CONSTRUCTION EQUIPMENT
Ideas and Insight for the Equipment Pro

Good Coolant Chemistry Saves Wet-Sleeve Engines

Consistent, timely maintenance of a wet-sleeve diesel's coolant can avert disaster by eliminating the dreaded process of cavitation.

July 1, 2002 By Walt Moore, Senior Editor

What would you guess is the most frequent type of diesel-engine failure caused by a poorly maintained cooling system? It's the perforation of cylinders in wet-sleeve engines, says Ed Eaton, chief engineer for Amalgatech, a laboratory in Phoenix, Ariz., specializing in research, development and analysis of engine coolants.

In a "wet-sleeve" engine, pistons operate in steel cylinders (also called sleeves or liners) that are sealed into upper and lower rings within the open structure of the block. The sleeves are "wet," because they are exposed to the engine's coolant, which is good for efficient heat transfer, but not so good for the sleeve if coolant chemistry is out of whack.

As the diesel works, combustion forces set up a natural vibration in the sleeves, causing the sleeve walls to first pull rapidly away from the coolant, creating a low-pressure area in which the surrounding coolant boils and forms tiny air bubbles. Then, as the sleeve springs back, it slams into the bubbles with a force estimated at up to 60,000 psi, causing the bubbles to collapse, or implode, violently.

This bubble-bursting action against the sleeve is called "cavitation," because it can create tiny cavities in the sleeve wall if the coolant inadequately protects the metal. Left unchecked, this "pitting" process can eventually perforate the sleeve wall, allowing coolant into the cylinder, where its incompressible nature can crack blocks, break pistons and bend rods.

Good coolant cures cavitation

Although cavitation can be devastating, it's also easy to prevent, simply by maintaining a film of cavitation-resistant native oxides on the sleeve's outer wall. The diesel engine's coolant is responsible for keeping this protective film in good repair, but to do so, it must in turn be adequately maintained. This means, essentially, keeping the coolant's additives in proper concentration.

For many coolants, a "supplemental coolant additive" (SCA) package not only has compounds that help the cooling system resist corrosion, scaling and attack by acids, but also contains nitrite, which mends the sleeve's protective-oxide film when cavitation tries to wear it away. Some SCA packages also contain molybdate, intended to enhance nitrite's healing action and thus allow lower levels of nitrite, which, in excessive concentrations, may contribute to solder corrosion.

If you still use "conventional coolant," a heavy-duty, low-silicate antifreeze with an ASTM D4985 specification, then remember that this antifreeze contains no supplemental coolant additives. At initial fill, along with mixing it with 50 percent water, you must add an SCA package, typically at a ratio of one pint to four gallons of coolant.

A better alternative, says Eaton, is to use "fully formulated" antifreeze that meets ASTM D6210 specifications. These antifreezes already contain SCA components and thus require no initial treatment. In fact, all makers of vehicles with heavy-duty diesels now require coolant meeting this standard.

If your diesel's cooling system is filled with an "extended-life coolant" (ELC), then it contains an antifreeze formulation of ethylene glycol and special organic (carboxylate) acid additives, which replace the compounds in a typical SCA package. All heavy-duty-diesel manufacturers at the present time, however, says Eaton, require that ELC formulations also contain nitrite or the nitrite-molybdate combination.

Yet another coolant family uses "hybrid technology" and contains benzoate and inorganic inhibitors, which offer extended service and improved compatibility. Hybrids intended for use in heavy-duty diesels also contain nitrite and are maintained similarly to other coolants meeting the ASTM D6210 specification.

You're the chemist

Although we offer here general guidelines for maintaining coolant quality, always defer to the engine or vehicle maker's recommendation for specific procedures.

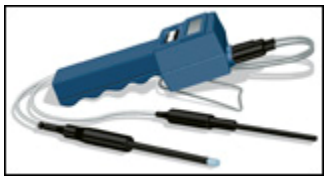
With conventional coolant, for example, your approach may be to add an SCA package at regular intervals, then to change the coolant every two years to prevent saturation with dissolved solids. Do, however, periodically test the coolant's freeze-point.

A variation is to periodically test this coolant (at two months, 250 hours or 20,000 miles) and to add make-up SCA only when needed. A fluid-analysis laboratory can test for you, or you can use test strips designed to measure nitrite and freeze point ("2-way"), or nitrite, molybdate and freeze point ("3-way"). These paper strips react to coolant by changing colors, which can be evaluated with a supplied chart. In theory, if the nitrite or nitrite/molybdate concentration is okay, then the rest of the SCA package is adequate.

Fully formulated antifreeze is designed to be maintained by a coolant filter that releases measured amounts of an SCA package over time, or, on an "as-needed" basis, which is the best way, says Eaton, to maintain optimum chemical protection. Properly maintained, he says, these coolants may last 600,000 miles or more in truck operations. Periodic test-strip sampling is advised, along with full laboratory analysis at extended mileage or hours.

If your diesel uses extended-life coolant, vehicle makers require the addition of an "extender package" at some interval. But, says Eaton, don't ignore the coolant. Periodically test its freeze point and visually inspect it, and get a laboratory analysis annually. At maintenance intervals, if it's orange and clear and has adequate glycol, then it's probably in good shape.

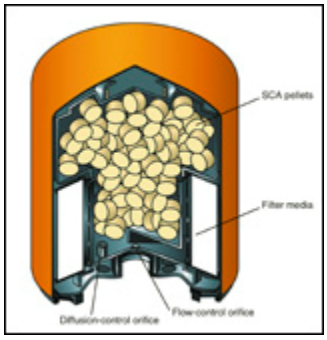
Quick Tip



Total dissolved solids (TDS) is a measure of additive concentration and contaminants in coolant. TDS in excess of 3 percent may promote water-pump and radiator failures.

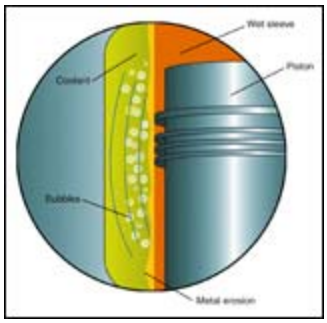
If you use a conductivity meter to measure TDS, be advised that glycol dramatically affects readings. You must dilute coolant samples 10-to-1 with water. Even then, varying concentrations of glycol can skew results. Source: Amalgatech

Fully Formulated Filter/Additives



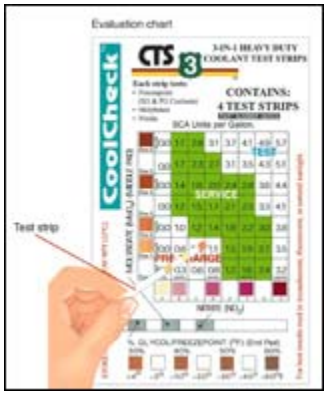
Filters trap debris in any cooling system and reduce contamination. In systems using fully formulated coolant, filters are available that dispense supplemental coolant additives (SCA) in a timed-release or as-needed fashion. Don't use bargain SCA packages or filters, which may contain nitrite (molybdate) but no other required (and non-testable) additives. Illustration: Baldwin Filters

Cavitation's Devastating Work



Cavitation, the implosion of tiny bubbles against a metal surface, can erode and perforate a sleeve. Piston movement causes the sleeve to vibrate, pulling away from the coolant (allowing bubbles to form in a low-pressure area), then slamming back into the bubbles and bursting them. Maintaining a native-oxide film on the sleeve wall protects it from cavitation. Illustration: Baldwin Filters

Test-Strip Guidelines



Freeze-point/nitrite (molybdate) test strips should be fresh, designed for your coolant and stored at temperatures below 90F. Collect samples from radiator or petcock, not from the coolant-recovery system. Test coolant at temperatures between 50F and 130F, but room temperature is preferred. Readings usually should be taken between 45 and 75 seconds after exposure to coolant; use a stopwatch. Freeze-point readings may be unreliable at glycol concentrations above 60 percent. Other test strips evaluate nitrite, freeze point and pH (acidity/alkalinity) levels, and some evaluate make-up water condition, measuring chloride, sulfate and pH. Illustration: Acustrip

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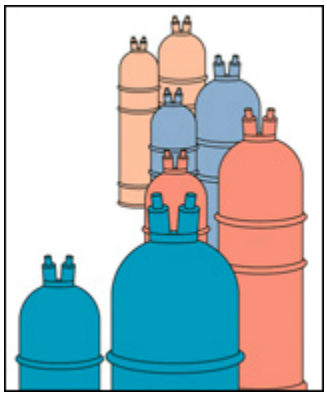
Practical Deionized Water



Tap water can undermine cooling-system maintenance if it contains substances that contribute to rust, scale and corrosion. Premixed engine coolant, sold as a 50/50 formulation of demineralized water and antifreeze, avoids these problems. So does deionized water.

Deionization units work like water softeners, but remove all the minerals. They trade sodium, calcium, magnesium and other "cations" with hydrogen ions (H+), and chloride, sulfate and alkaline "anions" for hydroxide (OH-) ions. The exchange process forms mineral-free water (HOH or H_2O).

A "cation resin" and an "anion resin" are required for the exchanges, and the resins can be contained in separate tanks or mixed in one. We talked to a local water-conditioning company that sets up a "mixed-bed" system for an initial cost of around $100, then exchanges the tank as needed for $80 or $90. Although the volume a tank will treat depends on feed-water quality, 1,500 to 2,500 gallons may be typical.