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EXHIBIT 10 14-69-C

Ground Potential Rise Explained

Back Ground Information For High Voltage Transmission Towers

Includes Information on Soil Resistivity Testing

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Ground Potential Rise (GPR)



Ground Potential Rise

This section will present an introduction to the information used in conducting a GPR study and why it is gathered.

This report provides relevant back ground information regarding GPR Studies and Soil Resistivity testing that is applicable to all Ground Potential Rise Analyses.



When conducting an Advanced GPR Study's one can utilize the MALZ software module in the CDEGS software program to simulate the effects of a fault on the buried component of the grounding system, by injecting the current directly into the tower footings, and calculating the voltage drop / current leakage across the conductor segments. Electrical data is typically provided by the power company.

Safety in the work place is mandatory near the world over, and electrical hazards are no exception. The effects of electrical faults and the ground potential rise they can create have been known since the earliest days of electrical invention. The ability of these electrical faults and/or lightning strikes to generate voltages with enough energy to fibrillate the human heart are well understood, the primary concerns being current pacing through the hands to the feet (Touch Voltage), and current flowing from one foot to the other foot (Step Voltage).

Federal regulations (29 CFR 1910.269) mandate that all known electrical hazards be eliminated in the work place. Appendix C specifically states that Ground Potential Rise (GPR) analysis are conducted and Step & Touch Voltage hazards be eliminated from high-voltage work environments. Transmission lines (high-voltage towers), substations, and certain transformers are the most common places that require these types of studies. Transmission lines (high-voltage towers) are often exempt as they are not considered work places, unless cellular communication equipment is installed on the tower; it is then considered a work place and must comply with 29 CFR 1910.269.

General Information about GPR Studies

The purpose of conducting a Ground Potential Rise (GPR) Study is to determine what the effects electrical faults, lightning strikes, and/or short circuits will have on personnel and equipment within the fault area. In the event of a ground fault, understanding what the clearing time and the dissipation of the high-voltage event will be, allows for the safest and most cost effective grounding system design possible, without over engineering allowing you to stay within budgetary constraints.



Ground Potential Rise

Ground Potential Rise (as defined in IEEE Std 367) is the product of a ground electrode impedance, referenced to remote earth, and the current that flows through that electrode impedance.

GPR studies use a series of calculations to determine Step and Touch Voltages in accordance with specific standards. These studies also help to determine grid "hot spots" enabling the engineer to understand the behavior of grounding systems and to modify the designs accordingly.

Copper wire communications cables within high voltage environments (substations, power plants, transmission towers) can be exposed to thousands of volts during a power system fault. In that instant, the entire site will experience a ground potential rise, and dangerous potential differences can occur between the power station and the remote (theoretically "zero") ground of the telecommunication cable (central office). Any voltage difference will trigger a current flow, which as the potentials equalize, may have destructive consequences for personnel or sensitive electronics.

Each year, GPR electrical damage is costing the industry millions of dollars, yet few engineers or their managers are even aware of the phenomenon.

Adherence to industry practices and standards, such as IEEE Standard 80, Standard 487, Standard 367, and Standard 1590, is highly recommended.

Benefits of Advanced GPR Studies

An Advanced Ground Potential Rise (GPR) Study provides a comprehensive examination of the effects an electrical fault will have on a grounding system. This enhanced study provides the ability to “inject” current directly into specific conductors and to calculate the voltage drop across the grounding network as the current flows through and out of the system.



MALZ Software Module – Frequency Domain Grounding Analysis

One can use MALZ it is one of the most powerful software modules in the CDEGS program. It analyzes the frequency domain performance of buried conductor networks and calculates the following quantities: earth and conductor potentials, longitudinal and leakage current distribution in the conductors, as well as magnetic fields in the air. This powerful grounding package is the ideal tool whenever coated conductors such as pipelines need to be modeled and / or if the metallic conductors can no longer be approximated as equipotential structures.

Additionally, MALZ calculates in the effects of the frequency of the fault (60Hz) on the grounding system.

For a common GPR study, equipotential calculations are typically used to determine the effect of the fault on the grounding system. In other words, once the voltage rise has been figured out, that voltage number is *locked* in place and used as a constant across every segment of the grounding grid. In some cases, such as when in highly resistive soils and/or dealing with a very small grounding grids, the use of equipotential calculations is a reasonable assumption.

It should be noted however that equipotential calculations can have significant disadvantages. The purpose of the grounding system, specifically of the buried conductor or ground rod, is to dissipate electricity into the earth, or to “drop the voltage” over its length. This is sometimes referred to as ‘leakage’ or even leakage resistance. An Advanced GPR calculates the voltage drop across every segment of the grounding system, providing greatly enhanced accuracy. This is especially true for Step & Touch Calculations where common GPR studies tend to show hazardous voltages at the corners of grounding grids, or at the ends of conductor extensions. Another prime advantage of an Advanced GPR is Current Injection. Obviously, if a fault or lightning strike were to occur on one side of a building or grounding system, current will flow to the other side, dissipating (leaking) in to the surrounding soil as it goes, creating a Ground Potential Difference (GPD). With a common GPR, every conductor and segment is at the same potential, so you cannot calculate what happens if one side of a grid takes a fault.

Ground Potential Rise (GPR) is the transient over voltage that enters the earth in the form of current causing differences of potential to form across the surface of the earth as the earth absorbs electricity in proportion to the level of conductivity of the earth and the distance from the entry point. Those differences in potential, not the actual voltage, are what is hazardous to personnel and equipment. It is the electrical engineers job to eliminate those differences in potential making equipment that has faulted and the area surrounding the entry point safe.



Electricity is "free" electrons in motion looking for a path to the earth. We control these "free" electrons by creating conduits to carry the electricity for our use. As we do this we run the risk of transient over voltage occurring which is hazardous to personnel and equipment. A transient over voltage is the temporary over load of "free electrons". Transient over voltages occur all the time.

When transient over voltage occurs (e.g. lightning strike, equipment fault, operation of a switching device), electricity (or free electrons) is absorbed into the earth. These "free" electrons will always take the path of least resistance to earth. Depending upon the composition of the earth, these electrons will either be absorbed or they will continue on looking for materials to bond with creating an unsafe environment for personnel and equipment nearby.

The purpose of a GPR study is to determine the composition of the earth and thereby determining the amount of electricity that will be absorbed into the earth and how much excess electricity will be left in the earth causing potential harm to personnel. We will also determine how long this excess electricity will remain in the earth and the distance or footprint the electricity will make (i.e. what is the size of the pool of electricity surrounding the transient over voltage strike point).

Electricity always seeks the quickest, easiest path to ground. Electrical professionals' preplan electrical grounding designs to ensure that any stray electricity is returned to earth safely.

If, however, electricity is released onto the ground, the electricity will fan out from the point of contact. There is a rippling effect like dropping a pebble into calm water. In the pool of water, the wave created at the point of contact gets smaller as it rings out.



Similarly, in this pool of electricity, the energy is at full system voltage at the point of ground contact, but as you move away from the contact point, the voltage drops progressively. This effect is known as ground gradient. The ground gradient, or voltage drop, creates two problems known as step potential and touch potential.

Assume that a live downed wire is touching the ground and has created a pool of electricity. If you were to place one foot near the point of ground contact (at x voltage) and your other foot a step away (at y voltage), the difference in voltage would cause electricity to flow through your body.

This effect is step potential. Similarly, electricity would flow through your body if you were to place your hand on an energized source, while your feet were at some distance from the source. The difference in voltage in this case is referred to as touch potential. If you touch an energized wire or another energized object and the ground at the same time, you may be killed or injured.

Personnel can either be harmed when physically touching the equipment that has faulted or by standing on the earth that the electricity has just entered. Unfortunately, the grounding systems that cure "step" hazards and "touch" hazards are very different.

A Ground Potential Rise (GPR) Study determines what the effects electrical faults and other transient over voltages will have on personnel and equipment within the fault area.

For further understanding of the safety requirements, please refer to 29 CFR 1910.269

Rules of Thumb

There are some general “rules of thumb” that should be addressed in regards to understanding proper grounding design and the mitigation of hazardous voltages.

Soil conditions determine practically everything in regards to electrical grounding. High-resistivity soils are a problem in virtually all scenarios. The more the soil impedes the flow of electricity (i.e. resistance), the greater the voltages that can form in the soil and the more difficult it is to clear a fault, man-made or natural (i.e. lightning).

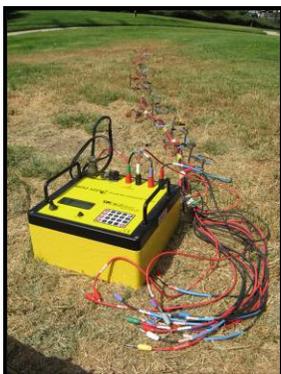
When designing a grounding plan, the methods used in the reduction of step & touch potentials can be at odds with each other:

- For step potential reduction, it is typically desirable to move the current away from personnel by placing grounding conductors into the earth as deep as possible.
- For touch potential reduction, it is typically desirable to keep the ground conductors as close to the feet as possible, thereby reducing the possibility of any difference in potential between the hands and feet of personnel.
- Step potentials are a concern across the entire compound (and beyond), as these hazardous voltages can form at great distances from the fault location. As electrical fault currents enter the earth, the electricity will travel through the grounding system and out into the surrounding soil. As this electricity propagates across the surface of the earth, personnel may be standing or ‘stepping’ in the way of the electrical surge, potentially injuring personnel. The difference in potential between the right foot and left foot of a person must be taken into account. Obviously, the further apart the two feet are, the greater the difference in potential can become, and thus a conservative number of one-meter (3.28-ft) is used as the maximum walk/run stride distance of a person.
- Touch potentials are only a concern for the distance that a person can ‘touch’ an object. In other words, since a person can only stretch their arms and ‘reach’ an object that is one-meter (3.28-ft) away, touch potential calculations are only relevant from the a given object to the reach distance.

Balancing the impact between what is good grounding design for reducing step potentials, versus what is good for touch potentials can be difficult. Often, a grounding design that reduces step potentials can adversely impact the touch potentials. For example, moving the ground ring down to a depth of 3-ft into the earth, may eliminate step voltages, however the added depth also creates a greater difference in potential between the hands and the feet, causing a sharp increase in touch voltage.

Soil Resistivity Measurements

This section will present information relevant to the collection of soil resistivity data for high-voltage environments and GPR sites.

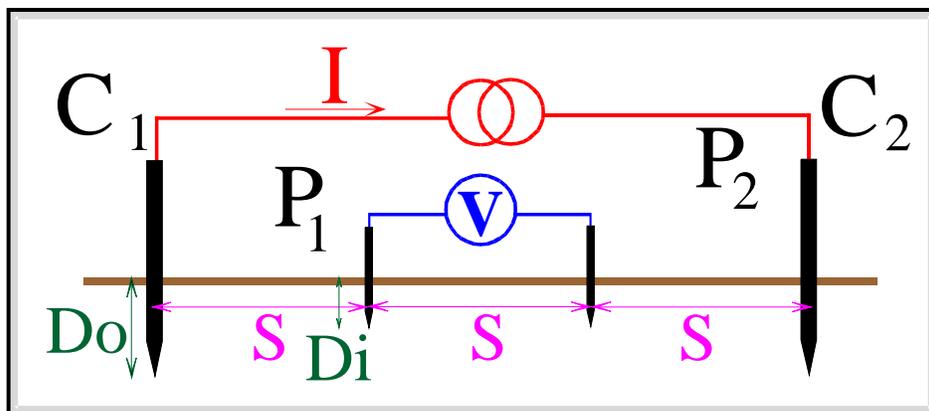


Soil Resistivity

The Wenner 4-Point Test Method was used to gather the data required in modeling the soil resistivity profile for the site. This test involves passing a known current through the earth and measuring the differential voltage drop across the tested earth. Various depths can be tested based upon probe spacing providing a complete profile of the soil down through any required depth.

Soil tests for GPR sites should be conducted using the Wenner 4-Point resistivity test method. Soil measurements are often conducted in open fields near the site. Test spacing's from 6-inches to 90-ft (270-ft traverse) or longer are typical. All tests should be performed on the site using 6-inch long current probes, and 6-inch long potential probes. Spacing's under 2.5-ft should be taken using 4-inch long probes.

The results of the soil resistivity measurements should be modeled with a multi-layer configuration one can use the RESAP analysis program, which is a software module from the main CDEGS grounding design program.



Wenner 4-Pin Soil Resistivity Arrangement

Frost Line and Comparison to Geotechnical Reports

It is important to note, that when the soil freezes, a 10x increase in soil resistivity can occur. Other indicators such as recent rainfall or snow are important to note when determining the effects weather will have on the soil model; for example if the weather conditions were below freezing on the day of the test, and the ground itself was not frozen.

If the site is in a freezing climate, it is recommended that an additional soil layer be added and set to 10X the ohm meters of the current top layer in the soil model when considering the effects of frost line to the site.

Wenner 4-Pin Method

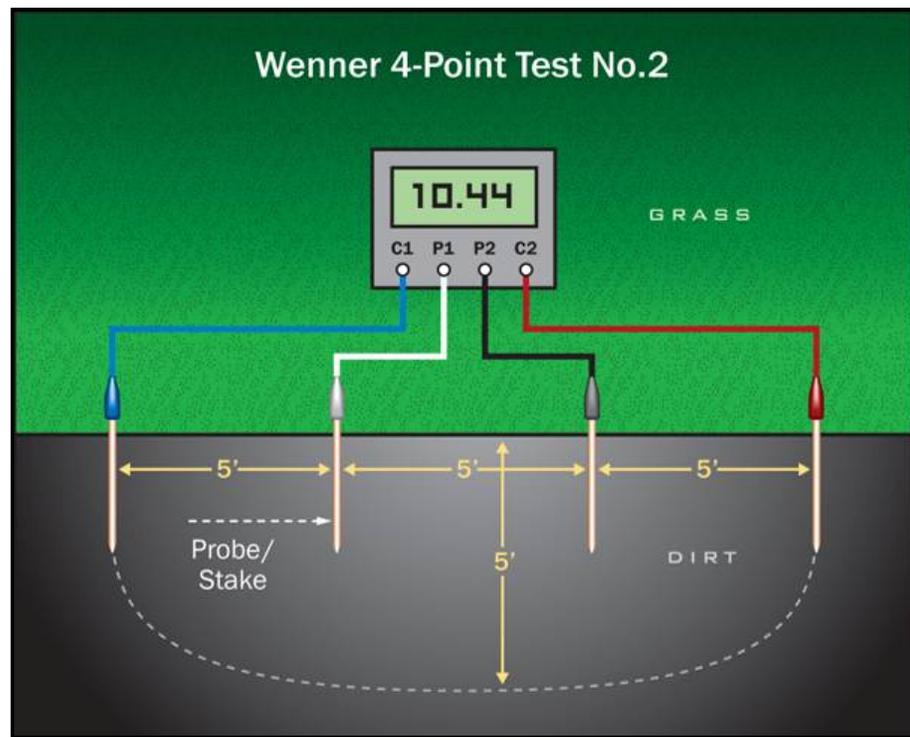
In order to determine an equivalent soil resistivity model for a given site, soil resistivity measurements are performed using one of several methods available. Typically one of the two four-pin arrangements (as mentioned below) is chosen to perform the measurements as they are the most reliable and accurate, and therefore are recommended in IEEE Standard 81-1986 ("IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth System Potentials of a Ground System"). The Wenner arrangement and the Schlumberger-Palmer arrangement are the two most common four-pin arrangements.

The four-pin methods involve the use of two current pins, one to inject current into the ground and the other one to collect the current. This current is measured by an ammeter as the current is injected. Two voltage probes are placed in line with the current probes, in between the injection and collection probes. A voltmeter is placed in between the probes to measure the resulting voltage.

The arrangement of the four probes in line with each other varies between methods. The Wenner arrangement uses equal spacing in between all probes. The Schlumberger-Palmer arrangement uses fixed potential probes but unequal current probe spacing.

The distance between the probes used in both methods is varied in order to determine different layers of soil resistivity. The probes should not be placed very deep in the soil (particularly for shorter spacing's since the probe could distort the readings). A typical recommendation is no greater than 1/20 of the spacing of the probes. When the current probes are placed into the soil and energized, they will act as a point source in the earth. The result is a hemispherical energization as the current spreads out as it flows through the different layers of the earth. In order to determine the top layer by taking measurements with probes close together, the majority of the voltage difference will occur near the surface of the earth, resulting in an effective resistance to characterize this top layer. Increasing the probe spacing increases the overall length of the path that is detected.

Measurements are taken over a long traverse with increasing spacing's to obtain the data necessary to determine the resistivity of each layer of soil. Typically it is recommended that these measurements determine the resistivity of the soil to a depth equal to the maximum dimension of the substation or grounded facility. This depth of soil will have an effect on the performance and resistance of the grounding system and therefore it is critical to know the full extent of this soil.



Wenner 4-Pin Soil Resistivity Test

Test Equipment

The instrument selection is important for soil resistivity measurements. One of the most recommended meters is the Sting R1 or "MiniSting" by Advanced Geosciences, or similar model be used. This Earth Resistivity and IP (Induced Polarization) meter is highly respected in the geological industry and is one of only two (2) brands approved for use by Safe Engineering Services & Technologies Ltd., the manufacturers of the CDEGS computer modeling software. This meter requires an external car-battery for its operation, as it generates an 800 Volt p-p DC signal, with current levels as high as 500mA. This kind of power is not to be treated lightly, and requires special precautions to be taken in the field to ensure personnel safety.



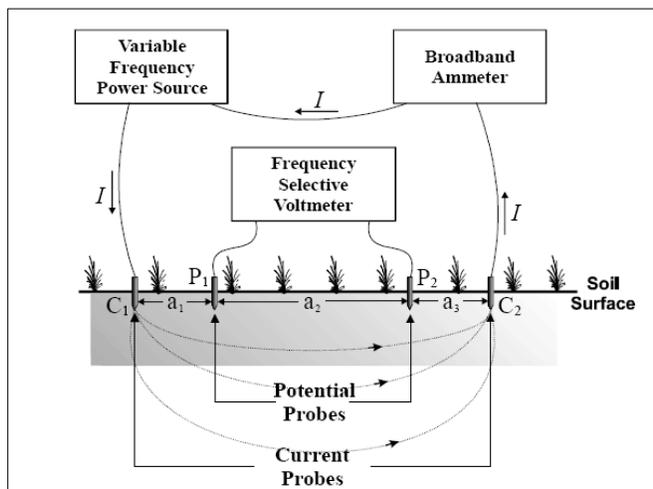
In addition to the impressive power supply, this meter has one of the most advanced electronic packages available on the market. The system's transmitter and receiver have been proven to provide the most reliable and accurate readings in even the most severe soil conditions. The signal processing and noise suppression systems are able to filter out stray voltages and unwanted signal noise. Numerous sites are prone to these excessive interference's from energized power

lines or other energized stations. The use of this system ensures that the received signal is the same as the one transmitted.

The Sting Resistivity Meter (manufactured by Advanced Geosciences Inc.) provides measurements in ohms as a ratio of the measured voltage to the injected current. A summary of the resistance measurements performed for each measurement traverse is included in the following sections. The measurements for this site were performed at 0 Hz (DC), a frequency that is not a harmonic of the power system and not an interference concern at the site as it may be subject to a large amount of 60 Hertz (or harmonic frequencies of 60 Hertz) interference. The Sting device uses higher power to avoid the influences of interference and transmits at DC frequencies to mitigate any errors from this situation.

Calculating Resistivity

After collecting field measurements of apparent resistances for various probe spacing's, equivalent apparent resistivities can be calculated using a simple formula. By injecting a current (I) between the two current electrodes, C_1 and C_2 , in the earth and then by measuring the voltage ΔV between the two adjacent potential electrodes, P_1 and P_2 , as indicated in the figures below. The spacing's between C_1 and P_1 , between P_1 and P_2 and between P_2 and C_2 are a_1 , a_2 , and a_3 , respectively. Depending upon the relations between a_1 and a_2 , one could have Wenner, Schlumberger, Unipolar, dipole and/or a general electrode configuration. The injected current should be at low frequency to reduce the inductive coupling between the leads of the circuit.



The equation to convert apparent resistance to apparent resistivity is:

Apparent resistance R_{app} is defined as

$$R_{app} = \frac{\Delta V}{I} = \frac{U(P_1) - U(P_2)}{I}$$

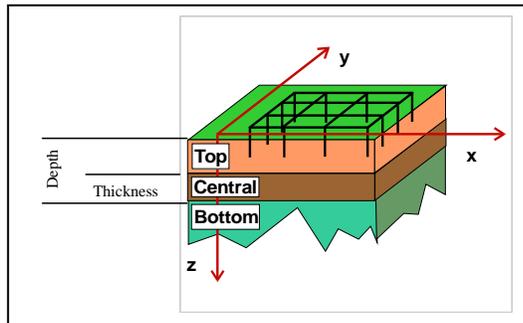
Apparent resistivity ρ_{app} is defined as

$$\rho_{app} = \frac{2\pi R_{app}}{G}$$

Additional information on soil resistivity calculations and equations is available upon request.

Soil Model Development

Using the apparent resistivities for each probe spacing (which coordinates with an equivalent depth of the measurement), a soil model can be calculated using graphical methods or advanced computational methods using computer software. Further details on developing a soil model graphically can be found in IEEE Standard 80-2000, "IEEE Guide for Safety in AC Substation Grounding."



The soil models can be developed using the RESAP module of SES's (Safe Engineering Software) CDEGS (Current Distribution, Electromagnetic Fields, Grounding and Soil Structure Analysis) software. The RESAP module uses the probe spacing's, probe depths, and apparent resistance measurements as input and

develops an optimized equivalent multi-layer soil model from this datum.

When the individual test point apparent resistivities are combined into an equivalent soil model with a finite number of layers, some error is introduced. This combines with errors in the measurements (distance between probes, equipment errors, etc.) to produce an overall model. Typical practice indicates that when possible the RMS error should be kept to under 10%, although errors as high as 20% are acceptable in certain circumstances (such as limiting to a two layer model).

When performing a grounding analysis the number of soil layers used in the model can have an impact on the results of the study. An equivalent single layer soil model can produce largely inaccurate results, and therefore is rarely used. At a minimum an equivalent two layer soil model should be produced. Some software used for grounding system analysis is limited to two layers, and therefore such a model must be used, even if not as accurate. The CDEGS software will allow over 20 layers for a soil model, which could produce a much more accurate representation of a grounding system's performance, reducing the RMS error of the soil model. However, as additional layers are considered, computation time increases significantly. Therefore a compromise must be met at some point and a certain number of layers must be determined for a final model.

Reference Specifications

The following electrical specifications should be standard for use at GPR sites:

- Copper-clad ground rods shall be a minimum 5/8-in diameter by 10-ft in length.
- All grounding conductors shall be a minimum 2/0 seven (7) stranded bare copper wire. Larger conductor sizes may be used unless otherwise noted.
- The exterior ground ring is to be connected to all gateposts, corner posts and every other fence post; 4/0 flexible copper jumper must be connected from the gate to the gate posts.
- All conductor connections shall be exothermically welded or connected by other approved permanent and irreversible bonding method.
- Routing of conductors should avoid the use of metallic conduits and sharp bends.
- All ground conductors shall be bare copper wire buried in direct contact with the native soil. Use of concrete around the conductors is highly discouraged.
- New ground grid must be connected any adjacent substation ground grid in at least two (2) locations.

The following table shows the ultimate current carrying capabilities for 2/0 AWG copper wire for a frequency of 60 Hz, current in kilo-amperes:

2/0 AWG Cable	6 cycles (100 ms)	15 cycles (250 ms)	30 cycles (500 ms)	45 cycles (750 ms)	60 cycles (1 s)
X/R = 20	51 kA	36 kA	26 kA	22 kA	19 kA
X/R = 10	56 kA	38 kA	27 kA	22 kA	19 kA
X/R = 0	62 kA	39 kA	28 kA	22 kA	19 kA

Table 2: 2/0 AWG Cable Capacity

The following table shows the ultimate current carrying capabilities for 4/0 AWG copper wire for a frequency of 60 Hz, current in kilo-amperes:

4/0 AWG Cable	6 cycles (100 ms)	15 cycles (250 ms)	30 cycles (500 ms)	45 cycles (750 ms)	60 cycles (1 s)
X/R = 20	81 kA	57 kA	42 kA	35 kA	30 kA
X/R = 10	89 kA	60 kA	43 kA	36 kA	31 kA
X/R = 0	99 kA	63 kA	44 kA	36 kA	31 kA

Table 3: 4/0 AWG Cable Capacity

Copper-Wire / Telecommunications Protection in High-Voltage Environments

This section will present relevant drawings that have been based on the templates provided, with mark-ups demonstrating relevant information presented in the study.

Telecommunications Protection

Copper wire communications cables within high voltage environments (substations, power plants, transmission towers) can be exposed to thousands of volts during a power system fault. In that instant, the entire site will experience a ground potential rise, and dangerous potential differences can occur between the power station and the remote (theoretically “zero”) ground of the telecommunication cable (central office). Any voltage difference will trigger a current flow, which as the potentials equalize, may have destructive consequences for personnel or sensitive electronics.



Ground Potential Rise

Ground Potential Rise (as defined in IEEE Std. 367, 487 & 1590) is the product of a ground electrode impedance, referenced to remote earth, and the current that flows through that electrode impedance. GPR studies use a series of calculations to determine the scalar potentials that will be found around the facility, enabling the engineer to determine how far away the copper-fiber junction (CFJ) needs to be placed.

Voltage Zones

In general, protecting the telecommunications system involves moving unprotected copper-wires outside of the 212-volt RMS (or 300 volt peak) zone. Any copper-wires connected to the telecommunications system inside that zone, requires additional protections as outlined in IEEE Standards 487 & 1590. In IEEE Std. 487, three (3) Voltage Levels have been identified:

- **Level I:** 300 Volts peak
- **Level II:** 301 to 1,000 Volts peak
- **Level III:** Higher than 1,000 Volts peak

IEEE Std. 1590 is primarily concerned with the placement of the Copper-Fiber Junction (CFJ). This standard requires that the CFJ be placed outside of the 300-Volt peak zone or a minimum of 150-meters from the station, whichever is less.

Ground Coverings

This section will present any additional relevant materials in regards to highly resistive ground coverings that will help to provide additional layers of safety for personnel.

Ground Coverings

Ground coverings can be used for a variety of reasons, from aesthetic, to water drainage, to electrical safety. Crushed rock is one of the most commonly used ground coverings.



Crushed Rock

The most effective way to prevent weeds from establishing is by maintaining a 6-inch layer of clean, crushed rock (similar to gravel) in and around hazardous areas. Crushed rock surfaces should also extend 6-ft outside the facility fence line to minimize the drift of seeds from outside, and to maintain public safety by reducing electrical exposure. Crushed rock has many features that contribute to electrical and engineering safety. In particular, it has a high level of electrical Resistivity (3,000 ohm-m when wet), which means it does not readily conduct electricity, thereby reducing the risk of electrocution over the ground grid. Additionally, crushed rock retards the evaporation of moisture from the underlying soil, thus lowering the resistivity of the soil and improving its ability to conduct the fault or lightning current into the ground and away from the surface. Other functions and advantages of crushed rock are:

- It allows rapid surface drainage.
- It is economical and readily available.
- It is non-flammable and helps to prevent fires in areas around oil-filled equipment.
- It provides a suitable surface for the movement of equipment and vehicles.
- It helps control dust.
- It provides a finished, aesthetically pleasing surface.
- It greatly impedes the establishment of weeds.

Over time, the resistivity and effectiveness of crushed rock surfaces is reduced due to construction activity, traffic, and organic matter build-up that encourages establishment of weeds. Therefore, for optimal safety and weed control, crushed rock surfaces are occasionally replenished.

Crushed Rock over Geotextile

The effectiveness of crushed rock for excluding weeds can be enhanced with a geotextile layer close to fence lines and in areas where herbicides cannot be used. Geotextile is a porous, polypropylene fabric that is laid underneath the crushed rock. It can also be staked to the soil in areas without crushed rock. Geotextile should not normally be used in drive-able areas because it may become damaged, or around oil-filled equipment because it will cause the oil to spread during a spill.

Asphalt and Concrete

Asphalt and concrete can also be used near electrical equipment, but are not as favorable as crushed rock. As shown in Table 7 of IEEE Std 80-2000, asphalt has 10,000 ohm-m when wet. Concrete will readily conduct electricity and tends to mimic the resistivity characteristics of the surrounding soil over time. Both asphalt and concrete are more expensive than crushed rock.

Neither asphalt nor concrete should be used around oil-filled equipment because they will cause the oil to spread in the event of a spill, and asphalt will burn at high temperatures. The use of asphalt and concrete is generally limited to access roads and storage areas inside facilities.

Alternate Surface Materials

Other surfacing materials, such as limestone surfacing and crushed oyster shell have been tested to see if they exclude weeds more effectively than crushed rock. Limestone has low resistivity, may impede drainage, is expensive, and is not readily available. Oyster shells are expensive and have limited application.

Restricting Organic Matter and Seeds

Organic matter and seeds should be kept from entering the facility and contaminating the crushed rock. This can be done by:

- removing trees (especially deciduous), grass, and shrubs growing close to the facility fence line to reduce debris deposition inside the facility
- maintaining a 6-ft crushed rock strip outside the fence line (over the ground grid) of substations to reduce the spread of invasive plants, such as blackberry, horsetail, broom, and groundsel