Coating Failures & Forensics - Part II
Investigating Premature Coating Failures

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The “CSI Mentality” Creates Unrealistic Expectations for CFI

- Solving the problem through lab testing often takes more than one hour
  - Testing can be very time consuming and expensive
- Results are not always conclusive or definitive
The Big Three Questions

- What do I THINK?
  - Hypothesis
  - Assumptions
- What do I KNOW?
  - Indisputable facts
  - Technical knowledge
  - Scientific laws
- What can I PROVE?
  - Lab testing on failures
  - Lab testing to recreate

Systematic & Analytical Process

- Document Review
- Site Investigation
- Shop Visit
- Interviews
- Literature Review
- Laboratory Testing
- Recreating Failure
- Analysis
- Report Writing
Objective, Systematic, Open-Minded Approach

- Do not predetermine the cause of the failure or the responsible party
- Failure manifestations that look similar may be due to entirely different causes
- Avoid the “single bullet” theory - especially during the site visit and sample collection phase
- Quick to listen and slow to speak
- Be prepared to hear new laws of physics and chemistry explained to you by one or more of the potentially responsible parties

Review Relevant Documents Before Visiting Site

- Project Specification
- Product Data Sheets
- Progress Meeting Notes
- Inspection Records
- Other Documents
Tools Used by the Coatings Investigator at the Failure Site

- Eyes & Mind (open)
- Inspection Tools
- Testing Tools
- Documentation Tools
- Sample Collection Tools & Containers
- Other Tools

On-Site Failure Investigation Sequence

- Get the overall (big) picture first (macro)
- Identify recurring patterns
- Re-inspect on a macro level and identify locations of each unique pattern
- Collect samples from areas with identified patterns for laboratory analysis
In this investigation, the blistering pattern at the balcony was observed on both the north and south sides of the structure in multiple areas.

Video & Digital Photographic Documentation

- Talk to indicate the area being videotaped
- Provide a macro view of prior to the micro view
- Let someone else videotape your sample taking if possible
- Do not speculate while videotaping
- Review the video when back at office
Look for Patterns & Possible Correlations

- Paint is stupid - it doesn’t know how to fail in patterns
- Orientation of the failure(s) on compass (North, South, East, West)
- Elevation (high vs. low areas)
- Any correlation between date(s) of application and the failed areas
- Any correlation between the batch of material and the failure location(s)

What Do You Observe?
Pattern Observed - Blisters below Balcony in Multiple Areas

In this investigation, the blistering pattern at the below the area where the balcony was attached to the wall was observed on both the north and south sides of the structure in multiple areas.
Sample Collection Procedures

- Photographic / video documentation prior to and after sample removal
- New gloves & new blades for each sample
  - Use clean non-oily blades
- Clean collection devices (preferably certified and uniquely numbered)
- Proper sample labeling
- Chain of Custody form

Sample Collection Procedures - Use Gloves for Sample Integrity

Change gloves between each new sample

Collect samples from both non-failing and failing areas.
Chain of Custody Form - Maintaining Sample Integrity

Common Field Testing Methods

- Non-Destructive
- Destructive
  - Adhesion Testing
    - ASTM D 3359
      - Method A
      - Method B
    - ASTM D 4541
      - Three different types of equipment
Identify the Failure Location(s) & Determine the Failure Type

It's Your Turn
What are Your Observations?
What are Your Next Steps?

Information from Interviews
Conducted with On-site Painter

- Tank was painted in fourteen (14) drops approximately thirty feet wide from the top to the bottom
- Painting occurred between November and February
There are Always Two Sides to Every Story - Opinion Changed?

Relationship between Location on Tank & Amt. of Degradation

Tank orientation southwest to west in picture
Visual Observations

- Paint delaminating between topcoat and intermediate coat
- Paint was very chalky
- Degradation worse on one side of the tank (the south facing side)
- Small blisters and craters were present on some areas of the tank

Zinc Rich Paint Needs Constant Agitation During Application

- Condition A: Zinc encapsulated by an ethane resin
- Condition B: Zinc (Zn) exposed – No resin observed
- Condition C: Zinc Hydroxide – Zn(OH)₂ Formation
Failure of Zinc-Rich Moisture Cured Urethane Coating

- MCU primer was applied at excessive dft in very low temperature conditions
- Excessive dft of an epoxy intermediate coat was applied over the MCU
- The MCU zinc failed cohesively
FTIR-ATR Testing Shows Uncured Moisture Cured Urethane (MCU)

Microphotograph of MCU Zinc Failure Shows Excessive DFT
Improper Ambient Conditions
Kept MCU OZ from Curing

Proper Ambient Conditions
Allowed MCU OZ to Cure Fully
Proper Ambient Conditions are Crucial to Proper Cure

Don’t Jump to Conclusions - Appearance Alone Can Deceive
Blistering from Mixing Problems (Equipment Related) - Off Ratio

Plural component equipment should be operated and maintained by qualified applicators. PCE problems include:

1. Blistering from off-ratio mixing
2. Blistering due to certain types of guns

Some 100% Solids by Volume materials solve some problems by significantly reducing cure times, substantially increasing dry film thickness ranges and providing VOC-compliant coatings but they also create new challenges.

Laboratory Failure Investigation Sequence

- Start at the microscopic level first
- List observations and identify patterns
- Select appropriate laboratory testing based on site visit observations and microscopic exam
- Obtain a control sample (exemplar) that was not exposed to the environment
- Run tests & compare to control sample
- Document tests to correspond to field numbers
- Perform additional testing (simulations) as required
Laboratory Testing

- Microscopic Evaluation
- FTIR
- FTIR-ATR
- SEM / EDX
- GC

Obtain wet exemplar (control samples) to compare against the samples taken from the site investigation.
Additional Remarks

- People expect you to tell them the cause on the spot shortly after looking at failure
- Talk to the person who actually applied the coating if possible
- All laboratory tests have limitations
- All field test equipment has limitations
- Draw conclusions from facts and evidence not speculation and unfounded opinions

Thank You!