Water Vapor from Water-Based Engine Coolants and Its Relationship to "Overheating"

The temperature at which an engine using a water-based coolant "overheats" is the temperature at which vapor in the cooling system presents itself. That temperature is the boiling point of the 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 the 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 coolants. How good is the insulation? Water vapor has just four percent of the thermal conductivity of a liquid coolant that is half water. With that insulation present, 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 wrap 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 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 for the fan use necessary to keep coolant temperatures low enough to keep water-based coolant functional is a significant user of the fuel.

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 de-rating 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 coolant, 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.

About Evans Cooling Systems Australasia:

Evans Cooling Systems Australasia, based in Melbourne, Victoria, continually seeks to improve engine performance and efficiency, and to contribute to a cleaner and safer environment. For more information on Evans Cooling Systems Australasia and Evans waterless engine coolants please visit www.evanscoolants.com.au, Dealer enquiries welcome, (03) 9318 9811