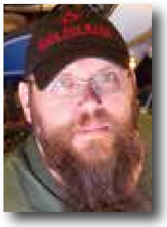
Ohhhhmmmm ... Ohhhhmmmm (Part 1: Electricity can kill you)

By Wes Fleming #87301



LEST YOU BELIEVE that the only problems in my motorcycling world revolve around a first-gen R 1200 GS and its wonky computer, I'm going to dig into another long-term issue I face. Before I do that, however, let's get into some basics about electricity.

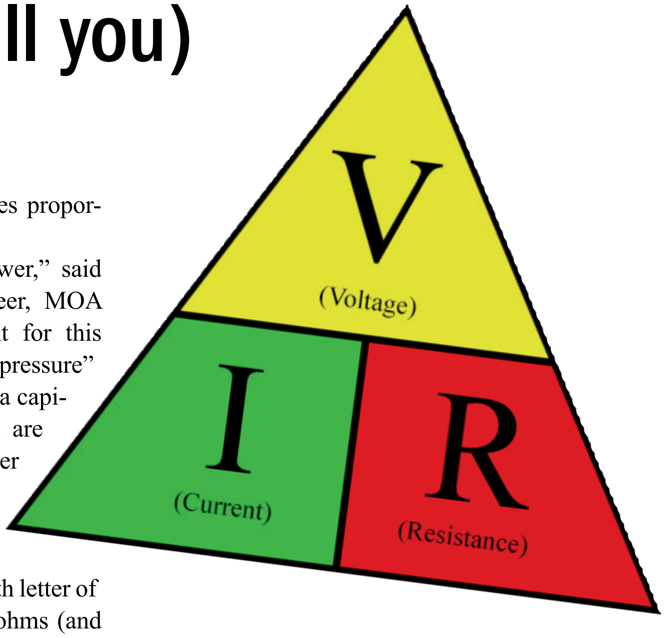
In June, I made an appointment for a routine checkup with my audiologist. As somebody who suffers from non-motorcycle-related hearing loss and grievous tinnitus, I take my hearing seriously. Though the ear plugs I've had made at various rallies are decent, nothing beats the full-coverage, custom-made silicone plugs I have made every few years through my audiologist.

Heather is a nice lady, but she's a little afraid of motorcycles. While she was making the molds for my most recent set of plugs, she casually mentioned that one of her neighbors was killed by his motorcycle. "Electrocuted by it," she said. "Right there in his own garage."

I know electricity can kill, and I've gotten some hard shocks from carelessly working on guitar amplifiers in the past, but I've never heard of somebody being killed by being electrocuted by a motorcycle. Just because I've never heard of it doesn't mean it's not true, though, so I decided to do some investigating.

First, let's take a look at electricity in general. Don't worry, we can do this without a lot of math. There are three components to electricity – voltage, resistance and current. Each has its part to play, and each changes proportionally as the others change.

"Voltage is a measure of power," said Stuart Ostroff, electrical engineer, MOA member #98405 and consultant for this series of articles. Voltage is the "pressure" in an electrical system, noted by a capital V. Most of our motorcycles are 12V systems, though some older bikes run on six volts. Resistance is opposition to the flow of current. Ohms (Ω) represent resistance. We use omega, the 24th letter of the Greek alphabet, to indicate ohms (and therefore resistance) because Welsh electrical engineer William Preece decided in 1867 that "ohm" and "omega" sounded similar enough to each other, and that's pretty much how we've done it ever since. Finally, we have current, the flow of electricity, and that is represented by an I in the equation.



Voltage and resistance combine to make current, and that's where math comes in, specifically by using Ohm's Law. German theoretician Georg Ohm's work culminated in the publication of his 1827 book, *The Mathematical Investigation of Galvanic Circuits*, in which he stated a mathematical equation now known as Ohm's Law.

Stating the law in words, Ohm's Law tells us that current (I) between any two points is directly proportional to voltage (V) between the same two points. Resistance (R) is independent of the current, which is what produces the proportional effect of the equation. If you increase the voltage in a circuit without changing the resistance, current increases. If you increase the resistance without changing the voltage, current decreases.

We talk about voltage regularly. Our cars, light trucks and motorcycles are 12V systems. Our homes in North America run on 120V. Power in many places around the world is supplied with 240V hookups. What we don't talk about as much is amperage, which in a lot of cases is more important.

Think of voltage as the force pushing the electricity through the circuit. Compare a little kid to a full-grown male bodybuilder squeezing a tube of toothpaste. The little kid is six volts, while the bodybuilder is 240V – one simply generates more force than the other. The end of the tube where the toothpaste comes out is the resistance – in this example, a fixed point that can only flow *X* amount of toothpaste per second. Amperage here would be akin to the viscosity of the toothpaste – its ability to flow based on the force behind it and the resistance holding it back.

Electricity kills by interrupting the heart's ability to pump blood, and it really doesn't take much to achieve that level of disruption. As little as seven or eight milliamps (mA) of power applied for as short a duration as three seconds can kill an average healthy adult human. Fortunately, your clean, dry, undamaged skin provides 5,000-plus ohms of resistance, which is quite a bit when it comes right down to it.

When you get a static electricity shock

from touching a door knob in the winter, you feel that zap and it can even be a little painful – but you recover from that 20,000-volt encounter quickly and get on with your life. A static shock has extremely low amperage, so it is unable to overcome the resistance inherent in your skin and get through to the liquid tissues underneath and do significant damage.

Electricity – including lightning – will always flow along the path (circuit) with the least amount of resistance. Since there are numerous paths electricity can take through your body, some of them are bound to have more resistance than others. If the path of least resistance flows through your heart, the lightning kills you. If not, you may suffer a myriad of other injuries, including severe burns or brain damage.

Since we know motorcycles don't contain a billion volts, we have to look at amperage as the culprit in a bike-related electrocution such as the one my audiologist told me about.

According to the National Institute of Occupational Safety and Health, human skin may have resistance as high as 100,000Ω. If the skin is wet or broken – as with an open wound, even a small one – that natural resistance drops considerably, to about 1,000Ω. Taking Ohm's Law into account, as voltage increases, current will also increase when the resistance is unchanged. This means that humans are more susceptible from damage and death from higher voltages, but because the resistance of human skin isn't linear, it's difficult to determine exactly what volt/amp combination will hurt any given individual.

What we do know for sure is that shocks of about 10 volts (like the kind you'd get from the 12V system on your motorcycle) are easily defeated by your skin. You might feel a slight tingle, but you're unlikely to suffer any permanent damage.

Unless.

If you have a heart condition of any sort or possess a heart rhythm-regulating device called a pacemaker, all bets are off. Even a microshock – that is, a shock from the tiniest of currents – can disrupt the heart's rhythm or damage a pacemaker if the current flows directly to the heart or the regulating device.

To recap, here's how the dangers from electrical shock break down for the average person.

- Ohm's Law: higher voltage produces higher current, given that resistance remains roughly constant. Higher currents are more likely to kill you.
- Time: the longer you're in contact with the current, the more likely you'll die.
- Path: if the path of the current includes your heart, you're probably going to die.
- Frequency: not how often you get shocked, but the frequency of the alternating current (AC) if that's what hits you. Certain frequencies can cause your muscles to spasm, which could prevent you from breaking contact with the source of the shock, thus prolonging the shock. Experiments performed in the 19th century showed that AC (most common in households and alternators) is about twice as likely to kill you as DC (direct current).
- Medical: pre-existing issues like heart, lung or brain conditions increase the likelihood of death from electric shock, as does the presence of heart rhythm-regulating devices like pacemakers or implantable cardioverter-defibrillators.

If you're an otherwise healthy person with no undiagnosed heart conditions, your motorcycle's electrical system is incredibly unlikely to kill you. The biggest risks you face from a motorcycle when it comes to electronics are from the ignition system or HID lights.

Energizing the ignition system in your motorcycle creates lethal levels of voltage because it takes a lot of electrical power to go through the heavy spark plug wires from the ignition coil to the spark plug and produce the spark that triggers the combustion process in the cylinder. Putting yourself into contact with any part of the ignition system while it is energized could definitely kill you. The ignition system on my audiologist's neighbor's bike may well be the culprit in his electrocution, especially if he was unfamiliar with the dangers involved.

HID stands for high intensity discharge, and that's exactly how that system works. Unlike the halogen headlights most 2005-2013 BMW motorcycles have, which use an electrically-charged filament (a thin wire) to produce light, HID lights work more like neon lights. They are arc lamps, producing light by arcing electricity across two tungsten electrodes inside a vacuum-sealed tube containing a noble gas like xenon. HIDs won't work with just 12 volts, so they require step-up transformers, dedicated circuitry and sometimes even special wiring to create the huge voltages – often in excess of 20,000V – needed to cause the arcing effect and produce the light. The part of the HID that does this work is referred to as the ballast, and if you've installed a system like this, you've seen the warnings included on the device by the manufacturer.

While 20,000 or more volts are required to light the HIDs initially, they stay on with the benefit of between 80 and 100 volts, depending on the system. The primary danger after the HIDs are on comes from the capacitors in the ballast, which can store lethal levels of voltage no matter how long the lights have been on. Once the lights are turned off, it takes time for that electricity to dissipate. The safest bet when it comes to HIDs is to never, ever open the ballast. If you have HIDs on your bike and are involved in a crash that compromises the ballast, warn the first responders and call for help from professionals that know what they're doing.

The bottom line for this column is that yes, it is possible for your motorcycle to kill you with electricity, primarily if you're working with the ignition system. If your motorcycle needs electrical work and you're at all unsure of your ability to survive doing that work, your best bet is to take your bike to a qualified professional technician.

Next time: choosing and using a digital volt-ohm meter (DVOM).

Listen to my conversation with Stuart Ostroff in Episode 28 of Chasing the Horizon, available at http://horizon.bmwmoa.org or wherever you get your podcasts.