Deep Continuous Wire Anode System Proves Enduring

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A non-conventional deep anode groundbed system at a large West Coast utility has accumulated more than 50 million operating hours in almost a thousand installations with only seven reported failures. This article examines the application history of this unique deep anode groundbed design

Deep anode groundbed systems have been utilized for decades to distribute cathodic protection current to protect pipelines, storage tank bottoms, well casings and other buried structures. Conventional deep anode groundbed designs typically consist of multiple individual discrete anodes in a coke backfill. However, in 1992, a major West Coast utility company standardized on a non-conventional deep anode groundbed system and the operating results since then indicate an enduring reliability.

The utility company is one of the largest combination gas and electric utilities in the United States and serves approximately 14 million customers throughout a 70,000-square-mile service area. It operates over 5,700 miles of gas transmission pipelines, and in excess of 40,000 miles of gas distribution lines to deliver gas to residential and commercial customers. The pipeline network traverses a wide range of soil conditions and environments from wet coastal areas, to very arid regions.

Maintaining such an expansive network is a significant challenge. This is especially true for the gas distribution segment because the segment's pipeline network provides services throughout some of America's busiest commercial and residential areas.

To ensure proper cathodic protection of the gas distribution lines, the utility has traditionally installed deep well anode systems to protect much of its distribution system. These deep wells are typically 125-200 feet deep, although this may vary from site to site. Current output from each of these groundbeds is kept low (four to five amps per anode bed up to eight to twelve amps per groundbed) to minimize stray current concerns and to assure the longest possible anode life to minimize costly anode bed replacement.

During a 14-year period, approximately 1,000 factory-assembled, continuous wire anode systems were installed and operated throughout the utility's distribution system. It appears the original decision to specify these anode systems was based on a comparative analysis of total installed cost. However, the long-term benefits of this type of system compared to a conventional deep well anode system surfaced in reliability data based on the extensive operating experience gained from these systems. This experience demonstrates that these systems have been extremely reliable while significantly reducing installation time and overall costs.

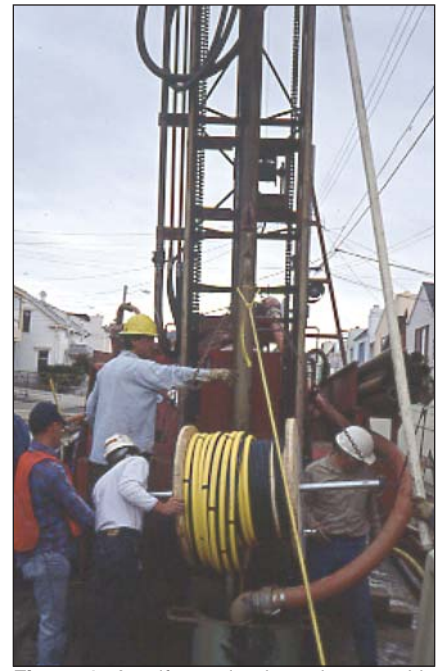

Figure 1: A self-contained anode assembly being prepared for installation down-hole in a residential neighborhood.

Historically, the utility used individual high silicon cast iron anode assemblies. In the late 1980s, they began to evaluate a new product design for these applications — the pre-assembled continuous wire anode deep well system. The successful implementation of this anode system resulted in its adoption as the utility's standard deep well system. Since the initial decision almost a thousand of these systems have been successfully installed.

The self-contained design of the continuous anode system selected by the utility is a contrast with the conventional anode systems that are commonly used for this application. Conventional deep well anode systems utilize anywhere from two to 15 individual tubular anodes, usually high silicon cast iron or graphite, arranged vertically.

The individual anodes are connected to a junction box or, when only a few anodes are used, they may be connected directly to the rectifier. A vent pipe is also installed into the well to keep chlorine gas from accumulating down hole. Finally, fluidized coke backfill is pumped down hole to approximately ten feet above the active area. The rest of the hole is filled with drilling mud, bentonite or some other similar filler material.

The individual anodes are available in standard sizes. Table 1 has examples of three common types of anode materials with Platinum and mixed metal oxide (MMO) anode materials available for use in continuous wire anode designs.

The conventional anode system has several disadvantages when compared to the self-contained continuous deep anode system now standard for the utility. The primary disadvantage has to do with installation. With this type of system, the well is often a larger diameter than a comparable self-contained unit. This means increased drilling time and more drilling spoils to dispose of after the well is completed.

In addition, once the well is drilled, each anode must be carefully lowered to the correct depth, tied off and then the next anode is lowered down and the process repeated until the complete set of anodes

Table 1: Comparison of Common Deep Well Anode Systems

Type of Anode	Configuration	Dimensions	Weight	Consumption Rate (lb/A·yr)
Graphite	Cylinder	3" x 60"	26 lb	2
High Silicon Cast Iron (Type TA2)	Cylinder	2-3/16" x 84"	46 lb	1
Platinum over Niobium substrate	Coated wire	Continuous wire segment	1 lb/ 20feet	.008 (g/A·yr)
Mixed Metal Oxide over Titanium substrate	Cylinder or Coated wire	Varies for Cylinders or Continuous wire segment	1 lb/ 20feet	Negligible[1]

[1]. *Mixed Metal Oxide (MMO) does not consume, per se, however the oxide film does degrade over time as a function of current density and current output. The design life of MMO anodes is developed by the manufacturer based on experience and testing.*

Figure 2: A self-contained anode system ready for installation.

is installed. The vent pipe is usually supplied in 20-feet segments that must also be coupled (assembled) and lowered into place prior to backfilling the well with fluidized coke. Since the conventional well may have a larger diameter than the diameter required for the self-contained anode system, more coke may be required and this may add incrementally to the installation time.

Installation time has a direct impact on the installed cost, and in many cases, these anodes are located in congested, commercial or residential areas and every effort is made to minimize installation time and the traffic disruptions that can occur.

The system adopted by the utility is a self-contained deep well system utilizing a niobium copper-cored wire with a co-extruded platinum jacket as the active anode element. In this design, there is only one continuous anode with an internal multi-loop dual feed configuration. The multi-loop dual feed arrangement is critical to the success of the continuous wire anode system and consists of internal connections every ten feet to a header cable which is fed from both the top of the anode segment and the bottom by dual feed cables.

This configuration greatly reduces IR drop and balances out the current distribution while providing tremendous redundancy; a single anode failure or cabling failure does not adversely affect the system performance. The entire anode system is factory assembled with a continuous integral vent pipe and lowering rope to simplify installation. The entire assembly comes in a heavy duty crate on a single cable reel for ease of installation. The system installs in the bore hole in minutes.

Since the anode element is platinum niobium co-extruded wire, the anode and vent pipe generally require a smaller diameter well hole and less coke backfill material than a conventional anode system. The combined effect of a single assembly to be lowered downhole and reduced well diameter reduces installation time — an important consideration when installing a system in a busy commercial or residential area. The anode design also reduces potential of damage to the cabling because the entire assembly is lowered into the hole as a single operation.

System Reliability

The large number of self-contained anode systems installed by the utility in the past 14 years provides a wealth of operating history. A recent audit by the utility determined that there have been only seven reported failures of any kind with these systems over the life of their installation. This rate is less than 1% of the installed base and equates to in excess of seven million hours of operations mean time between failures.

Figure 3: Recent installation of a self-contained anode system in Dallas, TX.

The large physical area and the diversity of geography, soil conditions and environment that is found in the utility's system makes the installed population a very good indicator of the type of results that can be expected for typical gas distribution installations anywhere.

The 14-year operating experience shows clearly that the self-contained systems have proven tremendously successful. Their ease of installation has made them the company's standard and resulted in significant installation cost savings. Operating in excess of 50 million hours in a wide range of applications across an expansive geographic system in a variety of terrains, these anodes have proven to be a highly reliable cathodic protection solution. ***P&GJ***