THE SEVEN DEADLY SINS OF ELECTRICAL GROUNDING DESIGN

Electricity is dangerous and proper grounding and bonding are necessary to prevent unwanted voltage from passing through personnel, critical equipment and other nearby metallic objects. But be careful of simply wiring everything to a ground rod and considering the job complete.

Although grounding system design is a vast subject let’s take a look at some common electrical grounding mistakes that can adversely affect your grounding design. The National Electric Code has strict requirements for professional electrical grounding system design. Always consult an electrical grounding professional to help ensure the safety of personnel and the protection of sensitive equipment at your site.

7 Common Electrical Grounding Design Mistakes

1. Using Concrete and Other Ground Enhancement Materials
2. Using Undersized Ground Wires
3. Using a Water Pipe as a Grounding Electrode
4. Bonding to a Water Pipe at any Point in the System
5. Using Building Steel for Grounding
6. Improper Bonding to Gas Pipes
7. Believing that Crushed Rock Eliminates Hazardous Step & Touch Voltages

Using Concrete and Other Ground Enhancement Materials

No doubt, that when it comes to grounding you’ve seen it all! From corrosive coke breeze, to Epsom salt, to concrete, to manure, there are a variety of different ground enhancement materials for sale in the market place. Most are simply ineffective, some have short-term benefits (with long-term costs), and a few actually make the grounding even worse. This section will help to guide you through the maze of different materials so you can choose which systems are best for you.

Coke Breeze and Iron-Based Supplements

Coke Breeze is a by-product generated during the processing of iron ore. It is a cheap ferrous material that is electrically conductive and can be finely ground, making it ideal for adding to a variety of materials. It is sold as a grounding enhancement material in many forms, commonly in a nearly raw form, or mixed in to concrete. Testing has shown that ground enhancement materials made from coke breeze will in fact lower the resistance-to-ground when used properly; however, coke breeze has a different electrochemical nobility than that of copper, thus causing a galvanic reaction where the copper is sacrificial. In other words, the coke breeze will eat the copper, usually in 5 years or less, and is therefore not recommended. As the electrode will be buried, you may not ever know that the electrode has been compromised.

Concrete

Many of the ground enhancement products contain concrete (often mixed with coke breeze), which is typically installed around a copper conductor or ground rod. The primary purpose of this is to increase the surface area and contact between the copper and the earth. The chief issue with concrete is that it has a very poor current (amperage) handling ability. The water that is naturally found in concrete will quickly turn into steam under fault conditions, cracking the concrete and thus making the electrode virtually useless. As the electrode will be buried, you may never know that the electrode has been compromised.
Epsom Salt and other salt products
Maybe you’ve seen it, or have watched someone else make up a solution of salt-water and poor it around the ground rod prior to the annual ground resistance test; while this will in fact temporarily reduce the resistance-to-ground, it is a short term solution (measured in days or weeks) at best, and may be detrimental to the environment.

Using Undersized Ground Wires
An undersized ground wire is probably the single biggest hazard that could be lurking in your walls, hidden from site, just waiting to cause a fire or fail to protect you from shock, just when you need it most! Article 250.66 of the National Electric Code governs the size of grounding electrode conductors, and is designed to ensure that faults occurring on your electrical service can be safely carried away to ground. When undersized conductors are used (often to save a few dollars), the ground conductor can actually burn open like a fuse when subjected to an electrical fault! When the ground conductor burns open, it cannot only start a fire, but it will leave your electrical system ungrounded which can prevent circuit breakers from working properly and creating a serious hazard for both equipment and people.

Using a Water Pipe as a Grounding Electrode
Everyone does it, but does a water pipe provide effective grounding? Unfortunately, the answer is almost always a qualified “No”. It is important to understand the difference between the terms bonded and electrode when speaking about electrical grounding. A “bonded” object is when an electrician makes an intentional metallic connection to ensure that there is no difference in potential, but is NOT intending that object to be used as a path to earth for electrical faults. An “electrode” IS an object that is intentionally connected and designed to conduct electrical faults to earth (and typically buried).

Water pipes provide a poor path to earth for electricity as the utility company typically coats the pipes with tar to prevent corrosion, installs electrically isolative barriers, or uses non-metallic pipes. This is why the National Electric Code requires that an additional grounding electrode be installed along with the connection to water pipe. It is better to think of water pipe as a required metal object that must be bonded to the ground system, rather than thinking of it as an electrode for the ground system.

Bonding to a Water Pipe at any Point in the System
We have all seen it where electricians simply run a ground wire to the closest available water pipe and mechanically connect the ground wire to the pipe. You may in fact see that this has been done at your house, where a bare copper wire is routed out of your box and is tied to the water faucet you use to water your lawn. Many times people find that after removing walls during a remodel that ground wires have been tied to copper pipes randomly throughout their house. Allowing electrical faults to flow through your water pipes and throughout your home, will not only shorten the life-span of your copper pipes, but could also cause serious harm and/or fire to the home should a serious electrical fault occur! It is also a violation of the National Electrical Code.

Article 250 of the National Electric Code (NEC) specifically requires that water pipes (both hot and cold) must be bonded to the grounding system of the building to eliminate any possible difference in potential should the metallic pipes become energized (such as what could occur at a washing machine). The NEC will further allow you to use cold water pipe as an electrode, given that the ground conductor be tied to the water pipe at a point no further than 5-ft from the building entrance and before any regulators or valves (that may prevent electrical current flow). E&S Grounding Solutions recommends bonding to a water pipe, but NOT using a water pipe as an electrode.
Using Building Steel for Grounding

The term “Building Steel” is often misunderstood and misapplied even more often. In grounding terms, Building Steel is ultimately about the rebar in the concrete and the ability of that rebar to provide a path to earth that can safely conduct electrical faults (from the rebar, through the concrete, and into the earth). This applies to both commercial and residential structures. Many commercial buildings have steel girders and I-beams that are also thought of as “building steel”; however, what is seldom understood is that there must be a metallic connection from the girders and I-beams to the rebar in the concrete. This connection is critical in order to prevent electricity from using the concrete as a conductor to the rebar.

Have you ever seen what happens to concrete when a blow torch is applied to it? All concrete is conductive and contains large quantities of water. When water is brought to boiling (212F) it very rapidly expands and turns into steam (1 to ~1600 ratio). So, when that blow torch is applied to the concrete it quite literally explodes! The same thing happens to concrete when a large amount of electricity is passed through it, such as what happens during an electrical fault. If there is no metallic connection from the girders and I-beams to the rebar in the concrete, the electrical fault will pass through the concrete slab to get to the rebar, heating the concrete and possibly destroying it. Using building steel as a grounding electrode is good way to shorten the life-span of your buildings foundation.

Other issues exist when using building steel as an electrode, such as electrical noise, harmonics, and magnetic issues that can adversely impact the performance of electronic components. Additionally, many concrete slabs have vapor barriers, effectively isolating the rebar and rendering building steel as an ineffective electrode.

While it is critically important that Building Steel be bonded to the grounding system, it should NOT be used as a grounding electrode.

Note: Most buildings in America today use a water pipe or building steel as the ONLY type of grounding electrode!

Improper Bonding to Gas Pipes

Yes, gas pipes must be bonded to your electrical grounding and lightning protection systems. I know it seems counter-intuitive, but both NEC 250.105 and NFPA 780 (the Code governing lightning protection) mandate it. Consider which is worse: gas pipes at the same potential as the other metal objects in the building, or gas pipes that are at a different potential where electrical faults can arc-flash between the two differing metallic systems?

The key is to ensure that your gas pipes are bonded, and NOT used as an electrode. I know, easier said than done. I recommend you call an expert before you blow something up... but at least read the Article 250.105 of the National Electric Code and call your city’s building department and your local gas company before energizing your electrical system.

E&S Grounding Solutions always recommends receiving written approval from your local gas company when bonding to gas pipes.

Believing that Crushed Rock Eliminates Hazardous Step & Touch Voltages

While the average electrician will never have to deal with Step & Touch Voltage hazards (stray voltages traveling through the earth and other objects with enough power to kill), as these tend to be the realm of transmission lines, power plants, and substations; for many electrical engineers trying to...
Federal Law (29 CFR 1910.269) eliminating these known electrical hazards can be difficult. It is often falsely believed that a thick layer of crushed rock is a cure all, when in fact crushed rock can actually make these hazards worse!

When in a high-voltage environment (600 to 500,000+ volts), extra precautions must be taken to ensure that people are protected from the special electrical hazards that these voltages can present. Items that at low-voltage are normally non-conductive, such as wood, at high-voltage become as conductive as steel! In these environments, stray currents traveling through the earth itself and/or other objects can be strong enough to kill, by either touching an energized object or simply by stepping near an energized object; thus the term Step & Touch Voltage Hazards.

It is often (mistakenly) believed that crushed rock will provide a layer of insulation between the earth and the person, preventing current flow and thus protecting the individual. This is not always true, especially in the case of Touch Voltages, where in order to provide protection, engineers often try to reduce the difference in potential between the hands and feet. Adding insulation (crushed rock) can actually increase the touch voltage hazard!

Federal Law (29 CFR 1910.269 Appendix C) specifically requires human safety studies in high voltage environments. These studies must determine the Sep & Touch Voltage hazard and demonstrate ways to safely eliminate those hazards, so that a safe work environment exists. These laws apply to anywhere that is considered a work place, including but not limited to: power plants, substations, and even to cellular sites that are mounted on transmission towers.


E&S Grounding Solutions are the experts in electrical grounding design and work closely with our client’s project engineers, providing them the safest and most cost effective electrical grounding and earthing solutions available. We believe that this close working relationship enables our clients to have the most comprehensive electrical grounding design team in the market place today.

Thank you for your interest in E&S Grounding Solutions. We look forward to working with you.