

Case Study: HDD CP Retrofit for Existing Critical Service Ethylene Above Ground Storage Tank

Shailesh Javia
MATCOR Inc.,
101 Liberty Lane,
Chalfont, PA 18914,
USA

Venkat Sreenivas
EQUATE Petrochemical Company,
Ahmadi 61001,
KUWAIT

ABSTRACT

This case study details the retrofit installation of a replaceable linear anode based impressed current cathodic protection for a critical service double wall cryogenic Ethylene Storage Tank in Kuwait. The ground bed underneath the tank bottom has been provided with the heaters to maintain the temperature of soil, preventing the ice film formation below the tank bottom. This critical service tank could not be taken out of service and the existing CP system consisting of discreet anodes around the perimeter of the tank proved ineffective in meeting NACE criteria for cathodic protection. Utilizing Horizontal Directional Drilling (HDD) to bore under the tank, offered the opportunity to install directly below the tank linear anodes and a portable reference electrode profile tube while remaining in service. This novel approach to installing cathodic protection on existing tanks offers several critical benefits but had not previously been attempted in the Middle East Region. This paper will discuss the lessons learned in bringing this technology to the Middle East Region and focus on the design process, the installation works including the use of advanced electronic tracking technology for the HDD bore, and the commissioning results.

Key words: Cathodic Protection (CP), Direct Current (DC), Mixed Metal Oxide (MMO) Linear anode, Impressed current cathodic protection (ICCP) Horizontal Directional Drilling (HDD).

INTRODUCTION

Corrosion has long been recognized as an extremely costly naturally occurring phenomenon that can be controlled through the proper application of corrosion prevention and control methods protecting public safety, extending the service life of assets and preventing damage to property and the environment. The landmark Cost of Corrosion Study published by the U.S. Federal Highway Administration estimated that corrosion costs were approximately 3.1% of the nation's GDP. Within the study, several key sectors of the US economy were studied. This paper is focused on one of those areas – the corrosion risks associated with storage tanks that contain hazardous materials. The study determined that the annual direct cost of corrosion for above ground hazardous material storage tanks (ASTs) in the US was ~\$4.5 billion.

Cathodic protection be applied to prevent corrosion of external tank bottom plates for above ground storage tanks (ASTs) that are exposed to soil or sand foundations. API Recommended Practice 651 notes that “cathodic protection for new aboveground storage tanks should be included in the initial design.”¹

For most of these new construction above ground storage tanks, an impressed current cathodic protection system is required due to the limitations of galvanic anodes in this application. Cathodic protection applied to above ground storage tank bottom plates has had mixed success and continues to be an area of great interest in the industry. Some of the challenges include improper design, poor installation, inferior quality materials, insufficient planning and other factors. This paper looks at the two of the more common approaches of impressed current cathodic protection system for AST.

TYPICAL AST TANK CONSTRUCTION

Continuous Concrete Pad

A properly designed concrete tank pad constructed on stable, properly prepared subsoil may be effective in eliminating intrusion of groundwater, soil-side corrosion, and the need for cathodic protection. Preparation of a stable soil to support the concrete slab is very important to ensure the continued integrity of the pad. Unstable soil may induce cracks in the slab through which water and contaminants can permeate to the steel tank bottom and provide a corrosive environment¹.

Although corrosion from the soil may be prevented by a concrete pad, there may still be a collection of moisture between the tank bottom and the pad due to condensation, blowing rain or snow, flooding due to inadequate drainage, rainwater from the roof of the tank flowing down the tank walls, for example. Corrosion may occur due to this moisture accumulation. Cathodic protection is generally not considered an effective way to combat this corrosion. It is important for these tanks to maintain a good seal around the perimeter chime to prevent the ingress of oxygen, water, salts and other contaminants that could act to induce localized corrosion cells. In situations where water may condense on the tank bottom or water is retained above the concrete pad, accelerated corrosion may occur¹.

Continuous Asphalt Pad

A pad of new asphalt may provide many of the same advantages and disadvantages as a concrete pad for reducing corrosion and eliminating the need for cathodic protection. Asphalt degrades with time and can provide a path for water and dissolved contaminants to come into contact with the steel tank bottom, allowing corrosion to occur. Cathodic protection, if applied, may or may not aid in stopping corrosion when the asphalt becomes deteriorated. In fact, deteriorated asphalt may shield cathodic protection current in a manner like disbonded coating on a pipeline. The condition of the

© 2022 Association for Materials Protection and Performance (AMPP). All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise) without the prior written permission of AMPP.

Positions and opinions advanced in this work are those of the author(s) and not necessarily those of AMPP. Responsibility for the content of the work lies solely with the author(s).

external surface of the tank bottom as well as the asphalt can be determined if coupons are cut from the tank bottom. For new tank construction, use of asphalt pads is discouraged ¹.

Oiled Sand Pad

Historically, in some cases oil has been added to sand for various reasons, including compaction and corrosion control. However, the use of oil sand in conjunction with cathodic protection has proven ineffective as shielding may occur due to the nonconductive nature of oil mixed with sand. For new tank construction, use of oiled sand is discouraged ¹.

Compacted Sand or Soil Pad

Tank is erected on some form of compacted tank pad materials. This would often include a concrete ring wall foundation and/or structural piling to provide sufficient load carrying capacity to support the tank and the weight of the tank contents. Different types of pads are constructed for aboveground storage tanks due to a wide variety of surface, subsurface, and climatic conditions. The pad material under the tank has a significant effect on external corrosion of the tank bottom and can influence the effectiveness and applicability of external cathodic protection. The use of fine particles will provide a denser pad to help reduce the influx and outflow of oxygen from the perimeter of the tank as it is emptied and filled. If large particle sizes are used, differential aeration corrosion may result at points where the large particles or debris contact the steel tank bottom. In this case, areas of the tank bottom may be shielded from cathodic protection current and would not be effectively protected ¹.

SECONDARY CONTAINMENT

For many hazardous material storage tanks, self-regulations by the operating company typically require a secondary containment system be installed under the tank bottom to prevent any release of hazardous materials into the environment in the event of tank bottom corrosion. When the secondary containment system is a nonconductive, impervious external liner (typically plastic sheet material) is installed under a new tank, the cathodic protection anodes must be placed directly underneath the tank between the external liner and tank. Cathodic protection systems are rendered ineffective when an external liner is installed between the anodes and the tank bottom to be protected, because the external liner acts as a shield to the flow of cathodic protection current necessary for protection.

Recently, the tank industry has seen an increased use of conductive geosynthetic clay liners (GCLs) combining layers of geotextile materials with a low permeability bentonite clay layer to provides tanks with the required secondary containment protection. These GCL materials are electrically conductive, allowing cathodic protection current to pass from outside the liner, through to the tank bottom ¹. This type of liner provides additional flexibility in the application of cathodic protection to tank bottoms.

AGING ABOVE GROUND STORAGE TANK

Soil side corrosion, is one of the causes of tank bottom failures, is typically caused by the ingress of external contaminants and moisture through gaps and spaces around the annular chime space. Filling and emptying of the stored product cause the bottom plates to flex drawing in more moisture and external contaminants. Tank leakage due to corrosion poses significant threat for the safety of the plant equipment and personnel due to possibility of occurrence of the fire hazards, if the tank content is hazardous material. The replacement of bottom plate due to corrosion damage is also found to be very costly.

Determining the Extent of Corrosion on Existing Systems. Information regarding the degree of tank-bottom corrosion is useful because considerable bottom damage may require extensive repairs or replacement prior to the installation of cathodic protection.

Field procedures for determining the extent of existing corrosion may include:

(a) Visual inspection (b) Tank bottom plate-thickness measurements (ultrasonic testing, coupon analysis, etc.) (c) Estimation of general corrosion rates through the use of electrochemical procedures (d) Determination of soil characteristics including resistivity, pH, chloride ion concentration, sulfide ion concentration, and moisture content.

Installing cathodic protection on existing tanks can be done in a variety of ways depending on the application.

- Is there a secondary liner?
- What is the tank diameter?
- Is there access around the tank for directional drilling?
- What other structures are in the area?

Installation of anodes Under aging Tank.

There is hardly anything that can be done if the existing tank bottom has CP system underperformance and there is also insulating material liner present in the tank foundation.

However, there are several aging tanks without any secondary liner and CP system retrofit is possible on such tanks, CP system retrofit options are as under:

- Close distributed anode system.
- Remote Deep anode system.
- Under the tank Linear anodes installed by HDD.
- Close Distributed Anode Groundbed System will be effective for smaller dia tanks. However, for large dia tanks there will be problem achieving protection at the center of tank bottom plate.
- The design current density of 20 mA/m² used to calculate the current requirement and estimate the anode quantity is generally found to be satisfactory, in case of incidental structures it is advisable to make provision for additional cathodic protection current.
- From past experiences, remote Deep well anode bed system was found to have varied success in providing sufficient protection to the tank bottom plates. Major of the protective current is picked up by Grounding system, underground pipelines/utilities thus resulting in under-protection or partial protection to the intended structures. Shielding of protective CP current due to reinforced concrete structures tends to restrict currents from remote deep anode groundbed to protect the Tank bottom.

The Solution – HDD Drilling below existing tank for Linear Anodes

Depending on the diameter of AST, age, coating and other parameters total number of anode segments to be HDD installed are designed. After drilling hole underneath tank, the linear anode is hooked up to the drill pipe stem and pulled back underneath the tank. After completion of all linear anodes through HDD, anode lead cables are terminated to junction box.



Figure 1: HDD Drilling Below Existing Tank

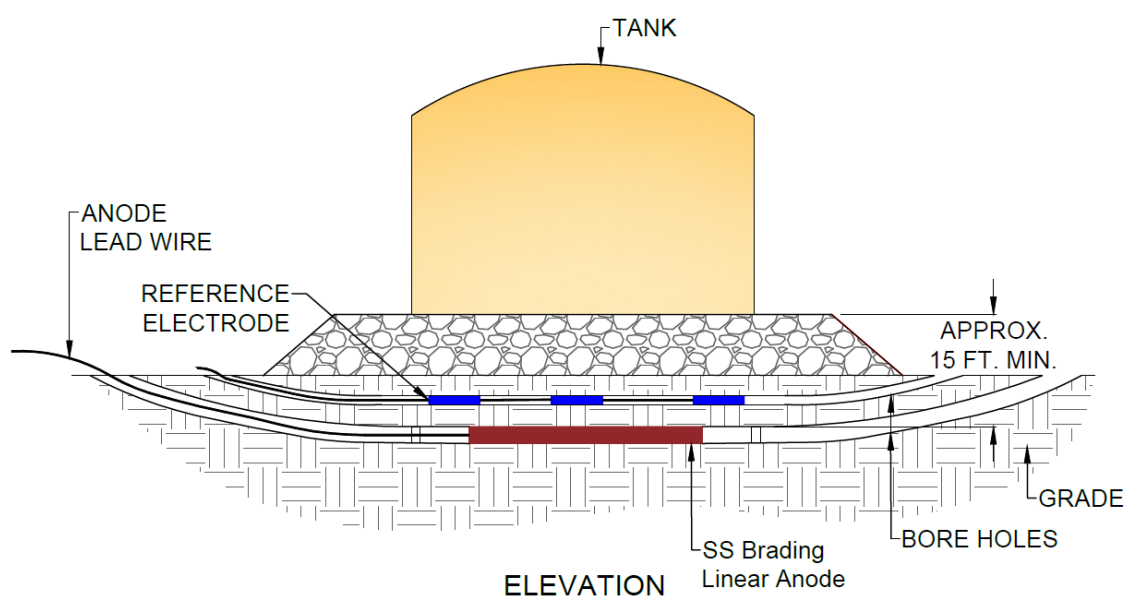


Figure 2: Elevation View Linear anode Installation for Existing Tank

CASE STUDY

Ethylene storage tank is a critical service tank for petrochemical facility's operations and this tank is at risk to corrosion of the external tank bottom because the existing cathodic protection is not performing adequately. The ethylene storage tank is a double wall structure designed for single containment. The inner tank is subjected to cryogenic temperature and liquid pressure of the stored product. The outer tank serves as a vapor tight container for the insulation. To minimize the product losses due to liquid vaporization, the tank is equipped with insulation in the shell, bottom and the deck. The complete outer tank rests on a ring wall foundation which is filled with compacted sand. An electrical foundation heating system is imbedded in this compacted sand layer and ring wall to maintain a temperature of 4 deg C in the soil. This prevents ice film from forming below the bottom insulation due to which bottom insulation can be damaged.