

Surveying a Diesel Engine - Engine Start Up

It is not possible to survey an engine properly unless it can be run. If the boat is out of the water then hook up an adequate water supply either directly to the raw water pump or to the inlet through hull. Running the boat out of the water will not cover all the following checks but it will give a good indication of the engine condition.

1. Pre-Start Checks:

Throttle mechanism - Before you start the engine check for full and free travel from stop to stop. Be sure the throttle arm returns to the idle stop.

Cable stop mechanism - Check for full and free travel, ensure the spring returns the lever to the run position.

Solenoid stop mechanism - Check the wiring is good, particularly push on terminals that often vibrate loose.

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2. Start the Engine and Check:

Instant Start - A good engine should start instantly, and not need several turns of the crankshaft before it kicks into life. Cold weather starting will take a little longer as cold metal absorbs heat from the compressed air. If there is some delay then shut the engine off and start again. This time the engine should start instantly. Instant start confirms good compression, good fuel delivery and atomization, good battery, starter and more, so is a very important check.

Although some older designs need oil to improve compression, starting fluid should never be necessary. If a diesel will not start without starting fluid then the chances are it is severely worn. If the engine will not start or proves difficult to start follow the Trouble Shooting Guide.

Oil Pressure - Should show with 15 seconds of starting or shut down the engine. Pressures vary between engines and will be higher when cold. Consistently low oil pressure suggests a worn engine.

Exhaust Smoke - Will indicate a number of factors. Modern designs are more environmentally conscious producing little smoke but an older engine may produce light smoke even in good condition. It is usual to have smoke during and immediately after starting but this should clear to almost nothing within the first few minutes. Excessive smoke indicates a number of possible problems.

Noise and Vibration - With the engine running listen and feel for anything abnormal.

Leaks - Look for oil, coolant and raw water. Check for fuel and air leaks around the injectors. Soot deposits indicate poor gas sealing of the copper seat washers.

Heat Exchanger Function - The purpose of the Heat Exchanger and Oil Cooler is to remove heat from the engine. A simple check of comparing holding the raw water inlet and outlet pipes will give a good indication of the heat being transferred. The inlet pipe should be little above ambient, and the outlet should feel WARM. If the outlet feels HOT these is too little water passing through the heat exchanger so check the raw water pump, strainer and exhaust injection elbow. If the outlet feels COLD then water flow is good but heat transfer is poor. Check the cleanliness of the heat exchanger on both the raw and coolant side.

Good Water Flow - With the engine running the exhaust outlet will give a good indication that the pump is working well.

Raw Water Temperature - At the injection elbow water hose. The temperature should be warm. High temperature suggests poor raw water flow, low temperature suggests poor heat transfer - check the heat exchanger.

Thermostat Operation - If a temperature gauge is fitted then the temperature should gradually rise from cold to operating temperature as the opening thermostat begins to control the temperature. A sticking thermostat will allow the temperature to rise well above operating temperature before it opens, or if it is already stuck open the engine may take a long time to reach the correct temperature.

Charging - Check the alternator output. The charging light should go out immediately after start up although some installations require RPM to be increased above idle. If an ammeter is fitted in the circuit then it will show output as soon as the alternator starts charging. Standard alternators will initially charge at high rate but decrease rapidly

as battery voltage increases. Alternators typically control voltage at 14 to 14.5 volts. Measuring voltage between the + output terminal and the casing ground will confirm output.

Check Transmission - Check positive selection in both directions.

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3. Increase RPM to Mid-Range and Recheck the Points Above, Plus:

Check No-Load Max. RPM - If a tachometer is fitted, briefly push the throttle to maximum and check the RPM. The engine should be within 10% of the rated RPM which is usually stamped on the injector pump data plate or can be found in the engine specifications. Failure to reach no-load RPM could just be a faulty tachometer, which is common, but more often suggests other problems.

Surveying a Diesel Engine - Controls and Instruments

Throttle Lever - If a separate lever, place on bottom stop and check the engine throttle arm fitted to the governor or fuel injection pump is hard against the idle adjustment stop. Move the lever to the top stop and check the engine throttle arm on the engine is hard against the maximum adjustment stop. Move the lever through its full range and check for smooth and easy travel.

Gear Change Lever - If a separate lever, a positive detent should indicate neutral. In this position check the selector arm on the gearbox is in mid position and the cable meets it at 90°. Move the gear change lever to the forward position and check the gearbox selector arm has moved well forward of that need to select forward drive. Repeat for reverse selection. Selection should be smooth and positive with adequate movement of the selector arm. If a manual for the gearbox is available it pays to check selector arm travel meets specifications.

Single Lever Controls - Combine both throttle and gear change selection into a single lever. The rules above apply with the additional requirement that positive gear selection should be made before the throttle is advanced. Otherwise the RPM will be increasing before the engine is put into gear - this can cause premature gearbox failure.

Control Cables - The cockpit end of the control cables are usually well hidden and almost impossible to access for inspection. The engine end should be checked for corrosion and splitting of cable outer sheaths. Cable runs should not include sharp bends or the inner will have difficulty sliding. The end of the outer should be well clamped with unrestricted travel of the inner.

Engine Control Panel - Check for broken lenses on the instruments. Remove panel and check connections behind are tight and show no signs of chafing or shorting. Corrosion is a major problem with cockpit mounted panels.

When the ignition is turned on gauges should "zero", warning lights should glow and the alarm should buzz or ring. Start the engine and warning lights should extinguish, the alarm should stop and the gauges start to indicate. Alternator driven tachometers may require the engine to be raised above idle before RPM registers.

Surveying a Diesel Engine - Sea Trial

1. Check Engine Under Load

If the boat can be taken out to a clear stretch of calm water, operate the engine at gradually increasing RPM. While under load visually inspect the engine especially for leaks and vibrating components. Note any exhaust smoke, oil pressure and water temperature.

2. Check Maximum Achievable RPM

Theoretically with the correct transmission and propeller the engine should reach the "MAXIMUM or ONE HOUR RATING" at the same time the boat reaches hull speed. This rule ensures the engine will not be overloaded and works well for performance boats but most cruising owners would feel the engine was racing at normal cruising speeds.

The engine should never be overloaded but as a general rule slight over propping that keeps the maximum achievable rpm within 10% of the manufacturers "CONTINUOUS RATING" will produce adequate thrust for slow speed maneuvering, a comfortable cruising RPM and a maximum RPM that will not overload the engine. In effect this is derating the engine closer to a commercial rating. It means you won't get as many horsepower out of the diesel but it won't be working quite so hard and will last much longer. Remember the governor has not been adjusted so a heavy hand on the throttle may cause overloading that will show as black smoke from the exhaust.

Surveying a Diesel Engine - Coolant System

Warning: Never attempt to check the coolant while the engine is hot. Removing the pressure cap can result in scalding water spraying the engine bay. Wait until the engine has cooled below 120°F. or just feels warm to the touch.

Coolant - Level should be checked daily before starting the engine. Coolant should be visible with the cap removed or where access is poor a finger should feel the level. Expect an air pocket on a cold system that has no expansion tank fitted. Coolant should look clean at all times. Color should be strong indicating adequate water/coolant mixture. Brown discoloration is due to corrosion often promoted by overheating.

Pressure Cap - Check cap is the correct pressure for your engine. Usually 7lb or 14lb. Check for good seal - stains on the header tank will indicate leakage. Remove cap and check spring and the sealing faces on both cap and tank. Corroded caps should be replaced.

Header Tank - Usually made from aluminum, often with integral heat exchanger core. Corrosion can be a major problem on older engines especially hose connections and heat exchanger end caps. Look for tell-tale signs are white corrosion products growing out from joints and under the hoses - if present strip for closer inspection.

Heat Exchanger - Check for external corrosion and leaks.

Expansion Tank - Not always fitted, but a good design feature that keeps the header tank topped up. Check level is close to hot or cold mark as appropriate. Tanks are often discolored and seldom cleaned!

'V' Belt - Check correct tension and deterioration of belt.

Circulating Pump - Check bearings and look for seal leakage

Hoses - Look for deterioration, usually visible with external cracking splits and swelling of the ends. Some "ballooning" is normal but if excessive indicates failure is imminent.

Hose Clamps - For tightness and corrosion

Freeze Plugs - Check for corrosion. First signs are usually pin-prick sized holes, or bubbling of surface paint.

Surveying a Diesel Engine - Electrical System

Engine and Domestic Battery(s) - Externally inspect for cracks and splits in the casing. Bulging indicates buckled and swollen plates. Check terminals for corrosion, tightness and good crimping of the wire fittings. If wet lead-acid batteries - remove caps and check cell electrolyte which should be within the level marks on the outside of the case or up to the base of the filler neck. Inspect plates which should not be buckled or swollen nor should there be white sulfation deposits.

Check voltage with a multi-meter. 12-volt batteries should read between 12.2 and 12.7 depending on their state of charge.

Battery Selector Switch - Check operation. Inspect the terminals for corrosion and tightness. Check casing for cracks.

Ground Isolation Switch - As above.

Ignition switch - Often vulnerably located close to the helmsman out in the elements. Corrosion is a common problem with the key mechanism seizing and terminals corroding.

Start Switch - If not part of the ignition key switch, is usually the push button type covered in a protective rubber boot. These do not suffer quite as much but check for corrosion.

Starter - Check attachment bolts and terminals are tight. Check for corrosion particularly on starters that are immediately below wet exhaust injection elbows. Extensive external corrosion may be caused by a high bilge water level when the starter should be stripped for further investigation. Burnt paint on the motor housing shows the starter has been abused and overheated.

Alternator - Check output. The charging light should go out immediately after start up although some installations require RPM to be increased above idle. If an ammeter is fitted in the circuit then it will show output as soon as the alternator starts charging. Standard alternators will initially charge at high rate but decrease rapidly as battery voltage increases. Alternators typically control voltage at 14 to 14.5 volts. Measuring voltage between the + output terminal and the casing ground will confirm output.

"V" Belt - Check condition and tension and correct alignment

Ground wire - Remove the ground wire from the block and check for corrosion. The contact faces must be clean and should be treated with a corrosion inhibitor.

Isolation Diodes - Check for corrosion and tight terminals. Look for any signs of overheating. Suspect diodes can be continuity tested with a multi-meter. With resistance selected, meter should read open circuit with the leads attached to the input and output connection and near short circuit with the leads reversed.

Wiring - Check particularly for loose wiring, chafing and signs of burnt or melted insulation. Any of which suggest a short circuit or overloading that could lead to fires. Wiring MUST be of an adequate size for the current it has to conduct.

Surveying a Diesel Engine - Intake and Exhaust System

Intake Filter - Remove the intake filter and check the condition of the element. If dirty clean or replace. If no filter is fitted check inside the inlet manifold for anything that may have inadvertently been sucked in. Excessive oil on the filter or inside the inlet manifold suggests worn piston rings and cylinders are causing a high crankcase pressure.

Crankcase Breather - Remove the hose that connects to the valve cover and check for blockages.

Exhaust Manifold - Check the tightness of the attachment nuts and bolts especially on engines which have heavy manifolds that incorporate header tanks and heat exchangers. Leaking manifold gaskets are the first signs of loosening.

Exhaust Injection Elbow - Salt or corrosion products indicate a leak caused by severe corrosion. First indications are usually small pin-prick sized holes adjacent to the point where raw water is injected into the elbow. Soot deposits by the mounting flange indicate a loose joint or gasket failure. Check tightness of attachment bolts which loosen through high temperature and settling of thick gaskets. Remove and inspect internally every other season.

Hose Clamps - Inspect for corrosion and cracking. Exhaust hose should always be double clamped throughout its length.

Lift Box/Muffler - Metal mufflers, even stainless, suffer from corrosion. Plastic lift boxes and mufflers suffer from split welds mostly through over tightening of exhaust hose clamps. Glass fiber boxes are usually maintenance free and provide long service.

Exhaust Hose - Check for cracking, softness, delamination, kinking and corrosion of the reinforcing wire.

Surveying a Diesel Engine - Fuel System

Remember: - if you disturb any components you must bleed the system of air afterwards.

Filler - Check for good sealing especially deck mounted caps that are often under water.

Filler hose - Difficult to access and therefore neglected. Make sure fuel resistant hose is used. Check hose and clamps.

Tank Breather - Fittings prone to corrosion and blocking. Popular place for insects to build nests.

Tanks - Periodic opening of the inspection cover (if fitted!) to clean accumulated water and sediment is advised. The frequency depends on the quality of fuel used plus the age and material of the tank. Inspection cover seals must be made from fuel resistant materials. Most seals will deteriorate with age and even the best materials will eventually break up and block fuel lines. Steel tanks corrode internally producing constant debris. Inspect stainless tank welds, which suffer from corrosion and fractures. Flexible tanks have limited life and can be prone to chafe.

Tank Drain - If fitted, annually drain off any water and sediment.

Tank Fittings - Check for tightness and leaks. Pick up tubes should reach the lowest point of the tank to prevent build up of sediment which will clog the primary filter next time the boat experiences rough weather. Tubes are prone to blocking with larger debris.

Fuel Valve - Check for smooth operation and full travel.

Supply Lines - Check for leaks, deterioration and tightness - clamped hoses that rotate on hose barbs are loose.

Primary Filter - Inspect bowl for water, dirt and algae growth. Remove the element and check condition.

Lift Pump - Check for leaks and external corrosion. Some pumps have an integral filter gauze which can be inspected by removing the top cover.

Secondary Filter - Check for external fuel leaks and general cleanliness. Secondary filters are often neglected.

Injector Pump - Should be firmly attached to the engine. Check all connections for leaks.

Injector Pipes - Check for tightness. Long runs should be supported to prevent fatigue cracking. Pipes must not be corroded externally.

Injectors - Check for fuel and air leaks. Soot deposits indicate poor gas sealing of the copper seat washers.

Return Lines - Check for leaks.

Cold Start Devices - Check wiring and operation

Surveying a Diesel Engine - Mechanical System

Engine Block - Check for loose bolts holding casings and components together. Tell-tale signs are leaking gaskets, black or rusty dust or rattling components.

Crankshaft and Reciprocating Components - Turning the crankshaft by hand 2 full turns will indicate any undue resistance.

Freeze Plugs - Check for corrosion. First signs are usually pin-prick sized holes, or bubbling of surface paint.

Cylinder Head Gasket - Check for leaks at the joint between the block and the cylinder head. A leak will obviously be more evident with the engine running, but usually a black oily residue will suggest leakage.

Engine Alignment - Rotating propshaft by hand will give a good indication of engine alignment. If tight then disconnect the coupling and check properly.

Adjustable Engine Mounts - Check all adjustment nuts are tight. Lower nuts tend to wind down. Black or rusty dust indicates mounts are loose and fretting. Check bolts holding the mounts to the beds are tight. Rubber mounts tend to settle with age - this is acceptable providing the engine is re-aligned. The rubber should not be split or separating from the metal. Corroded mounts make engine alignment almost impossible and should be replaced.

Surveying a Diesel Engine - Oil System

External Leaks- Nearly all engines have very slight oil leaks from seals and openings. Earlier engines placed less emphasis on gasket and seal design so expect more leakage. External leaks become more pronounced with age and use and can be a good indication of engine life and its quality of maintenance.

Oil - Oil will get blacker as normal combustion contaminants increase. Check for sludge, milkiness, very thin oil, strong diesel smell and metal.

Oil Level - Should be above the low mark and ideally close to high mark.

Oil Pressure Gauge - Many factors effect oil pressure especially oil grade, age, and temperature. As bearings wear and clearances increase the oil system has to work harder to maintain oil pressures. Therefore the oil pressure can give a very good indication of the general condition of an engine. Pressures are typically 40 - 60psi at idle on cold startup. Pressure must show on gauge within 15 seconds or shut down the engine and locate the problem. At high rpm these pressures should be maintained but will drop as the engine reaches operating temperatures. When returned to idle a hot engine may show pressures below 20psi. Low pressures throughout the operating range may indicate a well used engine but check the oil system specification before taking serious action.

Oil Pressure Warning Lights and Alarms - Use switches that operate at very low pressures. The light should extinguish within seconds of the engine starting, and should never show while the engine is running. When the engine is shut down the longer it takes for the oil light to come on the better the condition of the engine.

Exhaust Smoke - Oil in the exhaust gases will appear as predominantly white smoke with a hint of blue. Such smoke usually suggests a worn engine with many hours, it could also mean a simple seal has failed

Surveying a Diesel Engine - Raw Water System

Through Hull Fitting and Valve- Check for leaks, corrosion and good sealing. The valve must operate easily, but depending on the type may require a locking screw to be loosened before the valve can be turned. Some composite valves require part of the body to be slightly unscrewed before the valve will turn. Never force a tight valve especially if the boat is in the water.

Raw Water Strainer - Remove any debris from the basket. Check for leaks from seals and gaskets. Check for corrosion particularly on wing nuts that hold covers in place.

Hoses and Clamps - Check for tightness and corrosion.

Raw Water Pump - Check for leaks from the front cover gasket. Corroded cover screws are common, often severe enough for heads to be missing. Check the pump body drain hole for signs of raw water or oil. Slight seepage will not cause serious problems but any thing greater means the pump should be stripped and reconditioned.

Heat Exchanger - Check for external corrosion and leaks.

Exhaust Manifold - Some engines have raw water cooled manifolds that are prone to internal corrosion.

Waterways are the first to suffer and become restricted. Remove any hoses or covers to inspect properly.

Anti Siphon Valve - Remove the valve and blow through from both directions to confirm it's clear and functioning as a one way valve. Some Anti-Siphon valves just have a small overboard hose fitted with no valve.

Freeze Plugs - Check for corrosion. First signs are usually pin-prick sized holes, or bubbling of surface paint.

Zincs - Remove the zinc to check its condition There could be several in the raw water circuit so be sure to check them all.