PART 2 OF A 2 PART ARTICLE

Understanding Soil Resistivity Testing

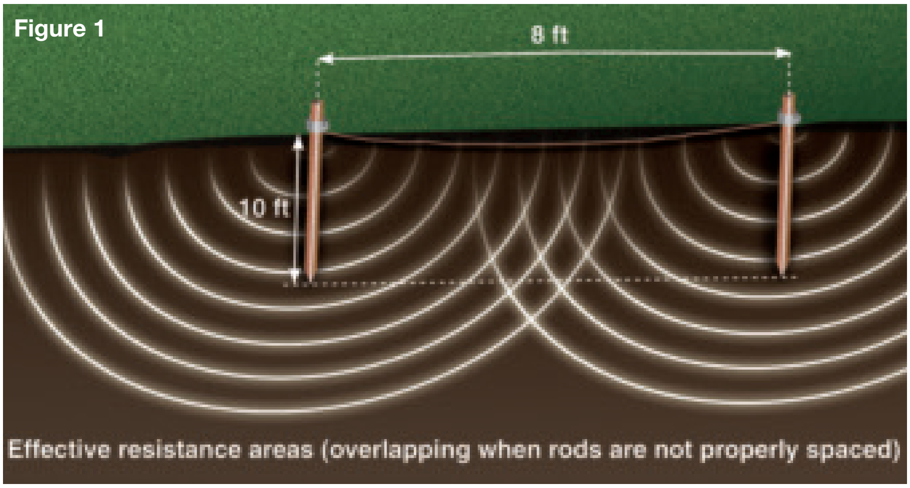
By John Olobri, Director of Sales and Marketing, AEMC® Instruments

Last month we discussed the process of taking soil resistivity measurements. We chose the Wenner method as it is easiest to employ when measurements are taken at one or two depths. We took readings in 5 different directions in the area of interest (north, south, east, west and the diagonal inside the area. Then we took the average of the five measurements to calculate Rho (ρ) expressed in ohm centimeters or ohm meters. In our test example we arrived at an average of 6.408 ohm-meters. Converting this to ohm-centimeters we get a value of 6,408. It should be noted that this value of soil resistivity assumes a homogenous soil condition which may or may not be true. In either case the results will assist us in the next phase of our work. Knowing the soil resistivity can benefit you in two ways: First and the most often used of these values is to calculate the depth necessary to drive your ground rod or group of rods to achieve the desired system grounding resistance for the site being developed. Second, this value can also be used to determine the depth of an existing ground rod in order to properly test its' effective resistance to earth.

Let's look at the process of calculating the depth needed for a new ground rod installation. For this we will use a calculating tool called a nomograph (See sidebar on page 8).

To begin with we need to make a few decisions. First what is the desired grounding electrode resistance needed? Second what is the diameter of the ground rods we will be using? With these two answers plus the measured soil resistivity we can use the nomograph to calculate the depth required to achieve our objective. Let's say we need a resistance from this grounding system to be no more than 10 ohms and that we chose ground rods that have a 5/8 inch diameter.

Figure 1



Effective resistance areas (overlapping when rods are not properly spaced)

Looking at our nomograph, we have five scales to work with: The R scale represents the desired resistance needed, for our work (10 ohms). The p scale represents soil resistivity. Our average value is 6408 ohm-centimeters obtained using a 4 pole ground resistance tester employing the Wenner test method. The D scale represents depth and is what we will use to find our answer. The K scale contains constants that will assist us in finding the depth. Lastly the DIA represents the diameter of the rods used. We will complete several simple steps to get our depth answer.

Using the nomograph (available on the Tech Info section of the AEMC website) we first put a dot at 10 ohms on the R scale as it is our desires resistance.

Next we put a dot at 6,408 on the p scale representing our soil resistivity measurement. We will have to do our best to approximate the location of this point between the 5000 and 10000 hash marks.

Next we take a straightedge and draw a line between the dots we placed on the R and P scales and let the line intersect with the K scale and place a dot on the intersecting point.

Now we again take a straightedge and draw a line from the 5/8 hash mark on the DIA scale representing our rod diameter through the dot on the K scale and continue through to intersect with the D scale and place a dot on the D scale at this intersecting point.

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The value at this point is the depth needed to drive a 5/8 inch diameter rod to achieve 10 ohms of grounding electrode resistance given the soil resistivity measured.

Looking at the completed nomograph in figure 1 we see that a single rod would need to be driven 30 feet deep to meet our 10 ohm objective. The completed nomograph is shown in the sidebar article.

In many cases this is not practical to drive deep rods. The alternative is to drive two or more rods to get the desired results.

There are a few important points to consider when driving multiple rods. First is that driving additional rods will not achieve linear results. For example three 10 foot rods will not yield the same results as a 30 foot rod. We need to apply an adjusting factor. Secondly to achieve the best effect of additional rods they should be spaced at least equal to the depth and preferably at twice the depth. For example multiple 10 foot rods should be spaced 20 feet apart to avoid being in the sphere of influence of each other (See figure 2).

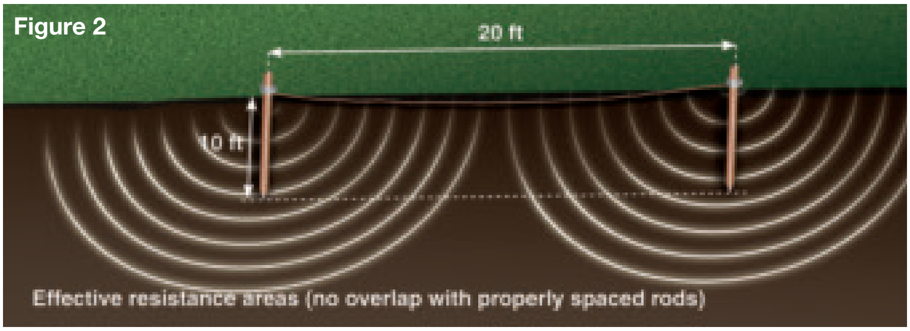

Figure 2

The adjustment factor required for multiple rods is shown in figure 3. If we were to use three 10 foot rods in parallel instead of one 30 foot rod we would expect each rod to contribute 1.29 times the theoretical value. Stating it another way, if we divide the 10 ohms needed by 3 to find the expected value of each rod we get 3.33 ohms. Applying the adjustment factor from the table for 3 rods in parallel we get 3.3 x 1.29 or 4.25 ohms contributed by each rod for a total of 12.75 ohms. In this case we would need to drive a fourth rod to get below our desired 10 ohms.

Sometimes the final results cannot be obtained by adding additional rods. There simply may not be enough real estate to accomplish it or the area is too rocky etc. In these cases soil enhancement techniques can be employed or chemical rods can be used. There are several companies that specialize in solving these types of problems that can be consulted.

Taking soil resistivity measurements prior to installing a grounding electrode system can save a lot of time and effort in planning the system properly. Using a few simple tools and procedures can give you quality results with less than one hour's effort. Bear in mind that these results are based on homogeneous conditions that won't necessarily exist at the site.

Further simplifying the task today is the fact that newer testers now have the ability to calculate soil resistivity internally computing Rho saving further time and effort. ❑

Figure 3 FOR MULTIPLE RODS

Number of Rods	X
2	1.16
3	1.29
4	1.36
8	1.68
12	1.80
16	1.92
20	2.00
24	2.16

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Grounding Nomograph

A nomograph is a mathematical tool consisting of several nonlinear scales on which known values can be plotted and the desired unknown value can be derived by simply connecting the points with a straightedge and finding the resultant by reading the intersecting point on the desired scale. In the case of grounding resistance, we will be dealing with known values for soil resistivity, rod diameter and desired system ground resistance. The unknown to solve for is the depth needed to achieve the desired resistance. The grounding nomograph was developed in 1936 by H. B. Dwight. In six simple steps depth can be calculated when the soil resistivity, rod diameter and desired resistance is known.

Step 1
Select the required resistance on the R scale

Step 2
Select the measured soil resistivity on the P scale

Step 3
Take a straightedge and draw a line between the values placed on the R and P scales and let the line intersect with the K scale.

Step 4
Place a dot at the intersecting point on the K scale

Step 5
Place a dot on the desired rod diameter hash mark on the DIA scale

Step 6
Take a straightedge and draw a line from the dot in step 5 through the dot on the K scale from step 4 and continue through to intersect with the D scale and place a dot on the D scale at this intersecting point. This is the resultant depth needed.