The "*Ufer*" Ground

The term "Ufer" grounding is named after a consultant working for the US Army during World War II. The technique Mr. Ufer came up with was necessary because the site needing grounding had no underground water table and little rainfall. The desert site was a series of bomb storage vaults in the area of Flagstaff, Arizona.

The principle of the Ufer ground is simple, it is very effective and inexpensive to install during new construction. The Ufer ground takes advantage of concrete's properties to good advantage. Concrete absorbs moisture quickly and looses moisture very slowly. The mineral properties of concrete (lime and others) and their inherent pH means concrete has a supply of ions to conduct current. The soil around concrete becomes "doped" by the concrete, as a result, the pH of the soil rises and reduces what would normally be 1000 ohm meter soil conditions (hard to get a good ground). The moisture present, (concrete gives up moisture very slowly), in combination with the "doped" soil, make a good conductor for electrical energy or lightning currents.

Ufer techniques are used in building footers, concrete floors, radio and television towers, tower guy wire anchors, light poles, etc. Copper wire does not function well as a "Ufer" ground due to the pH factor of concrete (+7pH is common). The use of steel reinforcement as a "Ufer" ground works well and concrete does not chip or flake as has been found with copper. The use of copper wire tied to the reinforcement rods outside the concrete shows none of these problems.

The minimum rebar necessary to avoid concrete problems depends on:

1. The type of concrete, its content, density, resistivity, pH factor, etc.
2. Amount of concrete surface area in contact with the soil.
3. Soil resistivity and ground water content.
4. Size and length of the reinforcement rod, wire, or plate.
5. Size of the lighting strike current.

The following chart shows the conductivity of lightning current per foot of Rebar (reinforcement rod). Only the outside Rebar can be counted. Rebar in the center of the footer or foundation does not count in this calculation. In a trench footer only the rebar in the sides and bottom of the footer can be counted.

Rebar Diameter In Inches	Surge Amperes Per Foot
.375	3400
.500	4500
.625	5500
.750	6400
1.000	8150

Mr. Ufer did not know what he had found until he experimented with various lengths of wire in concrete. Today's informed engineer benefits from Mr. Ufer's discovery and will tie in the bars of steel reinforcement in a building or other foundation to the building electrical ground. When bonded to the electrical ground, building steel, etc., the buildings reinforced floor and foundation become part of the building grounding system. The result is a much improved grounding system with a very low overall resistance to earth reference.

If Ufer grounding alone was enough, the manufacturers of ground rods would go out of business. But a Ufer ground alone it is not adequate. Few buildings, even those under construction today are built to take advantage of the Ufer ground. It is common to see the use of "Ufer grounding" in military installations, computer rooms, and other structures with very specific grounding specifications. It is not common in most industrial plants, office buildings and homes. More common today is grounding to national and local electrical codes. This will involve one or more driven ground rods connected (bonded) to the neutral wire of the electrical service entrance. The purpose of this bond is what is known as life safety ground. It is used for many other things but the code required life safety ground is why it is there to begin with.

Ground rods come in many forms, but the most common used in electrical service grounding are galvanized steel ground rods. Please remember, the best day a ground rod will normally see (resistivity) is the day it is installed. Corrosion, glazing, etc., all are factors that lessen the effectiveness of ground rods.

Ground rods in general are divided into one of the following sizes; 1/2",5/8",3/4" and 1". They come in steel with stainless, galvanized or copper cladding and can be solid stainless or mild (unclad) steel. They can be purchased in unthreaded or threaded sections that vary in length. The most common lengths are 8' and 10'. Some will have a pointed end, others will be threaded and can be coupled together to form longer rods when driven.

The effectiveness of a 1" ground rod over the 1/2" ground rod is minimal when resistance readings are taken. The larger rods are chosen for more difficult soil conditions. Clay or rocky conditions often dictate the use of power drivers, similar to an impact driver used by mechanics when working on your automobile. They are typically electric or pneumatic. The power drivers when used with the heavy 1" ground rods will drive in most soils.

A 1" copper clad rod when compared to a 1/2" copper clad rod in the same soil conditions will yield about a 23% improvement is performance. The surface area of the 1/2" rod is 1.57 compared to the 1" rod at 3.14 (3.14 x .5 = 1.57 and 3.14 x 1 = 3.14). So, for double the surface area, you only get about 23% improvement in performance.

The cladding of ground rods is to protect the steel from rusting. Most think the cladding, (copper on a steel rod) is for the increase in conductivity of the rod. It does aid in conduction, but the main purpose of the cladding is to keep the rod from rusting away. Not all clad ground rods are the same and it is important the clad rod have a reasonably thick cladding. High quality industrial quality copper clad steel ground rods may cost a little more but they are worth the small extra cost.

When a ground rod is driven into rocky soil, it can scratch off the cladding and the rod will rust. Rust is not conductive when dry, in fact it is a good insulator. When it is wet it is still not as conductive as the copper on the rod. Soil pH can be tested and that should determine the type of rod used. In high pH soil conditions only high quality clad rods should be used. If the soil is extremely acidic, stainless rods are the best choice.

One of the most popular ground rods is the galvanized (hot dipped zinc) steel ground rod. This rod is used with copper and aluminum conductors to form the service entrance ground in most buildings and homes. This is a poor choice for ground restivity over time. The joint between the ground rod and conductor are made above or below the surface of the ground and in most cases subject to constant moisture. Under the best of conditions the joint between two dissimilar materials will result in corrosion and increased resistance over time.

When dissimilar materials are joined, electrolysis occurs. If Aluminum is used with copper that is not tinned the aluminum will pit to the copper leaving less surface area for contact and the connection could come loose and even allow arcing. Any sharp blow or impact could cause the connection to be broken. When installing in the soil it is not recommended tinned wire be used. Tin, lead, zinc and aluminum are all more anodic than copper and they will sacrifice (disappear) in the soil. When the connection is made above the surface of the soil in the electrical distribution panel tinned wire is acceptable.

Another treatment for joint corrosion problems is using a joint compound to prevent moisture bridging between the metals. The more popular compounds are copper or graphite particles imbedded in a grease compound. Using similar material is a better solution as even joint compounds can loose their effectiveness if not maintained but their use is preferable to a dry joint. Joint compounds work by imbedding particles into the metals to form a virgin junction of low resistance void of air when they are placed under pressure. The act of tightening the clamp on the conductor and rod provide this pressure.

The problem of dissimilar material is not found in copper clad steel rods. Of all the reasonably priced choices, the copper clad steel rod with a copper conductor is your best choice. If money were no object a gold conductor, and ground rod would be ideal, but hardly economically practical.

The effective performance of ground rods is reduced by soil conditions, lightning currents, physical damage, corrosion, etc., and should be checked for resistance on a regular basis. Just because your ground was good last year it does not mean it is today. Have it checked by the fall of potential testing method.

A driven rod, when compared to a back filled rod, is much better. The density of undisturbed soil is much higher than even compacted soil. The connection of the soil is the key to the rod performance.

Installing ground rods is not difficult but proper procedures must be followed and the resulting rod(s) should be checked for performance. Testing for resistance by the fall of potential method is the only way to be sure what looks good is good, a low resistance ground.

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