

Failure of Coatings Over Mast Arm and Monotube Sign Structures In Florida

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Introduction

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- Professional Engineer
- MSChE Jun. 1997 University of South Florida Polymer Synthesis and Characterization Laboratory.
- BSChE Dec. 1994 University of South Florida
- Society of Protective Coatings Instructor BCI, C1, and C2.

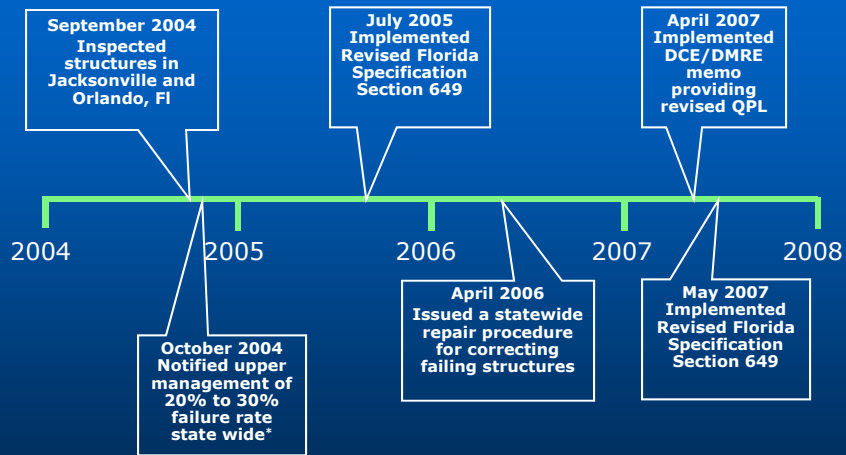
Issues

- 15% to 20% failure among ~15,000 structures statewide.
- Potential financial impact is \$150M
\$50,000 structure treated like a toy from the dollar store.
- How do we know what structures are failing and what constitutes failure?
- Hazard to the motoring public?

Issues

- How do we eliminate future failures on new structures?
- How do we remediate already in place structures that are failing?
- Current inspection processes are inadequate.

Timeline



How do we know which structures are failing?

Inspections - Not For The Squeamish

Inspections



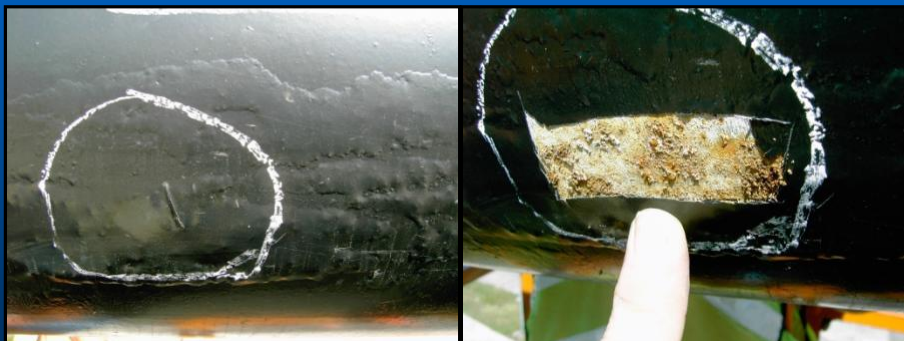
Inspections



Inspections



Inspections



Inspections



Inspections



Inspections



Inspections



Inspections



Causes

- Insufficient surface preparation
 - Painting over zinc corrosion products and wet storage stains.
 - Improper anchor profile and over blasting.

Causes

- Defective Galvanizing
 - Bare Spots
 - Dross Protrusions
 - Lumpiness and Runs
 - Flux Inclusions
 - Ash Inclusions
 - Rust Stains
 - Wet Storage Stain (White Rust)

Skimming Zinc Bath



Zinc Dross



Zinc Corrosion Chemistry

- Zinc is an active (anodic) metal and will corrode quickly in air or water
 - Surface corrosion products:
 - Common: ZnO , $\text{Zn}_5(\text{OH})_6(\text{CO}_3)_2$, ZnCO_3
 - Rare: $\text{Zn}(\text{OH})_2$, ZnSO_4 , $\text{Zn}_5\text{Cl}_2(\text{OH})_6 \cdot \text{H}_2\text{O}$

Zinc Corrosion Chemistry

- Volume occupied by corrosion products much greater than zinc metal
- Atmosphere + Time → ZnCO_3 , a stable and protective thin film (acid soluble)

How Do We Define a Failure?

- Delamination: Adhesion can vary significantly on a structure. Most common methods are not satisfactory.
- ASTM D 4541 Standard Test Method for pull-off strength of coatings using portable adhesion testers (dolly pulls).
 - Repeatability is questionable and methodology is sometimes impractical.
 - Destructive.

How Do We Define a Failure?

- ASTM D 3359 Standard Test Methods for Measuring Adhesion By Tape Test.
- Interpretation is based on an estimated surface area leading to inconsistency.

How Do We Define a Failure?

- Color Retention
 - Color Evaluation System – CIE 1976 L*a*b* (CIELAB).
 - A Requirement is needed to measure and record initial color.
 - Establish performance acceptance criteria.

2004 Florida Specification Requirements

- Galvanize according to ASTM A 123
 - Any blemish in the galvanizing larger than a quarter may be rejected.
 - Molten alloy must be at least 98% Zinc by weight.
 - Zinc Thickness must average 2-3mils (1.0-1.7 oz/ft²).

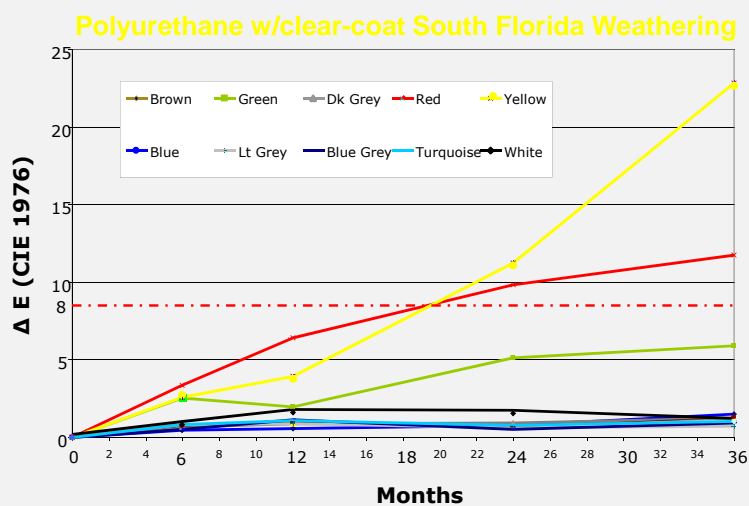
2004 Florida Specification Requirements

- Prepare all galvanized surfaces to be painted in accordance with ASTM D 6386.
- Liquid (epoxy & polyurethane) or powder coatings (polyester).
- SSPC QP3 (fabrication shop) contractor certification and NACE CIP Supervised Inspection.

2007 Florida Specification Requirements

- Failure is defined by color degradation greater than 8 ΔE 's or delamination of greater than 100 in².
- The Contractor shall designate a Responsible Party. The Responsible party shall deliver a bond to the Department ensuring the coating system requirements are met for five years after final acceptance.

Why 8 ΔE 's?



2007 Florida Specification Requirements

Painter must paint coupons concurrently with the structure and submit the coupons to the Engineer. Coupons establish the initial color and are stored for future reference.

Website Info. And Forms

The screenshot shows a web browser window displaying the Florida Department of Transportation website. The page features a search bar, navigation links, and a list of resources for prequalified fabricators. The resources are organized into two main sections: 'Prequalified Fabricators of Painted Galvanized Steel Strain Poles, Steel Mast Arms & Monotube Assemblies' and 'Required Forms'.

Resource	Format
Requirements for Becoming a Prequalified Fabricator (Effective on all contracts let after September 1, 2007)	PDF File, 9kb
Prequalified Painted Galvanized Steel Products Fabricators List	MS Excel Spreadsheet
Project Final Acceptance Information	MS Excel Spreadsheet
Required Forms	
Fabricator as Responsible Party (Need One Per Contract)	Form # 700-010-20
Fabricator's Annual Bond (Need One Annually)	Form # 375-020-65

State-Wide Repair Procedure for Remediation of Failing Existing Structures

- Does the inspection of the interior surface area of structure show iron oxide (steel corrosion)?
 - Yes = structure must be replaced
 - No = repaint

State-Wide Repair Procedure for Remediation of Failing Existing Structures

- Repaint
 - Field or shop
 - Pressure wash with 5000 psi
 - Abrasive blast SSPC SP-10 (exception: leave good zinc)
 - Apply organic zinc primer and either polysiloxane or fluorourethane finish coat. FDOT will be assessing the performance of both systems

Questions???

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