

pH Measurement During Cathodic Protection and DC Interference

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ABSTRACT

The increase of pH at the cathode-to-electrolyte interface is a recognized chemical effect due to cathodic protection. The alkalinity formed in cathodic protection could also reduce the corrosive effect of DC non-stationary anodic interference. In the present study, pH variations during cathodic protection and DC non-stationary anodic interference are recorded using a new arrangement of the sample-pH probe and a sufficiently fast pH logger. The test was carried out on low carbon steel immersed in simulated soil solution. As expected, the pH increases during the application of cathodic protection. In the DC interference cycle, which is 60 peaks per day with a duration of one minute, the pH at the mentioned distance gradually reduces. If the protection time between two peaks was long enough, around 10 minutes in the studied case, the pH could return to the previous value. If the protection time between two peaks is short, such as one minute, even anodic interference current equal to the protection current could destroy the high pH layer at the surface after 60 one-minute interference peaks.

Keywords: cathodic protection, anodic interference, pH, alkalization

INTRODUCTION

In cathodic protection (CP), the tendency of the corrosion is reduced to a deficient level. This corrosion reduction is a result of polarizing the surface to suppressed the local anodes. The primary effect of CP is the polarization of the surface, and the secondary effect is consuming oxygen and increasing the pH at the surface. This relation is presented in the oxygen reduction reaction equation: ¹



The measurement of pH during cathodic protection at a short distance from the cathodic surface can provide precious information about the proper electrochemical working condition of the metal, especially if this contribution is combined with other electrochemical techniques.^{2–5} As different researchers mentioned, increasing cathodic current protection current leads to increasing the pH at the surface. In the expected range of protection current and sufficient polarization time, the pH could reach more than 10. So, in protection potential range, which is more negative than -0.85 V vs. CSE, and pH more than 10, from a thermodynamical point of view, the steel goes to the passive state.⁶

The increase of pH at the cathode-to-electrolyte interface is a recognized chemical effect due to cathodic protection. Considering carbon steel structures in cathodic protection condition immersed in waters or soil, the pH increase is beneficial because it can promote the formation of the passive condition and the growth of a scale, as the calcareous deposit, that provides additional protection to electrolyte corrosiveness. The alkalinity formed in cathodic protection could also reduce the corrosive effect during intermittent CP and DC non-stationary anodic interference.^{7–10}

It is assumed that during CP, pH at the cathode is high, and the corrosion rate is low. When the DC interference is started, the pH reduces to the low values, and then the corrosion could be started. The schematic of the pH variation during the DC interference is presented in Figure 1. As presented in Figure 1, DC interference is started before (b), but corrosion could start in (c), where pH is sufficiently low. This incubation time, between interference start and corrosion start (b period in Figure 1), is in order of a few minutes and reported as a low corrosion time.^{9,11–13}

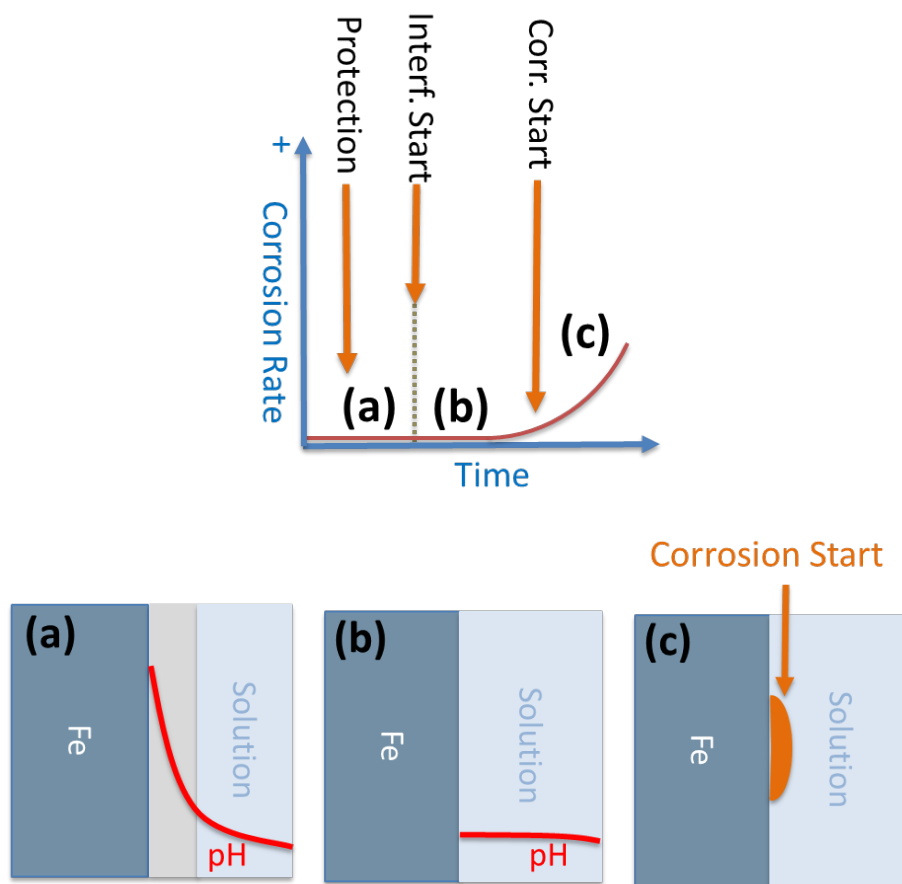


Figure 1: Schematic of the pH variation at the surface in the presence of Cathodic Protection and DC interference

In the present study, pH variations during cathodic protection and DC non-stationary anodic interference are recorded using a new arrangement of the sample-pH probe and a sufficiently fast pH logger. The direct pH measurement could be used to analyze the cathode surface in the cathodic protection state and the effect of DC anodic interference.

EXPERIMENTAL PROCEDURE

The carbon steel (API 5L)¹⁴ in a rod shape with the surface of 0.7 cm² is installed in the diameter of a cylinder plastic holder. In this arrangement, the distance between the electrode and pH probe tip (DeltaOHM®, model HD 8705), Figure 2, is low. The optimum distance between the tip of the pH probe and the surface of the sample for getting reliable data without the side effect of corrosion products is about 50-100 µm. All tip parts, including the sample holder, pH meter tip, and supports, are transparent, so it was possible to check the sample and its distance under an optical microscope. The distance of the sample and pH probe is checked before running each test. Silver/Silver chloride (SSC) reference electrode is used with a luggin capillary to reduce the distance of the sample and reference electrode. The simulated soil solution contains 0.2 g l⁻¹ NaCl and 0.2 g l⁻¹ Ca₂SO₄·2H₂O with pH around 7. The solution resistivity is around 10 Ω m.

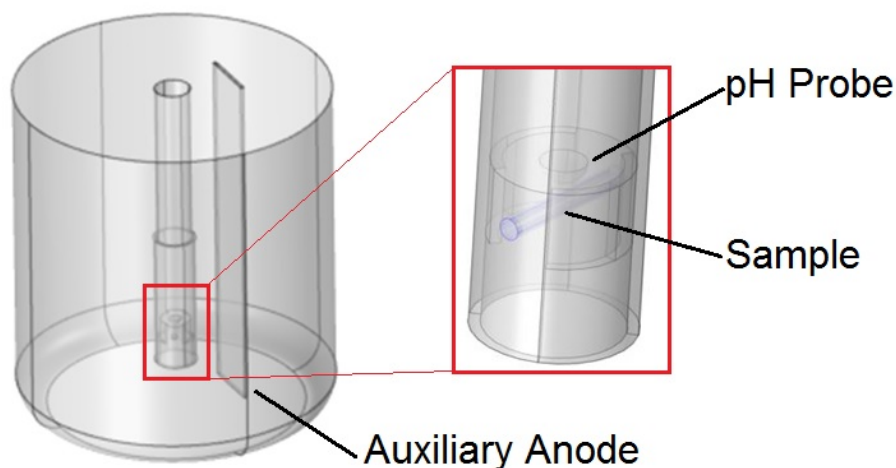


Figure 2: Sample holder arrangement

The pH is recorded every minute in a short period test and with a longer delay in long term measurement. pH logger is fast and gives data in a few seconds, but the stable values are extracted and reported. In the present arrangement and solution, the protection current for maintaining the electrode in the protection potential range is 430 mA m⁻². All samples before the DC interference test was stabilized for five days at the mentioned current density (430 mA m⁻²). The applied current profile on the samples is presented schematically in Table 1. After interference, constant protection current was applied. pH measurement have been done in both interference period and recovery time after that.

The interference pattern is presented in Figure 3. For tests 4 to 7, the interference period is splitted to anodic peaks and cathodic protection times. In this study, as presented in Table 1, every interference peak has a minute duration. In test 4, the interference period is 10 hours, and 60 anodic peaks are distributed at this time. While in test 5 to 7, the interference period is 120 minutes.