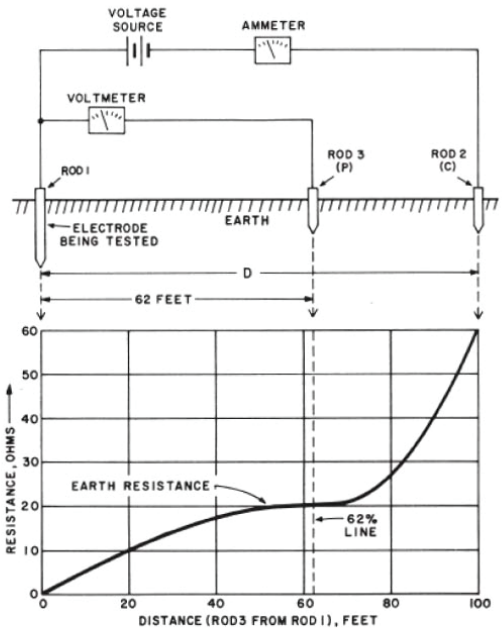
Quality Energy Services

TESTING GROUND RESISTANCE

The most widely accepted way to test grounds is the three point Fall-of-Potential test, which is where one lead is attached to the electrode in question. A current probe is placed a distance away from the test point and a potential probe is placed in a generally straight line between these points. The procedure is explained in detail in IEEE STD 81.

Most test sets will have three or four terminals. The sets with four terminals are labeled C1, P1, P2 and C2. For a Fall-of-Potential test the C1 and P1 are jumpered at the test set and a single lead is run to the electrode under test. The C2 is connected to the current probe and the P2 is connected to the potential probe. The test set, when activated, pushes current in a loop from C1 through the electrode and earth to C2. This current, along with the resistance of electrode to earth, creates a voltage which is read by the potential difference between P1 and P2. The test set takes the current output and voltage read and calculates the resistance of the electrode to earth. The three pole test set functions the same. The difference between test sets is that C1 and P1 are jumpered internally. This is why only three poles are needed. Note, in both of these configurations the resistance of the cable going from test set to electrode under test is included in the resistance reading. Due to this, the cable needs to be relatively short.

Where do your current and potential probes go? The current probe must be placed outside the sphere of influence of the grounding electrode under test.



The potential probe, assuming the current probe is far enough, is placed at 62% of current probe's distance. (The 62% rule is explained, including the math, in Annex C of IEEE STD 81.) How far is this? The closest AMP has found to a standard is in IEEE STD 81.2. It states, that the minimum distance for test probes will be at 6.5 times the extent of the grounding system to have an approximate accuracy of 95%. This extent is the maximum diagonal distance. The standard refers to a Fall-of-Potential test, but it also refers to placing the current and potential probes 90° to each other.

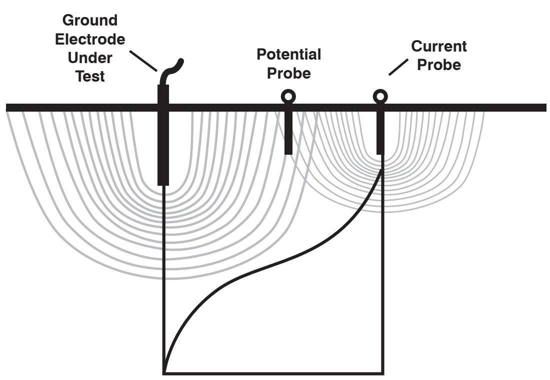
There are many "rules of thumb" out there for figuring out the required distance. Some of these are: five times the length of maximum distance; five (or more) times the ground electrode depth; and multiples of the electrode diameter. AMP uses ten times the maximum diagonal distance. This distance has worked for AMP a majority of the time. This method is also recommended in the Megger publication "Getting down to Earth." Any of these methods could be used as a starting point.

What if the test set does not come with leads long enough? Most test sets come with leads only long enough to test a single ground electrode. Manufactures offer cable sets of various lengths as optional extras. There is nothing exotic about the leads used to adequately conduct a ground test. The wire is fourteen gauge braided copper and covered with rubber insulation. Any suitable wire can be used. Connection is made to most test sets by terminals that accept spade lugs, banana plugs and even bare conductors. The probe end is an alligator clip. All of these materials are readily available and can be used to create test leads to needed length.

The only way to know for sure if your probe distance is sufficient is to plot the results on a graph of distance vs. resistance. On this graph the 62% reading should be on the plateau where plus or minus ten percent has reading of minimal difference. At a minimum, the graph should contain three points. These include the 62% reading, one farther, and one closer.

What do you do if a facility has a large ground grid and plotting the graph results in not finding the plateau? For example, if a substation has a ground grid that is 100ft by 100ft, the diagonal distance will be about 141ft. If one goes ten times this dimension, the current probe will be 1,410ft. At this point, one needs to consider the slope method for testing ground resistance, if that distance is not available.

The slope method is a modified Fall of Potential test. The method is based on calculus and the "rate of change of slope". With this test, one chooses a distance for the current probe. It is recommended to go at least twice the diagonal distance. If need be, go as far as possible, due to limited space. Measure the resistance with the potential probe at 20%, 40%, and 60% of current probe distance. With these measurements, calculate the slope coefficient. With that result, look up the value in the standard chart to get the percent of current probe distance. This percentage is the distance where the potential probe needs to be placed in order to get the most accurate reading. If the slope coefficient is not on the chart, then the current probe is not far enough and needs to be placed farther from the ground being tested.



Another type of test that is becoming popular to use is the Clamp-On method.The test sets for this induce voltage on the ground under test and measure the current produced. The test set, like the ones used for Fall of Potential, calculates the resistance (R=E/I). These sets are handy because there are no probes to drive, or long leads to extend out. Some disadvantages are that it does not conform to IEEE STD 81; a good return path is required for accurate measurements; and operator must take results on "faith." These test sets have no built in proving method. With a Fall-of-Potential test, the operator can confirm results by changing probe spacing.

References:
IEEE Guide for Measuring Earth Resistivity, Ground Impedance, Earth Surface Potentials of a Ground System.
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IEEE Guide for Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems.
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