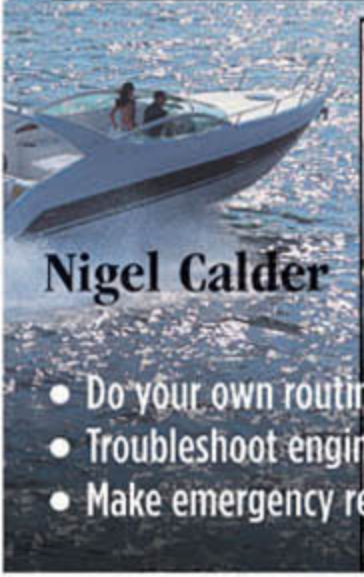
Captain's QUICK GUIDES

Diesel Engine Care and Repair

Waterproof



Nigel Calder

- Do your own routine maintenance
- Troubleshoot engine faults
- Make emergency repairs at sea

☐ Powerboats ☐ Sailboats ☑ Both

INTERNATIONAL MARINE

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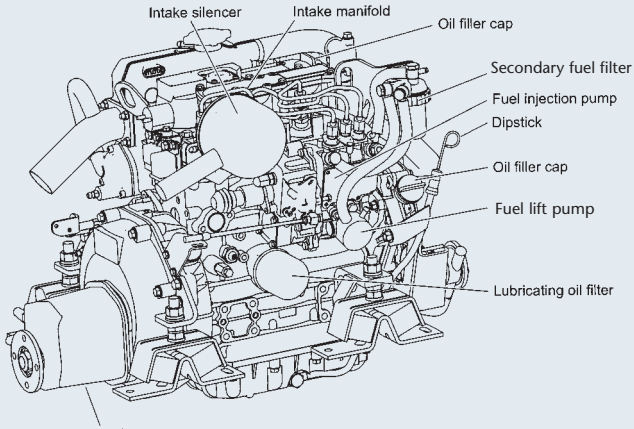
Meet Your Diesel Engine

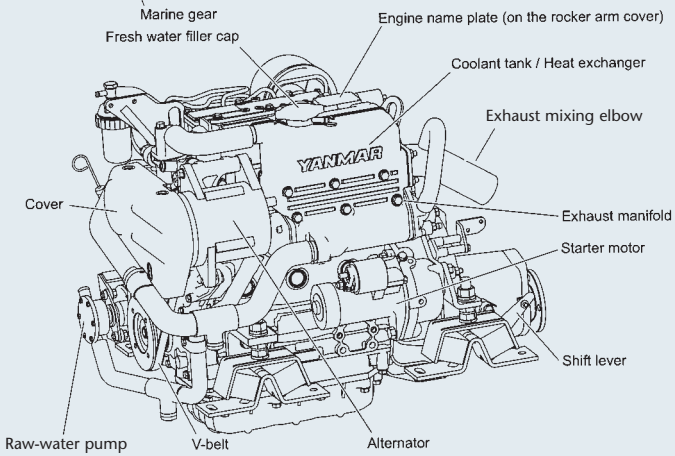
Unlike a gas engine, a diesel engine has no ignition system or spark plugs. Instead, diesel fuel ignites "spontaneously" when sprayed into air that has been superheated by compression within a cylinder. This combustion then generates a power stroke. Thus there are three preconditions for a diesel engine to work:

1. An adequate supply of combustion air.
2. Compression of this air until its temperature rises above the ignition point of diesel (this requires a higher degree of compression in colder air than in warmer).
3. Injection of diesel fuel into this cylinder of heated air at a moment that is precisely coordinated with the movement of the pistons up and down the cylinders.

Given air, adequate compression, and proper fuel injection, a diesel engine more or less has to run. Routine maintenance is designed to guarantee these three preconditions; troubleshooting focuses on finding out which of them is missing.

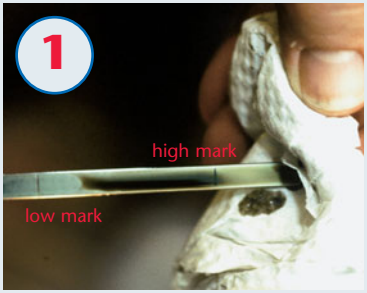
Maintenance requirements and troubleshooting procedures are similar across the variety of diesel engines found in powerboats and sailboats.





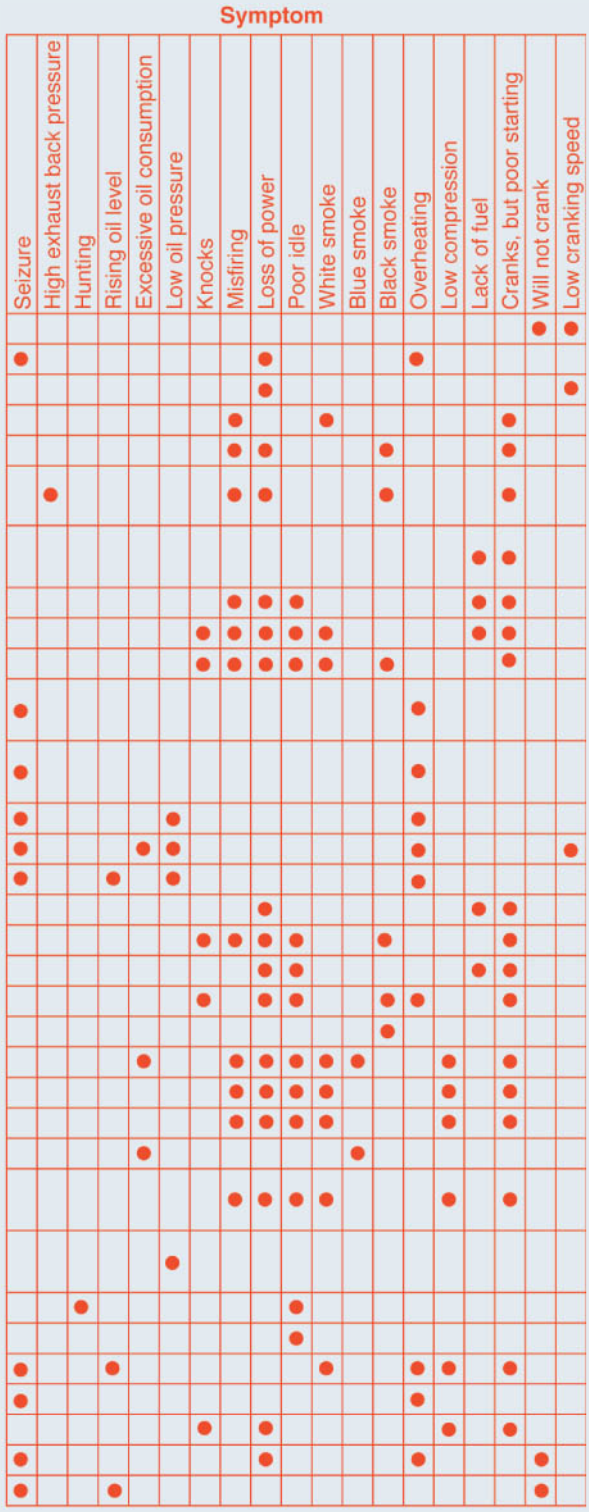
Standard Operating Practices

Before cranking the engine with the starter motor, check the oil level ① and the freshwater level ②. Also be sure the raw-water seacock is open, the raw water strainer is unobstructed (see Panel 9), any "stop" device is not activated (note: many diesels do not have a stop device), and the transmission is in neutral ③.



Immediately after the engine fires, be sure the oil pressure gauge is normal or the oil pressure warning light is out. Also be sure that the alternator is charging (i.e., either the ammeter shows charging or the light is out) and that cooling water is coming out of the exhaust ④. (Note: It is important to develop a sense of what constitutes normal flow.)

Troubleshooting

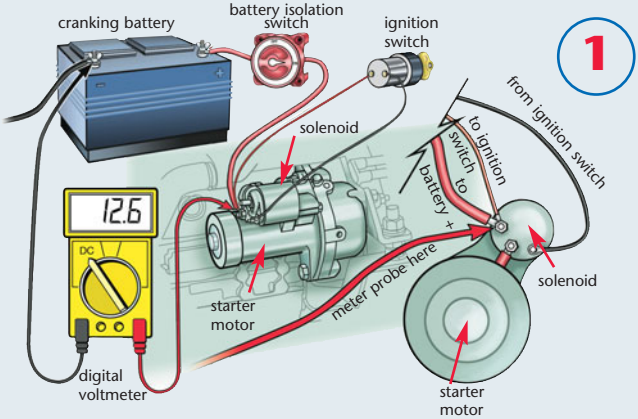


Overview

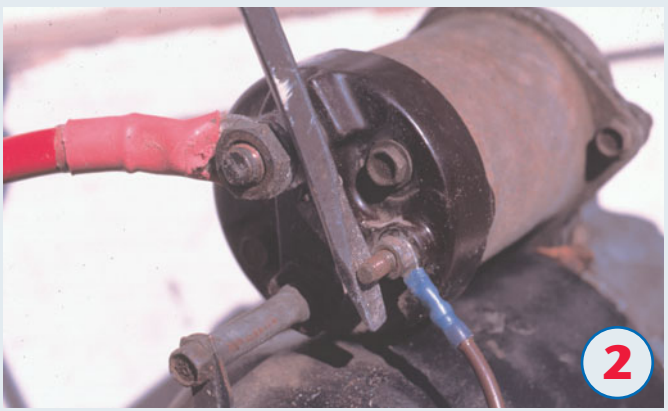
An engine that does not crank almost always has an electrical problem (Panels 5 and 6), but occasionally has water in the cylinders (Panel 7). An engine that cranks slowly and fails to start is probably not compressing the air in the cylinders sufficiently to attain ignition temperatures—the cranking speed will need to be increased. An engine that cranks at normal speeds and does not start (Panel 8) likely has one of the following: a fuel supply problem; an obstruction of the air inlet or exhaust; or a serious lack of compression. The latter requires a rebuild, and is particularly likely with an engine that has high operating hours, especially if it is harder to start in cold weather.

Possible Causes
Battery low/loose connections
Engine overload/rope in propeller
Auxiliary equipment engaged
Pre-heat device inoperative
Plugged air filter
Plugged exhaust/turbocharger/kink in exhaust hose
Throttle closed/fuel shutoff solenoid faulty/tank empty
Plugged fuel filters
Air in fuel lines
Dirty fuel
Closed seacock/plugged raw-water filter or screen/plugged cooling system
Defective water pump/defective pump valves/air-bound water lines
Oil level low
Wrong viscosity oil
Diesel dilution of oil
Lift pump diaphragm holed
Defective injector/poor-quality fuel
Injection pump leaking
Injection timing advanced or delayed
Too much fuel injected
Piston blowby
Dry cylinder walls
Valve blowby
Worn valve stems
Decompressor levers on/valve clearances wrong/valves sticking
Dirt in oil pressure relief valve/ defective pressure gauge
Governor sticking/loose linkage
Governor idle spring too slack
Blown head gasket/cracked head
Uneven load on cylinders
Worn bearings
Seized piston
Water in the cylinders

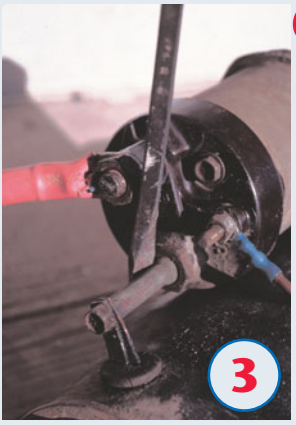
5 Engine Cranks Slowly or Not at All



1. Turn on the ignition, but do not crank. Place the '+' probe of a DC voltmeter on the terminal at which the battery positive cable connects to the starter motor solenoid ① and the '–' probe on the cranking battery negative post (or engine block if the negative post is not accessible):
   - Higher than 12.6 volts: OK
   - 12.4 to 12.6 volts: the battery is somewhat discharged
   - 12.2 to 12.4 volts: the battery needs recharging
   - Below 12.2 volts: the battery is almost completely discharged and needs recharging
   - No volts: a battery isolation switch is probably turned off!
2. Assuming a charged battery, put the meter probes as in (1) and have someone attempt to crank the engine:
   - If the voltage remains the same, either the ignition circuit is defective or the solenoid is out of action. To investigate further, connect a jumper wire or screwdriver blade from the starter motor cable terminal on the solenoid to the ignition switch terminal (the one with a relatively small cable going into the wiring harness ②). If the engine cranks, the switch circuit is defective. If it does not crank, use a screwdriver

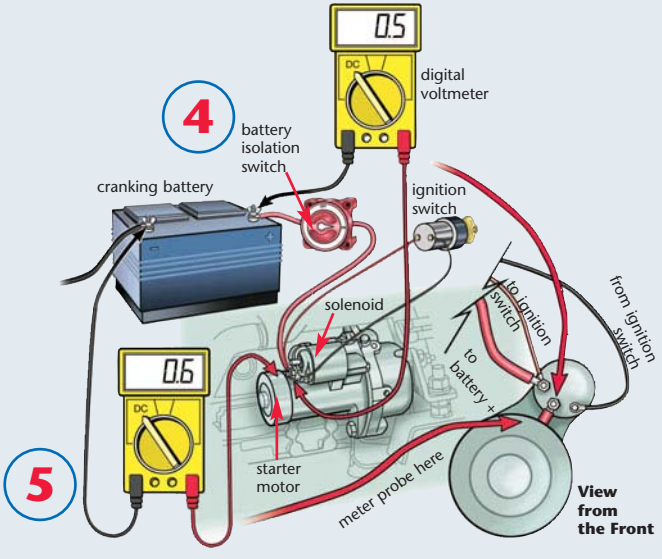


blade to short the two big terminals on the solenoid ③. **Caution: Sparks may fly—hold the screwdriver firmly to the terminals, and MAKE SURE THE SCREWDRIVER DOES NOT TOUCH THE STARTER MOTOR CASE.** If the starter motor spins (the engine will probably still not crank), the solenoid needs rebuilding (remove the end cover and check the points). No response means the battery is dead (check it again) or the starter motor is inoperative.



- If the voltage falls a volt or two but then stabilizes, feel all connections and cables in the cranking circuit (positive and negative). If any connections are warm, undo them, clean the terminals, and reconnect. If any cables are warm, they are undersized and need replacing with larger cables.
- If the voltage collapses, the battery is dead or has no remaining capacity, or the starter motor is shorted, or the engine is seized or full of water. Place a socket on the crankshaft pulley nut (see Panel 7) and attempt to turn the engine over. If it will not turn, the engine is seized or full of water.

Many cranking circuits on boats suffer from excessive voltage drop as a result of undersized cables. To test this, place the '+' probe of a DC voltmeter on the cranking battery '+' post, and the '–' probe on the terminal at which the starter motor '+' cable or strap attaches to the solenoid ④ and crank. Note the reading. Now place the '+' meter probe on the starter motor case and the '–' probe on the battery negative terminal ⑤ and crank. Note the reading. If either reading is above 0.5 volt, there is excessive voltage drop. Clean all the terminals and try again. If a high reading persists, fit larger cables. (Note: Given a high reading on the positive side of the circuit, before replacing the cables put the meter probes on the two large solenoid terminals and crank again. If that reading is high, the solenoid points need cleaning or replacing.)



Engine Seized Up

When a previously working engine seizes on start-up, suspect water intrusion into the cylinders. In an emergency, to clear the cylinders, CLOSE THE THROTTLE, ACTIVATE ANY "STOP" DEVICE, and flick the starter on momentarily with someone watching the crankshaft pulley:

1. If the pulley turns on the first "flick," do this repeatedly, pausing several seconds between each flick, until the engine turns normally. DO NOT AT ANY TIME HOLD THE STARTER ON UNTIL THE PULLEY TURNS FREELY—YOU WILL BREAK SOMETHING EXPENSIVE!

2. If the pulley does not turn on the first flick, *or if it stops turning at any point when the starter motor is flicked on*, STOP! You can try turning the crankshaft *in tiny increments* by placing an appropriate wrench on the crankshaft pulley nut ①. Better yet, remove the valve cover, identify the exhaust valves (those on the exhaust manifold side of the engine), find all those that are closed (the valves will not be depressed), and push a coin between the top of the valve and the rocker arm or camshaft to open the valve ②. Flick the starter motor on as above or use the wrench on the pulley nut until the engine turns normally. Remove the coins.

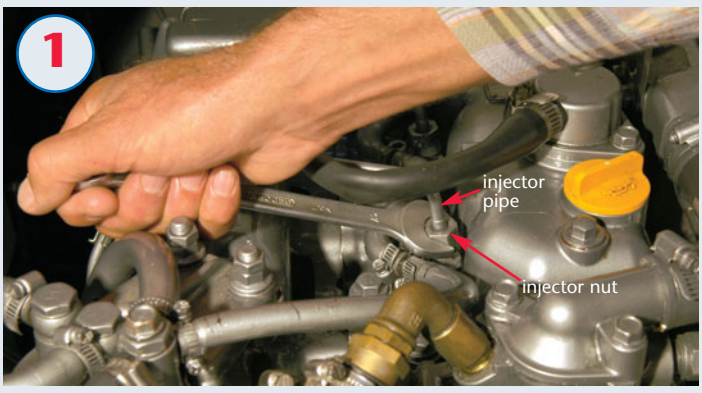
Once the engine is turning over, change the oil and filter. If there is any sign of water in the oil, run the engine for a few minutes and change the oil and filter again. Do this once more after 25 hours of running time.

If seawater has gotten into your engine, quite likely it either siphoned in from the raw-water system or was driven up the exhaust pipe by large seas (sailboats are especially vulnerable when under sail). To prevent these intrusions, any engine installed below the waterline requires a siphon break on the raw-water side (normally between the heat exchanger and the raw-water injection nipple into the exhaust, but sometimes between the raw-water pump and the heat exchanger) and a loop in the exhaust line that remains above the waterline at all heel angles and wave heights. Rectify as necessary.

Engine Cranks Normally But Does Not Fire

Suspect a problem with the fuel supply or insufficient compression of the air in the cylinders. A complete obstruction of the air supply is less likely.

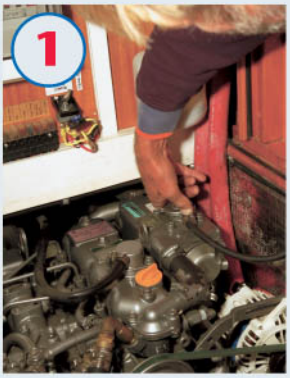
1. Ensure that there is fuel in the tank and any fuel valves are open.
2. Make sure any engine "stop" device is not activated. (Not all engines have such a device.)
3. Be sure the air intake and exhaust are unobstructed (is there a closed exhaust seacock?).
4. If the engine has glow plugs, check to see that they are working (the cylinder head in the immediate vicinity of each plug should be warm).
5. Open the throttle wide, crank 10 to 15 seconds, let the engine rest 2 minutes, and crank again. If the engine now fires, it probably has poor compression and needs an overhaul.
6. If the engine is cranking slowly, check the battery and cranking circuit (see Panels 5 and 6). If these are OK, block the air intake while cranking and then remove the blockage while continuing to crank (this will help the engine to crank faster). NEVER BLOCK THE AIR INTAKE ON A RUNNING ENGINE.
7. Still not running? On all but common rail fuel injection systems (some modern engines—check the manual), crack an injector nut ①, open the throttle wide, crank the engine, and check for fuel periodically spurting out of the loosened connection (DO NOT DO THIS WITH A COMMON RAIL FUEL INJECTION SYSTEM):
   - No fuel? Recheck any engine "stop" device. Look for a failed electrically operated shutdown solenoid. Bleed the system (see Panel 13).
   - Fuel? If the engine has been getting progressively harder to start, it likely has poor compression and needs an overhaul. If the failure to start is a new event, go back to (1) and try again!



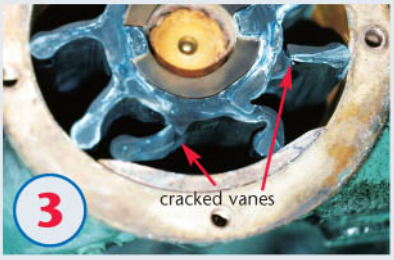
Engine Overheats

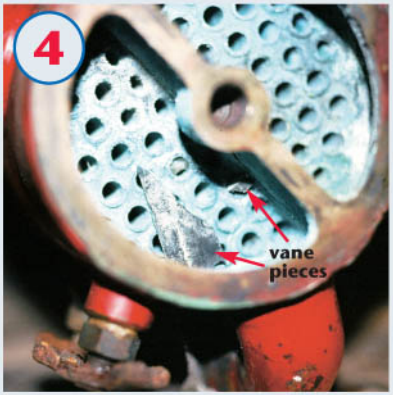
If the raw-water flow in the exhaust is normal, check the freshwater pump belt. If that is OK, check the header tank on the freshwater side of the engine (CAUTION: let the engine cool before removing the pressure cap) ①. If the level is OK, proceed with the next paragraph.

If the raw-water flow in the exhaust is reduced or absent, shut down the engine, then check the raw-water pump belt (note: some pumps are gear driven and have no belt). If that is OK, make sure the raw-water intake seacock is open. (If it is not, the raw-water pump impeller may have been destroyed.) Next inspect the raw-water strainer ②. If it is clean:



1. Close the raw-water seacock, disconnect its hose, and momentarily open the seacock to check for a strong flow. If the flow is reduced or absent, there is an obstruction at the raw-water inlet strainer on the outside of the hull.
2. Remove the raw-water pump cover and check the impeller for cracked or missing vanes ③. If any are missing, track down the pieces (they will likely be in the heat exchanger—see next item).
3. Check the tube stack in the heat exchanger for scaling (flaking) or obstructions (the tube stacks are often accessed by removing covers at one or both ends of the heat exchanger) ④. If necessary, have a mechanic descale an older engine.
4. Disconnect the raw-water hose from the injection nipple on the exhaust elbow and check for scaling or debris.





If an older engine only overheats when heavily loaded or after a move into warmer waters, suspect a scaled heat exchanger.

Miscellaneous Operating Problems

Exhaust Has Blue Smoke

A little blue smoke is normal on start-up. If it persists after the engine has warmed, the engine is burning oil and needs an overhaul.

Black Smoke

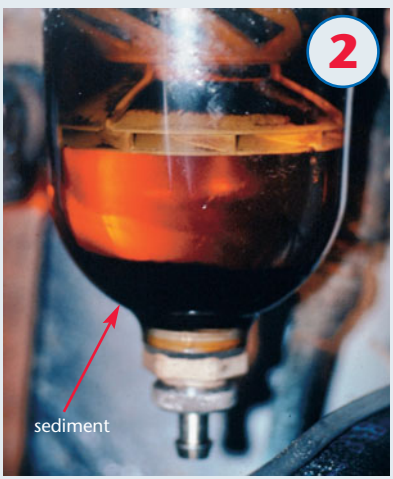
A puff or two of black smoke on sudden acceleration is normal for an older engine. In all other circumstances, black smoke indicates improper fuel combustion:

1. Check the air filter or inlet for obstructions.
2. Break the exhaust hose loose from the water lift muffler and check for carbon fouling in the exhaust ①. (This photo shows a carbon-free exhaust exit.) If more than a thin film of carbon is present, the exhaust needs cleaning (and the cylinder head and valves also probably need servicing).
3. If the black smoke only occurs at high engine speeds, check for overloading (a line around the propeller, a heavily fouled boat bottom, too much auxiliary equipment, etc.). If this is a new boat, the propeller may be oversized.

Misfiring

A rhythmic misfiring means that one or more cylinders are misfiring. A misfiring on start-up that stops once the engine is warm suggests that one or more cylinders are losing compression, and the engine needs an overhaul.

An irregular misfiring suggests dirty fuel (check for sediment in the base of the fuel filter ②), water in the fuel (check for water in the filter), or plugged fuel filters—especially if the misfiring only occurs at higher engine speeds and loads.



Routine Maintenance

The great majority of engine problems are caused by a failure to ensure clean fuel or a failure to change the oil at the prescribed intervals.

Clean Fuel

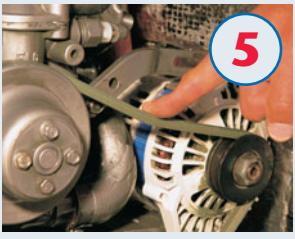
Dirty fuel is the #1 cause of marine diesel problems. There are four lines of defense to ensure clean fuel:

1. Adequate filtration of everything that goes into the tank. If adding fuel from dubious sources, use a Baja filter or water-separating fuel filter funnel.
2. Take one or more fuel samples from the base of all fuel tanks at least once a year to remove any sediment and water ①, ②, or employ a commercial fuel-polishing service.

3. Change the primary fuel filter at the specified intervals ③, and clean the tank if the filter is dirty.
4. Change the secondary filter at the specified intervals ④. If the filter is dirty, clean the primary filter and the tank, and check the filter screen in the lift pump. (See Panel 13 to bleed the fuel system.)

Additional Routine Maintenance

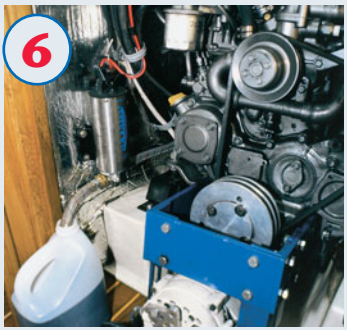
1. Change the air filter at the prescribed intervals (many small diesels do not have an air filter).
2. Periodically tighten the alternator belt. It should depress no more than 1/2 inch at the center of the longest belt run under moderate finger pressure ⑤.
3. Check the heat exchanger for a sacrificial zinc anode (many modern diesels do not have zinc anodes). If present, inspect it monthly until the rate of zinc loss is established. Replace the anode when it is no more than half gone.
4. See also Panels 12 and 14.



Changing the Oil

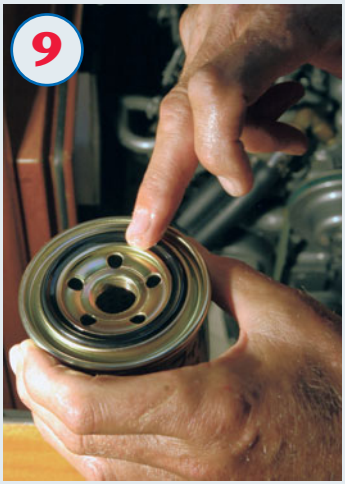
Along with ensuring clean fuel, this is essential for long engine life. A marine diesel engine needs an hour meter in the panel so you know when to do oil changes and other maintenance.

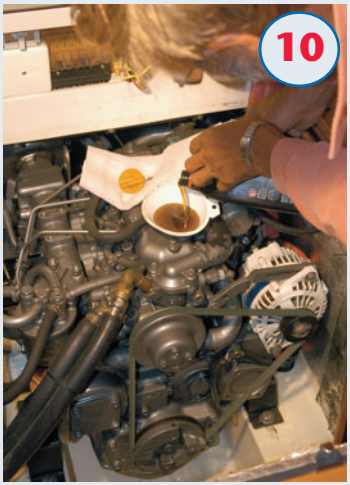
1. Run the engine until it is up to normal operating temperature.
2. Pump the oil out of the crankcase with the installed oil-change pump ⑥ or by sucking it out through the dipstick tube ⑦. Marine chandlers sell a variety of manual and electric pumps for this purpose.



3. Unscrew the oil filter with the appropriate filter wrench. In the absence of a filter wrench, use a spare alternator drive belt. Catch any spills in a disposable diaper or by placing a plastic bag around the filter ⑧.
4. Lubricate the sealing ring on a new filter with clean oil ⑨ and screw it on until hand tight. Tighten a further one-half to three-quarters turn with the filter wrench.
5. Add oil to the appropriate mark on the dipstick ⑩.

Crank the engine and check the oil pressure. (It may take a few seconds to come up to normal.) Inspect the sealing area around the new oil filter for leaks.



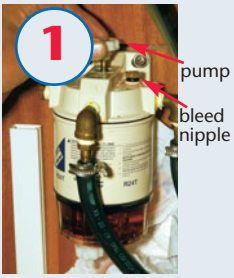


13 Bleeding the Fuel System

Air in the fuel system will stop most diesels. Many modern diesels can be purged of air by opening the throttle wide (on a single-lever engine control, push in the button in the center of the throttle before opening it so that the transmission is not engaged) and cranking 10 to 15 seconds at a time. Allow the starter motor to cool at least 2 minutes between cranks.

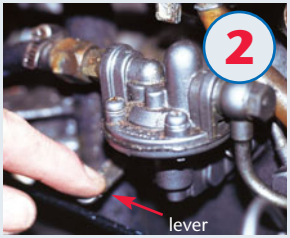
With older engines, air must be removed by bleeding the fuel system as follows:

1. Check for a pump and bleed nipple on the primary filter ①. If present, unscrew the bleed nipple two or three turns and operate the pump until fuel free of bubbles spurts out.



2. If there is no pump on the primary filter, find the engine-mounted fuel lift pump. If electric, turn on the ignition. If manual, find the pump lever ②. The engine may need to be turned over a half revolution to get the manual pump working.

3. Move "upstream" from the lift pump (i.e., toward the point of fuel injection on the engine) to the first bleed nipple in the system, which is normally on the secondary fuel filter, and unscrew the nipple a couple of turns ③.



4. Operate the lift pump until fuel free of air bubbles flows out, catching spilled fuel. Then close the nipple. If the air bubbles don't clear, either the tank is low on fuel or there is an air leak on the suction side of the pump; check the seal on the primary filter first, especially if it has been changed recently.

5. Move upstream in the fuel system to the next bleed nipple, which is normally on the injection pump, and repeat.

6. Once finished, open the throttle wide and crank 10 to 15 seconds.

7. If the engine does not fire, loosen the injector nuts (see Panel 8), open the throttle wide, crank until fuel spurts from each loosened connection, and then tighten.

CAUTION: You must never loosen an injector nut on one of the new generation of diesel engines with a common rail fuel injection system.

The engine should fire. Note: You can also bleed a newer engine after a fuel filter change in order to avoid the prolonged cranking that may otherwise be necessary to fill the new filter element with fuel.

Winterizing (or Annual Maintenance)

1. In freezing climates all raw-water systems must either be drained or filled with nontoxic (propylene glycol) antifreeze. If draining, remove the raw-water pump cover and pull out the impeller. If adding antifreeze, remove the raw-water hose from its seacock, dip into a bucket of antifreeze solution, and run the engine until the solution comes out the exhaust.
2. Inspect the raw-water pump impeller for signs of wear or cracking. Replace as necessary or at the specified intervals.
3. At least every two years, drain the freshwater side and refill with a fresh ethylene glycol antifreeze solution to restore the corrosion inhibitors.
4. Wash the valves on any vented loops in warm water to clean out salt crystals.
5. Change the engine oil at the end of the season rather than the beginning of the next (this removes corrosive acids from the crankcase).
6. Change the transmission oil.
7. Pump a sample from the base of the fuel tank (as in Panel 11) and remove any water or sediment. Fill the tank to minimize condensation.
8. Break loose the exhaust hose at the water lift muffler and check for carbon buildup (there should be no more than a light film) (Panel 10). If present, review the operating practices to prevent long-term damage to the engine.
9. Spray WD-40 or a similar penetrating fluid into the air inlet, then seal the inlet to prevent moisture entry. Place a note in a conspicuous place to remind yourself to unseal this before cranking the engine!
10. Remove the battery from the boat or ensure that it gets charged periodically (once a month for wet-cells; every few months for gels and AGMs).
11. Check the wiring harness and all electrical connections for signs of abrasion or corrosion and rectify as necessary. Spray with a corrosion inhibitor.
12. Check all hoses for signs of softening, bulging, kinking, or abrasion, and all hose clamps for signs of corrosion. Replace as necessary.
13. Every couple of years, or if confronted with unexplained vibration, check the engine alignment.

Recommissioning

1. Unseal the air inlet.
2. Replace the raw-water pump impeller (if removed).
3. Pump a sample from the base of the fuel tank and remove any water or sediment.
4. Replace the battery (if removed).
5. If the engine has a “stop” lever, activate this to prevent the engine from starting, then crank 10 to 15 seconds to initiate oil lubrication. Let the starter motor cool 2 minutes, then crank.

Captain's Quick Guides

Know how to:

- Save money by doing your own engine maintenance
- Recognize the early signs of trouble
- Diagnose and overcome common problems
- Keep your engine ticking

Nigel Calder, a diesel mechanic for 30 years, is the internationally acclaimed author of *Boatowner's Mechanical and Electrical Manual, Marine Diesel Engines, Nigel Calder's Cruising Handbook,* and other bestselling nautical books.

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