Fall 2016

Dear No-Rosion Customer,

This summer's heat was a good test of your car's cooling system… Hopefully it passed!

One of the questions we're often asked regards how to achieve the most temperature reduction from an automotive cooling system. In this newsletter, we'll address the issues most critical to a well-functioning cooling system, and then discuss how maintenance plays a key role in keeping a cooling system…. well… cool!

It's important to understand that a "*radiator*" in almost any vehicle built after about the mid-1930's actually isn't even much of a "*radiator*." Technically speaking, it is a "*forced convection heat exchanger*." That is to say, of the total amount of heat transfer that takes place within a modern radiator, only a small portion actually occurs via the process of "*radiation*."

The mechanism of heat transfer in a "modern" automotive cooling system relies almost entirely on two processes: (1) cool air passing through radiator fins, and (2) hot coolant being pumped through radiator tubes connected to said fins. Without the requisite quantity of air passing through the fins, and/or without the requisite quantity of coolant flowing through the tubes, cooling efficiency will be compromised.

Let's begin with the air part of the equation, and then we'll go into detail regarding the coolant…

Radiator core thickness impacts the rate of air flow through the radiator fins. How big should the core be? Assuming a core depth of 2.00" to 2.25", and 16 louvered fins per inch, a general rule of thumb is one square foot of surface area for each 125 horsepower.

Heat transfer is proportional to surface area. It's more important than core depth. It's easy to make the mistake of believing that "upgrading" to a thicker core will result in greater cooling capacity. This is true for race cars that are driven at constantly high speeds. But it's NOT true for street-driven vehicles that are operated at variable speeds. Having a core thicker than 3.50" actually works against you. As the core gets deeper, each row absorbs heat from the row(s) in front of it. And each additional row blocks air from reaching the row(s) behind it.

Regarding the radiator, there's the age-old question: Which metal conducts heat better, copper or aluminum? The answer may surprise you… COPPER conducts heat better! That being said, not all copper/brass radiators actually conduct more heat than aluminum radiators. Why?

It has to do with how the radiator is built. Aluminum radiators usually have wider tubes. This creates more surface area from the tubes to the fins, resulting in enhanced heat dissipation. Most aluminum radiators have 1" wide tubes, with some aftermarket/performance manufacturers using 1.25" and 1.5" tubes.

Comparatively, traditional copper/brass radiators usually use ½" tubes. So a four-row copper radiator has slightly less fin contact area than a two-row aluminum core with 1" tubes, especially when you take into account the loss of contact area at the curved ends of the tubes. Most OEM copper/brass radiators were built with the tubes on 9/16" centers. Aluminum cores built with the tubes on 7/16" or 3/8" centers create a more dense and efficient core than a standard copper core.

As a rule of thumb, a high efficiency copper/brass four-row radiator with tubes on 7/16" centers generally cools about the same as an aluminum two-row radiator with rows of 1" tubes. If more cooling is required from the radiator than either of these designs will provide, then an aluminum core with two rows of 1.25" tubes is the thickest recommended for a street application. Any thicker than that and you may have trouble moving enough air through the core when you slow down, or come to a stop. Even with an electric fan.

Let's turn our attention to coolant. Just as there's confusion regarding whether copper or aluminum transfers heat better, there's often confusion regarding what fluid type transfers heat more effectively, <u>water or glycol</u>?

"Specific Heat Capacity" is a measure of a fluid's ability to transfer heat. Water has a specific heat capacity of 1.00 cal/g·^{o}C. Glycol has a specific heat capacity of 0.573 cal/g·^{o}C. So water has thermal conductivity of 0.60 Watt/m· ^{o}C compared to glycol's of 0.25 Watt/m· ^{o}C. All else being equal, in an automotive cooling system, <u>straight water conducts 140% more heat than straight glycol, and about 60% more heat than a 50/50 mix</u>.

Not only does water conduct heat better than glycol, <u>it also flows better</u>. At a temperature of 200 ^{o}F, water has a viscosity of 0.305 cP, whereas ethylene glycol has a viscosity of 1.400 cP. At this same temperature, a 50/50 mix of water and ethylene glycol has a viscosity of 0.700 cP – meaning it is over twice as viscous as straight water. Assuming no modifications to your water pump, coolant flow is enhanced by running straight water coolant.

Unfortunately it's not practical to run straight water coolant in some parts of the country, because it provides no <u>freeze protection</u>. Additionally, it provides no <u>corrosion protection</u>, has <u>poor lubrication qualities</u> for the water pump, and <u>poor wetting abilities</u> due to its high surface tension. Fortunately, each of these problems is solvable.

You're already a customer, so you know that **No-Rosion** and **HyperKuhl** provide 100% corrosion protection – even when added to straight water. They pass ASTM D3306 specification, meaning they prevent corrosion and lubricate the water pump as well as any fully-formulated antifreeze or engine coolant – even in straight water. And in the case of **HyperKuhl**, it contains advanced surfactants that drastically improve water's wetting ability.

Many of you run straight water coolant during the summer, and revert to a 50/50 mix before winter hits. This solves the issue of freeze protection. What about <u>boil-over protection</u>? Keep in mind that, since your engine will be running cooler with straight water coolant, boil-over is already less of a concern. But some applications do involve sustained, extreme heat that requires elevated boil-over protection. Towing is one such example.

There's a direct relationship between <u>boil-over</u> and cooling system <u>pressure</u>. As pressure increases, so does boiling point. Switching to a higher pressure radiator cap provides increased boil-over protection. By using **HyperKuhl** to help prevent nucleate boiling in the cylinder heads, coolant temperatures can get surprisingly high without the risk of the engine suffering heat-related damage: over 270^{o}F with water, and 380^{o}F with glycol.

Most automotive radiator caps are 13 to 16 psi. Racing caps range from 22 to 35 psi (or more). There is no downside to using a higher rated cap, other than price, and having to overcome spring pressure when tightening or removing it. Just keep in mind that too high of a pressure may damage a marginally-designed system, or one that is fragile from old age. Here's a chart that shows the boiling point of water at a range of pressures:

Pressure (psi)	Boiling Point (degrees F.)
0	212
2	218
4	224
6	230
8	236
10	242
12	248
14	254
16	260
18	266
20	272

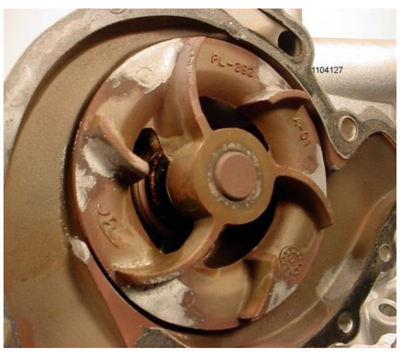
Sufficient coolant flow is critical to optimal radiator performance. Absent adequate flow, heat won't be properly transferred from the engine to the radiator, and from the radiator tubes to the radiator fins.

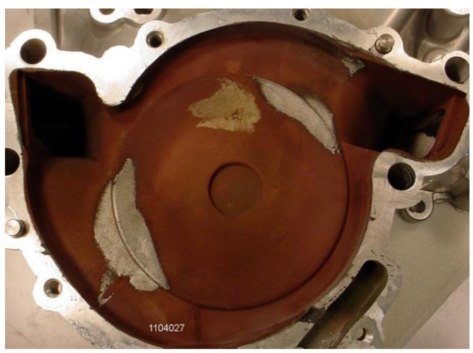
Coolant flow is dependent on a properly functioning water pump. It also requires a clean system that is unobstructed, and free of contaminants. What are these contaminants? And where do they come from?

Coolant contaminants accumulate over time. It usually begins with coolant pH decreasing below a certain threshold level. Gaseous combustion byproducts slowly make their way into coolant, causing the formation of acids. And glycol in antifreeze breaks down to form glycolic acid. This reduces the coolant's pH, and causes tiny rust particles to form. At the same time, dissolved oxygen in coolant acts as a catalyst to accelerate this process.

A reduction in coolant's pH causes inhibitors in antifreeze to drop out of solution. Once insoluble, they make it more difficult for water contaminants – if present – to remain in solution as well. Said contaminants can include calcium, magnesium, iron, silicates, etc. As these various insoluble materials accumulate and circulate throughout a cooling system, they combine with rust particles to form globules. Given enough time, globules increase in size, and eventually form coolant gel.

Coolant gel causes a number of problems. It collects in radiator tubes, thereby reducing coolant flow. It adheres to heat-exchange areas inside the engine and radiator, baking onto metal surfaces to form scales and deposits. It accumulates around the seals of water pumps. Due to the composition of gel, it is very gritty. Think of it as "liquid sandpaper." As it passes through water pump impellor blades, it causes them to erode. Eroded pump blades don't pump coolant as effectively, resulting in reduced flow. Gel also accelerates water pump seal failure, again, due to its gritty qualities. These photos show gel's erosive effects beginning to occur inside a water pump.





Mind you, scales and deposits only 1/16" thick can reduce heat transfer by up to 40%! The longer coolant gel is allowed to recirculate through a cooling system, the more time it has to completely drop out of solution and form scales and deposits. This will eventually result in overheating.

Scales and deposits cause other problems. Corrosion inhibitors in engine coolant protect metal surfaces through a process known as "passivation." In order to function properly, inhibitors in the coolant solution must constantly flow over the metal surface. But if the metal surface is covered in scales/deposits, no inhibitors can reach it, and corrosion will thrive underneath. This type of under-scale corrosion often results in a leak.

Inside a radiator, gel accumulation is usually worse in the bottom tubes. As gel thickens, it becomes heavy. Gravity keeps gel toward the bottom of the radiator. So if you open the radiator cap and use a flashlight to look inside the top, you could easily be lulled into a false sense of security. You'll see clear coolant and clean radiator tubes, when in fact, all the gel and clogged tubes are in the bottom of the radiator. You can't even see it! Most of the time when we see clogged radiators, the tubes in the bottom have 400% to 600% more gels and deposits than the tubes in the top. For example, in the photo on the next page, the top tubes are at the right, and the bottom tubes are at the left. Incidentally, the badly gelled coolant in this radiator was *Dex-Cool Extended Life Antifreeze*. This occurred after only a 3-year service interval in a 2012 Chevy Tahoe – proving that even newer cars with so-called "*advanced*" coolant chemistries are not immune to this type of problem!

Our **No-Rosion Cooling System Flush** and **HyperKuhl SuperFlush** products have been developed to effectively remove coolant gel. Their chemistry is entirely different than all other products on the market today. Both formulas were derived from industrial cleaning products used to maintain high-dollar industrial heat exchangers, many having tubes with a total replacement value of over $1 million. How do our flush products work?

Both products contain a chelant that solubilizes and removes loosely-adherent gels. Surface-active industrial grade detergents further help remove gels, and keep them in solution during the flush process. Lubricants protect water pump seals during the flushing process, when gels are stirred up in the coolant. (Water pump seals of older vehicles, in particular, are sensitive to abrasive gels during the flushing process, due to age-related wear.) And pH-buffering ingredients help neutralize acids left behind by broken-down antifreeze.

It is important to note: Neither product is designed to dissolve baked-on scales and deposits. Only a strong acid will do that. It is NOT recommended that acids be used in an automotive cooling system. They often do more damage than good. They eat through thin radiator tubes, causing pinhole leaks. Most require a "neutralizer" to be used after the flush, to prevent further damage after the flush process is complete. But neutralizers are not always effective – meaning acid could reside in the system after the cleaning is complete.

Both our flush products have a neutral pH. This makes them completely safe for all cooling system metals. It makes them safer for you to use as well. This is important, as splashing usually occurs during the flush process. The last thing you want is to get an acid cleaner in your eyes, on your skin, or on your car's paint. Both products are safe to take to drains or waterways, as they don't contain any hazardous ingredients.

Both products are also formulated with corrosion inhibitor ingredients. This "primes" metal surfaces for follow-up treatment with **No-Rosion** or **HyperKuhl** by leaving behind the beginnings of passive, non-reactive surface films. The difference between the two products is that **HyperKuhl SuperFlush** contains more aluminum-specific inhibitors. So if you have an aluminum-core radiator, **HyperKuhl Superflush** is recommended. If you have a copper-core radiator, **No-Rosion Flush** is recommended.

Some examples of when you should flush: (a) coolant is over 4-5 years old, (b) cooling system was "neglected", (c) water of unknown quality was used, (d) you had a leak and topped off the system multiple times, (e) you are switching to **No-Rosion** or **HyperKuhl** after using another additive, (f) after the 5 year **No-Rosion** treat cycle.

Please find the enclosed order form that you can use to place your next order. Or, for quicker service, visit our web site and place your order using our secure, encrypted server at: www.NoRosion.com.

Thank you for being a customer. We appreciate your support, and look forward to continuing to be of service.

Sincerely,

Applied Chemical Specialties, Inc.