

WARRANTY INFORMATION

SERVICE INFORMATION

## Gasoline Engines and Water Intrusion

### Models

All gasoline 4, V6 and V8 MerCruiser engines.

### Situation

This bulletin is meant to help marine dealers troubleshoot engines, in or out of the warranty period, that have water intrusion.

Marine engines are built to perform in harsh conditions, including saltwater. The vast majority of these engines perform reliably. Occasionally, an engine inadvertently will have water enter it and this water has the potential to cause damage. This water can be found in the oil or on top of the pistons. Rarely is water found in both locations. Sometimes, water is found inside the exhaust manifold but not inside the engine. To properly diagnose the failure, you need to know where the water was found.

1. Quiz the boat owner when they first report this problem to your dealership about who, what, when, where and how they first noticed the problem. Find out as much information as possible about what occurred just prior to the boater discovering the problem.
2. Ask if the boat sank or had a lot of water in the bilge.
  - a. If this has happened to the boat, drying all electrical components and getting the engine running as soon as possible after getting the water out of the bilge is critical. Once air (oxygen) comes in contact with the submerged components, corrosion will start.

Attach this information to the work order to help the technician when they work on the engine.

### First, Save the Engine

When a product comes in for repair that has water in the engine or the exhaust system, speed is an important factor. The primary goal is to save the engine itself. This has to be done immediately after the boat owner contacts the dealership with the problem.

1. Check engine oil to see if water is in the oil. If there is, change oil and filter.

2. Check for water on the top of the pistons. Remove the spark plugs and inspect them for signs of water. Ground the coil high-tension wire, then crank the engine over to purge any water out of the cylinders. Squirt engine oil into the cylinders through the spark plug holes and crank the engine over again.
3. Install new spark plugs and start the engine. If engine starts, run it at 1300 rpm until it reaches its' normal operating temperature.
4. Write on the repair order where water was found in the engine and what was done to save it. This will help the technician when they are ready to work on the engine.
  - a. When working on an engine with water intrusion, replacing the damaged parts is not enough. The root cause has to be determined and fixed so the boater will not be back later with the same problem.

## **Water Found in Engine Oil**

Refer to information noted on repair order during 1-4 above, preceding.

1. Water in oil, but not on top of pistons.
  - a. Start and run engine the second time at 1300 rpm until it reaches operating temperature. Check for water in engine oil again.
  - b. If water is in the oil again, the most likely reason is an intake manifold gasket or crack in the intake manifold, cylinder head or cylinder block.
  - c. If water is not in the oil again, the engine is sound and the water got in by an unknown way.
2. Water in oil and on top of pistons.
  - a. Do step 1. If water is not in the engine's oil again, then water got on top of the pistons and ran past the rings into the oil pan while the engine was not running. See "Water on Top of Pistons".

## **Water on Top of Pistons**

If water is found only on the top of pistons, the most likely way it got there is through the intake or exhaust valve. Rarely is it caused by a crack in the cylinder head or a bad cylinder head gasket.

1. Water entering through intake valve.
  - a. Sometimes water is found on top of the pistons and it is thought that it came in through the exhaust system. Look for signs of water entering the carburetor or throttle body then going into the intake manifold. The most common cause for water entering the engine this way is rainwater drainage onto the carburetor or throttle body.

2. Water entering through exhaust valve.
  - a. Water entering the engine through the exhaust valve can be caused by many reasons or conditions. Refer to “Water Coming Back In Through the Exhaust System”.
3. Bad cylinder head gasket or cracked cylinder head or cylinder.
  - a. This type of failure normally is in one cylinder only. The water may foul out the spark plug and draw water backward through the exhaust system into the exhaust manifold. The only way to find this problem is to remove the cylinder head and inspect cylinder, cylinder head and gasket.

## Water Coming Back In Through the Exhaust System

Water getting into the cylinders through the exhaust valve or even just getting back into the exhaust ports in the manifold can have many different causes. Unlike automotive engine exhaust systems, marine engine exhaust systems are wet and very close to water. A marine engine's cooling water and exhaust mix at the end of the exhaust elbow on the engine. Because of this, the engine's exhaust system is where water gets back into the engine the easiest. The primary causes for water to get back into the engine through the exhaust system are 1) Engine Running Conditions, 2) Boat's Waterline, 3) Water Ingestion and 4) Engine Exhaust System Component. Each is described in depth following.

## Engine Running Conditions

1. Ignition misfire (fouled spark plug).
  - a. If an engine has a spark plug that is not firing, that cylinder will act like an air compressor and it can draw water backward into the exhaust manifold. Inspect all spark plugs, wires and the ignition system to make sure this was not the cause for water in the engine.
2. Engine run-on (dieseling).
  - a. An engine that continues to run after shutting the ignition key off can draw water backward into the exhaust manifold. Engine can run in reverse direction when it 'diesels'. If an engine 'diesels' when the key is turned off, turn key back on and increase rpm (in neutral) to 1300 for 40 seconds then return engine to idle rpm. Let engine continue to idle for 60-90 seconds and then turn key off. Refer to Service Bulletin 97-17 for additional information.
3. Bad valves.
  - a. Valves that are not seating properly can draw water backward into the engine. Take engine compression. If low, grind valves and seats.
4. Sticking exhaust valve.
  - a. An exhaust valve that sticks in its valve guide can draw water backward. Cylinder will act like an air compressor. Repair cylinder head, as necessary.

## Boat's Waterline

The normal symptom for this problem is the engine ran fine until the boater turned the engine off for a period of time. When they went to restart the engine, it was 'locked up' or it did not run smoothly.

1. Swim platforms and transom plate 'pockets'.
  - a. Rapid boat de-acceleration and then shutting the engine off on boats with either of these can cause water to be forced back up the exhaust system. The sudden rush of water against the boat's transom can 'push' water higher than normal up inside the exhaust system. Boats with exhaust outlets on the side of the hull or that use 'water lift' type canister mufflers rarely will have this type of problem.
2. Exhaust elbow height too low.
  - a. With the boat setting at rest in the water, measure the distance from the boat's water line to the top of the engine's exhaust elbow. Compare your measurement to the specifications in the service manual for the engine that you are measuring. If the measurement does not meet specifications, 3 in. (76 mm) or 6 in. (152 mm), Riser Kits will have to be installed.
3. Too much weight at stern of the boat or boat was 'beached'. The customer has to be quizzed as how the boat was loaded or what was done just prior to the problem occurring. It is important to duplicate what was done to the boat just prior to the customer having the problem.
  - a. If the exhaust elbow height meets the specification, the water could have come in because of too much weight being in the stern of the boat. This weight could be either gear or people at the stern or on the swim platform while the boat was 'at rest' in the water. Equal weight has to be placed at the stern or on the swim platform and then recheck exhaust elbow height.
  - b. If the boat was 'beached' when the problem occurred, do the same and then recheck exhaust elbow height.
4. Exhaust hose/collect/muffler downward angle (engines with thru-hull exhaust only).
  - a. If 1, 2 or 3 was not the cause of the water entering the engine, then the boat's exhaust system has to be examined. Measure the downward angle of all exhaust components from the engine to where it exits the boat's hull to make sure they are within specifications. Make sure no component of the exhaust system is running 'up hill', allowing water to drain backward into the engine. See "Inboard Engine Exhaust Systems" in this bulletin.

## Water Ingestion

Engine cooling water mixes with the exhaust at the end of the exhaust elbow to go overboard. Under certain conditions, a fine mist or droplets of water can be drawn backward into the exhaust passage of the exhaust elbow while the engine is idling. They can travel backward until they 'wet' the vertical exhaust passage. When the engine is shut off, these droplets flow downward and collect in the exhaust manifold runners that go to the cylinder head. In saltwater areas, the water evaporates and leaves a salt crystal deposit in the runner. Over time, these salt crystals will cause rust to form on the exposed surface of an open exhaust valve. When this valve sticks, it will cause more water from the exhaust elbow discharge to be drawn backward into the engine.

This condition is more likely to occur on engines that have exhaust systems that exit out the boat's hull. Sterndrive engines that have thru-prop exhaust are least likely to see this condition. This condition is seen more in saltwater areas, but rarely seen in fresh water areas unless there is a poor engine running condition. Look inside the exhaust passage (at hose end of the exhaust elbow) to see if a salt or rust trail is present from that point on backward toward the manifold. If there is, the engine could have water ingestion.

1. All engines have valve overlap, even 4 cylinder engines. Gen+ V6 and V8 engines have more valve overlap than the older engines. The higher horsepower big block V8 engines have more than the base big block engines. This 'valve overlap' coupled with the 'tuning' of the boat's exhaust system can cause water ingestion. Valve overlap is more likely to cause water ingestion at idle or low engine rpm than it is at higher engine rpm.
2. Extended idling before shutting the engine off.
  - a. This affects an engine with thru-hull exhaust outlets more than thru-prop exhaust models. Because of 'No Wake' zones and other conditions, engines that idle 30+ minutes prior to being shut off, tend to be more likely to have water ingestion. Quiz the boat operator about their idle times. One way to stop or minimize this condition is to increase engine rpm (in neutral gear) to 1300 for 45 seconds then slowly return throttle to idle position and shut the engine off.
3. Throttle 'chops'.
  - a. Doing 'throttle chops' can cause water exiting from the exhaust elbow to be drawn backward into the engine on either thru-hull or thru-prop exhaust engines. Also, it can happen with the boat in the water or on a trailer with a flush device. Caution technicians and boat owners about doing 'throttle chops'.
4. Missing internal shutters in exhaust tips (sterndrive engines only).
  - a. Sterndrive engines with thru-transom exhaust are more likely to have water ingestion if the internal shutters are missing. The exhaust hose length is short on these installations. The internal shutters help break up the 'tuning' effect of the short hoses. Install exhaust tips that have internal shutters that will not burn out or break off. Installing exhaust tip silencers is another option. If there is room in the exhaust hose, installing the Exhaust Resonator Kit will help correct this condition also.

5. Silent Choice type exhaust systems (sterndrive engines only).
  - a. Sterndrive engines equipped with Silent Choice type of exhaust system normally will not have water ingestion if the boat owner directs the exhaust thru-prop while in 'No Wake' zones or while idling for an extended time. If the exhaust system is in the 'thru-hull' mode during this low speed operation, the engine may ingest water if the internal shutters of the exhaust tips are missing.
6. Boat exhaust systems (engines with thru-hull exhaust only).
  - a. Engines with thru-hull exhaust systems can have a 'tuning' effect. Exhaust hose length, 45°, or 90° fittings, location of collector and/or muffler and the thru-hull exhaust tip all can affect water ingestion. The only way to test for this condition is to monitor the amount of water that collects in the runners of the exhaust manifold after idling for 45 minutes. Engine has to be at normal operating temperature before starting the idle test. Using Exhaust Resonator Kits in the exhaust hoses will help stop the 'tuning' affect in the exhaust system. The Mercury Parts Exhaust Resonator Kit does not cause any horsepower loss.

## Engine Exhaust System Component

Just because there are streaks of rust on the outside of the manifold does not mean the elbow gasket was leaking toward the inside into the exhaust passage. The water pressure in the water passages of the engine exhaust system that these gaskets seal is lower than the exhaust gas pressure.

Before disassembly of exhaust system components, always draw a chalk line from the manifold up to the exhaust elbow. Use a single line on one side of the engine and two lines on the other side. By doing this, you can look at how the parts fit together while it was on the engine. This is important when trying to find the cause of the problem.

Drain water from exhaust components before disassembly. If possible, leave exhaust manifolds on the engine and remove just the exhaust elbow (and riser) so you can look down into the manifolds to see the condition of the exhaust ports. Do one side at a time.

1. Inspect gaskets.
  - a. On Fire Ring gaskets, look for a water path from one of the water passages to the exhaust passage. If black exhaust carbon is evident between where the fire ring was on the part's gasket surface and the exhaust opening, the gasket probably did not have a water leak to the exhaust passage. A water leak normally will prevent exhaust carbon from forming. Verify if the fire ring sealed all the way around the exhaust opening of the component on both sides of the gasket.
  - b. On Non-Fire Ring gaskets, look for a water path from the water passage to the exhaust passage. If the gasket has to be scraped off of the component's surface, it probably did not leak.

2. Inspect gasket surfaces. Look at the gasket surface on the exhaust manifold, riser (if used) and exhaust elbow.
  - a. Look for damaged gasket surface. If the gasket surface of a new or used part has a dent, groove or porosity that goes into a water passage, do not use the part.
  - b. Inspect gasket surfaces closely for corrosion. If the gasket surface has areas that are corroded away, replace the part.
3. Internal crack.
  - a. An internal casting crack in the exhaust manifold, riser (if used) or exhaust elbow will usually occur early in the life of the part. Do not confuse the casting's parting line for a crack. Check for freeze cracks. Freeze cracks always have one side of the crack pushed outward. Replace the cracked part.
4. Low inner gasket surface (exhaust elbow only).
  - a. Make sure the inner gasket surface (around exhaust passage) is the same height as the outer gasket surface. If it is not, replace the part.
5. Hole corroded through exhaust elbow (at hose end of the exhaust elbow).
  - a. Inspect exit end of the exhaust elbow for any holes that have been corroded through it. Replace any exhaust elbow that has a hole corroded through it.
6. External exhaust component problems. Several external failures may occur but they will not cause water in the exhaust. These problems will only cause an external leak.
  - a. Cracked casting at the core plug. Most frequently at the 2 core holes in the exhaust manifold, on either side of the exhaust elbow. Occurs when metal plug is installed too deep into the manifold. Seldom seen with a composite plug. Composite plugs has a Torx socket, cast iron plug has square socket and brass plug has hex socket. Rarely happens in risers or exhaust elbow.
  - b. Leaking composite 90° elbow at the bottom of the exhaust manifold. Leak occurs at the thread of fitting. Caused by engine over heat or if used with a closed cooling system that has the exhaust manifolds included in the closed cooling system. Failure is seen more on V8 454/502 cid engines because the 90° elbow is threaded into a partially water-cooled exhaust runner. Very rarely is this seen on V6 or 305/350 cid engines. Correction is to clean threads in exhaust manifold and use brass 90° elbow.
  - c. The V8 454/502 cid exhaust manifolds used a composite core plug on the side toward the cylinder head. If engine is slightly over heated, these plugs may start to leak. Correction is to clean threads in manifold and use either cast iron or brass plug. Make sure the metal plugs clear the cylinder head when the exhaust manifold is bolted up. V6 and V8 305/350 cid manifolds, risers and exhaust elbows rarely leak.

7. Repair.
  - a. Use a gasket scraper or a wide blade 'putty knife' to remove the old gasket. Do not use a wire brush or sanding disk on a drill to clean the surfaces because the surfaces will be rounded. Surface can be machined slightly to clean it up. See MerCruiser Service Bulletin 99-10 for machining specifications. Look around exhaust passage for discolored metal (dark in color). If the metal is dark after cleaning, replace the part.
  - b. Do not remove the paint from the gasket surface of new Mercury Parts exhaust components. This paint is a coating to help prevent corrosion. Sometimes a paint run or a build-up of the ceramic coating is on the gasket surface of a replacement manifold, riser or exhaust elbow. Use a file to remove just that defect. Leave the rest of the surface painted.

## Inboard Engine Exhaust Systems

When working on an inboard engine powered boat, check the boat's exhaust system also.

1. The muffler, collector and exhaust hoses must be supported adequately to maintain proper orientation and to prevent overstressing any exhaust component.
2. The drop in the exhaust hose must be continuously sloping downward so that a low spot does not exist at any point. The exhaust collector or y-pipe must also have the proper downward slope to prevent the retention of water.
  - a. Boats built prior to March 2001: ABYC recommends a minimum drop of  $\frac{1}{2}$  in. per 1 foot (42 mm per 1 m) with an overall drop of not less than 4 in. (102 mm) between the exhaust elbow outlet and the boat outlet.
  - b. Boats built after March 2001: MerCruiser recommends a minimum of 18 in. 457 mm) of exhaust hose be used between the exhaust elbows and the collector, y-pipe, first angular fitting or muffler. This portion of the exhaust hose must have a  $6^\circ$  downward slope for conventional inboards, including ski models, and  $4^\circ$  for V-drives.
  - c. The 496 cid (8.1L) models must be within  $+ or - 5^\circ$  of the exhaust outlet angle on the exhaust elbow.