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Investigation of pH and oxygen variations on steel structure under cathodic protection

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Abstract

Oxygen and pH variations were investigated in continuous cathodic protection (CP) and stray current interferences conditions of steel coupons in water-saturated sandy soil. The aim of this work was to describe the pH evolution and the oxygen concentration at the steel surface under the effect of both conditions.

Carbon steel samples were buried in quartz sands saturated with a simulated soil solution. Oxygen concentration and pH variations were measured by means of planar optical sensors (optodes). Further investigations on the pH variations were performed by means of Iridium Oxides (IrOx) sensors. Electrochemical measurements, i.e. Linear Polarisation Resistance (LPR) and potentiodynamic polarization, were conducted to evaluate the corrosion rate of the samples.

The oxygen concentration at the metal surface was found to start decreasing when CP was applied. The dissolved oxygen concentration decreased from 8 to 0 ppm within 30 hours under CP conditions at an E_{on} value of –0.85 V/(Ag/AgCl). On the other hand, an increase in pH at the metal surface to values above 8.5 occurred within only 1 hour after the application of CP, even at low protection current densities around 5 µA/cm^2. Analytical pH measurements were further performed using IrOx sensors positioned in the soil at given distances from the metal surface. In these experiments, a cathodic current density between 10 and 20 µA/cm^2 was used to protect the steel, which lead to pH values around 14.5 measured 5 mm away from the steel surface after 40 hours of cathodic protection.

Although the local pH close to the steel was found to be affected in tests where stray current interferences were introduced, the evaluated corrosion rate was mainly influenced by the average current density that can be calculated from interference current and CP current.

Results for corrosion rates obtained in this study show that pH is a fundamental parameter in protecting the steel.