Accelerated Testing and Durability

Qualifying your Industrial Anticorrosive Coatings
Overview

- Static Test Methods
- Cyclic Test Methods
- Exterior Exposure
- Comparison of Accelerated Testing
- Evaluating a Coating for Corrosion Performance
- Summary
Weathering Factors which cause coatings to fail

- Light – UV (short wavelength)
- Temperature
- Moisture – dew, rain, and high humidity
- Other contributing factors include: pollution, marine environments (electrolytes),
Common Accelerated Tests used for Qualification of Coatings – Static Tests

- Salt Spray (ASTM B117)
- Humidity Testing (ASTM D2247)
- Immersion Test (ASTM D870)
- EIS
Accelerated Tests used for Qualification of Coatings – Cyclic Tests

- Filiform Corrosion Test (ASTM D2803)
- QUV Condensation, QUV/Prohesion (ASTM D5894)
- Xenon Arc (ASTM D2568, G26)
Static Accelerated Tests
Salt Spray (ASTM B-117)

- Samples are placed in racks at an acute tilt angle.
- A 5% NaCl solution (6.50-7.20 pH) is mixed with humidified air at a spray nozzle in center of cabinet.
- The temperature of the cabinet is maintained at 95°F.
- Panels are subjected to static fog until failure or desired number of hours is obtained.
Salt Spray test — *The Good*

- Widely used and requested in numerous industries
- Can be used as a quality control method
- Process of Elimination — can eliminate coatings which have poor anticorrosive properties sooner.
Salt Spray test – *The Bad & The Ugly*

- High concentration of salt (5%)
- Corrosion rates differ among substrates (galvanized steel in sulfide environment)
- No exposure to UV light
- Variance between replicates
- Cabinet to cabinet reproducibility
- Static fog and temperature
Example of Salt Spray Failure

100 hours salt spray – Water based Acrylic – Substrate: CRS – 2.0 mils D.F.T
Humidity Test (ASTM D2247)

- Also referred to as Water Resistance Test
- Samples are exposed to 100% relative humidity
- Water vapor condenses on surface
- Failure can occur in many forms
Humidity Testing – Cleveland Condensation Tester
Humidity Testing Example

336 Hours Humidity

Long Oil Alkyd – CRS - 2.0 mils D.F.T
Humidity Testing Example

500 Hours Humidity – 2K High Solids Epoxy – Blasted Hot Rolled Steel –
3.0 mils D.F.T
Immersion Test (ASTM D870)

- Samples are immersed in 100°F de-ionized water bath
- Failure can be blistering, loss of adhesion, coating breakdown
- Other methods include using salt water, acids, bases, etc. Also at varying temperatures
Electrochemical Impedance Spectroscopy (EIS) — A *brief* summary

- Can detect changes in a coating before damage is observed
- Measures the breakdown of a coating due to electrolyte attack
- Measures the resistance (charge transfer) and capacitance (how the coating behaves when exposed to the electrolyte)
EIS- How does it work?

Equivalent Circuit for an intact coated metal

Electric Double Layer

S. Koka, A. Shi and J.S. Ullett, S & K Technologies, Dayton, OH
Reference: J.M. Fildes, P. Chen, and X. Zhan, North Western University, IL.
EIS Equipment

Reference Electrode - Ag / AgCl
Working Electrode - Coating Sample
Counter Electrode - Platinum Mesh

Pictures courtesy of S. Koka, A. Shi and J.S. Ullett, S & K Technologies, Dayton, OH
Data Collection

Nyquist Plot

Bode Phase & Magnitude Plots
Cyclic Accelerated Tests
Filiform Corrosion

- Filiform Corrosion is a unique differential oxygen cell occurring on coated substrates. FFC leads to development of thin thread-like filaments full of corrosion products beneath the coating.
- It occurs on Aluminum, Steel, Magnesium and other metals. Filaments grow by anodic propagation or undermining.
- De-lamination: corrosion products push up coating causing it to delaminate. The head is anodic and tail end tail cathodic.
- What conditions cause it to occur?
Filiform Corrosion Test (ASTM D2803)

- Scribed panels placed in corrosive atmosphere (salt spray ASTM B-117 for 4 to 24 hours) or immersed in a NaCl solution
- Panels exposed to humidity (77°F & 85% RH)
QUV (ASTM G154)

- QUV cycle – UV light – 4 hr followed by condensation cycle – 4 hr
- Fluorescent UV lamps
  - UVA-340
  - UVB
- Condensation Cycle – chamber maintains 100% RH, 50°C
Prohesion Cycle (ASTM G85 A5)

- Prohesion Cycle – Samples exposed to an electrolyte solution (0.05% NaCl + 0.35% ammonium sulfate) at 35°C for one hour then dried at 40°C for one hour, the cycle repeats
Example of Prohesion Failure

1080 Hours of Prohesion
QUV/Prohesion Test (ASTM D5894-5)

- Cyclic corrosion test consisting of one week in QUV and one week in Prohesion
- Cyclic, panels exposure to wet/dry periods
- UV exposure
- Correlates more to real world exposure
Example of QUV/Prohesion Failure

Initial

5 Cycles – 1680 Hours
Xenon Arc (ASTM D2568, G26)
Light Simulation

- Simulates full spectrum solar radiation-UV, visible, and infrared
- Xenon arc spectrum must be filtered
  - Daylight
  - Window Glass
  - Extended UV

Photo courtesy of Q-Lab Corporation
Xenon Arc
Moisture cycle
- Water spray
- Humidity controlled