INFLUENCE OF SOIL RESISTIVITY ON CATHODIC PROTECTION SYSTEMS – A NUMERICAL APPROACH

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Abstract - The protection against corrosion of buried and/or immersed metallic structures can be achieved by protective coatings and cathodic protection. Cathodic protection systems can be analyzed and optimized by the usage of numerical simulations. Among the different techniques that can be applied to this end, the boundary element method (BEM) has emerged as a strong alternative technique since boundary potential results are the only requirement needed for appropriate assessment of corrosion protection. The required information for the simulation includes experimental the following experimental data: cathodic polarization curves and medium resistivity measurements. The latter is discussed further in this work.

Keywords: Cathodic Protection, Soil Resistivity, Boundary Element Method, Numerical Simulation

1. Introduction

The protection against corrosion of buried and/or immersed metallic structures can be achieved by protective coatings and cathodic protection. Galvanic or impressed current can be applied in order to achieve a minimum electrochemical potential that assure effective cathodic protection. The concepts of these techniques are widely discussed in the literature [1]. In real systems, however, it is difficult to measure the potential in order to guarantee satisfaction of the cathodic protection criterion (minimum potential of -0.8VAg/AgCl). So, the use of numerical simulations to evaluate and optimize cathodic protection systems has recently been widely applied. Computer simulations using three-dimensional applications of the boundary element method and experimental analysis of different resistivity media has been effectively carried out [2-5]. Parameters such as distance between anodes and pipelines, level of injected currents, efficiency of aged coatings and presence of scattered/localized defects can be taken into account. The good correlation between in-situ measurements and numerical results largely depends on the appropriate prescription of boundary conditions that are based on experimental tests obtained in laboratory. Therefore, polarization curves and resistivity values, applied as problem conditions, need to be carefully determined to guarantee accurate results. The importance of resistivity can be seen in a good number of practical applications such as: pier structures (seawater/soil interface), long buried pipelines (heterogeneous soil) and pipelines through soil/seawater media (horizontal directional drilling).

2. Methodology and Results

Figure 1 shows the experimental laboratory apparatus needed to obtain polarization curves, as typically seen in Figure 2. The soil resistivity, besides its physical-chemical properties, affects the potential distribution. The resistivity value can be obtained in laboratory using a soil box, as shown in Figure 4. In order to ensure the most unfavorable corrosion situation in the numerical simulation, the most aggressive condition (higher humidity) should be considered. As more water is added to the soil sample, increasingly lower resistivity values are obtained. A minimum resistivity is reached, for a certain quantity of water, depending on the retention capacity of the soil.

The resistivity of the medium where the structures are immersed has a great influence on the potential distribution. Horizontal directional drilling (HDD) and pier structures are examples involving different medium (soil/seawater or soil with different resistivity values) problems. Figure 4 presents the case of a pipeline passing through a HDD complex resulting in not enough cathodic protection over part of the pipeline system. Galvanic anodes protect the pipeline buried in seabed but not inside the HDD.

3. Conclusions

The present paper discusses the influence of resistivity of the medium in the design of cathodic protection systems commonly employed to protect metallic structures against corrosion. A brief presentation of how important reference parameters are determined through experimental techniques has been introduced. To illustrate the points of view put forward, a practical example is commented upon indicating that not enough protection may occur as soon as the pipeline crosses the interface between low and high resistivity media.
4. References


