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Electrochemical Corrosion Testing Methodology

Corrosion is a form of wear and an essential consideration in determining materials compatibility, and the cause of failures involving corrosion. Corrosion testing is frequently done by immersion, vapor exposure, salt spray, or similar means. These tests are easy, requiring no sophisticated equipment or experience, and appropriate for situations involving materials that are not highly corrosion resistant. This approach becomes more limiting as materials and coatings with higher corrosion resistance enter the market, and as better corrosion inhibitors are developed for fuels and lubricants. Electrochemical corrosion testing provides insight into the cause and mechanism of corrosion in ways that exposure testing will never offer.

All corrosion testing is intended to provide a reliable estimate of how quickly a coating or metal will corrode in an environment, or how quickly metals and coatings will corrode in fuels and lubricants that possibly contain corrosion inhibitors. The reality is that all types of corrosion testing have limitations in meeting this intended use because of the nature of corrosion processes. Surfaces, by their nature, are not inherently stable and change both over time, and as the environment changes. A major benefit of electrochemical corrosion testing is that it is sufficiently fast enough to allow examination of a variety of conditions in a short time (weeks, not months). Thus, a practical approach to making corrosion testing more accurate is to examine a variety of conditions, which can only be done with electrochemical testing.

DC (direct current) potentiometric electrochemical methods are widely used because they are relatively simple, but they have substantial limitation. AC (alternating current) methods require more expensive and sophisticated equipment, and substantial mathematical expertise and experience, but they overcome the difficulties dc methods have with protective coatings that are electrically insulting and with fluids such as fuels and lubricants that have poor electrical conductivity.

A practical approach to electrochemical testing is to perform several types of corrosion tests, which allow detection of abnormal behavior when it exists. We have the equipment, expertise, and experience to utilize the powerful, more recent ac corrosion tests as well as the conventional dc methods, so weuse a methodology that measures corrosion rates by several methods and under a variety of exposure conditions such as temperature and fluid chemistry. The following table provides excellent general guidance, and we offer consulting to provide more customized solutions.

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Method	Cost	Time	Complexity	Insight	Reliability
Situation – QC and Screening of Metals with Moderate Corrosion Rates in Eclectically Conducting Solutions and without Electrically Insulating Protective Coatings					
Immersion and Salt Spray over Weeks Duration	Lowest	Moderate	Very Low	Lowest	Lowest due to the time dependence of corrosion and no mechanistic information.
Situation – Life Prediction of Metals with Moderate Corrosion Rates in Eclectically Conducting Solutions and without Electrically Insulating Protective Coatings					
Immersion and Salt Spray over Many Weeks to Many Months Duration	Low	Lengthy	Very low	Low	Low
dc Tafel method and Linear Polarization over a week to months	Moderate	Short to Moderate	Moderate	High	Moderate
Situation – Screening and Life Prediction of Metals with Low Corrosion Rates.					
Electrochemical Frequency Modulation over a week to months	Moderately High	Short to Moderate	Moderately High	High	Moderately High
Situation – Screening and Life Prediction of Metals in Poor Eclectically Conducting Solutions and of Electrically Insulating Protective Coatings					
Electrochemical Frequency Modulation (EFM) coupled with Electrochemical Impedance Spectroscopy (EIS) over a week to months	High (extensive analysis and modeling is required)	Short to Moderate	High	Highest	High (especially with varying conditions)
Situation – Highest Reliable Life Prediction for Mission Critical Needs					
EFM coupled with EIS, plus dc Tafel and Linear Polarization when possible over a week to months with varying conditions.	Highest	Short to Moderate	High	Highest	The most reliable way known to estimate field corrosion performance.

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Falex Litigation Technical Investigations was formed to provide litigators, insurers, and corporate counsel with expert witness consulting and scientific investigations that are informed by core competencies in the physical sciences, materials performance, and tribology – the science of friction, wear, and lubrication – to provide better outcomes at lower cost with intellectual property disputes, product failures, process incidents, accident investigations, and Consumer Product Safety Commission recalls and issues.