Coating Failures – Lessons Learned

Period #2

Pipeline Coatings Course
2017
WHY DO COATINGS FAIL?
ONE BIG REASON:
NORMALIZATION OF DEVIANCE
WHAT IS NORMALIZATION OF DEVIANCE?

“Social normalization of deviance means that people within the organization become so much accustomed to a deviation that they don’t consider it as deviant, despite the fact that they far exceed their own rules for the elementary safety.”

~Dianne Vaughn - 1996
Pipeline Rupture

Appomattox, Virginia 2008

- 30-inch natural gas pipeline
  - Installed in 1955
  - Operating at 800 psig when it ruptured
- Left a crater 37’ long x 15’ deep
- 5 residents injured
- 95 homes affected, two homes destroyed

- Primary and contributing factors of cause
  - Pipeline external corrosion
  - Extremely corrosive soil conditions
  - Failure of pipeline’s protective coating and CP systems
Pipeline Rupture

Bellingham, WA 1999

• 16-inch hazardous liquids pipeline
• Released 237,000 gallons of gasoline into a creak (Whatcom Falls Park)
• 1.5 hours after the rupture, the gasoline ignited
• 3 people killed, eight injured, a water treatment facility and a home severely damaged

• Primary and contributing factors of cause
  • Inadequate inspection by during a pipeline relocation project in 1994
  • ILI results evaluation, failure to test safety devices, failure to investigate a failing block valve, & SCADA reliability
Can you think of just one time you’ve seen normalization of deviance in the application of protective coatings?
Example – Coating of Separator in Mississippi

Coating System Specified:
• One Coat of Epoxy Primer 2-3 mils
• One Coat of Coal Tar Epoxy 6-8 mils
• One Coat of Coal Tar Epoxy 6-8 mils
Total system thickness: 14 – 19 mils
What Was Found?

Intercoat Delamination
What Caused the Delamination?

Solvent Entrapment:
Well: What Caused The Solvent Entrapment? Primer DFT

The primer is supposed to be 2-3 mils thick, here is a chip of 6 mils thick primer, and there is still primer left on the substrate.
What Caused the Primer DFT to Be High?

• Of course it was application, but why wasn’t it caught?
  • Applicator did not check DFT or ignored DFT
  • Inspector was not present during application to witness WFT readings
  • Inspector did perform holiday detection as a final hold point but didn’t perform, or didn’t report, DFT readings (the entire system had a high DFT)
What Caused the Mistake to Be Missed?

- Institutional Normalization of Deviance for the owners and the applicators.
- The owners had a viable coating specification but did not ensure (inspect) that it was followed.
- The Applicator was ISO 9001 Certified and should have been checking all QC hold points.
Example: Pipeline Station Construction

Coating System Specified:
• One coat of inorganic zinc 3-4 mils
• One coat of polysiloxane 5-6 mils
• Total coating system thickness of 8-10 mils
What Was Found?

- Intercoat delamination
- 200 psi adhesion between primer and topcoat
- Topcoat delaminated during hydrotesting, especially in inside diameter of bends and fittings
Hydrotest Coating Failure
Failure in Multiple Stations with Multiple Applicators
Root Cause of Failure

The ultimate reason for the failure was too short of a recoat window for the inorganic zinc. The inorganic zinc primer needed 24 hours to cure, the primer and topcoat were often applied in the same shift. This was discovered with a review of paperwork and repeated interviews with multiple applicators.
What Caused This Mistake to be Missed?

- Institutional Normalization of faulty construction management practices
  - The inspection firm was also the project managers for the procurement of coated piping
  - One firm was responsible for quality and schedule
  - One person was assigned to a fabricator/applicator
  - When schedules were tight, the final step in the process, cure time between primer and topcoat, was shortened to meet delivery schedules
Example: Holiday Repair

Coating System Specified:
• One coat of patch stick
• No specified thickness
What Was Found?
Patch Stick Repairs Could be Removed With a Fingernail in Some Cases
Root Cause of Failure: Two Reasons

Under magnification it becomes clear that there was very little abrasion before the patch stick was applied. The individual scratches from each grain of abrasive on the sand paper used to abrade the surface are visible.
Nothing Sticks to Smooth*

*Law of Physics
Second Reason

It is suspected that at the factory, the substrate wasn’t heated enough to allow the thermoplastic coating to flow down into the profile that was there.

In proper application, the substrate is heated before the patch is applied, and the heat of the substrate is used to melt the stick, with assistance from the torch.
General Application Steps

1. Roughen the surface of the parent FBE coating using 80-mesh to 120-mesh sandpaper. Clean the surface and wipe away the sanding residue with a non-contaminating cloth.

2. Preheat the parent-coating surface using a non-contaminating heat source, such as a portable hand-held butane torch. Heat should be applied in a manner that avoids burning or charring of the epoxy coating. Slight browning of the parent coating is acceptable, but charring or blistering is not. Avoid heat application directly to the patchstick while prewarming the coating surface.

3. While continuing to heat the FBE surface, occasionally draw the patchstick across the repair area until it leaves a residue. Then rub the stick in a circular motion and utilize the torch to help melt it and maintain the pipecoating temperature. Continue until the patch is smooth and has a thickness of at least 15 mils (380 microns) greater than the parent coating.

4. Allow the patch to cool before handling.
What Caused This Mistake to be Missed?

• Institutional Normalization of faulty construction management practices
  • Because of the routineness of the patching of holidays, the amount of abrading and preheating of the substrate was allowed to lag
  • No feedback loop on how the patches were performing in the field was available to notify the workers and supervision that there was a problem until dozens of miles of pipe were in the field
Example: Holiday Repair

Coating System Specified:

- One coat of two part
- Minimum 20 mils
What Was Found?
Uncured Coating
What was Happening? Two Part Coating Application in Poor Conditions
Root Cause of Failure:
Coating Needed to be >50°F Until Cured
What Caused This Mistake to be Missed?

- Institutional Normalization of Faulty Construction Practices
  - The temperature of patch repairs was not monitored even though it was part of the specification
Example: Above Grade Valve Coating

Coating System Specified:
• Epoxy Primer 4-6 mils
• Urethane Topcoat 2-3 mils
Total system – 6-9 mils
What Was Found?
Topcoat Delamination
What was Happening?

Topcoat could be easily delaminated and there was a solvent smell coming from the primer.
What was Happening?

Topcoat sometimes had a hexagonal delamination pattern.
What was Happening?

Topcoat could be peeled off in sheets.
Root Cause of Failure:
Solvent Entrapment – The primer was not allowed enough time to flash off and cure before the topcoat was applied, violating the recoat window.

Water is dripping from blister, water was pulled through topcoat by osmotic pressure of having solvent present in primer.
What Caused This Mistake to be Missed?

• Institutional Normalization of not following the specification and the Manufacturer’s Technical Data Sheet
  • Technical Data Sheet contained detailed information on recoat windows
What was Happening?

Field coating repairs blistered shortly following installation (<3 years)
Root Cause of Failure:
Salt content on the blasted surface – Blistering resulted from a high concentration of chlorides

Water is behind each blister, water was pulled through coating by osmotic pressure of chlorides moving into the soil
What Caused This Mistake to be Missed?

- Institutional Normalization of not following the specification
  - Owner’s specification detailed chloride tolerances, yet there is no record or evidence that testing transpired prior to sandblasting, resulting in premature coating failure
What is the Cost?

- Case 1: Interior of separator had to be recoated.
- Case 2: Several stations had to be recoated.
- Case 3: Thousands of patch stick repairs on dozens of miles of 30” diameter pipe were removed and replaced with two part epoxy.
- Case 4: A week’s worth of repair work had to be scrapped and replaced
- Case 5: Dozens of large valves had to be repainted
- Case 6: Multiple excavations were required for sandblasting and recoat.
Integrity Management Practice – Example 1

• An operator performs 500 integrity excavations annually, at an average cost of $100,000 per dig
• Total Annual Budget - $50,000,000
• Cost of a full-time coating inspector $3,000,000 annually (+6%)
• Revised budget $53,000,000
• Question:
  • How many days would you need to extend the life of the asset to achieve favorable ROI?
  • Are there hidden savings?
Integrity Management Practice – Example 2

• An operator performs 5 integrity excavations annually, at an average cost of $100,000 per dig
• Total Annual Budget - $500,000
• Cost of a full-time coating inspector $30,000 annually
• Revised budget $530,000
• Question:
  • How many days would you need to extend the life of the asset to achieve favorable ROI?
  • Are there hidden savings?
QUESTIONS?