EVANS
WATERLESS ENGINE COOLANT

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Water Vapor from Water-Based Engine Coolants And Its Relationship to Engine Cooling Problems

The temperature at which an engine using a water-based coolant "overheats" is the temperature at which water vapor in the cooling system presents itself. That temperature is the boiling point of water for the pressure of the system.

When water-based coolant boils, the vapor generated is almost entirely water vapor, no matter how much glycol is in the mixture. The glycol part of the vaporized coolant condenses immediately, but not the water vapor component. The water vapor cannot condense unless the immediate environment is colder than the boiling point of water, a temperature that is lower than the boiling point of the glycol-water coolant.

What water vapor does to an engine cooling system

Water vapor in a cooling system always occupies a volume that displaces a like volume of liquid coolant from the location of the water vapor. The hottest parts of the cylinder head are the likeliest locations for localized boiling of coolant and water vapor creation. If the nearby surrounding liquid coolant is hotter than the boiling point of water at the local pressure, the vapor will remain at that location, forming an insulating barrier between the hot cylinder head metal and the liquid coolant. How good is the insulation? Water vapor has just four percent of the thermal conductivity of a liquid coolant that is half water. With water vapor present and its attendant poor thermal conductivity, less heat is conducted from the hot metal, the metal temperature rises, and a "hot spot" forms.

A cylinder head hot spot in any engine stresses the metal, possibly causing the head to warp or crack. In a spark-ignition engine, the hot spot can be a site for pre-ignition and detonation.

Pump cavitation is a possibility whenever water-based coolant is operated too close to its boiling point. The reduced pressure at the "eye" of the coolant pump can be low enough to cause the coolant to boil and make water vapor at that location. The ability of the pump to function is compromised when there is water vapor in the eye of the pump. The coolant flow will diminish and may stop altogether. An interruption in coolant flow causes a sharp increase in coolant temperature and widespread boiling.

Operation of water-based engine coolant near its boiling point creates the conditions for cavitation erosion of cylinder liners in heavy duty engines. Each piston oscillates within its cylinder liner, vibrating the liner at the frequency of the piston movement. Locations of the liner that move away from the liquid, form low pressure areas where the coolant boils and water vapor forms. On the other half of the vibration cycle, those locations move toward the liquid, causing an increase in pressure, and the vapor condenses. The cycles repeatedly scrub these sites making them vulnerable to cavitation and erosion.

Afterboil is caused by water-based coolant that is at a temperature near its boiling point in an engine that has been stressed by running hard and then shut down. Heat stored in the cylinder head continues to dissipate into the coolant in the head cooling jacket. Boiling and water vapor occur when the coolant temperature exceeds the boiling point of the coolant for the pressure of the system. Afterboil can be a cause of a mysterious loss of coolant from a non-leaking cooling system that has a pressurized expansion tank. Water vapor from the after-boiling displaces liquid coolant in the cylinder head, forcing the pressure high enough to open the pressure relief valve at the cap on the expansion tank. Liquid coolant is pushed out of the expansion tank and onto the ground.

OEM efforts to address the problems of water vapor and "overheating"

Large radiator fans, that draw between 25 and 75 horsepower (depending on RPM), are used to hold coolant temperatures low enough to prevent the boiling of coolant. Most of these fans are driven by the engine through an on-off fan clutch. The activation temperature of the clutch is below the boiling point of the coolant for the pressure of the system. The power drain of the fan is significant. A heavily loaded truck climbing a mountain generally needs a lower gear when the fan turns "on". The energy need for a fan that is sufficient to maintain coolant temperatures low enough to keep water-based coolant functioning, negatively impacts fuel economy.

If use of the fan cannot prevent the coolant temperature from climbing past approximately 107°C (225°F), the final lines of defense are deployed: The engine undergoes derating or it automatically shuts down. Automatic shut-down frequently means a long delay before the engine can be re-started. Such delays, common when ambient temperatures are high, prevent efficient use of equipment and manpower.

Evans waterless engine coolant - A better answer to the issues relating to cooling system water vapor and "overheating"

Evans waterless coolants don't contain water and they have a boiling point considerably hotter than the temperature at which they are operated. The huge separation between operating temperature and boiling point means that any locally generated vapor immediately condenses into nearby liquid that is much colder than the coolant's boiling point. There is no vapor to contend with.

With Evans waterless engine coolants, this is what *doesn't* happen:

1. There is no displacement of liquid coolant by vapor.
2. There is no vapor to insulate hot areas of the cylinder head from liquid coolant.
3. Hot spots in the cylinder head don't develop.
4. In spark ignition engines, the spark is at a more efficient setting because less knock is sensed.

5. The coolant pump doesn't cavitate because no amount of reduced pressure at the eye can make the coolant boil.
6. Cavitation erosion of cylinder liners doesn't happen because the low pressure instants from vibration are not low enough in pressure to make the coolant boil. There is no vapor made and no vapor to condense during the high pressure instants, sharply reducing any surface scrubbing.
7. There is no afterboil because the coolant in the cylinder head is much colder than its boiling point and acts as a heat sink with the capability to absorb all residual cylinder head heat without boiling.
8. If the cooling system has no leaks, there will be no need to replace lost coolant because the only pressure at the expansion tank will be from the expansion of the liquid coolant from being heated. There will be no component of vapor in the system causing a pressure increase.

Maintenance benefits of Evans waterless coolants

1. Evans coolant lasts the life of the engine.
2. If the system has no leaks, no topping-up of coolant is necessary.
3. No SCAs nor testing for SCAs is needed.
4. There is no cylinder liner cavitation erosion.
5. The vapor pressure of Evans coolant is low – see Figure 1. Hoses have a longer life because they are not subject to high coolant pressures.

Evans coolants provide performance and fuel saving features in heavy duty diesel engines

1. Engines can safely tolerate higher coolant temperatures because hot engine metal is never insulated from liquid coolant by vapor. Excellent heat transfer to the coolant is maintained at all times. Figure 2 shows that water-based coolant has a superior thermal conductivity but only when water vapor is not present, i.e. only at temperatures that are below the boiling point of water for the pressure of the system.

2. Running a heavy duty diesel engine at elevated temperatures, enabled by the use of Evans waterless coolant, reduces fuel consumption. By using higher temperature thermostats with Evans waterless coolant, a 3% reduction in fuel consumption was proved by SAE Type II testing at Auburn University.

3. With higher coolant temperatures enabled by the use of Evans waterless coolant, the radiator becomes more efficient at dissipating heat and the cooling system gains a reserve capacity. Cooling systems are "air-side limited", meaning that the limiting factor for a cooling system lies in its ability to remove the heat from the radiator to the ambient air. With the engine able to safely operate with elevated coolant temperatures, the radiator metal can now be hotter, providing a greater temperature difference to the ambient air. (The "delta T" is increased.) The greater temperature difference means that the same amount of heat can be removed with less fan-on time. The fan still draws between 25 and 75 horsepower but, if it turns on at 230°F instead of 210°F, the fan-on time will be reduced considerably, saving fuel and adding to the truck's usable power on hills.

4. Heavy equipment used in high ambient temperature and/or high altitude environments is frequently inefficient to use because of shut-down devices that actuate for coolant temperatures as low as 215°F. The shut-down temperature is chosen at a level where the coolant in the cylinder head still has some capacity to absorb heat after shut-down, without massive boiling. Generally there is a time delay required before re-starting can commence. Machine time and labor are wasted and the prospect for more shut-downs remains. With Evans coolant in the cooling system, there is no need for easily-reached shut-down temperatures. The shut-down temperature can be raised because there is no vapor competing with the liquid coolant. The coolant temperature is so much colder than the boiling point of the coolant that in the event of an abrupt shut-down, all of the remaining heat in the cylinder head can dissipate into coolant in the cylinder head without causing the boiling of coolant. The engine can be re-started at any time, including immediately.

An additional benefit to spark-ignition engines

Modern spark-ignition engines are generally computer controlled to adjust spark and in some cases mixture in the event that "knock" is sensed. When knock is sensed, the engine automatically shifts from a more efficient setting to one that will protect the engine from detonation. The engine loses performance and fuel economy whenever the engine settings shift toward the "protection mode." By avoiding vapor in the cooling system, through the use of Evans waterless coolant, hot spots are avoided and the prevalence of knock is reduced. The engine spends more of its time operating under optimum conditions, offering better performance and improved fuel economy.

Evans Waterless Engine Coolants

Evans High Performance Coolant (aka Evans NPG+[C])
Evans Heavy Duty Coolant
Evans Powersports Coolant

Boiling Point:	190.5°C (375°F)
Min Thermal Conductivity:	.250 W/m·K
Max Viscosity (-40C/-40F):	2.4 Pa·s (2400 cP)
Max Water, mass %:	0.5

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Figure 1
Comparison of Vapor Pressures
Evans Waterless Coolant vs. 50/50 EG-Water Coolants

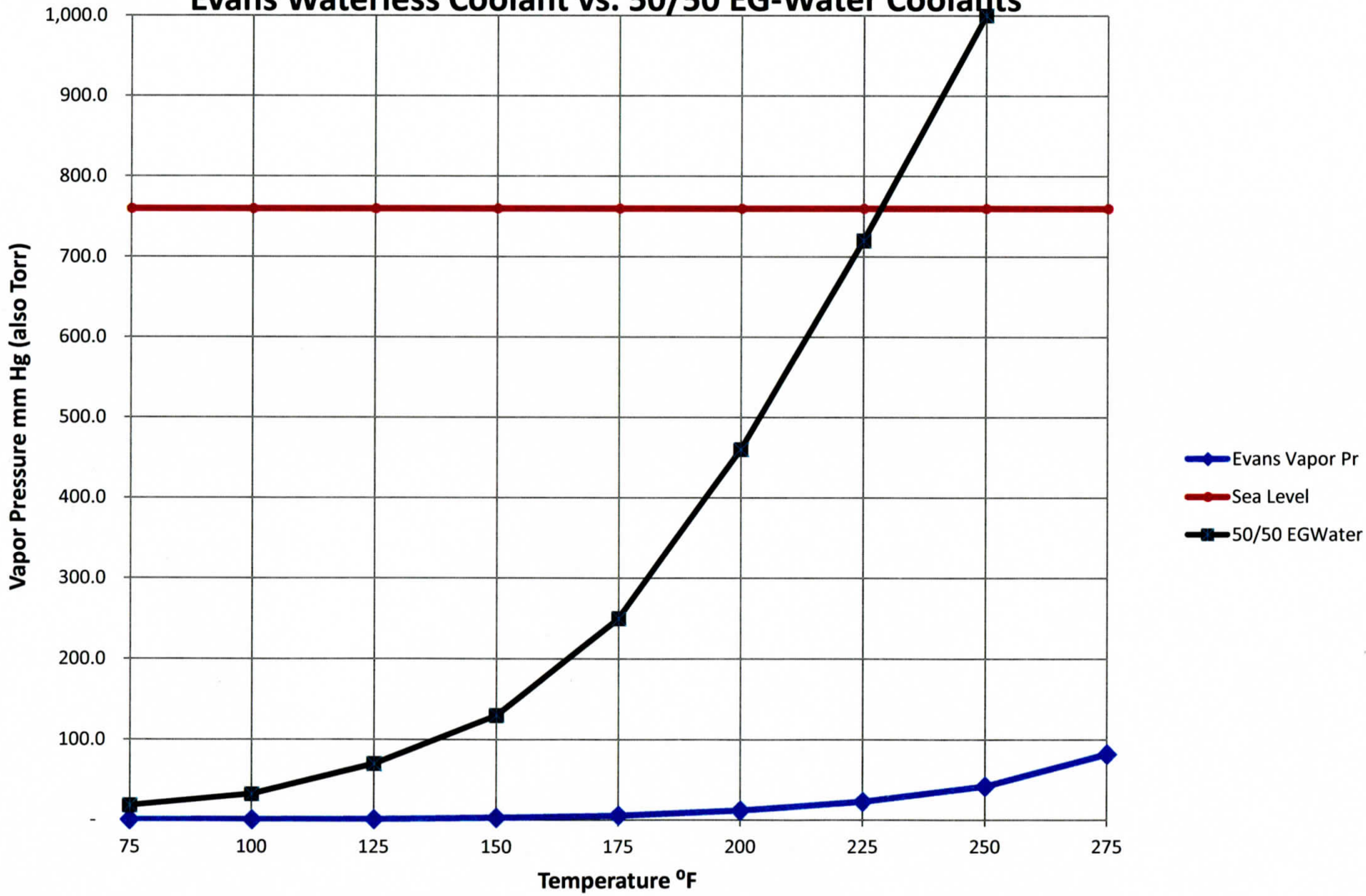

Figure 2

Thermal Conductivity of the Liquid and Vapor Phases of Water-Based Coolant vs. Evans Waterless
(The vapor phase of water-based coolant has almost no thermal conductivity.)