

Case Studies on Vapor Corrosion Inhibitor Monitoring Using Electrical Resistance Probes for Oil and Gas Assets

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ABSTRACT

Electrical Resistance (ER) probes are used as the central corrosion rate monitoring process to evaluate the effectiveness of Vapor Corrosion Inhibitors (VCI). The dependability of ER probes has become one of the major resourceful instruments being used to periodically examine corrosion rates underneath Aboveground Storage Tanks (AST). There are many approaches to detect corrosion levels underneath such tanks. One that is reliable and trackable is using a data logger to take readings on ER probes continuously and analyzing the data using a graphical method that thoroughly shows a linearized comparison of metal loss over time. The analytical range of check values is important during the analysis process with regards to making sure the reference points are standardized and within a good variant. A linear trend is used to quantify the corrosion rate and performance of VCI over time. The decision to either inject or reinject VCI are usually made in conjunction with analyzed data from the moving point average method that shows a proportional reduction in metal loss and inhibitor efficiency beneath the tank. Case studies on VCI monitoring in different geographical regions are outlined in this paper.

Key words: Electrical Resistance (ER) Probe, Vapor Corrosion inhibitor (VCI), Corrosion monitoring, Field measurement of corrosion.

INTRODUCTION

Aboveground storage tanks (ASTs) are assets that contain valuable goods for the oil and gas industry.¹ Consequently, monitoring and preventing loss of containment and extending the service life of those assets is a priority for the abovementioned industries. To monitor the degradation process of the tanks, ER probes are typically used to determine the corrosion rates.² Corrosion rates can be used to forecast the service life of an asset by estimating the time at which the degradation reaches a critical thickness of the tank. If the corrosion rate is such that the critical thickness is expected to reach below the expected service life of the asset, the lifespan can be extended by corrosion mitigation methods.³ Cathodic protection (CP) and vapor corrosion inhibitors (VCI) are the most used method to mitigate corrosion in ASTs.⁴

The injection of corrosion inhibitors consists in introducing a Vapor corrosion Inhibitor (VCI) solution under the tank bottom to mitigate soil-side corrosion. Nonetheless, one caveat of the corrosion inhibitor injection is the depletion of the inhibitor over time. Therefore, monitoring the efficiency of the corrosion inhibitor with time is a crucial task to assure the expected service life of the asset. One mean to monitor the impact on corrosion rates is to use an Electrical resistance Corrosion probe.^{3,5}

ER probes can continuously monitor the corrosiveness of the surrounding environment to evaluate the corrosion mitigation efficiency of a VCI. The ER probes are positioned close to the tank floor and exposed to the same environmental conditions as the tank floor. Therefore, they provide a realistic measurement of how the corrosion rate / metal loss evolves. Generally, Multiple ER probes are installed and uniformly distributed to cover the tank bottom plate area. They are usually installed away from the inhibitor injection point to confirm inhibitor diffusion and evaluate the overall effectiveness of VCI dissemination. Therefore, ER measurements, along with visual inspection and physical and analytical testing of soil samples, allows to determine how and when to replenish VCI solutions along with ER probes before extensive corrosion failure occurs. Consequently, the objective of this paper is to analyze the results of three different case studies and assess the suitability of using ER probes for corrosion monitoring of aboveground Storage Tank bottoms.

METHODOLOGY

Data Collection

The data used in this case study was collected from ASTs at different geographical locations (Africa and different locations across North America). The conditions at which the measurements were taken lie within the following ranges: ambient temperature between 30 and 40 °C, humidity levels of 50 to 80%, and at least 6 months of ER monitoring before the VCI injection. For all cases, the inhibitor was injected in the sand base to provide protection to the bottom plate as illustrated by Figure 1. The inhibitor was a 5% blend of amine carboxylate VCI corrosion inhibitor.

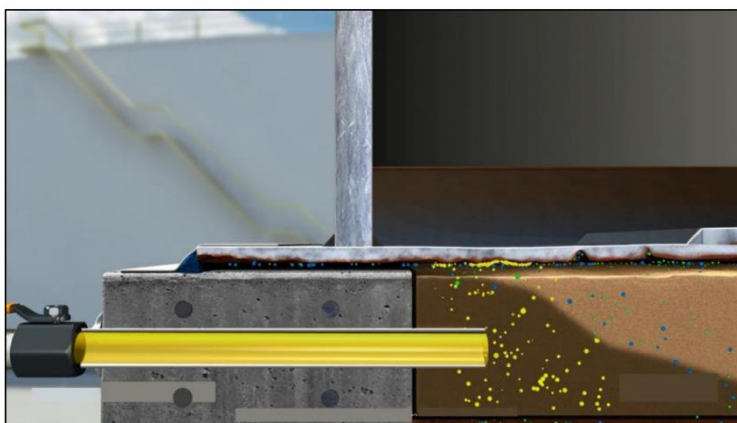


Figure 1: VCI injection port on the sand base to provide protection to the bottom plate of the tank.

Corrosion Rates

Corrosion rates were obtained by using a commercial electrical resistance (ER) probe and a data logger (MS4500E⁽¹⁾) with a cylindrical sensing element. The basic principles of the ER probes are summarized as follows.⁶ Typically, the probe consists of a sensing element and a reference element (usually employed for temperature compensation purposes⁶). The cross-sectional area of the sensing element is exposed to the corrosive environment, while the sensing element is outside such environment. When the sensing

⁽¹⁾ Trade name.

element undergoes corrosion, its cross-sectional area decreases, and the electrical resistance (R) increases as shown by Equation (1):

$$R = \rho \frac{l}{A} \quad (1)$$

Where: R is the electrical resistance, ρ is the resistivity of the element, l is the length of the element, and A is the cross-sectional area.

Then, a small current is applied to the sensing element to measure a potential drop *via* Ohm's law to obtain the resistance.

Data Analysis

Corrosion rates from commercial aboveground storage tanks (AST) were collected with time. For the sake of analysis and for comparative purposes, the data was restricted to a working timeframe of 15 months. The data for each case is divided into two parts: uninhibited phase (first 5 months of the analysis with active corrosion before the injection of VCI inhibitor) and inhibited phase (after the injection of the VCI inhibitor). The sampling period for corrosion rates ranges between 2 to 4 measurements per month before the injection, and once per month after the corrosion inhibitor injection.

For statistical and comparative purposes, all the data collected was normalized by dividing all the values by the highest corrosion rate found in all the case studies. Then, the corrosion rate trends observed in the study cases were divided into three main types: Exponentially increasing corrosion rates before VCI, medium corrosion rates before injection, and low corrosion rates before injection. All these cases will be further expanded and explained in the following section. For each case, the average and the standard deviation of the corrosion rate was calculated according to the Equation (2) and Equation (3):

$$\mu = \frac{1}{N} \sum_{i=1}^N x_i \quad (2)$$

$$\sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{N}} \quad (3)$$

Where: μ is the average, N is the size of the sample, x_i is each value of the sample.

Finally, to quantify the data dispersion, the relative standard deviation (RSD) was obtained as per Equation (4)

$$RSD = 100 \left(\frac{\sigma}{\mu} \right) \quad (4)$$