Accelerated Performance Evaluation of Railcar Coatings: A State of the Art Update

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Testing Paints – Fitness for Use

Standardized Testing Methods – Physical/Performance Properties

- **ASTM D5894** *Standard Practice for Cyclic Salt-Fog/UV Exposure of Painted Metal (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet*
- **ASTM B117** *Standard Practice for Operating Salt Spray (Fog) Apparatus*
- **ASTM D4587** *Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings*
- **ASTM D4585** *Standard Practice for Testing Water Resistance of Coatings Using Controlled Condensation*
- **ASTM D1735** *Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus*
- **ASTM D4541** *Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers*
- **ASTM D522** *Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings*
- **ASTM D2794** *Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation*
- **ASTM D4060** *Standard Test method for Abrasion Resistance of Organic Coatings with Taber Abraser*
- **ASTM D870** *Standard Practice for Testing Water Resistance of Coatings Using Water Immersion*
- **ASTM G8** *Standard Test Methods for Cathodic Disbonding of Pipeline Coatings*
- **ASTM G95** *Standard Test Method for Cathodic Disbondment Test of Pipeline Coatings (Attached Cell Method)*
- **NACE TM0174 Method A & B** *Standard Test Method – Laboratory Methods for the Evaluation of Protective Coatings and Lining Materials on Metallic Substrates in Immersion Service*
- **ISO 20340 (NORSOK)** *Paints and varnishes — Performance requirements for protective paint systems for offshore and related structures*
- **ISO 12944** *Paints and varnishes – Corrosion protection of steel structures by protective paint systems*

Accelerated Coatings Testing – *Lab*

Standardized Lab Test Equipment

PHYSICAL PROPERTIES

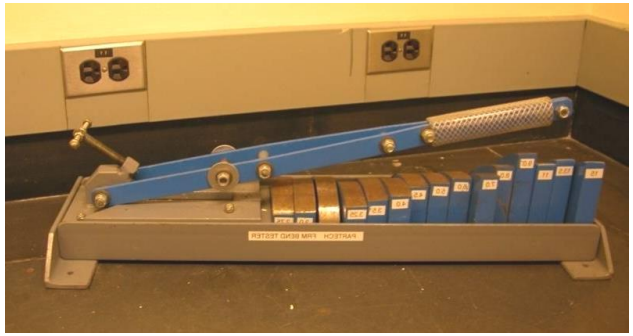
Impactors
Taber abrasion tester (dual),
Conical mandrel tester
Cylindrical mandrel tester
Heavy-duty fixed radial tester
Hydraulic press
Ovens
Gravelometer

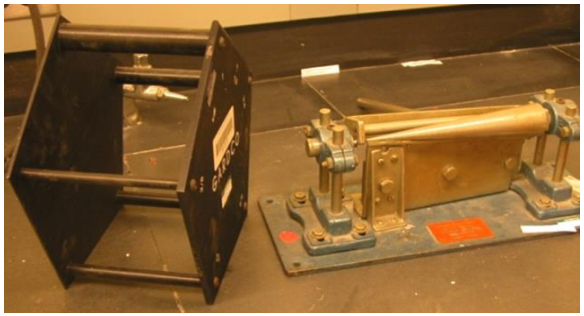
PERFORMANCE PROPERTIES

Electrochemical Potentiostats/Multiplexers/Function Analyzers
Atlas cells / Corrocells
Reaction flasks for full immersion testing
Oil baths
Water baths
Salt fog chambers
Q-Fogs
Programmable Cyclical Environmental Chambers
Humidity chambers
QUV cabinets
Cleveland Condensation cabinets
Cathodic Disbondment Tanks
Xenon Arc Weatherometers

Physical Testing - *Lab*

- Adhesion
- Flexibility
- Impact
- Abrasion



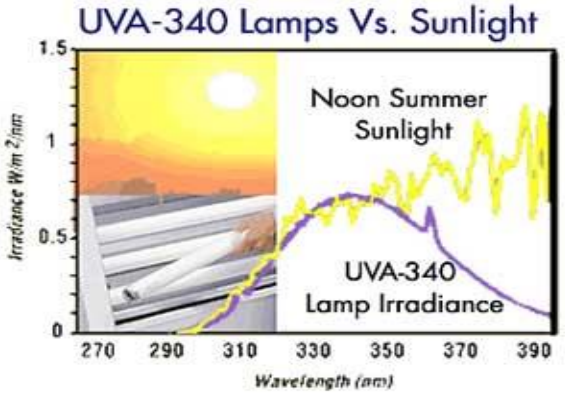


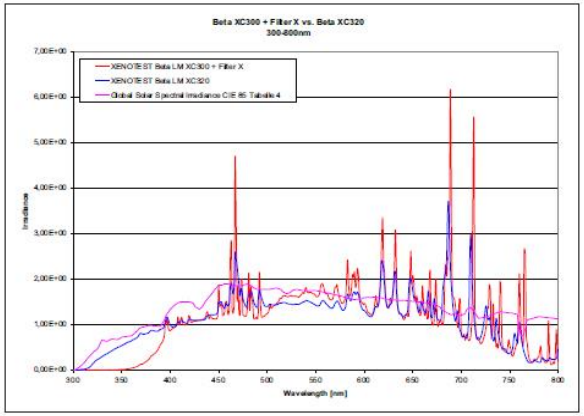
Performance Testing

- Weathering/Durability
  - *Color*
  - *Gloss*
- Corrosion Resistance
  - *Rusting*
  - *Blistering*
  - *Delamination*
  - *Undercutting*

Weathering Tests – *Lab*

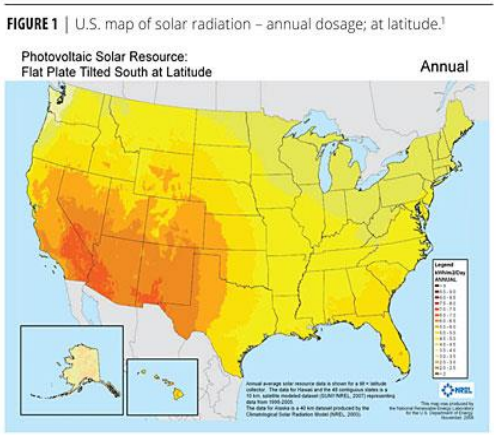
- Q-UV
- Xenon Arc Weatherometer

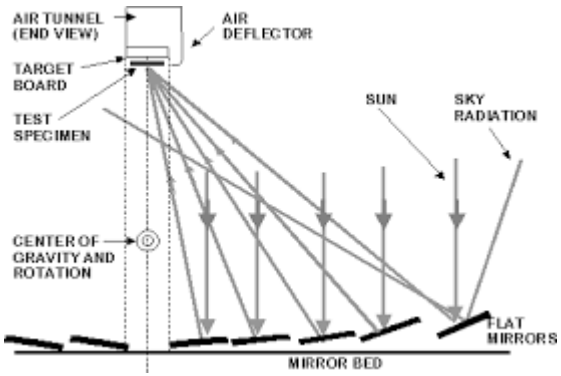


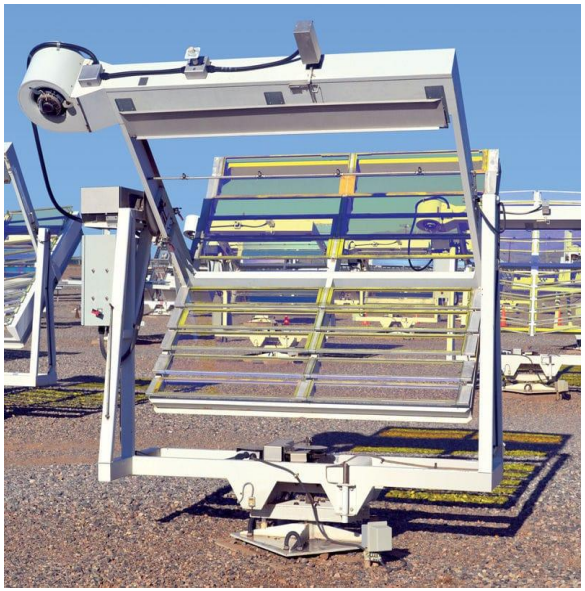


Weathering Testing - *Exterior*

- Solar concentrator:Low-Temperature EMMA®/EMMAQUA®
- Natural Exposures

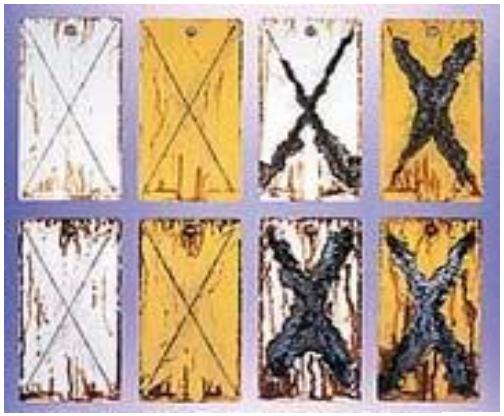


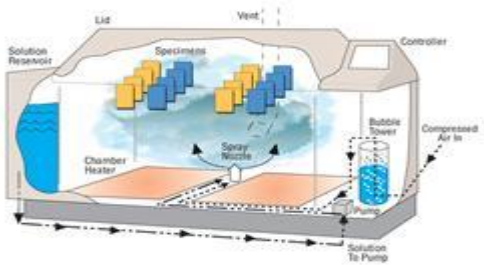




Corrosion Testing – *Lab*

- Salt-Fog ASTM B-117
- Wet/Dry Cyclic Testing ASTM G-95
- Cyclic Corrosion/Weathering Testing ASTM D-5894





Test Methods – Product Development

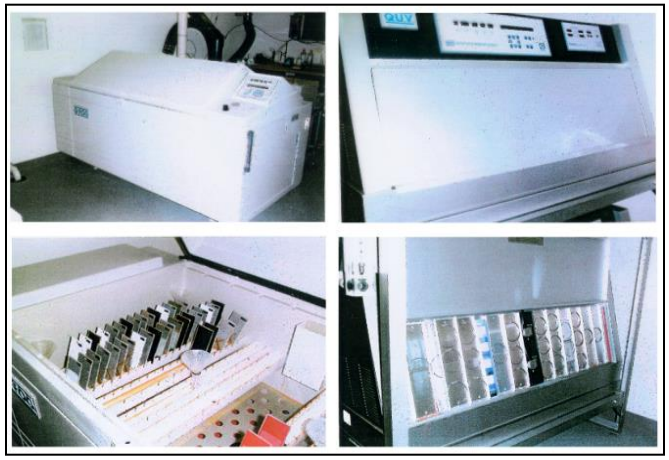
Mimic the Service Environment

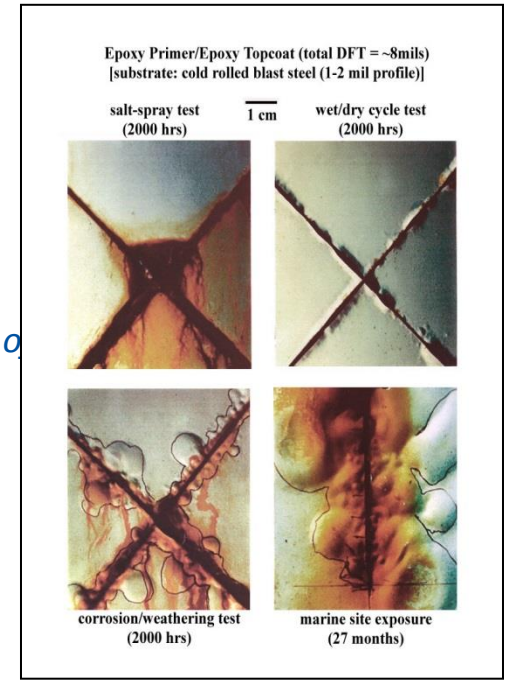
Accelerate the correct rate determining step

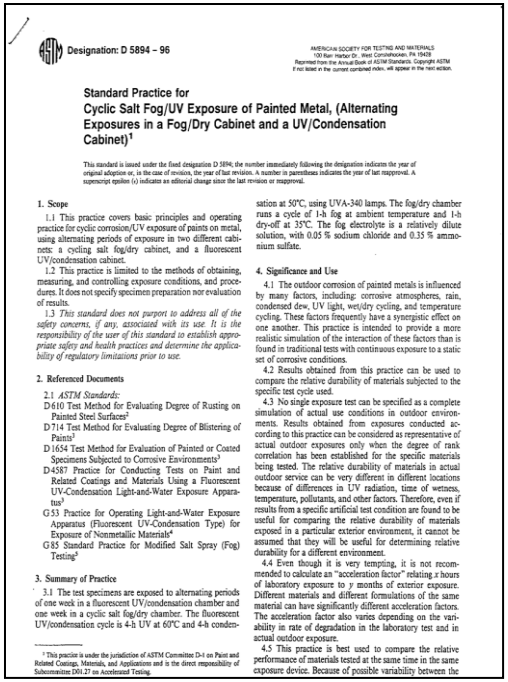
Required Correlation: (Lab vs. 'in service')

* **Rank order performance**
* **Degradation** *(rusting/blistering/delamination)*
* **Intact paint** *(polymer/resin chemistry changes)*
* **Damaged sites** *(structure/morphology/chemistry o*

  corrosion products)







Designation: D 5894 – 96

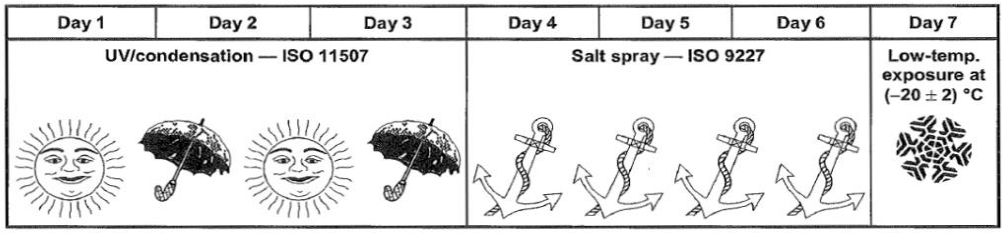
Standard Practice for
Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)[1]

1. Scope

2. Referenced Documents

3. Summary of Practice

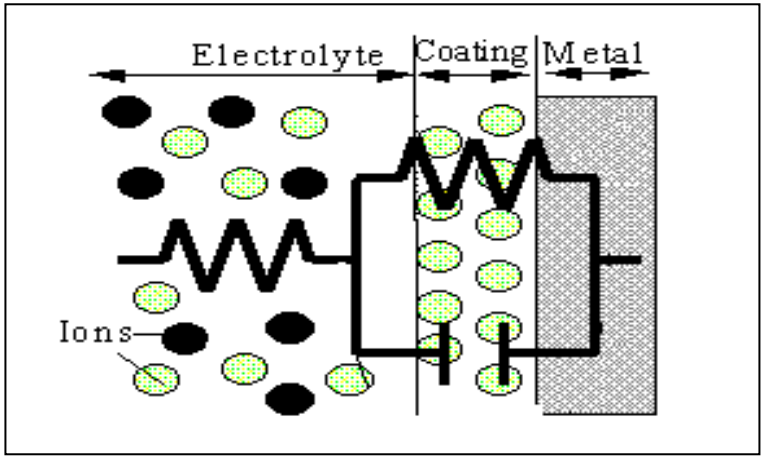
4. Significance and Use

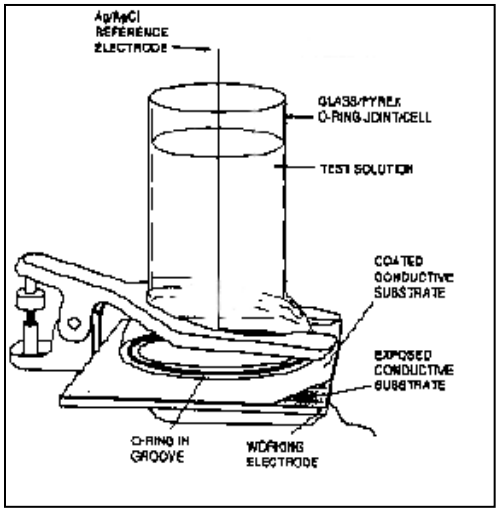


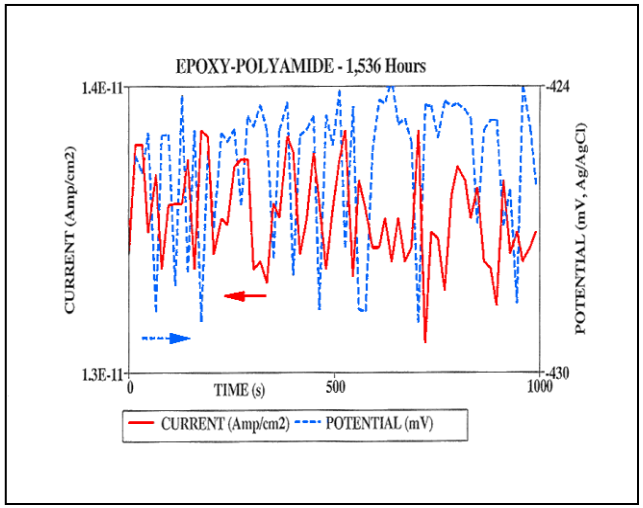
Results obtained depend on the test method – not on the coating!

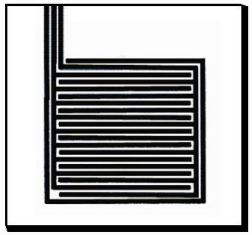
Corrosion – *Electrochemistry*

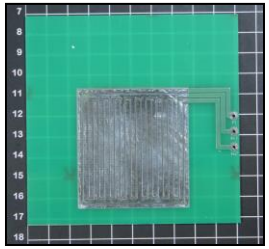
* **Electrochemical Impedance Spectroscopy (EIS)**
  - Coatings performance ranking.
  - Performance changes before visual detection.
* **Electrochemical Noise Method (ENM)**
  - Coatings performance ranking
  - Mechanistic information
  - Performance predictions (?)

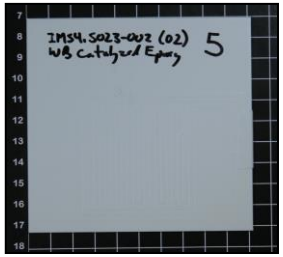








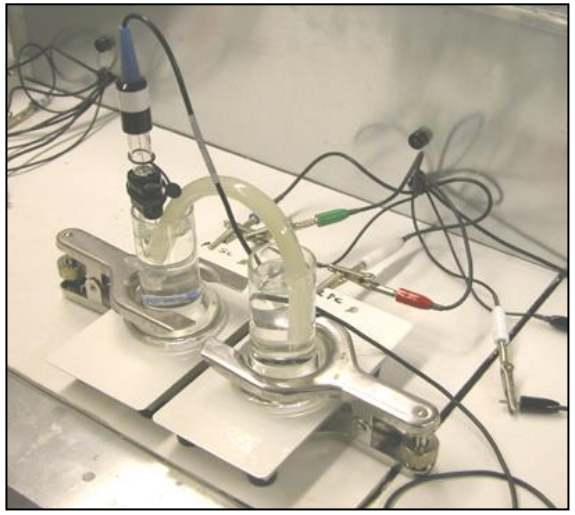


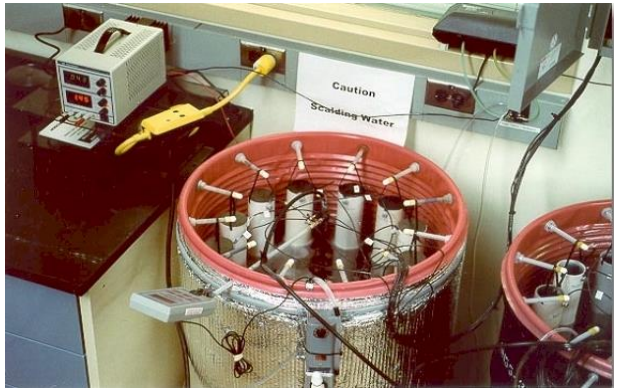


LABORATORY TESTING – REPRESENTATIVE PROTOCOLS

- ISO, NACE, ASTM, MATERIALS SYSTEM SPECIFICATIONS

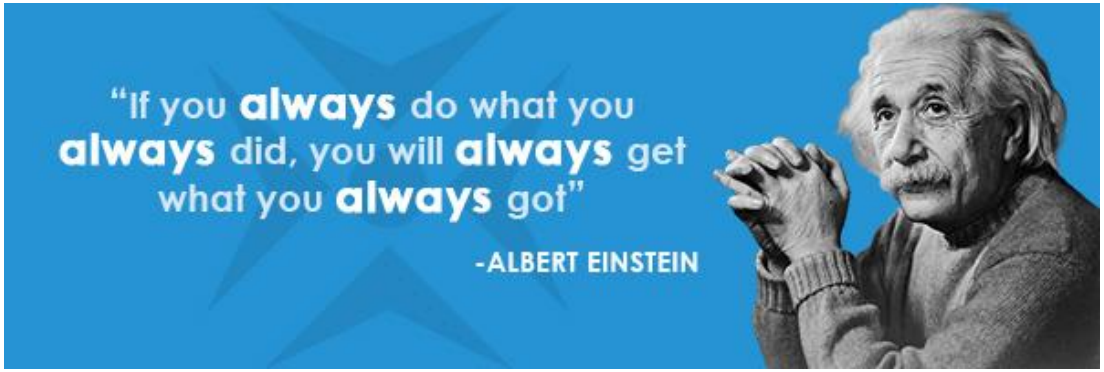
Atmospheric
Immersion
Chemical resistance
Autoclave
Adhesion
Abrasion resistance
Flexibility
Temperature resistance
Cathodic disbondment
Hardness
Atlas Cell
Application properties
Cure time
Solvent content
DFT
VOC





What's *New* in Protective Coatings/Testing/Technology?

Roadmap to the Future!



Industry Trends – 2016

Drives Need for Improved Testing Procedures

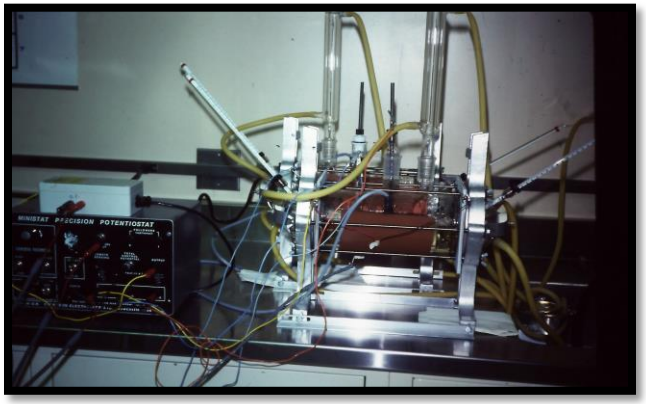
- Regulations force change *(lower or 0 VOC's/solvent free/0 HAPs)*
- Fewer coats *(2-coats ➡ 1-coat)*
- Less surface preparation/more surface tolerant
- Faster return to service
- Longer working time/pot life
- Less maintenance
- Single component
- Improved performance/service life

Advancements in Coatings Technology

- High Performance Acrylics *- cross-linking, 0 VOC*
- WB High Build Acrylic Epoxies *– high performance*
- 100% DTM/WB Urethanes *– high performance > S/B ($$)*
- Polysiloxanes *– appearance, durability ($$)*
- Polyaspartics *– durability, working times, 1-coat ($$$)*
- Fluoropolymers *– appearance, life cycle costs ($$$$)*
- Styrene-free Vinyl Esters *- safety, HAPS free, 'green'*

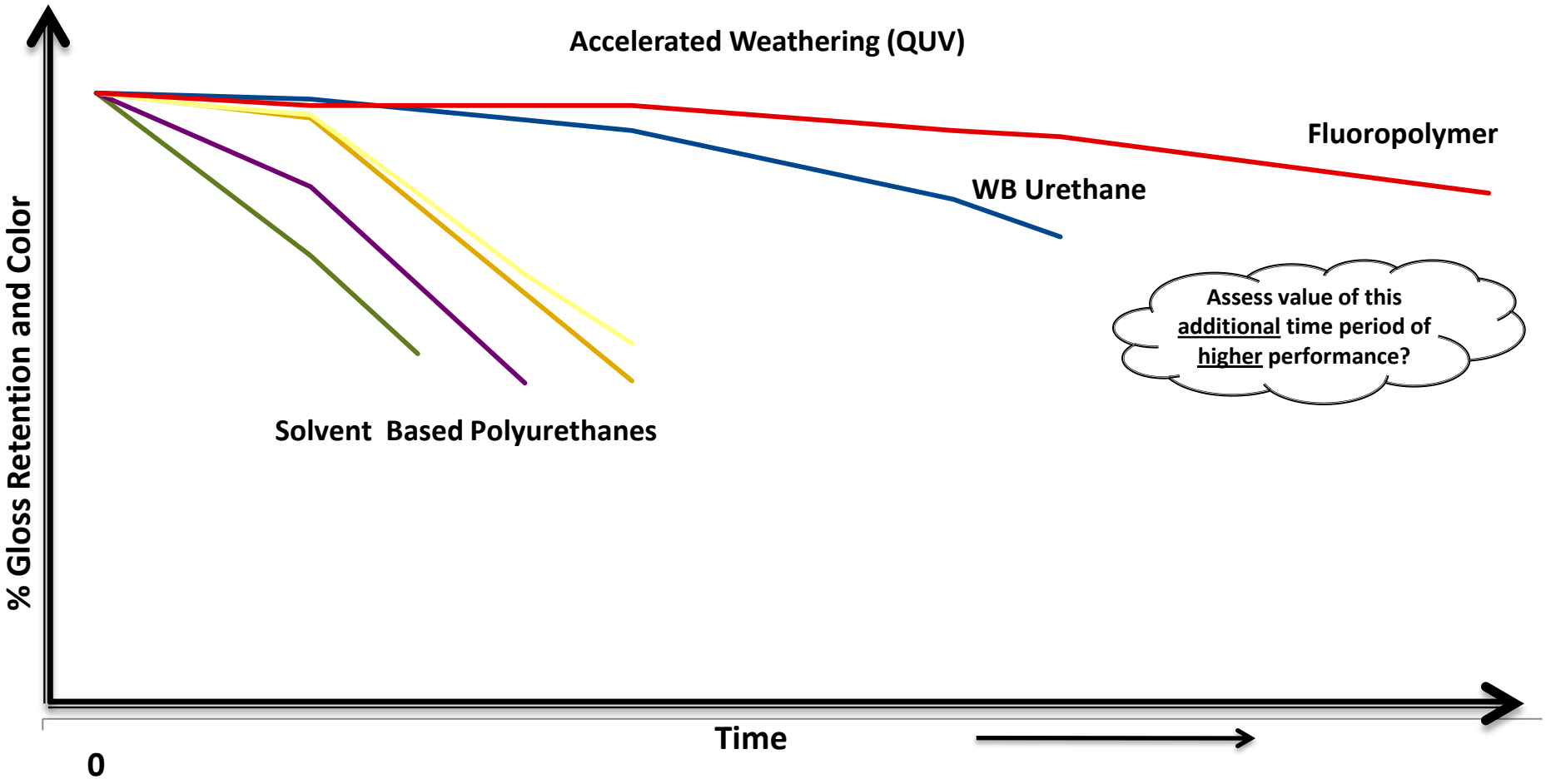
Lab *vs.* Field - *Correlation*

- **Replicate** *rate determining steps in degradation*
- **Measure/monitor** *– electrochemistry, analytical*

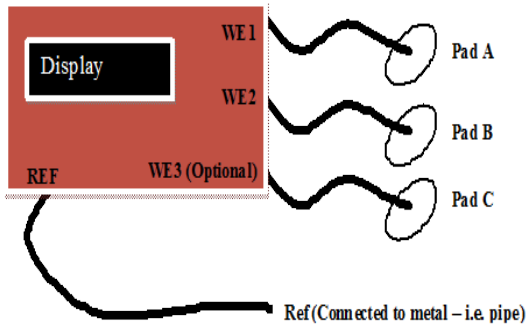


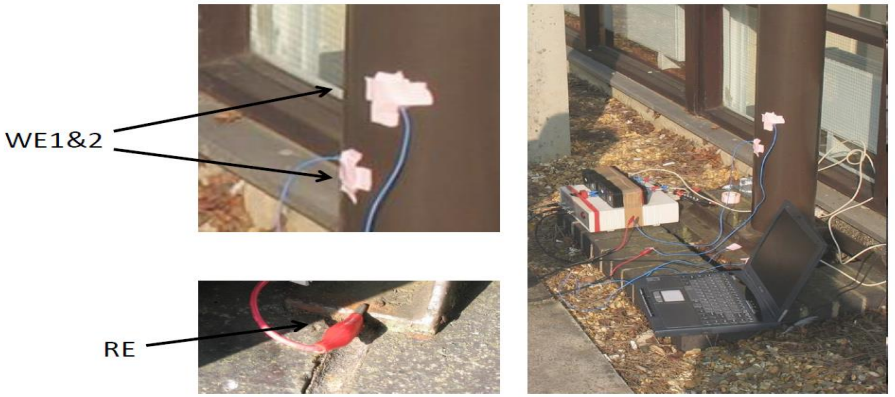
Lab vs. Field - *Correlation*

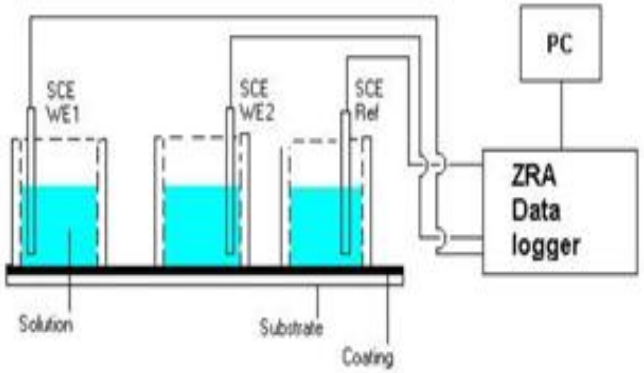
Accelerated Weathering Testing

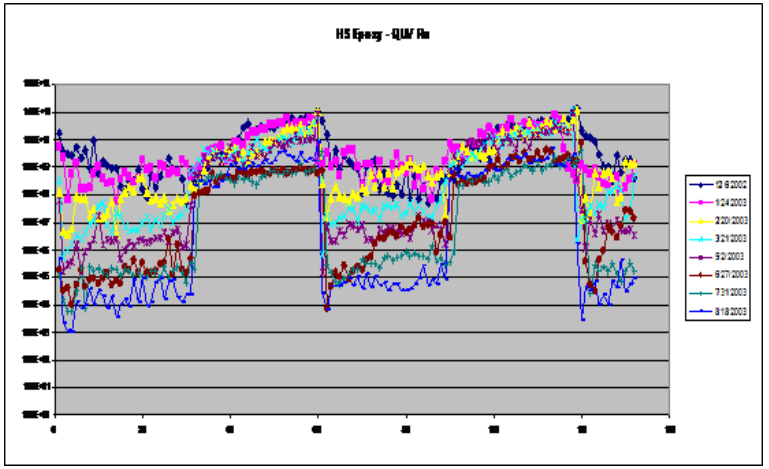


Lab *vs.* Field – *Correlation*









Where will the future take us?

Improved Test Methods Are Available!

- Water - 1K waterborne = 2K solventborne for steel/atmospheric
- Waterborne tank linings
- New polymer designs
- Nanotechnology
- Engineered surfaces
- Self-healing and smart coatings
- Renewable – resources/biobased