

## ELECTROLYSIS & COOLANT VOLTAGE

The term “electrolysis” has a technical definition that is different than its common use in the automotive service industry. In automotive service, almost any cause of corrosion is called electrolysis. The term is so universally misused that even cavitation and Alumina damage is often blamed on electrolysis.

The most commonly recommended test for electrolysis is the coolant voltage test. It is almost never performed properly and therefore actually contributes to a great deal of misdiagnosis and repeat failure of a variety of components. If you are using a typical voltmeter to check coolant voltage, you are probably part of this problem. I’ll get back to that and explain how to do this correctly a bit latter.

Cavitation and abrasive aluminum oxide erosion (corrosion erosion) are both far more common than any electron related damage. But, three types of electron related damage that are usually called electrolysis are very real and do need to be addressed,

1. Chemical Electrolysis – This is more accurately called galvanic cell electrolysis and isn’t actually electrolysis. When two different metals with different galvanic potential are connected by an electrolyte (coolant) or direct contact, they will cause a chemical reaction and generate a voltage. The process will gradually destroy the anode
2. Ground Fault Electrolysis – The engine coolant conducts electricity. When engine ground straps have trouble carrying the alternator or starter current, current flow through the coolant tends to increase resulting in destruction of grounded components that contact the coolant.
3. Static Discharge Electrolysis – Engine cooling fans, blower motors and water pumps can generate static electricity. The associated build-up of electrons can jump to ground through the cooling system. Over extended periods of time this can gradually erode heater cores, radiators and other components.

Technicians must understand each of the above. Understanding just one will frequently lead to inappropriate attempts at repairs. Destruction of heater cores and radiators has increased dramatically when technicians misdiagnosed static charge electrolysis and added improper grounds to the heat exchangers.

Galvanic cell electrolysis varies greatly depending on the types of metals used in the system and the type and condition of the coolant. There are many different alloys of each metal used in cooling systems. The variation in alloys and coolant formulations diminishes the accuracy of any attempt to predict galvanic activity. But, the following chart is a good guideline.

## Construction Material Compatibility

Corrosion and voltage potential varies depending on various conditions including coolant formula and the different alloys of the given metal. In general, the greater the difference in the listed electrode potential or galvanic index, the greater the corrosion potential. Copper should never be in direct contact with iron, aluminum or steel. The copper will cause the other material to corrode.			
	Material	Electrode Potential	Approximate anodic Index
Most Sensitive to damage	Magnesium	-2.37	~1.75
	Aluminum	-1.67	~0.75 - 0.95
	Zinc	-0.76	~1.25
	Chromium	-0.74	~0.40 - 0.60
	Iron	-0.44	~0.85
	Nickel	-0.24	~0.30
	Tin	-0.14	~0.65
	Lead	-0.13	~0.70
	Hydrogen	0.00	
	Brass		~0.40 - 0.45
Least Sensitive to damage	Copper	+0.34	~0.35

When Copper and Iron are both present in a cooling system, their combined difference in electrode potential is 0.78 volts (negative 0.44 and positive 0.34). This pair of metals actually makes up a battery. The copper would serve as the cathode or positive electrode. The iron would serve as the negative electrode or anode. Since electrons flow from negative to positive, and tend to take some material with them, anode is the sacrificial electrode that will be damaged.

A coolant that contains additives to suppress this potential is required to prevent galvanic cell corrosion of the iron when copper is present in the system. When aluminum started showing up in cooling systems, the difference in electrode potential between copper and aluminum increased to 2.01 volts (negative 1.67 and positive 0.34). The coolant formulas had to be changed dramatically to prevent damage to Aluminum.

Installing a copper or brass connector into an aluminum or cast iron intake manifold presents a similar corrosion potential. And, coolant additives won't help when the two metals are in direct contact.

Copper and brass solder (tin & lead) has largely disappeared from modern cooling systems. Steel and even some cast iron alloys may contain some chromium and nickel but iron and Aluminum are now the primary electrodes of galvanic cell activity. This represents a difference in electrode potential of 1.23 volts (negative 1.67 and negative 0.44). This is far easier to control than the older systems that included copper. However,

adding aftermarket copper and brass components will create problems that the original OEM coolant may not be capable of controlling.

Testing coolant voltage is recommended by virtually every manufacturer of heat exchangers. Unfortunately they don't tell you that the test must be performed with special neutral Platinum voltmeter leads. When you place a typical Chromium plated test lead in the coolant, and connect the other lead to the cast iron block, you are creating a galvanic cell of chromium and iron with a voltage potential of 0.30 volts (0.74 and 0.44). That by itself will fail the standard of 0.100 volts that heat exchanger manufacturers suggest.

Nickel plated test leads (also common) are only slightly better with a voltage potential of 0.200 volts (-0.24 and -0.44). The amount of error will also change based on the type of coolant, Aluminum engine blocks and the different iron and aluminum alloys.

Coolant voltage is a valid test. But, you must use a neutral platinum test lead in the coolant. You simply put the platinum lead or electrode in the coolant (at the radiator cap opening) and connect any type of lead to the engine block. Polarity does not matter. A digital voltmeter will display the voltage potential. Just ignore the negative sign if one appears on the screen. Unless you go to the trouble of locating and purchasing a platinum electrode or test lead from a scientific supply store, it's best to ignore the results of this test. If you fail the test at a voltage higher than 0.300, the polarity does become important in identifying the cause of the problem and the appropriate solution. But, that will have to wait for another article or training program.

High quality cooling system service and repairs requires a good understanding of:

- Ground fault electrolysis,
- Static discharge electrolysis
- Aluminum oxide contamination
- Water pump cavitation
- Voltage drop testing
- Current ramping
- Flushing
- Purging
- Coolant formulas
- ECD resistant hoses
- Nylon 6.6 degradation
- Cooling system filtration
- Recovery & Surge Tanks
- Dissolved Oxygen variables
- pH, Nitrite, Molybdate and concentration testing

If you were not aware of the problems related to testing coolant voltage with standard test leads, or using aftermarket parts containing copper or brass, you are probably also missing a lot of other valuable update information on modern cooling system service. Contact Kevin S. McCartney at [crashh@prodigy.net](mailto:crashh@prodigy.net) or 209-873-1155 for additional educational materials and training opportunities.