



Diesel Engine Failure Analysis During Disassembly For Major Repairs

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Introduction

Survey of running engines is done without major disassembly. However, when it won't run right or at all, use the following suggestions.

Professional engine mechanics develop the ability to detect important clues about engine failures during the disassembly of an engine, at the time of major repairs. They don't merely take an engine apart to rebuild it, as is done in many automotive engine shops.

Furthermore, where heavy duty engines are concerned, such as those in marine vessels, remote construction jobs, even battlefield locations during conflict, rapid, partial repairs are done to quickly return the engine to service. This is in contrast to the way smaller engines are taken to engine shops in pleasant places where the sun shines every day, and supplies are plentiful. These worn out smaller engines are completely disassembled, and hot tanked for cleaning. Each component refurbished or replaced, and then completely reconditioned.

Heavy duty engine mechanics use the time of disassembly to identify potential areas of trouble that may have caused the failure, in an effort to avoid future failures. Care is taken not to introduce additional problems during the disassembly, by handling the parts carefully to avoid

dings and scratches. One example of this is to lay a cylinder head on a clean soft surface after removal, to avoid scratching the head gasket sealing surface.

Further, such things as debris, fasteners, tools, or even small shop cloths, falling unnoticed into vital oil, fuel, coolant, or air passages will later cause havoc. Professional engine mechanics cap, plug, tape, or cover all openings as they remove components from the engine. This also results in more timely assembly, as cleaning time is reduced.

Whenever possible, they also avoid doing engine jobs where there is going to be a lot of foot traffic in the work area. Working in very close quarters, such as oil rigs, in ship yards on vessels, and some construction sites, requires careful measures when an engine is opened up. Dust and metal grinding near an engine rebuild is just asking for trouble. In the case of a construction site, it's better to do the engine rebuild either before or after the other personnel are gone. This is a safety consideration as much as anything else.

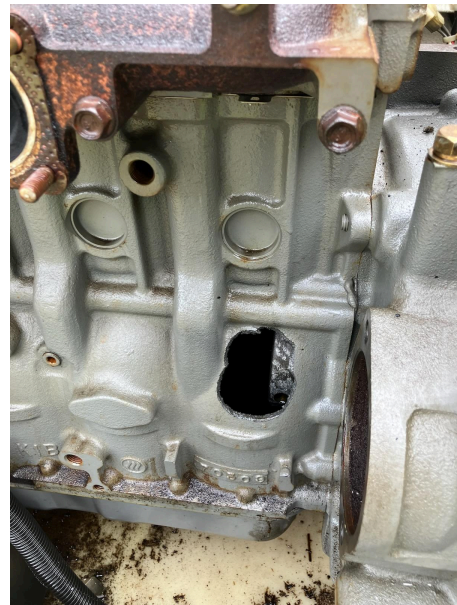
In a truck or piece of heavy equipment it's not too hard to change engines in a day's time. However, on a boat it's no simple matter to replace or rebuild an engine. Hatch covers and bulkheads must be opened, removed, unbolted, or even cut, to pass large and heavy engines, or pieces of an engine, through to the top deck and then back to the engine room after repairs are made.

Point-by-Point Failure Analysis

Following is a troubleshooting tour of an engine during dis-assembly for repairs:

Is the engine paint burned or darker in some areas due to overheating of the engine or some part of the engine?

How does the exterior of the engine look? A hole in the block also indicates severe crankshaft damage.



If the head and upper engine are discolored, watch for signs of internal overheating damage. This damage will include things like cracked heads or a damaged cylinder block.

Are aluminum pieces corroded and iron pieces rusted? If so, the engine may have been chronically wet or even submerged in water. Corrosion will be less in fresh water and worse in salt water.

Does the oil pan or even the cylinder block have a "high water mark" on the outside that indicates swamping, in the case of a marine engine? Is the exterior of the engine dented, scuffed, or are there bent or broken parts on the exterior of the engine? If so, it has had rough handling.

Are there streaks of leaking oil down the side of the engine? This indicates an oil leak, often coming from a valve cover gasket

Are there streaks of white mineral down the side of the engine? This indicates a coolant leak with poorly maintained coolant containing high levels of dissolved solids.

When the oil pan drain plug is loosened, what appears first, water or oil? If water shows first, then there is water (or coolant) in the oil pan. As the dis-assembly progresses, it is vital to find the source of this water in the oil pan.

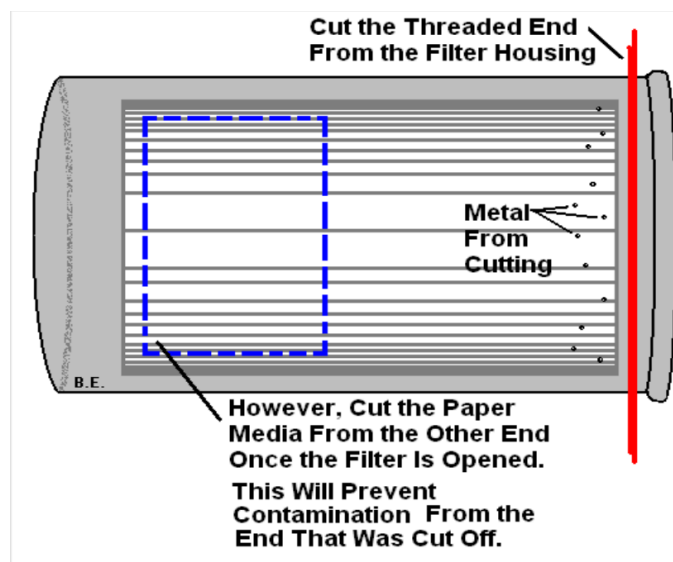
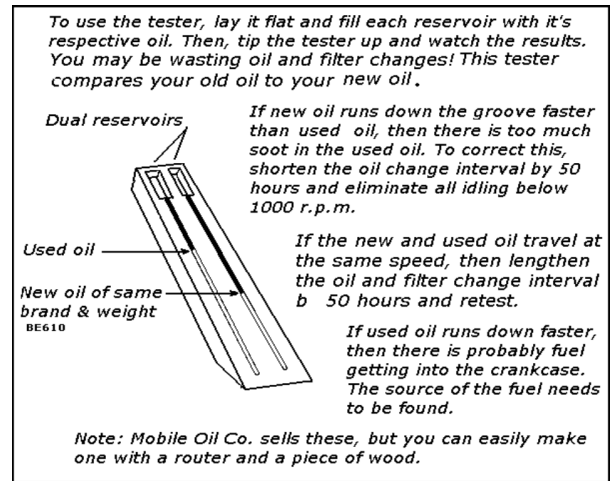
Check the viscosity of the old oil in the oil pan for excess soot. Excess soot predicts high levels of wear throughout the engine.

After cutting open a fuel filter, is it full of rust, algae, or even water? These are signs of water in the fuel. Finding water in the fuel can turn what was supposed to be a quick "in-frame" overhaul into a more costly job because the injection pump and injectors will need to be replaced.

After cutting open the lube oil filter and inspecting the pleats of filter media for contamination, is aluminum present? This is piston material. Are there a lot of black soot particles? This shows excessive piston ring blow-by, too much time between oil changes, or poor maintenance.

Before removing the water pump and alternator belts, notice if they allow slippage, and are they glazed? Are the belt pulleys badly worn? These are signs of belts slipping. If the engine overheated, it is possible it overheated because the coolant pump was not turning as fast as it should have.

If it is important in the context of the job and the urgency of the situation, you can also collect and test the antifreeze for the level of freezing protection and also do a pH test. The coolant must be slightly alkaline in pH to prevent galvanic corrosion from attacking dissimilar metals inside the engine. Inexpensive pH tape is available at most drug stores. Acidic coolant means



the engine you are reconditioning may be going back into a boat, a drilling rig, or another machine, where the cooling system needs thorough cleaning and flushing.

How does the valve cover gasket look? Is the gasket crushed from over tightening of the cover bolts? Over tightening of these bolts, using excessive silicone sealer on a valve cover gasket, or using it instead of a gasket are all signs of a novice. On the other hand, Caterpillar Green (contact cement) or 3M weather-stripping adhesive, applied sparingly, on the valve cover side of the gasket only, are signs of a pro.

Do the engine's gasket surfaces show signs of someone having previously scraped an old gasket off during a previous rebuild? If so, the engine has been rebuilt previously. If not, it may be that you are rebuilding the engine for the first time since it was new. Are the scraped surfaces gouged or scratched? If so, you are not the first to repair the engine.

Inspect fasteners as they are removed. Are the fasteners you are removing all similar and of the type the manufacturer used when the engine was new? Or does the engine have a mixture of some factory and some aftermarket fasteners? These are more clues to help you learn if the engine has been repaired previously, and if the job was done well.

Is the bottom wear surface on the rocker shaft excessively worn? This will show the engine had a high amount of hours on it. If so, new rocker arms and shafts will need to be ordered.

Also notice the valve setting before you remove the rocker arms, after checking them for looseness or over-tightness. This can tell you the engine's state of tune and indicate poor maintenance if loose.

Loosen the valve adjustment lock-nuts and back off the valve lash before removing the rocker arms. This will help you avoid bolting the rocker arms back onto the engine in a bind as you reassemble later on. This is important because the cylinder head valve faces and seats will be cut during the rebuild, or replaced to new specification, and the valve stems may protrude upward through the valve guides a little higher after the heads are done.

Note: Before removing the head bolts, be sure to remove the injectors, because the injectors sometimes take a little force to remove. Injectors are easier to remove while the heads are bolted securely to the engine. Injector tips also often protrude through the cylinder head and will be damaged if the head is set on a workbench, so remove the injectors to prevent injector tip damage.

Be sure to notice the level of head bolt tightness as the bolts are removed. Are they uniformly tight? If not, they may not have been tightened properly, or one may have been missed during the tightening procedure. If you find one that was not tight, notice which cylinder it was near. Then, once the head is off, make note of any places the head gasket may have blown out. These places will show darkening or actual destruction of the head gasket.

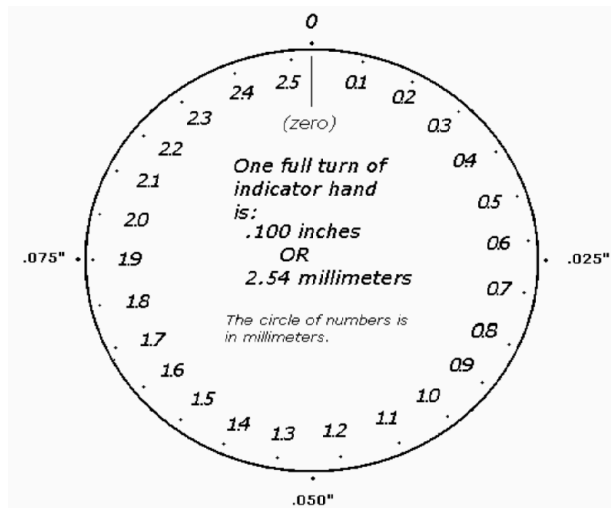
Any engine will have a certain number of head bolts under the valve cover, protected from the elements. These “inside” bolts will have no paint on their heads.

There will also be a certain number of “outside” head bolts. However, these bolts will have painted heads from when the engine was painted.

As you disassemble the engine, make note if any painted bolt heads are found under the valve cover. Likewise, notice if any of the unpainted bolts were used as “outside” bolts. If any irregularity is found here it will prove previous service work, and also poor quality engine work.

Head bolt threads should have been lubricated during assembly, according to the manufacturer’s directions. Most often engine makers call for engine oil on the threads of the bolts and under the head of the bolt. They should not be lubed with Never-seize compound, also known as anti-seize compound. The compound is a thick paste often containing minute flakes of graphite, copper, nickel, molybdenum, and grease. The compound works great on exterior engine bolts, but it should not be used on bolts inside the valve cover or crankcase, because the residue will contaminate any oil analysis sampling that is done on the engine.

As the head bolts are removed, smell the oil on the bolts. If the engine has been overheated it will have a very strong burned smell.



Can you wiggle the valve stems a lot? Put a dial indicator on the stem and measure the movement. How does this amount of movement compare with the service manual specifications? If the guides are far out of specification, the engine, or at least the heads, will have a lot of running time.

When removing the push-rods, keep them in order. As the push-rods are removed, check to see if they can be rolled smoothly on a flat surface. If so, they are straight. If not, they are bent. A bent valve actuating push-rod tells you that a valve contacted a piston. Can you

see a mark on any of the pistons that will verify this contact?

Another important check for hollow tubular push-rods, like those used in older Cummins engines with PT fuel systems: Hold them up by one end and tap them gently with a hammer and make sure each will “ring” with the same resonance as the others when tapped. This indicates they are not filled with oil. When one has a different tone than the others, then it does have oil inside and must be replaced.

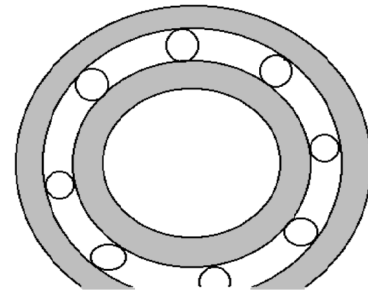
Inspect the head gasket surfaces on the head and block immediately after removing the head. Watch for discolored areas where coolant or compression may have been poorly contained.

Similarly, watch for a deep scratch or gouge under a critical area of the head gasket. Scratches will let fluids pass under gaskets, preventing them from holding pressure.

Watch for bolts that are mismatched, wrong length, or of various strength ratings, and bolts with painted heads inside of the engine covers. This includes the flywheel housing, the timing gear cover, and the oil pan and the valve cover. Mismatched bolts are signs of poor or sloppy workmanship.

Inspect the inner race of any ball or roller bearings, because the inner race being of a smaller diameter, takes most of the wear.

When inspecting the head or heads further, look for cracks between the exhaust valve (often the smaller diameter valve in each cylinder) and the injector hole. Cracks here prove overheating occurred. Are there gouges on surfaces where gaskets have been scraped?



*When inspecting needle, ball or roller bearings, always pay special attention to the inner race!
Per revolution, the inner race gets considerably more use.*



If time permits, lay the cylinder head on its side and fill the upward facing ports with water. Then use a blow gun and shop air pressure to blow back through the valve seats. If the seats are weak, air will bubble in the water filled port.

Is the head straight, flat and true according to a straight edge? If not, it has been overheated.

As the exhaust manifold is removed, is there any trace of red (rust) in the intake or

exhaust ports of the head or the passages of the exhaust manifold? If there is, this is a sign of water in the corresponding cylinder.

Looking into the exhaust ports of the head, are all of them flat black in color and tone? This is good. It shows that the cylinders were in good shape and that each was probably doing its share of the work of keeping the crankshaft turning.

Or, are one or more of the exhaust ports a shiny wet-looking black color? If so, this indicates the possibility of weak cylinders, and especially cylinders that are low on compression and not completely burning the fuel.

Do the engine fasteners on the exterior (out of the crankcase) bolts have never-seize on them? Good! This is a sign of prior repairs, with craftsmanship. However, if interior bolts have never-seize on them, this is not good, and is the sign of a novice at work. As mentioned above, never-seize compound inside of the crankcase will cause faulty oil sample results. Never-seize compound will make an oil sample from a sound engine appear as though it is self-destructing.

After the cylinder head (or heads) is removed, it is time to check the tops of the pistons for evidence of contact between valves and pistons. This is a sign of overspeeding, or can also be a failed rod bearing with its extra clearance.

Are the O-rings hard on the lube oil pump suction tube? This could explain damage to the crankshaft bearings even when there is no fuel in the oil. Hard O-ring seals on the suction side of the lube oil pump will aerate the lube oil, as will faulty suction pipe gaskets and loose bolts on the pipe.

What is the condition of the main and rod bearings that are farthest from the oil pump? If the engine runs low on oil, these will be damaged first.

Are the oil pump gears deeply scratched? The gears are supposed to be soft, so that hard particles will embed rather than lock the pump gears. Scratches, though, do indicate contaminants in the lube oil system.

What is the condition of the water pump impeller? If it is missing a blade, the missing blade may be trapped in the cooling system. It also means the engine may have been running hot.

Also spin the water pump to check its bearings. Either way, water (coolant) pumps are most often replaced or reconditioned during extensive large engine repairs.

Is the crankshaft rear main bearing sloppy? This indicates extreme crankshaft wear and poor maintenance.

Are all locating dowels present on the front and rear cover and top of the block? Note: On certain engines the locating dowels protrude upward from the cylinder block and they are what aligns the head gasket and the head itself to the cylinder block.

Take the lid off of the injection pump (if it has one) and look for rust in the pump. If there is rust in the pump, the injectors and injector lines must be replaced.

Is the flywheel ring gear worn in several spots? If so, order a new one.

Inspect the crankshaft vibration damper. If it is constructed with a rubber ring between the inner hub and the outer weighted ring, check for deterioration of the rubber ring. Also check the alignment between the inner hub and outer ring. If either the rubber is bad or you find misalignment, replace the unit.



Note: The author received extensive engine experience in Kodiak, Alaska, Some of that time was spent in this building on the docks off os Shelikof Street.