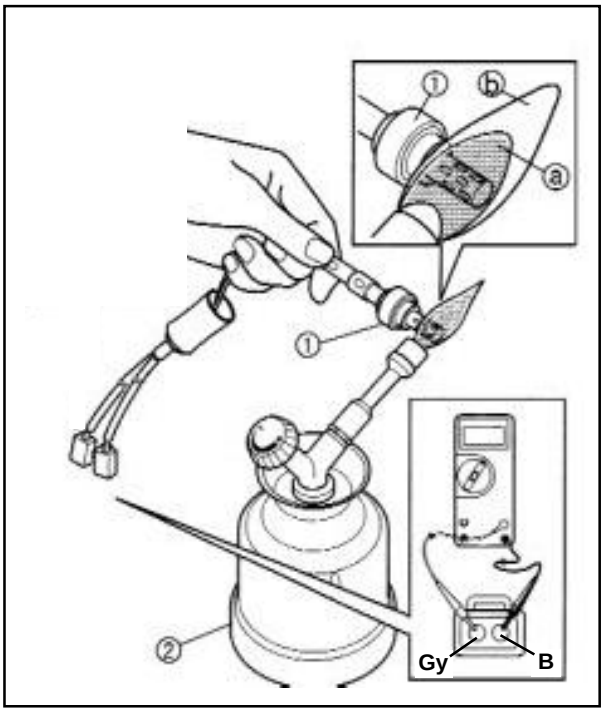
After soaking the sensor, spray off the tip with Contact Cleaner (ACC-CNTCT-CL-NR) and allow the sensor to **dry thoroughly** before proceeding to retest the sensor.

If spraying the O2 sensor is intended, spray the tip of the sensor with Contact Cleaner to remove the carbon build up. Again, allow the sensor to **dry thoroughly** before proceeding to retest the sensor.

O2 Sensor Retesting

Perform the following procedure to retest the O2 sensor after cleaning:

1. Reconnect a digital voltmeter to the black and gray wire leads.



2. Expose the O2 sensor ① to a propane torch ② for approximately 15 seconds.

⚠WARNING

To prevent an explosion when performing this procedure, keep all flammable products (e.g., gasoline) away from the testing area and provide proper ventilation.

CAUTION:

- **Do not use a welding torch. This type of torch may damage the sensor through excessive heat.**

- **Do not heat the O_2 sensor above 1,472°F (800°C) or continuously for more than 1 minute at a time or the sensor will be damaged.**

  This should result in a 0.6V reading or higher. Using a cigarette lighter as an alternate means to heat the sensor should take approximately 2 minutes to reach 0.6V or higher. Time will vary depending on the size of the flame (b).

  Rapid variation in voltage should occur as the sensor is passed back and forth through the blue portion of the flame (a). When removed from the flame, the voltage should drop below 0.3V within 5 seconds as the sensor is blown on or waved through the air to cool.

  If the voltage does not drop rapidly, use Yamaha Contact Cleaner and clean the element. **Allow the element to dry thoroughly**, then repeat steps 1 and 2 again.

If the sensor is still slow to respond, it is an indication of excess contamination and the sensor must be replaced.

ROUTE TO: ☑ SERVICE ☐ PARTS ☐ WARRANTY ☐ SALES

OUTBOARD	4/04/03	O2003-007

Technical BULLETIN

ALL OX66 MODELS

New O2 Sensor Essential Tool (YB-06999) Test Harness and Test Procedure

INTRODUCTION

SERVICE PROCEDURES

Yamaha has developed the O2 Sensor Test Harness (YB-6999) along with a specific diagnostic procedure for the O2 sensor. Together, they will help you properly diagnose running complaints.

Improper diagnosis of the OX66 Fuel Injection System can lead to repeat failures and dissatisfied customers. Many times O2 sensor failures are a symptom, not the root cause of failure. Improper maintenance procedures can result in O2 sensor failures.

Evaluation Tips

When evaluating a unit with a running complaint, consider the following:

1. Today's fuels are changing and a boat sitting for more than two weeks may have fuels that have degraded enough to cause poor performance or component failure. If there is any question about the quality of the fuel, replace it. Also, the use of Ring Free® is recommended on a continuous basis to help maintain fuel system cleanliness.

2. We recommend the use of Yamalube 2-M to ensure the reliability and durability of our engines. You should discourage your customers from using "off the shelf" oils which may contain additive packages that can cause damage to O2 sensors.

3. Verify that all electrical harness connections and grounds are secure and clean from corrosion. This simple but important step is the most overlooked.

Remember that use of poor quality fuel or oil is related to customer use and/or maintenance and should not be covered by warranty.

Diagnostic Testing
The adjacent flow chart was designed to help you properly diagnose the engine when there is poor throttle response or the engine will not reach its normal peak rpm. Refer to Technical Bulletin O99-008 for more O_2 sensor operation, testing and cleaning.

When testing the O_2 sensor with Test Harness YB-06999, perform the following procedure:

1. Install a new spark plug in cylinder #1 to ensure proper combustion.

2. Install the the test harness, replace the cowl, and run the engine under normal conditions (not on a dyno or test tank).

3. Keep the engine between 3000 ~ 4000 rpm and watch the O_2 sensor output voltage. It should be 0.3V $\pm$ 0.1V.

NOTE: If the engine is run outside of this rpm range, the O_2 sensor output voltage will fluctuate over a wider range and may indicate an inaccurate reading.