Electrolysis Problems Continue to Mount

There's a Downside to the Electronics Revolution

By Ralph McDarmont,
Managing Editor of **Radiator Reporter**

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Nowhere is the impact of electronics more obvious than in the automotive world. Today's cars and trucks are packed with motors, sensors, and task-specific microprocessors, and while the gadgets are interesting if not always practical, they have greatly complicated the task of diagnosing and repairing today's vehicles. In fact, the proliferation of electronic gadgetry, under the hood as well as under the dash, has triggered a whole new set of vehicle problems and diagnostic challenges.

Take electrolysis, for example. Before the days of front wheel drive and transverse-mounted engines, cooling system electrolysis was a rare occurrence. But today, with most cars and many light-duty trucks featuring electric cooling fans in conjunction with ungrounded plastic-tank radiators, cooling system electrolysis is becoming a frequent problem.

Electrolysis occurs when electrical current routes itself through the engine's coolant in search of electrical ground. Current can be introduced into the cooling system in many ways, but the two most common causes are a poor ground to the radiator's electric cooling fan, or a poor ground from the starter motor and engine block to the battery. Any vehicle with accessories bolted to the radiator support or to a nearby component is also a good candidate for electrolysis.

The Causes and Effects of Electrolysis

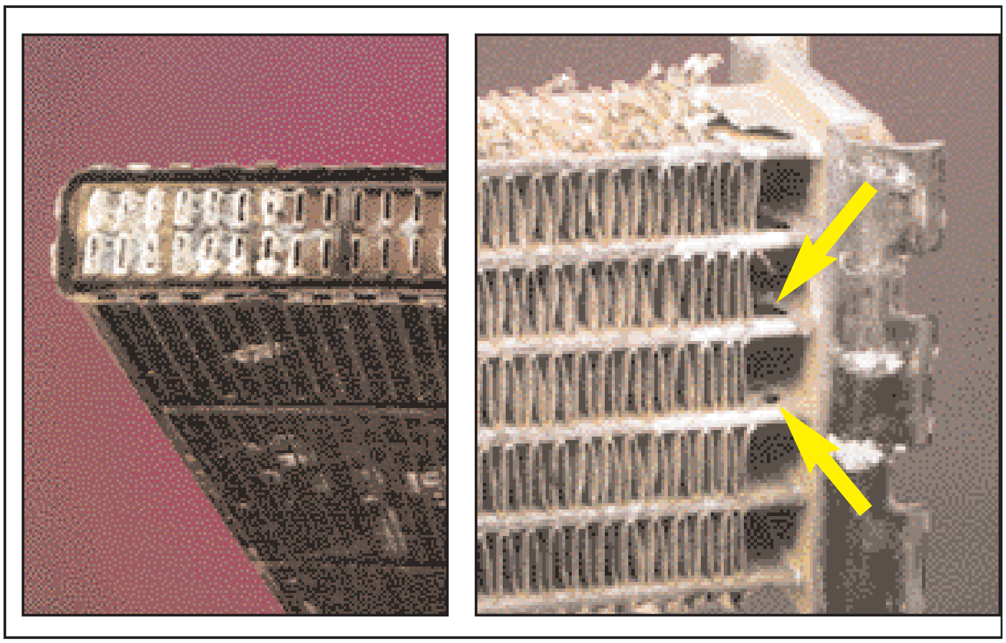
Electrolysis is a fast-acting menace that attacks not only radiators and heaters, but can destroy an entire engine in a mere 20,000 miles. Though a small amount of measurable voltage can be detected in most engine cooling systems, due to reactions between the coolant and cooling system metals, the detected voltage should never exceed a tenth of a volt in vehicles equipped with aluminum engine blocks and/or cylinder heads.

Cast iron engines and cooling system components can tolerate higher stray voltages, perhaps as much as three-tenths of a volt. But that doesn't mean three-tenths of a volt is acceptable. It's not.

In cases of electrolysis, a defective or missing ground on an electrical device causes the electricity to seek the path of least resistance whenever the component is energized. Sometimes the path of least resistance is a radiator or heater hose, or the radiator or heater core. As the current draw of the poorly grounded accessory increases, so does the destructiveness of electrolysis.

A poorly grounded engine and starter motor can zap enough current through the cooling system to blast apart a heater or radiator in a matter of weeks or even days, depending on how often the vehicle is started. A partially grounded electric cooling fan, on the other hand, may only shoot a small percentage of its supply voltage through a cooling system, and the effect may take months to reveal itself.

Evidence of electrolysis includes unexplained and/or the recurring pinhole leaks in a radiator or heater. Pinholes may form anywhere along the tubes or tank walls, but damage is often concentrated at tube-to-header joints, or in the tube walls near the center of the core, where the electric cooling fan mounts come in contact with the core.



Stray current inside the cooling system can cause excessive corrosion of metal components (left) as well as an electrochemical reaction that will produce voids in radiator tubes. Photos courtesy of Modine Manufacturing.

Simple Shop Test for Electrolysis

To test for electrolysis, connect the negative probe of a digital D.C. voltmeter to the battery's negative post. Then submerge the meter's positive probe into the coolant at the filler neck. Be sure that the positive probe does not touch any metal.

Next, note the meter reading, which should be no more than 0.10 volts. If a higher voltage is detected, methodically shut off or disconnect one electrical component or accessory at a time while watching the voltmeter. When the voltage reading drops to zero, you've pinpointed the electrical component with the defective or missing ground. Since electrolysis might occur only when a certain component is energized, have a helper switch each vehicle component on and off while you observe the voltmeter readings.

To check components or accessories that don't have an on/off switch, use a long jumper wire connected to the battery's negative post to provide a temporary ground to each electrical accessory. Ground each component with the jumper wire and watch the meter. If the jumper wire restores a missing or faulty ground, the meter will drop to zero.

Be sure to check for intermittent voltage surges generated by the starter during cranking. To do so, watch the meter as you crank the engine. Any jump in voltage during cranking indicates a loose, faulty, or missing engine ground. Any electrical device with a huge current draw, like a starter motor or radiator cooling fan, will chew up a cooling system far faster than a trickle of voltage from a poorly grounded underhood relay or other low-amperage device.

Static Charges: A Second Cause of Electrolysis

A small number of electrolysis problems have been traced to static buildup somewhere in the vehicle. Likely sources would be rubber-mounted driveline parts, a plastic blower wheel spinning in a plastic HVAC case when the blower motor is improperly grounded, and certain tires. In fact, not too many years ago, Michelin received a rash of complaints from vehicle owners who were getting zapped whenever they stepped from their vehicles. The problem was traced to the tires, which generated a static buildup in the vehicle when driven under certain conditions.

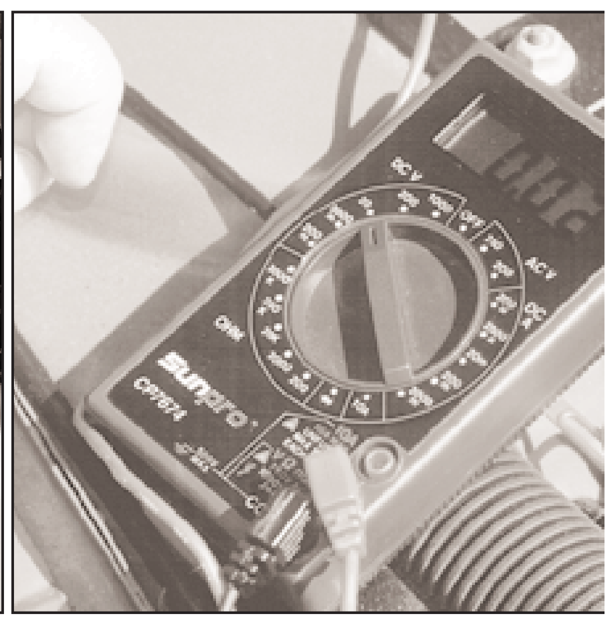
Some of the newest vehicles coming off the assembly lines feature a different type of blower motor circuit which may actually increase the incidence of electrolysis caused by static discharge.

Conventional HVAC blower motors are usually wired so that the motor is always grounded and speed is controlled by applying battery voltage to the positive terminal of the motor. Speed is varied by routing the battery voltage through a series of resistors before it gets to the motor. Some newer vehicles, however, are wired so that the HVAC motor is always "hot" with 12 volts from the battery. Speed is controlled by applying a variable ground to the ground-side terminal of the motor.

When an HVAC motor is always grounded, static charges that might form inside the HVAC blower case are likely to "zap" the motor's housing and then be routed harmlessly to the ground post of the battery. But on vehicles with a variable ground to the HVAC blower, static buildup has nowhere to go, or at the very least it must overcome higher electrical resistance as it travels toward the best available ground. By "best" we mean the "path of least resistance," a key concept in electronics and the diagnosis of electrolysis. Don't ground the heat exchanger!

Early on, when electrolysis first cropped up as a problem in cooling systems, many mechanics attempted to solve the problem by grounding the heater or radiator in order to "collect" any stray voltage and route it to battery ground. But mechanics soon discovered that grounding a heat exchanger to "collect" stray current merely accelerated the damage to the heat exchanger. What they really needed, they found, was a way to draw the stray voltage away from the heat exchanger, similar to what boaters do when they install "sacrificial" zinc anodes that collect and dissipate stray electrical current before it chews up a boat's engine, propeller, or metal hull.

It isn't practical, nor is it advisable, to install sacrificial zincs to protect an automotive cooling system, though several rad shop owners with a knowledge of boating have inquired about the idea. Instead, the proper repair is to locate and eliminate the



After turning your digital volt-ohm meter to DC volts, touch the negative connection to the battery (left). Next, dip the positive lead into the coolant at the filler neck (center). Be sure not to touch the sides or bottom of the radiator with the lead. Finally, look at your reading (right). Anything over .10 volts is cause for concern.

source of the stray current.

In a handful of cases tracked by RR, shop owners facing recurring "electrolysis-like" heater comebacks were never able to locate the source of stray or static voltage. Convinced that stray voltage was zapping the heaters into oblivion, they have experimented with the idea of lining the HVAC blower case with heavy-gauge aluminum foil and grounding the foil to the battery. The foil is held in place with a general-purpose aerosol adhesive. So far, no more comebacks.

Explaining Those "Unexplainable" Pinholes

For several years rad shop owners have called RR to report all types of heater and radiator core failures involving unexplained pinholes in the centers of the cores, or pinholes located just an inch or two away from the headers. Many of the callers have been quick to accuse the coremakers of using inferior tube stock, but over time it has become clear that the problem of unexplained pinholes is too widespread to fall upon the shoulders of a single manufacturer or tube supplier.

Sure, there is plenty of sloppy manufacturing taking place in the aftermarket heat exchanger industry, but it manifests itself mostly in products that don't fit right, don't provide adequate heat transfer, or don't have decent tube-to-header joints. But a breakdown of the tube wall, often several inches or more from the header, can't be classified as an assembly or manufacturing defect.

With the exception of tube wall failure triggered by flux residue left over from the manufacturing process and not washed off prior to boxing and shipping, center-of-the-core tubewall failure cannot be pinned on the OEM and aftermarket parts makers.

With the manufacturers in the clear, this time, rad shop owners are left with a lot of unexplainable core failures. Abrasive coolant is often blamed for core failures, and rightly so, but abrasive coolant causes erosion of the inlet header and tube ends. Similarly, acidic and/or depleted engine coolant can chew up a radiator, but again the damage is usually concentrated at the headers and tube ends, not toward the center of the core.

In general, aftermarket manufacturers have been pretty good sports when it comes to replacing product that has developed unexplainable pinholes. Yet the root cause of the problem appears to be vehicle-related. GM, and presumably other carmakers, has noticed an uptick in heat exchanger warranty claims. In 1997, GM issued a service bulletin to its dealer network advising technicians to check for depleted coolant and the possibility of electrolysis whenever a heater or radiator springs a leak and must be replaced under warranty.

It bears repeating that not all pinholes are caused by electrolysis. We've already mentioned that tube erosion can be caused by abrasive coolant, a problem which is accelerated on vehicles with high-output water pumps. And with the miles and miles of tube stock used by OEM and aftermarket coremakers, there is bound to be an occasional product defect.

Tube wall erosion midway down a core's length can sometimes also occur if the tube becomes partially plugged. The plugged area forces coolant to pass through the unrestricted portion of the tube, often at an accelerated speed, hitting the inside of the tube wall with an increased force similar to the increased force that results when you narrow the stream of a garden hose nozzle.

One telltale sign of electrolysis and/or electro-chemical corrosion is discoloration of the affected area. Aluminum components usually turn black and pitted, while copper/brass components are likely to develop a blue-green corrosion byproduct. Unfortunately, bad coolant can cause similar discoloration, so a blackened PTR core doesn't always mean electrolysis is to blame, but it should raise the possibility in your mind during diagnosis.