EVANS WATERLESS COOLANT: OVERVIEW OF RESEARCH RESULTS

Evans offers several different iterations of their waterless coolant products. Each is 100% glycol. Some are 100% propylene glycol, and others are a mix of propylene glycol and ethylene glycol.

The premise of their marketing is that, by excluding water from coolant, certain benefits can be achieved. Some of their advertised claims are: little to no pressure change during heat/cool cycles, less corrosivity, extended coolant life, less nucleate boiling, greater heat transfer, and improved performance. In our research, we evaluated each of these claims.

We ran Evans waterless coolant through ASTM D1384 tests, and compared the weight losses due to corrosion (in milligrams) to that of No-Rosion for each of the metals tested:

Metal	Evans Coolant	No-Rosion	ASTM Max
Copper	2	1	10
Solder	12	0	30
Brass	2	2	10
Steel	0	0	10
Cast Iron	1	0	10
Aluminum	-7*	0	30

* A negative weight loss indicates a weight gain.

The product provides very good overall rates of corrosion protection, and passed ASTM D1384. The only concerns were: (a) the relatively high rate of corrosion for solder, and (b) the net gain in weight on aluminum. Inspection of the aluminum test coupon indicated inhibitor deposition from the Evans product. In a cooling system, this can cause problems. Inhibitor deposition causes hot-spots to develop on metal heat exchange surfaces. This can cause granular fatigue in aluminum radiators, and result in stress cracks and failures, depending on the thickness of the metal.

It is important to note that this level of corrosion protection can only be achieved if the coolant consists of 97%-100% Evans coolant. If only 3% or more of coolant previously used in the system remains, the corrosion resistance of Evans coolant is lost. When this happens, water combines with the glycol in the Evans coolant to form glycolic acid. The result is reduction in coolant pH, and corresponding corrosion problems.

It can prove problematic to fully remove 97%+ of coolant from a system. But doing so is mandatory in order to meet the Evans conversion requirement. It is a difficult, tedious process. Engine block frost plugs must be removed, the radiator must be disconnected, hoses evacuated, etc. In our testing, when we followed the Evans procedure for complete removal of coolant for our various test vehicles, the average observed removal rate was 94%. This would not be acceptable for conversion to the Evans products.

To aid in this process, Evans sells a *conversion fluid* that can be used to facilitate more effective removal of previous coolant. It costs $34 per gallon. In most systems, one gallon is enough. But larger systems will require two gallons. Evans also has a list of authorized *conversion centers*, where vehicles can be taken, and mechanics perform the conversion process for you. We found typical conversion costs $150-$180 in labor, plus a minimum of one gallon of conversion fluid at a cost of $34 per gallon.

When we followed Evans directions for conversion, and did it ourselves, we were able to successfully achieve the required 97%+ coolant removal in about 60% of our test vehicles. Certainly it could be achieved by dismantling the engine. But we considered that to be beyond the scope of our testing. Most consumers using the product would also probably consider the idea of dismantling their engine to facilitate a change in coolant type to be excessive.

After proper conversion to the Evans products, the average temperature of engine cylinder heads increased by 115-140^{o}F, versus running with No-Rosion and water.

The reason for hotter cylinder heads relates to the specific heat capacity of these different fluids. Water has a specific heat capacity of 1.00. It transfers heat more effectively than any other fluid, and is therefore used as the reference fluid in the scientific measure of specific heat capacity. Comparatively, the specific heat capacity of the various glycol solutions in the Evans products ranges from 0.64 to 0.68. So they conduct roughly half as much heat as does water, or water with No-Rosion. (No-Rosion does not alter the specific heat capacity of water.)

Cylinder head temperatures of 115-140^{o}F hotter with the Evans products translates to a stabilized bulk coolant temperature increase of 31-48^{o}F, as compared to No-Rosion and water.

As case in point, conversion of a Chevrolet LS-1 engine from No-Rosion and water to Evans Waterless Coolant resulted in an increase of 128°F at the cylinder heads. We saw a stabilized bulk coolant temperature of 192°F with water and No-Rosion, and 236°F with the Evans product. So the temperature increased by 44°F after converting to the Evans product.

By having engine cylinder head temperatures 128°F hotter with the Evans product, a number of performance setbacks were observed: (1) the octane requirement was increased by 5-7 numbers, (2) the computerized ignition system retarded timing by 8-10° to avoid trace knock, (3) horsepower was correspondingly reduced by 4-5%, as confirmed on a chassis dyno.

In our pre-1970s test vehicles, we also saw evidence of increased recession rates of non-hardened valve seats. When cylinder head temperatures are elevated to this degree, *brinelling* damage can occur. This is a process in which the metal seat softens due to heat that is beyond what it was originally designed to tolerate. Recession therefore occurs at an accelerated rate. Valve seat *brinelling* is seen in engines of vehicles built prior to the early 1970s, after they have been allowed to run too hot, for too long.

Conversion to Evans products also requires reprogramming of ECUs in modern vehicles with electric fans. Most vehicle ECUs are programmed to turn the fan on at a coolant temperature of 200-210°F, and turn the fan off at 180-190°F. Because engines run so much hotter with Evans coolant, the ECU must be reprogrammed to an Evans-recommended turn-on temperature of 230°F, and an Evans-recommended turn-off temperature of 215°F. Without reprogramming the ECU, the fans would run continuously.

Evans advertises a number of performance benefits in the area of reduced coolant nucleate boiling. In our research, we found that with proper conversion to the Evans product, its elevated boiling point did yield a 46% reduction in localized cylinder head nucleate boiling. However, even with this reduction in nucleate boiling, there were no observable enhancements in engine performance. This was due to the fact that the specific heat capacity of the 100% glycol coolant was not sufficient enough to translate into any meaningful temperature reduction.

Comparatively, when used in straight water coolant, the high cloud point surfactants in No-Rosion achieve a 39% reduction in the <u>size</u> of localized nucleate bubbles. Smaller bubbles release quicker from the hot surface of the cylinder head, resulting in enhanced overall contact with the metal. Because water has a higher specific heat capacity than glycol, it is better able to translate this into meaningful temperature reduction. For this reason, No-Rosion achieves a net reduction in cylinder head temperatures, versus a net increase in cylinder head temperatures when Evans products are used.

Cylinder head temperatures in our test engines ranged from 650^{o}F to over 980^{o}F. The Evans products have boiling points in the range of 369-375^{o}F at 0 psi pressure. Straight water coolant with No-Rosion has a boiling point of 250^{o}F at 15 psi. The interface between the cylinder head and engine coolant is the location of nucleate boiling. It does not matter whether coolant has a boiling of 375^{o}F, or 250^{o}F. Either way, nucleate boiling occurs. The fact that Evans coolant has a boiling point that is 125^{o}F higher than water is not enough to completely prevent nucleate boiling. The only way this could be achieved would be through the use of coolant having a boiling point higher than the cylinder head temperatures, in the range of 650-980^{o}F.

(As an interesting side note, research is currently underway regarding the efficacy of glycerine as engine coolant. Itâ€™s extremely high boiling point of 554^{o}F may offer benefits for future cooling applications.)

It is important to realize that straight water has a high surface tension of 72 Dynes/cm^2. When added at the proper dose, No-Rosion reduces the surface tension of water to 26 Dynes/cm^2. Through this reduction in coolant surface tension, No-Rosion has the ability to alter the localized dynamics of heat exchange in cylinder heads, despite the fact that water has a lower boiling point than glycol. Comparatively, Evans coolants have surface tension in the range of 36-44 Dynes/cm^2.

In their advertising, Evans makes the claim that *Evans NPG Coolant can maintain a substantially vapor free liquid to metal contact (nucleate vapor only) at all coolant temperatures and engine loads*. In our research, we did not find this to be an accurate statement. As already referenced, we did observe a reduction of nucleate boiling with the Evans product. But we did not observe a *substantially vapor free* condition of nucleate boiling, as advertised by Evans. This was confirmed in laboratory simulations, utilizing an electric heat source that produced metal temperatures in the range 650-980^{o}F.

Further contributing to cylinder head temperature elevation is the fact that Evans waterless products are considerably more viscous than water, or a 50/50 mix. At operating temperatures, water, and water with No-Rosion, has a viscosity of 0.28 cp. (No-Rosion does not alter the viscosity of water.) A 50/50 mix has a viscosity of 0.70 cp. The Evans products have viscosities of 2.3 to 2.8 cp. In other words, Evans waterless products are almost 10 times more viscous than water coolant, and 3-4 times more viscous than a 50/50 mix. This creates significant drag on water pumps. OEM auto manufacturers design water pumps for the viscosity of a 50/50 mix.

In our research, we observed a 20-25% reduction in coolant flow through radiator tubes when Evans waterless products were used. This is a direct result of Evans products higher viscosity. As coolant flow rates through radiator tubes drop, the ability of coolant to transfer heat via the radiator has a corresponding drop as well.

Coolants decreased ability to transfer heat at lower flow rates is a result of the Second Law of Thermodynamics, as best expressed in the following the equation:

$$Q = M \times Cp \times \Delta T$$

Where: Q is the heat load

M is the mass flow rate of coolant

Cp is the specific heat capacity of coolant

ΔT is the change in temperature of coolant in the radiator

Apparently in recognition of how their products negatively impact coolant flow rates as a result of their high viscosity, Evans now sells high volume water pumps for various engines, to include the Chevrolet LS1/L6. These pumps provide 20% more flow that OEM units, which would be almost enough to overcompensate for the greater pump effort required to move their considerably more viscous coolant fluids.

There is speculation that, when OEM water pumps are used with viscous Evans waterless products, water pump life span could be reduced, and result in a greater frequency of water pump failures. Additional testing would be necessary in order to validate this.

There is also speculation that cylinder head temperature increases of 115-140ºF as a result of using 100% glycol coolant may cause warping and related damage to cast iron heads in some engines. OEM engines are designed to be run at temperatures that are consistent with what is produced using coolant consisting of a 50/50 mix. The higher temperatures produced by 100% glycol coolant could increase the frequency of cast iron head damage. Again, additional testing would be necessary in order to validate this.

Because Evans waterless products are 100% glycol, they are slippery when spilled or leaked onto pavement. Assuming a baseline friction co-efficient reference of 1.00 for dry pavement, the friction co-efficient of water, and water with No-Rosion, is 0.65. (No-Rosion does not appreciably alter the friction co-efficient of water, when used at the proper dose.) The friction co-efficient of Evans products is 0.16. Evans products are 4 times more slippery than water. Race tracks now ban the use of engine coolant that contains ANY glycol. Instead, they require engines to run straight water coolant. This is one of the reasons why the Evans products can not be used in the engines of vehicles that are operated on a race track.

The other reason that Evans products are prohibited at race tracks is that they are flammable. They have flash points in the range of 225-232ºF. This means that if Evans coolant were released at or above the flash point, it could ignite. Because we observed coolant temperatures in this range during actual operating conditions, this is a real risk. On a comparative basis, straight water with No-Rosion has no flash point, and is not flammable at any temperature.

The cost of Evans waterless coolant is about $225 for an average 4 gallon cooling system. If you were to pay an authorized Evans *conversion center* to perform it for you, it costs another $150-$180 in labor, and $34 for the conversion fluid. So the do-it-yourselfer will pay a total of about $259. Consumers who have the shop do it for them will pay as much as $439.

On a comparative basis, water is free. No-Rosion costs $10.00 per bottle at retail. The proper dose of No-Rosion for straight water coolant requires two bottles, at a total cost of $20.00.

Are there engine cooling systems that will benefit from the physical properties of Evans waterless coolant? Absolutely. As a case in point, we have worked with a car collector who owns a

1931 Rolls-Royce Phantom II. It is powered by a 12-cylinder, Rolls-Royce Merlin aircraft engine, taken from a WWII P51 Mustang. The engine displaces 1,649 cubic inches, and creates an estimated 1,100 horsepower. Because this engine was originally designed to be operated in an airplane that flies at altitude, where the air is very cool, it has some significant cooling challenges when used in a vehicular application. The cooling system is essentially non-pressurized. So water coolant will boil at only 212ºF, instead of the 250ºF that it would boil at if the system were pressurized to 15 psi. Using water coolant results in boiling and engine overheating. This is the perfect application for Evans waterless coolant because of its high boiling point, even at zero pressure.

But how many of us drive a car with a 1,100 horsepower Merlin WWII airplane engine taken from a P51 Mustang?

SUMMARY OF FINDINGS

Conversion costs of $259 if you do it yourself, or over $400 if you pay a shop to do it.

97%+ removal of all previous coolant is mandatory in order to prevent corrosion.

Inhibitor deposition occurs on aluminum surfaces, which could cause issues in some radiators.

Engines run 115-140ºF hotter (at the cylinder heads) with Evans products.

Stabilized coolant temps are increased by 31-48ºF, versus straight water with No-Rosion.

Reprogramming ECU fan temp settings is mandatory to prevent the fan from running continuously.

Specific heat capacity of Evans waterless products ranges from 0.64 to 0.68, or about half that of water.

Engine octane requirement is increased by 5-7 numbers.

Computerized ignition must retard engine timing by 8-10º to prevent trace knock.

Engine horsepower is reduced by 4-5%.

Accelerated recession of non-hardened valve seats in older engines is possible, due to brinelling.

Viscosity is 3-4 times higher than what OEM water pumps are rated to accommodate.

Coolant flow rate through radiator tubes is reduced by 20-25% due to the higher viscosity.

Race tracks prohibit Evans products because they are flammable and slippery when spilled.