INTRODUCTION

Physical infrastructure plays a major role in the most modern societies. So-called whole-of-life assessments increasingly are being used for decision processes. Such algorithms require models of sufficient rigor and robustness to represent (a) the demands or loadings expected to be placed on the system; (b) the ways in which the system may respond; and (c) prediction of likely future response, including deterioration and effectiveness of repairs. Consistent with modern decision theory, the models required for (a) and (b) are probabilistic (Melchers, 1998). Until recently, models for (c) were largely ignored.

Most infrastructure has expected lives of several decades. As argued previously (Melchers, 2005), the only way such predictions can be made is to invoke a combination of scientific understanding of deterioration processes and sound mathematical modeling. The present paper is concerned with the development of corrosion models, particularly for longer-term exposures. Despite good maintenance regimes, and the availability of protective coatings and of various forms of cathodic protection, field evidence shows that existing infrastructure often shows signs of corrosion, particularly in severe environments, such as for offshore facilities, along marine coastlines and in harbors.

Below some general comments are made about the basic requirements for models with prediction capabilities. This is followed by a a description of the development of probabilistic/mathematical models for corrosion loss and for maximum pit depth. The main characteristics of the model are presented, and its theoretical underpinnings reviewed. Attention is then turned to pitting corrosion and the representation of uncertainty about maximum pit depth using Extreme Value distributions. Some ongoing application-based research projects are then referenced, followed by concluding remarks.

MODELS AND MODELING

Models may be considered as mathematical constructs that, at some level of abstraction, represent the phenomenon of interest. Typically models are tailored to their application and used for specific purposes. They also need to provide meaningful answers. A statement such as obtained from electrochemical potentials, “Corrosion is highly likely,” may be of some general interest but is of limited technical value for estimating the rate of corrosion.

Various approaches to model development exist. For some, a model is the outcome of an attempt to establish correlation between available data for corrosion loss or pit depth and data for the various factors believed to be of influence. Typically it provides a best fit curve (or surface) through data points. There is a long history of this approach in the atmospheric corrosion literature. However, any objective evaluation repeatedly shows high levels of uncertainty, low confidence levels or poor correlation coefficients (e.g. Dean and Reiser, 2002). The reason is that these models are empirical and lack reference to fundamental understanding of the processes involved. Also, extrapolation is questionable since there is no theoretical basis for it.

Potentially more powerful and therefore more interesting are models based on fundamental principles and the calibrating of these models to actual (particularly field) data. The tenuous link between corrosion measured in the laboratory and in the real world has been commented upon many times, over many years (e.g. US-ONR, 2007).

Theory-based models are developed from reasonable hypotheses of the processes likely to be involved, including physical, chemical, electrochemical and, if appropriate, microbiological influences.

Calibrating a theory-based model implies that each set of data is treated as a sample set of all possible observations. In essence this approach asks: Can the data be interpreted as consistent with the model? It is implicit that some degree of uncertainty always is associated with each data point. (It is also possible for some data points to be called wrong owing to errors in observation or data processing.) As in science generally, the test is whether it is possible to disprove the model; if so, model refinement (or abandonment) is required. And then the process can be repeated. This is a completely different way of proceeding than the traditional idea that the data are somehow sacrosanct, and that the data points