

# DRILLING FOR BETTER RESULTS



**Ted Huck, Matcor Inc., USA**, discusses a tank cathodic protection retrofit project in the Middle East that used horizontal directional drilling technology.

One of the world's largest producers of ethylene glycol operates a critical service ethylene storage tank at its flagship Kuwait petrochemical facility. This cryogenic tank was originally constructed in 1995. The cryogenic tank consisted of a dual wall construction design with an insulation layer between the inner shell and the exterior shell. Additionally, installed below the exterior tank bottom is a series of heater conduits that prevent the ground from freezing directly below the tank. A cathodic protection system was initially installed as



**Figure 1.** Anode and vent pipe assembly being installed in bore hole.



**Figure 2.** Horizontal directional drill bit commencing bore.

part of the tank design to protect the external tank bottom in contact with the ground (and thus subject to corrosion). Over time, the original cathodic protection system stopped providing enough current to meet NACE criteria for the control of corrosion. The typical cathodic protection system design life for systems installed in 1995 would have been approximately 20 to 30 years. The tank owners looked to retrofit a new cathodic protection system to ensure that the external tank bottom was not compromised by corrosion in the absence of sufficient cathodic protection.

### Basics of cathodic protection for external tank bottoms

Larger diameter aboveground storage tanks are commonly installed on a sand or soil prepared foundation where the underside of the tank bottom is in direct contact with the prepared base. When the tank is erected from steel, the underside of the tank is subject to corrosion as the steel naturally reacts with its environment. This corrosion can result in significant pitting and ultimately tank leaks. Cathodic protection is an effective means to prevent corrosion of steel in contact with soil and is typically used on all critical service tanks to extend the tank operating life. Cathodic protection is the process of creating a DC

circuit to flow current from an external source (anode) through the soil to the structure (cathode) being protected. If enough DC current can be distributed properly over the entire tank bottom, the corrosion reaction can be effectively halted and the tank is deemed to be cathodically protected.

The proper selection of anodes and their configuration and location are design issues that are generally addressed prior to erection of the tank when there is ample opportunity to locate anodes directly underneath the tank. For existing tanks, there are several challenges that must be considered when looking to install cathodic protection as access directly below the tank is not readily available.

### Initial retrofit approach

For the ethylene storage tank, the first retrofit cathodic protection system consisted of installing discreet anodes augured into place and offset around the perimeter of the tank. The installation of several anodes strategically located directly around the perimeter, while commonly applied to many smaller diameter tanks because it is relatively easy to install, often struggles to drive current to the centre area of the tank. As a result, only the outer edge of the tank bottom has adequate protection levels, while the centre areas of the tank bottom are not protected. For the ethylene storage tank, the presence of heating pipes below the tank bottom only exacerbated the current distribution challenges. Ultimately, the results were not satisfactory, and a different approach was required.

### Trying something different

An alternate approach, which was successfully being performed in the US but that had not been tried previously in the Middle East, was the installation of multiple strings of linear anodes directly below the tank using horizontal directional drilling (HDD) technology. By drilling under the tank, it is possible to install multiple parallel anode strings under the tank spanning the entire length of the tank. This approach eliminates the concerns over current being discharged from the perimeter of the tank only protecting the outer edges of the tank and helps to ensure a more thorough distribution of current over the entire tank bottom. Another benefit of this approach is that a potential profile testing tube can be installed that allows for the installation of a testing device to be pulled along the entire tank bottom profile to measure the effectiveness of the cathodic protection system

### Installation risk mitigation

The plant's engineering and operations team had significant reservations about this approach. The tank was critical to the plant's operation and could not be taken out of service and any loss of integrity to the ethylene storage tank could result in a catastrophic failure. When considering this approach, significant concerns existed should the drill head drift up to the



**Figure 3.** Potential profile slotted pipe and reference electrode assembly.



**Figure 4.** HDD drill rig and support equipment preparing for installation.

tank bottom. With today's sophisticated HDD technology, however, it is possible to put together a thorough installation procedure incorporating sophisticated drill head tracking systems to ensure that the drill head location was being continuously monitored throughout the bore. After reviewing the procedures and safeguards and carefully examining the qualifications and experience of the project team, the tank owner felt confident that the installation could be performed safely.

### Anode system design

The anode system being installed consisted of a series of parallel slotted PVC pipes, which were bored into place under the existing tank. The slotted PVC pipes, once installed under the tank, allow for the insertion of the anodes. The anodes consist of a linear mixed metal oxide coated titanium wire connected to a parallel dual jacketed cable connected to each end of the anode and strategically along the length of the anode. The header cable jacketing is a combination of a tough high molecular weight polyethylene outer jacket and a chemically inert fluorinated PVDF inner jacket material. In addition to the anode, a small vent pipe is installed in the PVC pipe to prevent the build-up of any gases generated as part of the cathodic protection reaction at the anode. Finally, coke backfill is

pneumatically blown into the PVC pipe using a small tremie hose to fill the interstitial space inside the PVC pipe and to ensure good low resistance earth contact around the anode and assure a conductive current discharge path to the tank bottom through the pipe slots. One of the unique features of this design is that it is suitable for future anode replacement. The vent pipe can be used to fluidise the coke to allow for the extraction of the anode assembly at the end of its useful life and a new anode assembly can be reinserted in the PVC pipe.

### Potential profile monitoring tube

One of the biggest challenges with existing tanks being retrofitted with a new cathodic protection system is ensuring that tank potential readings can be made at the centre of the tank. Potential readings are used to measure the effectiveness of the cathodic protection system. For new tanks, it is common to install fixed reference electrodes under the tank to allow for potential readings. These fixed reference electrodes have a finite life, typically less than 20 years, and eventually they stop providing accurate data. Many new tank designs are now including monitoring tubes that allow for calibrated reference electrodes to be pulled through the tube to provide potential readings across the entire tank profile from one end to another. With the existing ethylene tank, the reference electrodes installed during the initial construction were no longer reliable and the only measurements that could be taken were from the perimeter of the tank, giving no indication that the centre of the tank was being protected. Along with installing the PVC tubes for inserting the anodes, a monitoring tube was also installed to allow for testing of the cathodic protection system across the full tank profile.

### Completed installation

In December 2019, the HDD linear anode retrofit system was successfully completed. The initial commissioning results showed that the anodes were installed properly with each anode distributing current as expected, and that the polarisation levels were meeting appropriate NACE criteria. The system has been left to operate and fully polarise, and a subsequent visit was completed to make final adjustments to the anode system current output and to confirm that the system continues to meet NACE criteria.

### Conclusion

This successful installation in Kuwait of a horizontally directional bored cathodic protection system under an existing critical service tank is a first for the Middle East region. The innovative design, when properly designed and installed, makes this an interesting and cost effective option for other tank owner/operators in the Middle East and around the globe to consider for their existing tanks with cathodic protection systems that are not performing properly. 