Flooded Engine

To most people a flooded engine is one with too much fuel for the available air, and the mixture is just too rich for combustion so the engine won't start. At least it won't until we crank the engine to pump some more air through it, and the fuel/air ratio drops back down into the combustible range.

However, in the marine environment there's another much more serious kind of flooded engine – water flooded. This means the engine, or the whole boat, have been at least partly submerged and water has entered the engine through the air intake or the exhaust. When this happens you need to act quickly because severe (and expensive) damage can very quickly result from internal corrosion, or when trying to start an engine with too much water still in the cylinders. Also the methods you need to employ to get a marine engine dried out and back running again vary considerably, depending on whether it's a 2-stroke or 4-stroke. We'll deal only with the common petrol fuelled engines in this article.

2-Stroke Engines

What could be damaged? Lots of engine parts can be damaged by water, but there are two main threats, - First, if lots of water enters a running engine suddenly it can cause a hydraulic lock in one or more cylinders, bending con-rods, twisting cranks and even splitting a cylinder wall. The other big threat is internal corrosion (rust) that can quickly destroy the highly polished/hardened bearing surfaces leading to an expensive bearing failure next time the engine is run.

Quick action is vital. An engine full of salt water will be ruined in **as little as 3 hours**, once it is back above the water surface. Even fresh water can ruin an engine overnight, so it's vital to either get the water out, or add some preservatives to halt any further internal rust. (See the sketch for an explanation of why this small amount of rust can be so damaging)

Has the engine been on the bottom for several hours, or longer? If so there is likely to be some sand or silt inside. So first step when an engine is recovered is to visually inspect for signs that any sand or silt has entered. Open throttles and look into the intake manifold, or up the exhaust. If there is any suspicion of sand or other abrasives in the engine, don't try to start it. Instead, flush the engine liberally with fresh water, then add some preservatives, like WD40 or similar dewatering fluids. Use lots because you won't be able to get it in everywhere easily. Then get it to the workshop where it can be stripped for a proper clean out, as soon as possible. Haven't got any dewatering fluids?, or can't get to the workshop for many hours/days? Then at least fill it with fresh water. Corrosion occurs at a much slower rate under water (less oxygen), so keep the air out by filling the engine with fresh water. Even re-submerging the engine in salt water is better than not doing anything and leaving it exposed to the air.

If the engine shows no signs of sand or dirt getting in, then the best method of getting it cleaned out is to run it. 2-Strokes being crankcase scavenged engines are actually self-cleaning, if you run can the engine so that lots of fresh air, fuel and oil gets through all internal areas. But first make sure we can run it without further damage.

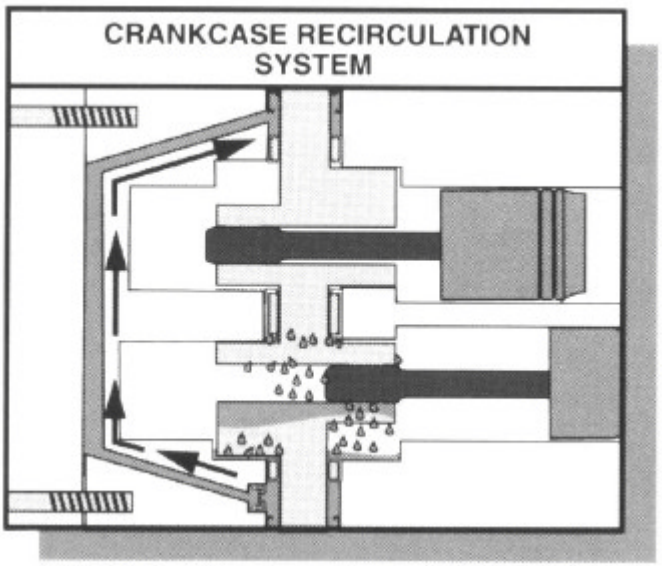
Safety First

If there's no signs of sand/silt inside, then the first thing you must consider is safety. There WILL BE some fuel in the water we remove from the engine, presenting a significant fire risk, so step one MUST BE to disable the ignition system. Methods vary with the brand, but most will involve removing the power supply to the ignition and as an additional safety feature always ground the spark plugs leads to the engine. Some craft, personal watercraft for example, have special grounding brackets on the engine for this very purpose.

Once we've disabled the ignition, remove the spark plugs and drain the carburettors and air box. Now SLOWLY rotate the engine by hand. This is so you can feel if any hydraulic lock damage has taken place inside. If there are tight spots, don't try to start it. Get it back to the workshop quickly and strip it.

No tight spots? OK, now let's get the water out. Make sure the fuel system is NOT connected. We don't want any extra fuel floating around, so leave the carburettors empty. Make sure any electric fuel pumps are disconnected. For portable motors lay them spark plug holes towards the ground. Crank the engine **slowly and**

by hand until no more water is seen coming out the spark plug holes. Then crank the engine faster, using the starter on electric start models. Crank in short bursts of less than 5 seconds each to keep the starter motor's temperature down. It will take several cranks to get all the visible water out. When no more water in obvious, inject plenty of dewatering fluid into the engine.



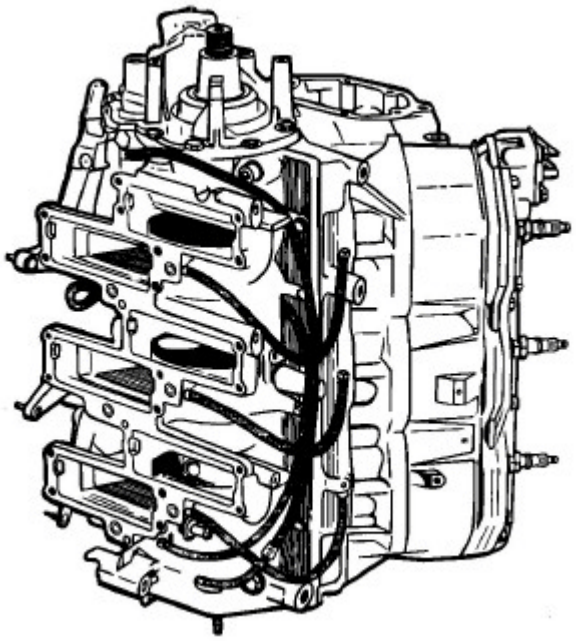
Typical main bearing oiling system on smaller engines

Once all the visible water is out, we can get ready to start it up and finish the internal cleaning job. Before we do, make sure ALL the spilt fuel/oil that came out is mopped up. A nasty fuel fire is very definitely the last thing you need now. Now we need to make sure the fuel and oil systems are re-connected and primed, but ONLY with clean fuel and oil. Did the fuel and oil tanks go underwater too? If they did make sure any water is removed now, before we try to start it.

With all systems re-connected and the mess around the engine cleaned up, now you can re-connect the ignition system, and screw in some dry spark plugs. Prime or choke the engine and attempt to start it. It will usually take several attempts to get the engine to keep running after it initially fires. This is because even after all the cranking there will still be quite a lot of water inside the crankcases and ports. If the engine won't fire at all, it's possible there's still way too much water in there, so disable the ignition again, remove the spark plugs and do several 4/5 second cranks again. Remember that you are cranking an engine with fuel available, and the plugs out so there WILL BE fuel available to start a fire, if there is an ignition source.

Let's assume you've got this far OK and the engine fires up and keeps running. Probably fairly roughly at first because there's always a little water in one or more cylinders. After a few minutes it smooths out and starts to sound normal. Great! You may thinking, we've done it, but you're not finished yet, this is just step one.

Now we must run the engine, with some load so the throttle is opened to get plenty of air through the engine and for quite while, at least 30 minutes. Why? Because the lubrication systems on modern 2-strokes have many small passageways where the fluid travels slowly. Water in these areas takes a long time to be flushed out. Even the smallest two cylinder engines have a re-circulation system to get puddled oil/fuel out of the lower main bearing (where it collects due to gravity) and up to the upper main bearing (which gets no help from gravity), then into the top cylinder where it is consumed.



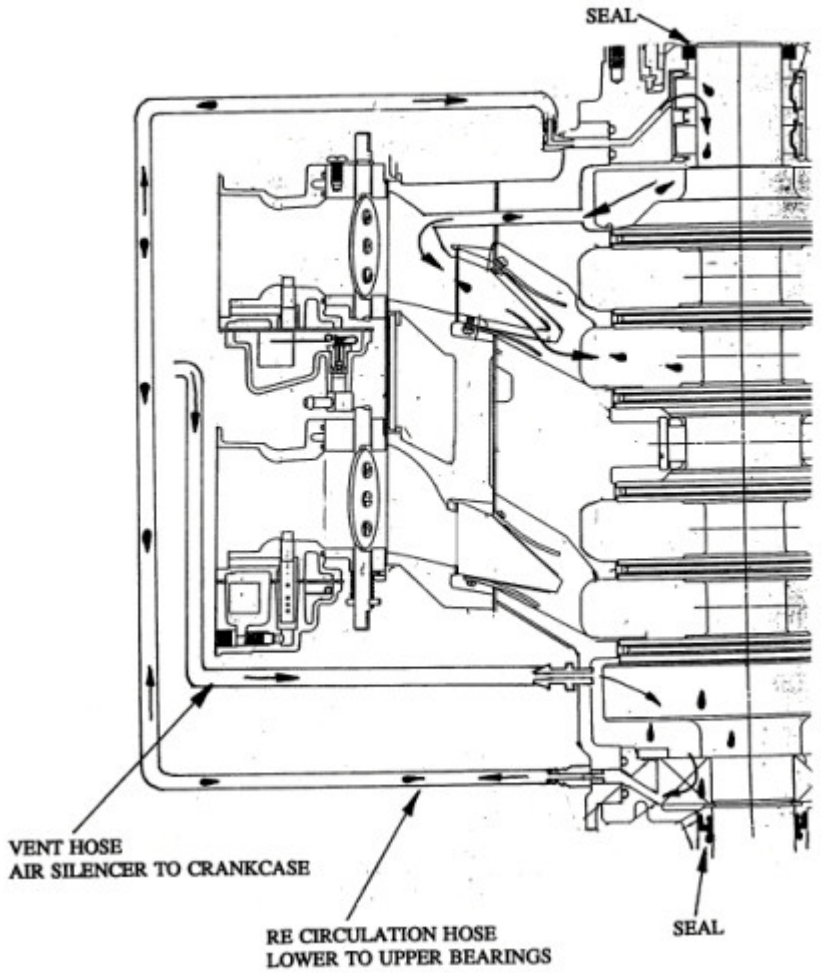
External re-circulation system on a V6 outboard powerhead

Larger engines of 3 or more cylinders have even more complex systems that also drain puddles from some low crankcase areas. These systems will also contain some water after a submersion. Some are external and cleanable (see sketches) while others are hidden from sight and only cleanable by running the engine or when it's apart.

Tests have shown that even 15 or 20 minutes of high speed running still does not guarantee a completely dry engine. Test engines have still contained some water in the main bearings area when stripped down, but because they had been run and there was plenty of fresh oil around, further corrosion had been prevented, at least in the short term.

That may be a different story if the engine was stored for a while, so it's a wise move here to run the engine as long as possible, at least 30 minutes.

What's left? Let's assume again everything has gone OK this far, it's running sweetly and sounds good, but what about all those external accessories that also got wet? Under the flywheel (on outboards) we have at least part of the ignition system, the alternator stator, some magnets and a seal area on the crank. These areas are not quite as critical as getting the water out of the crank bearings and cylinders, but still important and possibly expensive if we forget.



Typical upper main bearing lubrication system on a large outboard

Get the flywheel off and clean up the area. While you're at it, dismantle the starter motor and fuse panel (if fitted). Again clean and dry these areas. Any electrical items on the engine that are not sealed, should now be cleaned or replaced. Don't forget any relays and solenoids. If the whole boat went under then you need to also consider the dashboard instruments, warning buzzer, trim switch and ignition key switch. Most of these are rarely cleanable will usually need replacing.

And don't forget to go right over the wring harnesses, if the boat went down with the battery connected, there will have been some severe electrolytic corrosion going on powered by the battery. This will be evident on any exposed live wire terminals by an corroded, almost sand blasted appearance. Because the corrosion is powered by the battery is will be much more aggressive than Mother Nature's usual and can erode away terminals very quickly. Replace any with these signs.

Is that it? Not quite. Remember how we said getting all the water out is very difficult, and if we leave any in there it's likely to be a big problem later? Most manufacturers now recommend with larger engines at least that you also strip it down for an inspection. For a few hours labour, a couple of gaskets and some O rings, you can really make sure it won't be damaged during the few days or weeks of storage. Performing the above steps can really reduce and/or prevent most damage, but the risk of even one drop of water left on a crank still deserves a closer look.