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Scope:

This test was an actual installation of Poly-Ground®, Utility Structural Systems' newest line of engineered backfills. We believe Poly-Ground® has various benefits, such as worker safety and enhanced grounding, but perhaps one of the most significant benefits that can be noted is the lower impedance, which decreases line loss of the system. With this test being conducted on a transmission line, Poly-Ground® also provides a safer, faster, and more effective path to ground for electrical discharges of all types and will potentially greatly reduce the incidence of nuisance tripping.

Conditions and Installation:

We arrived the morning of September 25th and met with utility personnel at the company's yard and we determined exactly what needed to be accomplished. We decided to test the installations completed in July 2004 to check for discrepancies in installation methods and to see if anything had changed since installation. It was going to be difficult to perform the latter because there were no recorded installation numbers from July 2004 but they recalled the numbers were not as good as they had hoped. So an actual July 2004 resistance reading was not possible.

The soil in the area was typical for the location with the exception of rainfall. According to their personnel, there had been an abnormal amount of rainfall in this area for several days and the soil had more moisture than normal. I attempted to do a soils resistivity test, but for several reasons, it could not be performed. The probes used to measure the soils resistivity are driven no deeper than 6" incrementally by ½" throughout the test but the sandy soil had no cohesive properties and could not adequately hold the probes in place. A soil reading could have been taken in another location, but it may not have accurately reflected the location where we were doing the installation. Several attempts were made to find additional locations to do a soil sample readings but surrounding rocky soil conditions made it too difficult to drive the probes into the ground.

The pole being tested was connected to the rest of the line with regards to the overhead static. In order to test properly, the static line had to be disconnected so the megger would be reading the individual pole and not the system resistance. We disconnected the static from the installed ground wire that was in turn connected to a 10' cooper clad ground rod. Several different installation methods were used in July 2004 to test the Poly-Ground®; however, we decided to find a structure not influenced by Poly-Ground® to have an in-situ pole to compare against (since we were unable to determine a July 2004 reading). The circuit being tested was a double circuit 230kv with a 69kv underbuild mono-pole structure. These particular structures were corro-coated to the ground line. Consequently, auxiliary grounding had to be employed and 10' x ¾" copper clad ground rods were used. According to the on-site crew, these rods were placed in the annular space of the backfill zone because driving these rods would be nearly impossible due to the poor soil conditions. The crew was unable to tell me if the ground rod was bonded to the rebar cage of the concrete base of the angle poles set on concrete foundations. The rod being bonded to the rebar cage could influence the reading.

For comparison, we set up to test the structure we identified as the "base pole" which was a pre-cast concrete foundation with the pole bolted to the top of the foundation. The pole was not in direct contact with the soil so, according to construction personnel, it had a 10'x ¾" ground rod placed in the annular space (although it appeared the ground rod was driven outside the hole given the proximity of the rod to the backfill).

Pole 1: This is a close up view of the initial pole used for base comparison. Note the location of the ground rod at the front base of the structure. Although the rod cannot be identified, the #6 solid copper wire connected to the rod is clearly visible.

We set up the megger to read in the "Fall-of-Potential" Method for reading single-made grounding electrodes. This meant the shield wire would have to be disconnected in order to get an accurate reading, otherwise we would be reading the system. Utility Structural Systems uses a DET 2/2 Auto Earth Tester manufactured by AVO International. The instrument was most recently tested and calibrated on October 25, 2004 by Instrument Repair and Calibration in Houston, Texas. This is the most common and accurate method for measuring this type of system.

Pole 1: This is a close up view of the actual reading obtained on the above structure. The two red leads are attached to the grounding electrode itself, and the yellow lead is attached to a stake at 62' from the electrode and the blue is attached to a driven stake at 100'. The resistance reading was 19.50 ohms.

This reading was surprisingly lower than expected given the nature of the soil in desert southwest. The soils are generally not considered conductive due to the soil composition and the lack of annual rainfall. The average rainfall in the area is ½" per month.

Pole 2: This is a close-up view of the second structure tested. It is a direct embedded pole set in concrete

Pole 2: Normal, concrete backfilled pole with 10'x ¾" copper ground rod. Reading is 24.3 ohms.

The next pole was backfilled with concrete and not set on a pre-cast concrete foundation and the reading was taken again using the "Fall-of-Potential" Method for testing single-made electrodes. This pole was identified as one of the poles treated with Poly-Ground® in July 2004. The procedure (as described by their personnel) was to install a galvanized plate measuring approximately 12" wide by 18" in length by 1/4" in thickness. #6 Copper wire was used to connect the pole to the plate and the plate was installed vertically with Poly-Ground® poured over it. These plates were backfilled using one PG30W kit manufactured by Forward Enterprises Inc of Houston (sold under the name of Utility Structural Systems).

Pole 3: This particular pole had been post-installation retro-fitted with the above described steel plate backfilled with Poly-Ground®. It also had a driven rod that was installed during the initial installation.

I was told the reading was not as favorable as they thought it would be, so instead, the ground wire was connected to a ground rod installed during the initial installation. Both of the grounding electrodes in place on this pole were measured isolated and then tied together just to see the effect of combining the two. The readings shown on this structure show a slightly better reading on the ground rod versus the Poly-Ground® backfilled plate, but the results were even better when the ground rod and Poly-Ground® backfilled plate were tied together (see below).

Reading #1

Reading #2

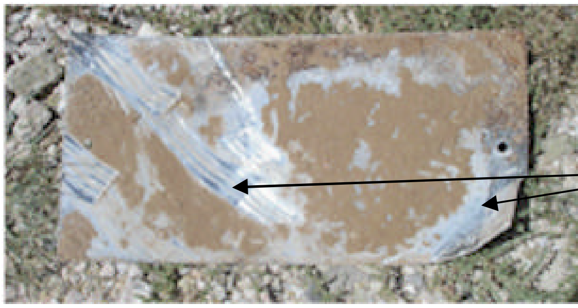
Reading #3

Pole 3: #1 is the ground rod isolated; reading= 10.45 ohms. #2 is the Poly-Ground backfilled plate isolated; reading=13.53 ohms. #3 is the copper rod and Poly-Ground plate tied together; reading= 8.68 ohms.

After reviewing the topography of the area, we began to discuss our observations. We concluded something significant was at work here given the unusually low readings on the ground rods in native soil. We determined that due to the unusually heavy amounts of rain in the Las Vegas area over the past few weeks and the poles being tested were in a run-off valley, it was entirely possible moisture had collected in these locations. Although the readings were correct, they may have been falsely influenced by excessive moisture not normally present. We decided it would be prudent to check another structure much higher in elevation in order to confirm those theories. The following structure was the first in the line that would possibly fit the description. After taking an initial reading on this structure, we realized our excessive moisture theory was indeed possible as evidenced by the numbers:

Pole 4: This structure was set on a pre-cast concrete foundation that had a galvanized plate put in the trench but was not treated with any backfill other than native earth. The plate was placed vertically in the trench and backfilled with the excavated material. The reading was 98.0 ohms.

We decided to dig up the plate to check the connection and the condition since it had been in the ground since the July 2004 installation. During the excavation, we confirmed the idea that there was excess moisture located in the subsurface soil. The subsurface soil was very moist in nature and would "clump" together when squeezed. This was completely different than the soil present at the surface. This discovery was slightly disturbing but in all honesty, it was expected. The galvanized plate was dug up using the backhoe (in the above photo) and reviewed for connection and condition. It appeared to have been properly connected using Kearny clips. What was more disturbing was the condition of the plate after 13 months. It would explain the issue currently being discussed throughout the utility industry of the effects of corrosion on steel poles. See photos below:



This is the galvanized plate. The scrape marks are from the backhoe and the excavation process. The hole on the right hand side is where the copper wire was connected. The rust is visible all along the upper and right hand edges.

In this particular case, we decided to re-install a new plate matching the size of the excavated plate and reposition it horizontally and cover with Poly-Ground®. The trench was dug to a depth of about 24" and a width of almost 30". We did not intend to fill the entire trench, but enough Poly-Ground® was placed in the hole to be effective. One Poly-Ground® PG30W kit was poured in the trench and as the foam was expanding the plate was pressed into the foam to insure solid bond and contact with Poly-Ground®.

Pole 4: This is a photo showing the trench dug with a Poly-Ground® kit poured in the trench and the galvanized plate placed on top of the rising foam.

Pole 4: This photo shows a second kit being poured on top of the galvanized plate to insure maximum contact with the plate and to insure a water resistant seal to protect the plate from further degradation.

After the kit was poured, the foam was allowed to cool for about 10 minutes and a reading was taken. The reason this was done was to show the cumulative effects of surface area of the Poly-Ground®:

Pole 4: This is the reading of one plate encased in Poly-Ground®. It is important to note the only contact the plate/Poly-Ground® had with the ground was the bottom section as there are no sides and there is no backfill on the top. It is open air. The reading is 167.8 ohms.

We decided to place a second galvanized plate in the other end of the trench and backfill it in the same manner as the first one. Below is the photo and reading:

Pole 4: This photo shows the second installation and megger reading was 103.4 ohms. This reading is a cumulative reading of the first plate tied together with the second plate. So there are actually two plates tied together being read here, but there is still only bottom contact being made as the hole is still open air.

We had extra material so I suggested we "tie together" the two individual plates using a Poly-Ground® connection. The ***only*** connection here would be through Poly-Ground®. Another Poly-Ground® kit was poured into the gap between to the two plates and again allowed to cool slightly and then tested. The photos and readings are below:

Pole 4:This photo shows the "connecting" of the two plates using a Poly-Ground® only connection and the subsequent reading, keeping in mind there is still only a bottom connection to the earth.

After taking the last reading, the backhoe operator was given the go-ahead to begin backfilling the top of the trench. This was done quickly and the decision was made to let the soil compact naturally. The possibility remained to come back and check it at a later date. See the photo below for the final reading:

This is a photo showing the final reading of the two installed galvanized plates tied together in a single layer of Poly-Ground® after the trench had been backfilled with soil but not compacted. The final reading was 76.8 ohms.

I would like to take this opportunity to give a little background on Poly-Ground® itself. The Poly-Ground® had to be applied in several steps given the large void to fill and kit sizes of the Poly-Ground® being supplied. Poly-Ground® is supplied in a two component system consisting of an "A" and a "B" component with each kit pre-measured by ratio. The "A" component MUST be premixed prior to combining the two components because the materials making up Poly-Ground® can settle during shipping and while waiting in a warehouse to be used. The premixing requirement is clearly marked on the containers. Once premixed, the “B” component is poured into the “A” component and mixed again for approximately 25 seconds (on average) making sure to move the supplied mixing apparatus up and down in the pail to insure adequate mixing. The process MUST be done with a ½” drill that is either electric, gas driven, or battery operated and has enough power to adequately mix several kits throughout the day. Once the components are mixed the process of expansion cannot be stopped. The reacting material is poured into the void, making sure to scrape all Poly-Ground® materials from inside the bucket using the supplied wooden paddle. The paddle is NOT to be used to mix the product because it will not adequately mix the components. During the Poly-Ground®/Poly-Set® reaction an exothermic reaction takes place resulting in the generation of heat. Heat is resistance electrically speaking and this is the reason we waited 10 minutes for the heat to dissipate in order to get a somewhat accurate reading without heat influencing the reading. We performed this very same process, for each Poly-Ground® kit poured and waited a minimum of 10 minutes prior to taking a meg reading.

Conclusions:

We feel quite confident, as evidenced by the numbers, that Poly-Ground® had a significant, positive effect on the grounding of these types of poles. Furthermore, it indicates surface area is playing a key role in the grounding of structures when Poly-Ground® is used. The reason we conducted the test in this fashion was to prove that very theory. It is also of primary interest that given the evidence of the galvanized plate that was excavated and the corrosion that had already set in, Poly-Ground® would in fact be a far superior backfill due to its water resistant nature. The galvanized plates should be well protected once encased in the Poly-Ground®. This theory would also translate to poles backfilled with Poly-Ground® in the traditional sense. Something has become quite apparent during these tests that I believe is important to note. Although the general feeling on the prior Poly-Ground® installations were "not as good as expected", we must note Poly-Ground® was able to obtain ground resistance numbers very close to the ground rod numbers. Even though the ground rods have access to soil conditions at 10' deep, the Poly-Ground® was no deeper than 18"-24" at anytime. If Poly-Ground® had access to the soil at deeper locations like the ground rod (i.e. a ground rod in a 6" augured hole that is backfilled with Poly-Ground®), the results would have been much different.

Submitted by:

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