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Inspection and Mitigation of Corrosion for Pipe Cable Systems

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ABSTRACT

Recently, a power company identified their current procedures for corrosion protection with industrial coatings of pipe cable sections as an opportunity for process improvement. The power company sought to decrease the difficulty of maintaining coatings on these assets, increase the service life of the coating systems, and decrease life cycle cost. This presentation will provide a narrative of the steps taken during the process improvement, i.e., evaluation of the current paradigm, development of improved procedures and identification of better materials afforded through advances in coatings technology, implementation of the improvements, and lessons learned.

Key words: Coatings, Pipe Cables, Immersion, Inspection

INTRODUCTION

Recently, a power company was not satisfied with the performance of the coatings they were applying to pipe cables. The pipe cables are steel protective covering for conductors transmitting as much as 140,000 volts. The pipe cables are filled with pressurized oil or nitrogen to prevent internal corrosion and short circuiting. The pipe cables are buried with exception of intermittent concrete underground concrete chambers. For oil filled pipe cables the chambers provide for access to valves for sampling and inspecting the oil. Manholes provide access to the chambers. The chambers frequently fill with stormwater and the pipe cables are immersed. This environment and set of circumstance pose many challenges for external corrosion protection of the pipe cables with coatings including limited access, confined space, immersion, high humidity, and poor visibility. Coatings were failing prematurely, and the company engaged a corrosion and coatings consulting company to develop process improvement to increase coatings service life and decrease life cycle cost.

EXPERIMENTAL PROCEDURE

Premature coating failures are typically caused by inadequate surface preparation, faulty application, or improper material selection. To identify the cause and recommend process improvement the consultant used a two-step technical approach – (1) Review of Background Information, and (2) Existing Coatings Condition Assessment.

Review of Background Information

The Consultant interviewed the client, reviewed current client specifications, QA/QC practices, and previous inspection reports. The consultant learned through discussions with the client performed by a contracted asset maintenance firm. The spot repair maintenance painting tasks are completed by personnel without specific coatings training responsible for other maintenance activities. Comprehensive specifications are not used however, the surface preparation and coating products requirements are included in the task orders in a general standard, table format. The utility had been using mostly bitumastic as the standard coating system and in some instances used a silicone coating for spot repairs. Review of QA/QC practices revealed critical inspections were not being conducted, e.g., monitoring of ambient conditions, soluble salt testing, by the maintenance personnel. Lastly, third party inspection had not been used.

Existing Coatings Condition Assessment

The client identified four manhole locations where significant coatings issues had been identified by the previous inspection. An existing coatings condition assessment was performed at each of these locations. The purpose of the assessments was to collect the information necessary to determine a root cause for the issues, provide maintenance coating recommendations, and to develop improved processes and specifications. Prior to the assessments, the water was pumped from the manhole chambers.

A certified Protective Coatings Specialist used the following procedure for existing coatings condition assessments:

Visual Observation: During visual observation the PCS first made note of general and specific properties of the pipe cables and their location. This information included: service environment; access; and configuration (complexity); Second, the PCS determined the type (general, spot or pinpoint rusting), degree (percent surface area affected) and distribution of corrosion and coating defects (e.g., peeling, blistering, etc.). The extent of corrosion and defects on a structure is the primary factor that dictates the recommended scope of maintenance work. Whether a structure may be spot painted; zone painted; overcoated; or needs full removal and replacement of coatings is mainly dependent on the extent of coating deterioration and existing corrosion. ASTM D 610, “Standard Practice for Evaluation Degree of Rusting on Painted Steel Surfaces” and SSPC-Vis 2, “Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces” provide definitions and visual tools for determining the extent of corrosion on existing steel structures.

Dry Film Thickness (DFT) Measurements: The scope of services for this assessment included DFT measurement with a SSPC-PA 2, Type 2, magnetic DFT Gage and a Paint Inspection Gage (PIG). Each has inherent advantages and disadvantages. Multiple non-destructive measurements can be taken quickly with the Type 2 DFT gage. However, the Type 2 DFT Gage can only measure total DFT.

The PIG can determine the number of coats and DFT per coat, but measurements are relatively slow and destructive. PIG measurements for this assessment were not feasible due to the brittleness of the existing coatings.

Adhesion Testing

The adhesion of the existing coating system is one of the most important factors when determining whether overcoating or full removal and replacement of the existing coating system is the most viable option. The scope for this condition assessment included adhesion determination of existing coatings in accordance with ASTM D 3359, "Standard Methods for Measuring Adhesion by Tape Test", Method A. The evaluator uses a sharp knife to cut a "X" into the coating down to the substrate. Adhesive tape is applied over the "X" cut and then removed in a steady motion at an angle of 180°. The amount of coatings removed by the tape are then evaluated on a scale of 0A to 5A where 0A indicates the minimum adhesion (almost all coating has been removed) and conversely, 5A indicates maximum adhesion (no coating has been removed). Adhesion measurements by tape test were not possible during this assessment. The PCS was unable to obtain a sufficiently dry surface for the adhesive tape to adequately stick to the existing coating surface. Alternatively, the PCS used a knife to probe the coatings and assess the adhesion subjectively.

Examination of Substrate

The existing coating system is removed from the substrate and evaluated with and without magnification. The PCS looked for the presence of underlying rust and mill scale. Mill scale is a product of steel fabrication. It is characterized by a hard, smooth, dark steel surface. The presence of mill scale on an existing structure suggests the steel on the structure has never been abrasive blasted and therefore there is no existing surface profile. Further, residual mill scale is cathodic to carbon steel and may accelerate corrosion.

RESULTS

General

The pipe cables evaluated are situated in concrete chambers ranging from approximately 12-25 ft (3.9-8.1 m) underground. The areas were accessed via manholes and ladders. The environment surrounding the pipe cables most closely resembles SSPC Environmental Zone, 2A. SSPC Environmental Zone 2A is defined as frequently wet by fresh water involving condensation, spray, or frequent immersion. Runoff from storms frequently fills the chambers. The manholes are in congested, urban areas. On the days the evaluations were conducted, the pipe cables were immersed in storm runoff. Most of the water was pumped out by a contractor hired by the client personnel but approximately 3-6 in (7.6-14.2 cm) of sediment and 4-8 in (10.2-20.3 cm) of water remained in the bottom of the chambers. Since the pipe cables were very difficult to completely dry and the air was excessively humid, adhesion testing by tape test was not feasible. The tape would not adhere to the pipe cable surfaces. Alternatively, adhesion was evaluated subjectively by probing with a knife. With the exception of the silicone coating maintenance coating, the coatings were brittle. Further, the original coating systems exhibited marginal adhesion to the substrate and were easily disbonded under force from cutting. Therefore, Paint Inspection Gage measurements were not possible. The coatings crumbled or lifted when cut for PIG examination. Considerable surface area of pipe cables was covered with concrete splatter and detritus.

Pipe Cable Manhole Location #1

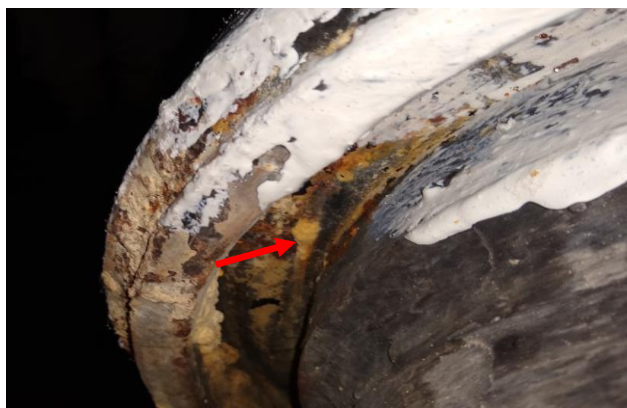
From a corrosion perspective, the exteriors of the pipe cables are in good condition. Visual examination did not reveal any pack rust or metal section loss. Spot surface rust was evident (See Photograph Nos. 4-6), but determination of surface area percentage affected was not possible due to the presence of cement on significant surface area of the pipe cables. The original coating system (black finish) is very brittle and probing with a knife revealed very little adhesion to the substrate. On the pipe cables that ran the full length of the chamber, the average DFT of the original system without white maintenance paint was 18.2 mils (462 μm) and the average DFT of the original system with white maintenance paint was 22.2 mils (559 μm). On the capped pipe the average DFT was measured as 73.2 mils (1859 μm). Spot maintenance painting with a silicone coating (white) was present on approximately 40% of pipe cable surfaces.



Photograph No. 3 – Location #1, General View



Photograph No. 4 – Location #1,
Spot Rust on Pipe Cable



Photograph No. 5 – Location #1,
Spot Rust on Pipe Cable



Photograph No. 6 – Location #1,
Spot Rust on Pipe Cable