Fall 2021

Dear No-Rosion Customer,

Hopefully this newsletter finds you and your family well during these continued unusual times.

A question we are often asked is: **"What type of water is best to use in my cooling system?"**

Water contains dissolved impurities that can cause a number of different issues in a cooling system. How quickly and severely these issues unfold depends on the type and concentration of contaminants. Chief among these issues are scales and deposits formed from ***hardness*** in water. Once formed, they are difficult to remove and will reduce heat transfer enough to eventually cause overheating.

Purifying water helps control these issues. But not all water purification methods are created equal. When water is purified, it alters the chemical properties of water molecules. Meaning, in some instances, the wrong choice of purified water can open an entirely different can of worms. This is mostly the case only if/when you use straight water coolant, or less than 50% glycol antifreeze in the coolant mix.

So let's begin by breaking down water into two categories: unpurified and purified. The most common unpurified water choices are: tap, well, and rain water. And the most common purified water choices are: softened, distilled, deionized (DI), filtered, and reverse osmosis (RO) water.

Tap water. It of course comes from your local municipal water treatment plant. Depending on where you live, municipal water can be derived from rivers, lakes, streams, ponds, reservoirs, springs, groundwater wells, or even the ocean. As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals and picks up various contaminants. These can be biological as well as non-biological, and naturally occurring as well as non-naturally occurring.

As mentioned, the most common tap water contaminant that's problematic to your cooling system is hardness. It is composed primarily of dissolved calcium and magnesium carbonates, and formed when ground water percolates through deposits of limestone, chalk or gypsum. In engine coolant, hardness drops out of solution and bakes onto hot surfaces inside cylinder heads and radiators to form scales and deposits. Insulative in nature, they reduce heat transfer, and eventually cause overheating and possible engine damage. **Scales only 1/16" thick can reduce heat transfer by up to 40%!** Hardness also functions as an electrolyte that increases electrical conductivity of engine coolant, which accelerates galvanic action type electrolysis of dissimilar metals.

In coastal areas, reduced availability of fresh water from waterways and ground sources has resulted in municipal water increasingly being sourced from seawater, and processed by desalination. This removes salt (sodium chloride) from seawater, making it possible to use as tap water. The problem with desalinated water is carryover of ***chloride ions*** from salt. No matter how effective the desalination process is, a certain amount of chloride ion will bleed through. Chloride in engine coolant is very problematic.

Chloride ion is very small, with a diameter of 0.000167 micrometers. Because of this, it has the ability to penetrate the matrix structure of aluminum alloy on a molecular level, and cause ***intergranular corrosion***. In severe instances, this type of corrosion becomes electrochemically autocatalytic, meaning it accelerates as it goes further into the metal, and will not stop until the entire thickness of the metal has been penetrated.

Chloride ion can also combine with hydrogen from water to form weak aqueous solutions of ***hydrochloric acid*** as engine coolant goes through repeat heat/cool cycles. This reduces the pH of engine coolant, making it acidic and corrosive to system metals. For this reason, ASTM D3306, the standard specification for engine coolant followed by all OEM's, lists maximum allowable chloride at 25 ppm. To put this into perspective, it is not uncommon for tap water from municipal desalination plants to contain 50-100+ ppm chloride.

Another way tap water can become acidic results from ***chlorine*** used by municipalities to disinfect source water. Various biological contaminants need to be killed before bulk water can be treated, and typically chlorine gas is used. Chlorine is bound by naturally-occurring nitrogen compounds to form chloramines, which do not disinfect as effectively as "*free chlorine*." So in some instances they over-chlorinate to reach and exceed the "*break point*" whereby free chlorine is achieved for effective disinfection. In the process, chloroacedic acids are formed that can carry over into tap water. When recirculated through repeat heat/cool cycles in a cooling system, they reduce the pH of engine coolant, making it acidic and therefore corrosive to system metals.

Well water. While tap water certainly has its issues, untreated well water in most cases is worse. Iron, sulfur, hardness, and biological contaminants are typically the main culprits. Even treated well water has its issues, as treatment options (and the quality of their output) vary widely and are thus beyond the context of this writing.

Iron deposits out on hot surfaces inside cooling systems. Sulfur forms weak aqueous solutions of sulfuric acid, reducing coolant pH and accelerating corrosion. And bio-contaminants consume carboxylate-based inhibitors in extended life antifreeze as nutrient, leaving insufficient residual corrosion protection for metal surfaces.

Rain water. The problem with rainwater isn't just that it often contains environmental contaminants washed out of the sky, it's also often acidic. This is especially the case if you live near the ocean, coal fired power plants, or in an urban area with smog. For these reasons and more, we recommend against its use in a cooling system.

Softened water. When calcium and magnesium *hardness* is removed from water, it is said to be softened, and therefore sufficient to prevent buildup of scales and deposits in a cooling system.

Household water-softening appliances use ion-exchange resin beads. They exhange hardness ions (calcium Ca^{2+} and magnesium Mg^{2+}) for sodium Na^{+} ions, with the sodium coming from sodium chloride salt. When all available sodium ions have been replaced with calcium/magnesium ions, resin is regenerated by replacing calcium and magnesium ions using a solution of sodium chloride salt. Waste water from the ion-exchange column containing the unwanted calcium/magnesium is discharged, along with chloride ions left behind from the salt regenerant.

The problem is bleed-through chloride. Domestic water softeners are not the most sophisticated water purification devices. Depending on how well they are made, maintained, and regenerated, they can allow enough chloride ion (25+ ppm) into effluent softened water to create corrosion of metals when used in a cooling system. And mind you, water softening ONLY removes calcium/magnesium – but not other contaminants!

Distilled water. When water is boiled into vapor, and the steam is condensed back into liquid, it is said to be distilled. Contaminants such as salts and minerals are left behind, and bio-contaminants are killed due to the high temps. Because of its purity, you would expect distilled water to have a neutral pH of 7. And if you measure the pH immediately after distillation, that's what you'll find. But it soon changes to become acidic. Why?

Distilled water is electrochemically imbalanced, or "*ionically hungry*." It readily/aggressively absorbs anything it can in order to regain electrochemical balance. In the environment, the material most easily found is carbon dioxide. Freshly distilled water will absorb carbon dioxide until it comes into equilibrium with the atmosphere. Once it enters solution, carbon dioxide reacts with water to produce carbonic acid, per the chemical equation:

$2H_20$ (water) + CO_2 (carbon dioxide) --> H_2O (water) + H_2CO_3 (carbonic acid)

Depending on temperature and water purity, it can take less than an hour for a sample of distilled water to absorb all the carbon dioxide it can from the atmosphere and achieve its final **acidic** pH of 5.0 to 5.5.

“Ionically hungry” distilled water will also leach ions from more sensitive metals in a cooling system to satisfy its electrochemical imbalance. In the process, metals are slowly ***dissolved***, which translates to pitting of thicker surfaces (such as cylinder heads) and pinhole leaks in thinner surfaces (such as radiator tubes).

Deionized (DI) water. When water is passed through cation and anion exchange resins, it is said to be deionized. These two resins attract positive and negative ions, respectively, replacing them with H^+ and OH^-. Combining H^+ with OH^- produces H_2O – or water. The combination of filters and DI resins removes nearly all contaminants. It accomplishes the same as distillation, but by using the mechanism of ion exchange instead of boiling.

So like distilled water, DI water is electrochemically imbalanced and ionically hungry. It readily absorbs atmospheric carbon dioxide to form carbonic acid, and will leach ions from metals in a cooling system.

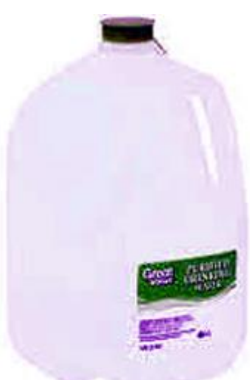
Filtered water. When contaminants exceeding a certain particle size are removed from water by pushing it through porous media, it is said to be filtered. Water filtration can incorporate a wide variety of different media types, and is a general term that can be inclusive of a wide variety of different methods. Because of this breadth, it is difficult to compare to other methods. But suffice to say, it is not sufficient to remove chloride ion because at its absolute best occurs on a **MICRO** level, as compared to the **NANO** level of Reverse Osmosis.

Reverse Osmosis (RO) water. When water is pushed through a semi-permeable membrane that selectively separates ions, unwanted molecules, and particles exceeding a certain size, it is said to be purified by RO. It is by far the most sophisticated method of water purification.   It removes nearly all types of dissolved and suspended chemical compounds, as well as biological ones. It is used in industrial processes requiring extremely pure water (such as microchip production), as well as for production of purified bottled drinking water.

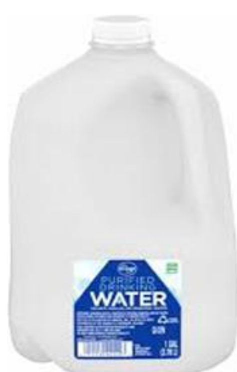
Because the membrane through which water passes is ion-selective, it produces water that is not only ultra-pure but electrochemically stable and balanced. This is very important in the context of engine coolant.

RO differs from filtration in that the mechanism of fluid flow is by osmosis across a membrane rather than through filter media. So whereas the mechanism of contaminant exclusion with filtration is limited to size exclusion of pores 0.01 micrometers or larger, RO uses a membrane with pores that size exclude to 0.001 micrometers. And with RO, the mechanism of contaminant exclusion further differentiates on solubility or diffusivity, which allows RO’s ionic membrane to bind and remove 100% of chloride ion present in water.

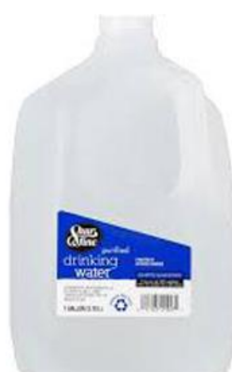
You’ll find RO water in gallon jugs on the shelf of your local supermarket, labeled as “**Purified Drinking Water**,” and priced around $1.00 per bottle. Often the fine print indicates “*purified by Reverse Osmosis*.”



Great Value



Kroger



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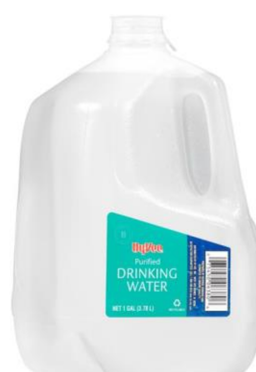

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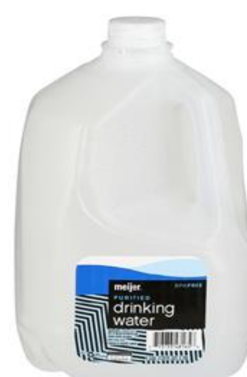

Meijer

Also on your store shelf is bottled **Mineral Water**. It is best avoided, as mineral content may be too high and thus not only risk scale/deposit buildup, but increase electrical conductivity and allow galvanic action electrolysis.

We also get asked about dehumidifier water. As a condensate, it has similar undesirable properties as distilled water – and is not pure because not derived from steam, and contains contaminants from the air it dehumidified.

Distilled and DI water **CAN** be safely/effectively used in a 50/50 mix. This is because electrochemical balance is satiated by complexing with glycol and other chemicals in antifreeze. And because antifreeze is pH-buffered, it has reserve alkalinity sufficient to protect against carbonic acid that will be present in distilled/DI water. Also, bear in mind that a 50/50 mix contains half as much water as straight water coolant, which further mitigates any of distilled/DI water's harmful effects.

Which begs the question: **"Will I benefit from using a lower percent of antifreeze?"** The answer is: YES.

Compared to antifreeze: (a) water's higher specific heat capacity allows it to better transfer heat, (b) it's lower viscosity allows it to flow more rapidly through radiator tubes, and (c) unlike glycol, water won't gel in engine oil and damage bearings if coolant seeps into the crankcase. The only things water lacks are corrosion protection and freeze protection. It's lack of corrosion protection is easily resolved by the addition of **No-Rosion**.

Unless you live in a location that sees temps of minus 30 deg F, you don't need a 50/50 mix. For example, 35% glycol freeze-protects to 0 deg F, which is adequate for all but the northernmost states. You will see noticeable benefits by reducing antifreeze percent by only 15%, from 50% to 35%. Or if you don't require freeze protection, you can maximize benefits by switching to straight water, plus No-Rosion or Hyperkuhl for corrosion protection.

There are two types of antifreeze: (a) **Pre-dilute 50/50** that is ready to use, or (b) **100% glycol concentrate** that you dilute before use. It costs less to buy concentrate and dilute it yourself. Concentrate contains twice as much corrosion inhibitor as ready-to-use, to compensate for being diluted by 50%. So if you do decide to use less than 50%, you will not have enough inhibitor for sufficient corrosion protection. Adding **No-Rosion** solves this issue.

To have the best of all worlds, we recommend our new **HyperKuhl Pre-Mix**, now available in 5 gallon containers. It is blended with the highest quality ultra-pure RO water. And as a pre-mix, assures dosing is spot-on accurate. It is ideal for aluminum radiators, as it contains the same OAT corrosion inhibitors found in extended life antifreeze blends. In addition, it contains specialized wetting agents that further enhance heat transfer and reduce engine cylinder head temperatures. It is ideal for high performance and/or high compression engines – or tow vehicles requiring an added layer of protection against overheating.

HyperKuhl Pre-Mix also contains some extra surfactant ingredients not found in the additive form of HyperKuhl. And because it is a 100% water-based formula blended with ultra-pure RO water, it has the lowest electrical conductivity of ANY engine coolant available – making it the perfect choice for systems prone to electrolysis!

We thank you very much for your support, and look forward to continuing to be of service to you and your cars.

Sincerely,

Applied Chemical Specialties, Inc.