Coolants and Cooling System Maintenance

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Marine diesel engine specialists say the most frequent source of premature engine failure is the cooling system. Improper coolants and inadequate cooling system maintenance can result not only in catastrophic overheating, but also in corrosion damage and even vessel flooding. Because most of the cooling system is internal to the engine and difficult to observe, damage can occur gradually over time, essentially rotting the core of an otherwise hearty diesel.

Nearly all marine diesels are cooled by either a keel cooler (or some variant such as grid cooler or skin cooler), or by a heat exchanger. Both systems depend on circulating coolant to remove heat from the engine block and transfer it to the environment. Closed systems are called "freshwater cooling" because seawater is not circulated through the block, but straight fresh water should not be used in diesel engines. Coolants normally consist of a mix of water, antifreeze, and a conditioner or inhibitor.

Coolant must:

- effectively remove heat
- prevent freezing and resultant block damage
- prevent deposits of scale and sludge on interior passages
- inhibit corrosion
- prevent cavitation erosion
- lubricate components such as water pumps
- be compatible with hoses and seals

Most operators know that a 50-50 mixture of ethylene glycol antifreeze and water provides good heat transfer and freeze protection. (It's usually yellow or green. The pink stuff, sometimes called "RV antifreeze," is propylene glycol, and is nontoxic for winterizing drinking water systems. It transfers heat poorly and should not be used as a coolant. Unfortunately, the color doesn't always indicate the contents, so read the label.)

A 50-50 mix will stay fluid down to minus 34°F and will prevent freeze damage to a somewhat lower temperature. Vessels that winter at temperatures colder than 40 below may go as high as 60-40, while those that operate in warm waters may go as low as 30-70. Straight antifreeze should never be used as a coolant because it doesn't transfer heat as well as a mixture, nor does it protect against freezing as well. Minor overheating sometimes can be remedied by diluting the coolant with more water, or by switching to an antifreeze with different heat transfer properties. According to a recent posting on an Internet diesel message board, adding the proper mix of Nalcool 3000 will lower the engine operating temperature 7-10 degrees, which can be important in a high-output engine.

Select carefully the water to be used in coolant, since the oxygen and chlorine in city water enhance corrosion, and mineral impurities contribute to scale buildup. Chlorine is particularly corrosive to aluminum, which is used in blocks, heads, and heat exchangers of some lightweight, high-speed diesels. Well water should never be used in cooling systems due to mineral content. You can get your water lab tested for impurities, and in a pinch you can use a water-softening additive. Some antifreeze brands are blended to compensate for impurities in city water. Most municipal water is satisfactory for cooling systems, but "de-ionized" or distilled water is best.

Use a Conditioner

However, you can't rely on pure water and antifreeze alone to protect your cooling system. Any high quality, heavy-duty, low-silicate antifreeze is appropriate for marine diesel use, but most need a coolant conditioner, also known as inhibitor or supplemental coolant additive, formulated to protect surfaces from both galvanic corrosion and cavitation erosion, and also prevent or reduce the accretion of scale. The Detroit Diesel 71-series manual states it succinctly: "The importance of a properly inhibited coolant cannot be overstressed."

An intricate maze of cast iron, steel, bronze, brass, and sometimes aluminum passages comprise a marine diesel cooling system, an ideal breeding place for galvanic corrosion, particularly if seawater is present. (Some engines with keel coolers for the engine block still incorporate raw water for exhaust elbows and other peripheral cooling.) Zinc plugs should protect the raw-water side, but are not normally fitted in the freshwater system. Furthermore, vibration inside the block, particularly around wet cylinder liners, causes tiny pockets of reduced pressure, where heated coolant vaporizes, forming bubbles of steam. As these bubbles collapse against internal surfaces they physically erode the metal. This "cavitation erosion" can eat pinholes right through liners and cooling jacket walls, allowing coolant into the cylinder.

Scale, a hard coating of mineral solids derived from magnesium, calcium carbonate, and other impurities in the water, may clog passages and diminish the transfer of heat through the water jacket walls into the coolant. A quarter inch of scale on top of one inch of cast iron slows heat transfer to the same rate as four inches of cast iron alone, enough to cause overheating. Suspended solids also grind away seals, causing water pumps to leak.

Popular supplement additives include Baldwin's BTE, Penray's Pencool (formerly known as Nalcool), and DCA by Fleetguard. Sold as either liquid or packages of water-soluble powder, they are mixed into the water-antifreeze coolant. Some brands of antifreeze (Caterpillar and Fleetguard among them) are formulated with conditioners included.

Conditioners become depleted with use, and coolant should be tested twice a year. Some makers sell test strip kits that allow you to check your coolant for conditioner strength, and also may indicate presence of combustion gasses, electrical current, etc.

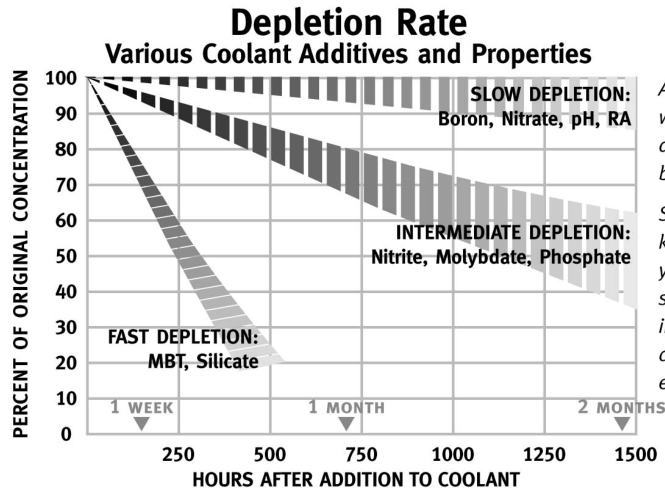
Going a step further, you can send coolant samples to a test lab (testing kits are sold for this purpose) which will return an analysis indicating total dissolved solids, pH (acidity), glycol percentage, and the freeze point.

Be sure to use only the test strip made for the coolant you are using, and don't mix additives from different makers, or add a conditioner formulated for one antifreeze to a different antifreeze. They may not be compatible because different manufacturers use different bases. If changing brands, drain the system and flush before adding fresh coolant.

Because solids usually are present in coolant, some mechanics say a coolant filter is a good idea, even essential, while others say it's unnecessary. Follow your engine manufacturer's recommendation. If you do decide to use a filter, select carefully—some have surface filtering elements in the 15-60 micron size range, others have deep filters at 1-5 microns. Obviously the latter take more crud out of your coolant but also need more frequent replacement. Some companies, Baldwin and Gulf Coast Filter included, make filter devices that incorporate a controlled-release coolant conditioner. The filter should be changed in accordance with manufacturer recommendations.

Antifreeze doesn't deteriorate or lose its ability to prevent freeze damage very quickly. Some sources say that as long as it is reasonably clean and the conditioner potency is maintained, it is good for several years. Follow your engine manufacturer's recommendation; for example the recommended change time for Caterpillar's ELC is three years or 3,000 hours, and with addition of an extender is good for six years or 6,000 hours. Otherwise, it's a good idea to test the conditioner annually or each 500 hours.

A word on draining antifreeze: the stuff is poisonous and classified a hazardous material, so dispose only in approved receptacles, never on the ground or in open containers. Antifreeze tastes sweet to animals, particularly dogs, but the result of lapping it is a slow and agonizing death.



Additives become depleted with use; the rate of depletion varies greatly between components.

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System Maintenance

Even with correct coolant, cooling systems require some maintenance. When the antifreeze is drained, the system should be flushed with a radiator-cleaning compound or a de-solvent consisting of one part muriatic acid to two parts water. Afterward, reverse-flush the system using air pressure to blow hot water through the plumbing in the opposite direction of its normal flow.

If you have a heat exchanger, once every couple hundred hours check the zinc plugs. Bang them with a hard object or scrub with a wire brush and most of the corrosion should flake off, exposing nearly bright metal. If not, or if they are more than 50 percent diminished in size, replace them. At around 500 hours, drain the raw water side and clean with a wire brush. At the time of engine overhaul or if there is a coolant problem, disassemble the heat exchanger, removing the core, and inspect the tubes. Minor deposits can be pushed out with a rod of soft material, such as a wooden dowel, or a rifle-cleaning rod and brush with oxalic acid solution can be used. Don't use a hard rod that could damage the thin copper tubes. If rodding doesn't clear the deposits, take the core to a radiator shop for cleaning in a chemical bath.

Periodically, and any time coolant level in the expansion tank drops, check the "weep hole" at the bottom of the freshwater circulating pump. If it is weeping, or even if it shows stains where it has been weeping, it may be an indication that the water pump seal is going. Replace it right away, or you'll soon find you can't keep coolant in the system, and this leads to overheating and engine failure. (That is, unless the pump has a ceramic type seal, which is designed to leak a little to provide cooling and lubrication.)

Some types of engine water temperature sensors don't show an overheat condition if the water level drops below the level of the sensor. This means that if your system develops a leak, such as through the circulating pump seal, the coolant could escape, the engine could fry, and the alarm wouldn't sound. Consider installing a coolant level alarm in your expansion tank.

Coolant can also escape through faulty seals elsewhere in the cooling system, including the cylinder head water seal rings or the head gasket, and through leaks in oil coolers, fuel coolers, gear oil coolers, cabin heaters and other devices that are plumbed to coolant lines. Don't use any antifreeze containing methyl alcohol, which can dissolve seals and hoses, and don't put any soluble oil or any kind of radiator sealer in your cooling system. (Oil mixed with ethylene glycol forms a varnish that can cause engine failure.) Coolant can also leak through a faulty pressure cap or pinhole leaks due to corrosion in castings such as the heat exchanger or expansion tank. You can use a pressure tester to detect breaches of system integrity.

Remember, if one gasket has started to leak, it's time to replace all such gaskets, because the others will soon start to leak also.

Inspect hoses and hose clamps at least once a year. Cracked, soft, or puffy hoses should be replaced, as should any hose clamps that exhibit rust or cracks.

If your system includes a raw water pump, drain it when winterizing by loosening the end plate screws and pulling the end plate out a bit, or better yet, remove the impeller so that it doesn't take a set. (If the boat is in the water, be sure the seacock is closed, and tag it so you will remember to replace the cover and reopen the seacock before starting the engine.) Also, check the sea strainer for clogging, and be sure to drain it thoroughly when winterizing, or the water inside may freeze and break the container.

The daily pre-starting ritual includes checking the fluids, which means both the oil and the coolant levels. And merely looking at the little plastic recovery tank doesn't do it; open the expansion tank and look inside.

Troubleshooting

The possible causes of overheating are numerous, but you can start with a brief checklist:

1. Is it really overheating? Gauges often fail or provide faulty readings. Check with a separate thermometer.

2. Is there coolant in the system? Open the cap and check the tank. If not, you have a leak, so start looking for it. Meanwhile, you can use plain fresh water as a temporary coolant. Allow the engine to cool, then add the water slowly so that it doesn't cool any castings so quickly that they crack.

3. If coolant is vanishing, check the header (expansion) tank cap (if it is loose or defective coolant may escape there), the weep hole in the circulating pump, and all the system fittings. If you find coolant in your engine oil or gear oil, or if you have white, steamy exhaust the problem is likely a corroded oil cooler, head gasket, or other internal seal.

4. Is the coolant circulating? You can watch it swirling in the header tank (once the engine has warmed and the thermostat has opened). If not, the circulating pump has malfunctioned, or the passages are clogged.

5. Is the thermostat operating correctly? On most engines they are easy to remove and inspect. You can test by putting it in a pan of water with a thermometer and heating the water until the thermostat opens,which should begin at between 165 and 180 degrees and complete 15 degrees hotter, depending on model. New engines have 190 and 205 degree thermostats. Thermostats are cheap—carry spares.

6. If you have a heat exchanger, is the raw water system working properly? Look for flow from the wet exhaust, and check the seawater strainer. Mud or kelp can plug the intake grate. Blocked flow, stripped raw water pump impeller vanes, or loose v-belts could be the problem.

7. Did the overheating condition appear after replacing the coolant? The problem could be an air lock in the system. This is particularly likely where there are long hose runs, such as to water heaters and cabin heaters. Bleed the system by starting at the water source and progressively opening fittings until any air is vented and water comes out.

8. Did overheating occur after changing coolant? The problem may lie in different heat transfer properties in the new coolant mix. You may need to dilute with water or revert to your previous brand of coolant.

9. If overheating developed after modifying the hull, changing prop, adding weight, increasing injector size, or adding power takeoffs to the engine, the problem could be an overloaded engine. Does it reach its rated wide open throttle speed? Black smoke indicates rich fuel setting, which raises temperature. The solution lies in engine adjustments or reengineering the system. ✥