CHRONIC UNDERLOADING AND OVER-COOLING

It's a subject that comes up again and again in *PMM*'s Letters to the Editor column, and the volume of correspondence on this subject is only exceeded by the confusion, concern, and lack of understanding it generates. While I've addressed it in my responses on several occasions, I believe the time has come for a formal treatment in the Gearhead column.

I recently read a boat review in which the reviewer boasted that, because the subject vessel achieved cruising speed while using only a fraction of the engine's available power, the engine should therefore last "forever." It's a concept that's commonly misunderstood, and one that seems counterintuitive; the lighter the load on your engine the *greater* the likelihood of developing problems. It's true, when a diesel engine is chronically underloaded several phenomena occur that conspire to shorten the life of the engine and increase the need for maintenance and possible repairs.

The environment inside a diesel engine combustion chamber is a hellish one. The temperature can reach over 1,000°F while the pressure may be many times that of the atmosphere outside the engine. Interestingly, however, this is how a diesel engine is designed to operate, at a comparatively high temperature under relatively high load. The high pressure found within the combustion chamber represents the very philosophy of the diesel ignition process: compressing the air increases its temperature, which in turn enables it to ignite the subsequently injected fuel. While I'll be the first to recognize that it's not always possible for recreational vessels to be operated in this manner, *ideally*, a diesel engine should be run at approximately 80 percent of its output capacity, 80 percent of the time. When operated in this manner

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Top: Carbon buildup is one of the more common side effects of chronic underloading, the result of which include clogged and malfunctioning piston rings as well as fouled and sticking valves. The buildup on this piston crown is clear to see. The cleaned away area represents the correct appearance the piston should have. Above: Engine loading has a significant effect on oil temperature, which in turn plays a role in its overall health and longevity. Chronic underloading leads to oil that runs "cool," which leads to sludge and varnish buildup, and eventually oil starvation.

the temperature within the engine ensures efficiency and longevity. Contrary to popular belief, new electronically controlled engines are not immune from issues created by chronic underloading.

When discussing proper operating temperature, it's important to remember that there are several regions within the engine, all of which may be operating at different temperatures under differing load conditions. For instance, when you start your engine and run it at idle or at low rpm you may notice that the temperature gauge measuring coolant temperature doesn't move very much. If the gauge is graduated in numbers as it should be, it's unlikely that the needle passes 140°F. When a load is applied, on the other hand, if you are motoring hard to make port before a weather system descends upon you, then the needle should hover around the engine's maximum design operating temperature. For closed cooling system engines this is typically between 160°F and 195°F. In the light load condition, when the coolant temperature is low, the temperature of the combustion chamber is also lower than that which is optimal. This leads to the formation of excess soot or carbon, which is deposited on the piston rings, injectors, and valves, a scenario

that reduces efficiency and may shorten the life of these components.

Cylinder wall glazing, which exacerbates blowby, also occurs when an engine is chronically underloaded, especially early on in its life. Generators are notorious for suffering from this malady because they are often chronically underloaded in the critical break-in period (the first 50–100 hours).

Even under moderate load, when the coolant reaches a normal operating temperature, the oil temperature often remains cooler, too cool for optimal operation (unless the engine is equipped with an oil cooler thermostat). This is a significant and often overlooked aspect of underloading. Also, few engines are equipped with an oil temperature gauge; however, you can measure yours by "shooting" the approximate vertical and horizontal center of the oil pan with an infrared pyrometer.

The consequences of running an engine with "cold" oil are an increase in sludge and varnish production within the oil as well as an inability for the oil to vaporize water that accumulates as a result of piston ring blowby, which itself is exacerbated by the aforementioned carbon formation. Blowby is essentially combustion chamber gasses "leaking" past the rings into the crankcase, a small amount of which is normal, and carrying with them some water that's part of all diesel exhaust. Whether the blowby is normal or excessive, the water will only evaporate when the oil gets hot, over about 160°F. Sludge is a combination of water, carbon, and other contaminants. It impedes oil flow, and as the name implies, it's greasy and often brown or tan in appearance. Varnish is a precipitate that is much harder, like, well, varnish. It adheres tenaciously to metal surfaces within the engine. Both of these contaminants are harmful to an engine as they starve vital components of lubricating oil.

The bottom line is, avoid chronically underloading your engine. If you must do so, run it up to 80 percent load for 15 minutes every four hours to stem the sludge, varnish, and carbon tide, and perform oil analysis with each oil change. The former will increase oil and combustion chamber temperature to preferable levels, thereby reducing buildups, and the latter will alert you to contaminant-related issues caused by underloading before they become critical.—Steve D'Antonio