Modeling The Influence Of Differential Aeration In Underground Corrosion

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Abstract

Corrosion of buried infrastructure, such as pipelines, is an issue that leads to significant economic loss. Corrosion induced pipe failures are increasingly encountered by water utilities with aging pipe networks around the world. The issue of corrosion in soil is complex, involving inter-relationships between the electrochemical activity on the pipe, soil properties and other external parameters. Macro corrosion cells formed due to differential aeration in soil are known to cause significant levels of localised patch corrosion, which can lead to the loss of structural integrity of buried pipelines. In a practical sense, it is difficult to locate and predict regions of buried pipeline undergoing corrosion, due to a lack of access to the underground asset, and usually, a lack of information related to the asset condition. Furthermore, it is challenging to develop empirically based predictive lifetime equations owing to the difficulty in collecting sufficient data over an asset lifetime that are both accurate and span the range of relevant variables. These challenges have necessitated a method to locate and predict the condition of a buried pipeline without physical exhumation and examination. This paper presents a finite element model developed using COMSOL Multiphysics® software to identify and characterise regions experiencing high levels of underground corrosion due to differential aeration. The model uses the secondary current distribution and transport of diluted species to couple the electrochemical reactions on the pipe surface to the reactant transport mechanisms - through the soil to the pipe depth. Closed form equations are used to characterise the electrical and mass transport properties of the three-phase soil medium using commonly used soil parameters that include porosity and the degree of saturation. Inter-dependencies between processes and parameters are defined using mathematical functions. The present model enables a study of the effects of variations in soil properties and external conditions on pipeline corrosion. Modelling results indicate agreement with results presented in the literature and case studies conducted at pipe failure sites in the field. It is envisaged that the model developed herein will enable the water utilities to develop predictive tools that may be useful in condition assessment.

Figures used in the abstract

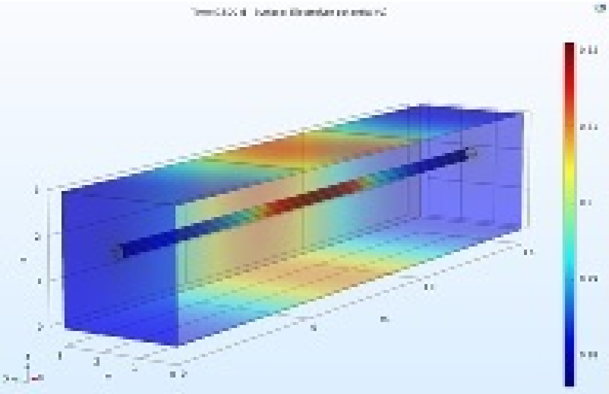

Figure 1 : Soil potential variation along a pipe running through a cover.