Deep Anode Systems

Period 4

Advanced Corrosion Course 2017
Deep Anode Pros and Cons

• Advantages
  – Small geographic footprint
  – Good current distribution
  – Long Lasting (few repairs necessary)
  – Typically have low anode to earth resistance

• Disadvantages
  – Difficult or impossible to repair
  – Expensive
  – Can cause environmental issues
When to Apply Deep Anode

• Easement is difficult to obtain
• Easement is expensive to obtain
• Power Plants, compressor or pump stations
• Chemical plants
• Surface soils have high resistivity properties (seasonally or year round)
• When money is no object
Components of Deep Anode

- Rectifier/Power Source
- Positive Cable
- Junction Box
- Individual Anode Cables
- Anodes
- Centralizers
- Carbon Backfill
- Vent Pipe
- Hole Plug (Bentonite or Pea Gravel)
- Structure Cable and Negative Connection
- Sometimes Surface Casing and Cap Apply
Schematics

2017 Underground Corrosion Short Course

Advanced Corrosion Course – Period 4

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Engineering Considerations

- Management Support
- Alternative Systems
- Site Selection
- Soil Resistivities (Barnes Layer Preferably)
- Geology
- Current Requirement
- Budget
- Local Laws

- Environmental Impact
- Easement
- Anode Material Selection
- Backfill Material Selection
- Installation Method (Specification)
- Contractor Availability
- Contractor Qualifications
- Cost
Specifications Recommendations

• Specify materials for your system
• Specify dimensions of well
• Specify rectifier
• Specify contractor qualifications
• Specify installation process
Material Pictures
General Deep Anode Types

- Standard Deep Anode
  - Uses pumpable coke breeze grit
  - Does not use a full length casing
  - Must vent gases
- Replaceable Deep Anode
  - Uses pumpable coke breeze grit
  - Uses full length perforated casing
  - Must vent gases
- Aquifer Friendly Deep Anode
  - Uses coke breeze impregnated grout (bentonite, cement, or polymer)
  - Does not use a full length casing
  - Cannot vent gases
Standard Deep Anode

• Most Commonly Used
• Tried and True Results
• Less Expensive
• Has potential for environmental liability
• Long Lasting
• Reliable Service
• Instant Gratification
Replaceable Deep Anode

- Controversial acceptance in the industry
- Environmental liability
- Spent anode material can be flushed from existing hole and refilled with anodes and backfill
- More expensive to install initial anode
- If successfully replaced, economic benefit may be realized
Aquifer Friendly Deep Anode

- Cured backfill material is not permeable to water
- Prevents aquifer cross contamination
- May have significantly longer life than other systems
- Not effective in all soils
- Expensive relative to standard system
Installation Process

• Using mud rotary rig, drill anode hole to specified diameter and depth. Collect soil log while drilling.
• If specified, install surface casing and grout annulus.
• Circulate fluid to clean out bore hole.
• If full length casing is specified, insert it into the bore hole.
• Collect electrical log of hole.
• Install vent pipe and anodes to specified depth.
• Pump specified backfill into bore hole from bottom up through approx. 1” pipe.
• Allow backfill to settle into place (typically 12-24 hours).
• If specified, install bentonite or pea gravel plug over the backfill.
• Terminate vent system above flood water level.
• If specified, install cap on surface casing.
• Terminate anode leads in junction box.
• Install positive lead from rectifier to junction box.
• Restore workspace to specified level.
Installation

• Regardless of which type or design, quality installation is the most important factor in a successful system.
• The single most important installation process is pumping backfill.
• Also very important is the attention paid to isolating surface water from entering aquifers through the well.
Absence of Pictures

• While we all know that a picture is worth a thousand words, things that take place underground are hard to take pictures of, therefore I have opted for several thousands of words to compensate for a lack of pictures.

• I can poorly sketch some of the following steps upon request, so if it is confusing, I will try to clear it up.
Drilling

• Drilling should be performed using properly sized bit for materials purchased.
• Try to maintain a borehole that is smooth, straight, and clean from debris.
• Use potable water for all drilling operations.
• Consider drilling slightly deeper (5-10’ deeper) than design calls for. When cuttings settle out of drilling fluid and fall to the bottom of borehole, it is not uncommon to lose a small amount of the desired depth. The cleaner the drilling fluid, the less hole depth loss will be experienced.
• If surface casing is to be used, a larger diameter hole (in the cased area) may be necessary to facilitate installation of surface casing.
• Be cautious of high pressure aquifers (flowing wells), small pockets of natural gas, caverns, zones of lost circulation and other drilling phenomena that may be present in your area. Always have a contingency plan for these issues. The possibility of not being able to install anodes in that location does exist.
Install Surface Casing

• If surface casing is to be used, it should be installed and grouted in place before drilling the anode column with a smaller diameter bit.
• The surface casing pilot hole should be at least 4” larger than the diameter of the surface casing so that it can be grouted completely around the annulus of the casing pipe.
• The surface casing may need to be centralized with wooden blocks to ensure that annulus can be grouted.
• Grouts for the casing may include: bentonite, cement, or other impermeable and flowable materials.
• The grouts should be pumped from the bottom of the annulus to the surface to ensure adequate isolation of surface waters from the ground water.
Install Perforated Casing

• If full length perforated casing is used (as in a replaceable anode system), it should be installed after the borehole is completed and sufficiently cleaned of cuttings in the fluid.

• Perforated sections of casing should not be used toward the top of the borehole so that surface water can be isolated from groundwater.
Install Pipe for Pumping (Tremme Pipe)

- Pipe material should be able to withstand the weight of the backfill material and the pressure caused by pumping.
- Materials that have been used successfully include ¾” or 1” Schedule 40 PVC (bell and spigot joints are preferred) and ¾” or 1” seamless HDPE.
- If using PVC, ensure that the joints are connected well with primer and cement. A poorly connected joint may cause a portion of the pipe to be left in the hole.
- If using HDPE pipe, remember to allow the pipe to straighten out on the ground for a decent amount of time before inserting into the borehole. If the pipe still has “memory” inserting it into the borehole may be difficult or impossible.
- Insert the pipe material to the bottom of the borehole then back it up a couple of feet so that is does not plug off when the backfill is pumped.
Loading Anodes

• Anodes should be handled as gently as possible.
• Install centralizers as necessary to keep anodes from direct contact with the soil or rock.
• Some or all of the anodes may be installed with the vent pipe from the beginning to provide buoyancy control for the vent pipe. Some anode systems are designed such that all of the anodes are to be connected to the vent pipe during installation. The cables to any anodes that are installed with the vent pipe should be secured to the vent pipe (with electrical tape or like material) to help insure that they are not damaged in the process.
• When anodes are loaded individually after the vent pipe is installed, they are lowered by slowly and gently inserting them into the borehole and lowering them by the anode cable until anode reaches the appropriate depth.
• If anodes are not installed “smoothly” the anode leads may get tangled around the vent pipe, tremme pipe or around other anodes as they are being lowered.
Pumping Backfill

• The backfill/water slurry should be thick and heavy. Continuous agitation of the slurry is necessary to attain the appropriate density for a successful installation.

• Actual slurry density will depend on the backfill being used. Please consult your material provider for specifications.

• Use potable water for slurry mixture.

• The slurry can be mixed in the grout pump on the drilling rig or in a separate mixing machine.

• Pump the backfill from the bottom of the borehole so that it displaces the drilling fluid.

• Pump the slurry slowly and consistently into the borehole so that turbulence does not hinder the settlement of the backfill in the borehole.

• Occasionally withdraw the tremme pipe (20’ at a time is typical) so that pumping activity does not disturb the coke column. Try to time the tremme withdrawals such that a commensurate amount of backfill has been pumped into the hole.

• When pumping is complete, rinse the tremme pipe contents into the hole with potable water. If this is not done, the tremme pipe will be plugged and cannot be used in the future.
Photos
Completing the Well

- After the backfill has compacted to the satisfaction of all parties involved (may be several hours or several days), the well needs to be completed.
- Any void space in the well should be filled with a plug of some sort (bentonite or cement). The exception to this is for replaceable systems that are designed to have an open casing.
- If the design calls for a buried surface casing, the casing must be trimmed off 18” -24” below grade and capped. Remember to bring the vent pipe and anode leads out of the casing before sealing the well.
- If the design calls for a well head to be above ground, bring the anode wires out of the casing below ground level through the side of the casing. Then fill the casing with a hole plug material before installing the cap.
- Typically the anode lead wires will be terminated in a junction box and the vent pipe can be terminated on the junction box post (with sufficient distance from metals as to not corrode the metal with vented gases).
- Use a cap with small holes for vent to deter insects from plugging ventilation system.
Final Wiring

• The anode leads should be connected to a common positive cable from the rectifier.
• Shunts are commonly used to measure each anode current.
• Resistors may be necessary on individual anodes to keep certain anodes from depleting more rapidly than others.
Installation Complete

- Now the new deep anode system is installed.
- Performance of deep anode systems can vary dramatically from one location to another.
- The anode system might be considered a success if it is ¼ Ohm in some environments or if it is 15 Ohms in some other environments.