The Undeniable Value of Inspection

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Too frequently, industries underestimate the necessity of preventative quality control methods. Actually, what truly happens is that the value is convoluted because of a simple accounting practice: capital expenditure versus maintenance expenditure. A capital expenditure is accounted for differently than a maintenance expenditure, which may be regulation required, and budgeting may be less elastic on the capital side. Thorough inspections and rigorous examination may be compromised in the name of speed and productivity goals. While this approach may accelerate the speed to the initial in-service, neglecting quality standards can only result in temporary solutions that generate consequences down the line.

As a consumer, imagine the inconvenience of purchasing a defective product, especially one due to poor workmanship. When spending thousands of dollars on a car, you trust that extensive quality checks were conducted during the assembly of your vehicle. Your transaction is built on the promise that you are receiving a car that is reliable, well-built and void of glaring imperfections. Even though you are unable to physically see all operating elements of the car, you trust that your system is performing exactly as specified. As extra assurance, you might be offered a warranty for a period of time. If an avoidable mistake were glossed over or disregarded entirely, your car's functionality could be compromised, which might result in unnecessary service fees.

Spending thousands of dollars on a car only to result in malfunction would be at minimum an undesirable outcome. Now imagine that value changing from thousands of dollars to millions. For many industrial pipeline operating companies, this type of financial loss is a reality. These oil and gas distributors spend millions of dollars purchasing pipes to deliver sources of energy across the world. The operating and maintenance cost, or worse, a potential catastrophic failure, could have lasting ramifications. In the same way that a car being manufactured must undergo numerous quality reviews, the pipelines that will power our cities must be inspected just as thoroughly. The purchaser, for the large part, must rely on the reputation of the company they are purchasing from. In this relationship, there is not an option for a warranty. But one option to reduce defects is vendor surveillance, or inspection, during the manufacturing process to catch defects before they are sent to the field or accepted in the field.

Buried steel structures will eventually corrode if not provided corrosion control. The primary form of corrosion protection for buried steel structures is usually one or more protective coatings supplemented by conjunction with cathodic protection. The coating systems reduces the surface area of the pipe to be protected by the CP. For structures transporting materials under pressure, such as pipelines, the need to prevent corrosion failures is important to prevent loss of product. If the product being transported is hazardous, the need to prevent corrosion failure is even greater. As pipelines age, their coating systems deteriorate. Atmospheric corrosion is easily handled though monitoring and maintaining the protective coating system. For buried pipelines, the cost of access alone is a challenge to maintaining the coating system, so the corrosion control system is commonly supplemented by cathodic protection.

The effectiveness of the coating and cathodic protection system can be measured using a method called Direct Current Voltage Gradient. The DCVG technique was developed to locate coating faults, quantify their severity and measure the effectiveness of the cathodic protection used without having to disturb the pipeline. When talking about a pipeline, it is possible to have design service lives that are in excess of 25 years, and actual service lives that may exceed 60–75 years. Coatings are the first pillar of below-grade corrosion control since they reduce the surface area of the pipeline that may experience corrosion. The design criteria for below-grade pipelines is the assumption of less than 1% failure of the coating systems for a 30-year design life. If the coating fails sooner, either the pipeline is excavated and coating repairs are performed, or more cathodic protection must be installed if that solution is possible.

Case study after case study can affirm that preventative inspection measures are more effective long-term than reactive corrections. If we apply this logic to construction practices, the need for preliminary coating inspection becomes clear. Locating coating defects during application prevents the financial impact incurred when the coatings fail prematurely (Fig. 1).

Both solutions, inspection and corrections, are expensive. Excavation for coating repair is expensive and can be dangerous; often, the pipeline as-built drawings have margins of error or are incomplete, which could lead to excavation damage or catastrophic failure. Post-installation repairs may require removal of significant concrete and asphalt as well as deep excavations.

For this case study, when looking from a financial standpoint, coating failure investigation of buried pipelines required workers to first dig down to the location of the defect, which could be anywhere from 5 to up to as much as 40 feet deep or more.

Life Cycle Costs

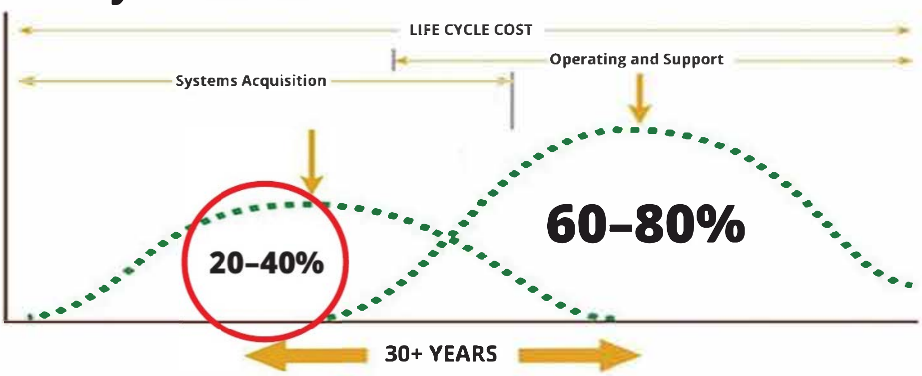

Fig. 1: Acquisition and operational costs of projects
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Accessing the pipe could be a challenge due to obstruction by roads and other blockages. Imagine a swamp crossing requiring cofferdam shoring. From a process management, financial and safety considerations standpoint, the only solution that meets all criteria is vendor inspection of purchased pipeline construction materials and best practices during installation.

Digging these trenches and putting up (shoring) walls to prevent collapse is a tedious, costly endeavor (Fig. 2). Not only does the process run up to $500,000 per excavation, the egregious cost of performing these O&M remediations and the risk associated with them is a challenging model to follow. What if we could prevent these defects from arising in the first place?

Qualified coating specialists are dual-trained to recognize mechanical defects are also equipped to recognize failure modes before

Fig. 2: View of excavation shoring to access buried pipeline
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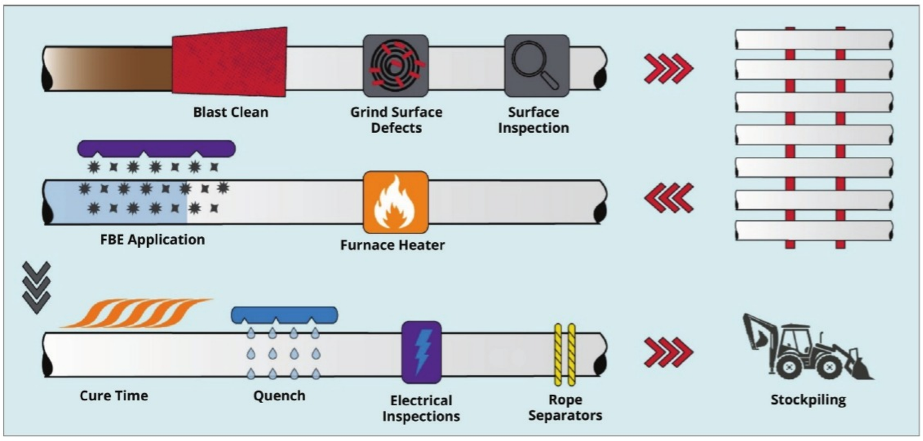

Fig. 3: Fusion bonded epoxy coating application process

Fig. 4: View of mechanical defect

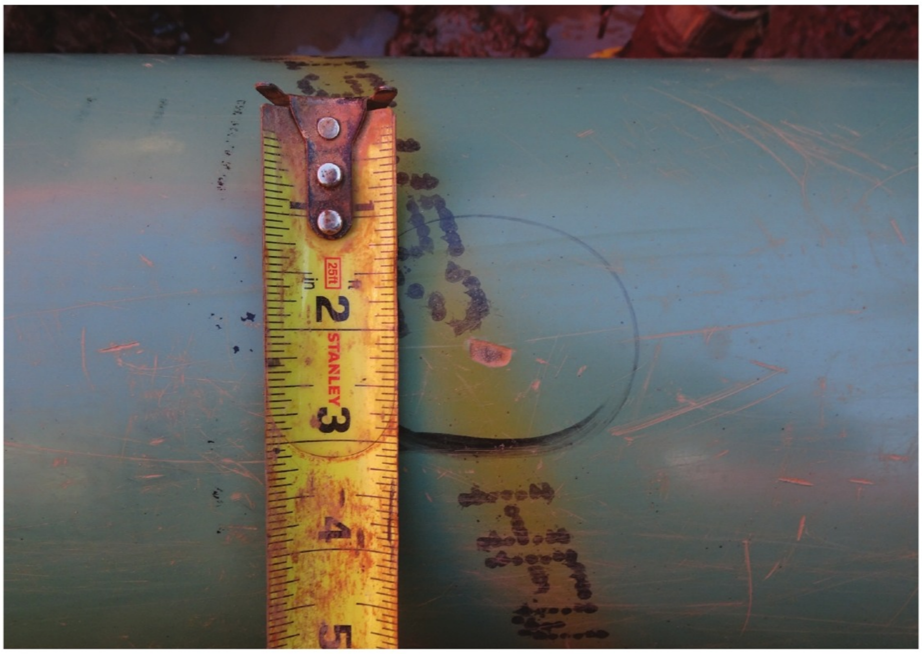

Fig. 5: View of coating defect produced during installation

they even make it to the project site. Once these defects are discovered, the failure is usually attributed to things such as poor surface preparation, substandard application or handling damage. Each of these issues could be identified prior to installation and these underlying concerns wouldn't evolve into larger problems. Operators best value is to incorporate a trained coating specialist during the preconstruction phase. This investment decreases the likelihood that issues will warrant an extensive repair.

CASE STUDY

When the pipeline is installed and buried, corrosion control is maintained through CP systems. CP protects bare metal spots at coating failure from rusting by either connecting a metal that corrodes preferentially to the pipeline, thereby sacrificing itself, or through an impressed current system that provides outside current to drive the electrochemical corrosion reaction to perform the same function. As previously mentioned, one way to identify areas of coating failure is to use a method called a DCVG survey, which identifies voltage drops during an over-the-line survey. Voltage drops often correlate to areas of coating failure along the buried pipeline surface. Depending on the operator's mechanical integrity plan, this may require confirmatory excavation that no cross-section wall loss is occurring at the location.

In this situation, the pipeline was coated with fusion-bonded epoxy. FBE is a shop coating application in which dry, charged particles of epoxy powder are blown towards a preheated surface and melted and fused to the pipe. The performance of a coating system requires specified materials, applied over a properly prepared surface, under the required conditions in order to maximize service life. The process is detailed in Fig. 3.

The pipe must first be blast-cleaned to the specified level of cleanliness, with the specified roughness and anchor profile. Then the pipe is passed through a furnace to heat the surface and then, the charged epoxy powder is blown onto the oppositely charged metal surface, where it melts and fuses to the surface. The pipeline is then quenched, holiday tested and shipped to the site or to a staging location prior to field installation.

As with any manufacturing process, a certain amount of "rejects" is inherent in the process. Defects may be generated at the pipe mill and may make it to the coating plant. A critical part of the inspection process is to identify mechanical damage of the pipe either pre- or post-coating. Another source of coating or mechanical defects is during the installation process—from movement or transport to the jobsite, from transport to yard, or from the yard to in-situ.

After a pipeline is placed into service, the corrosion system performance is monitored. A DCVG investigation identified locations of coating defects from the coating process or from mechanical damage of the pipeline coating. Locations identified with coating defects were identified, and confirmatory digs were scheduled. Several different defects were identified. One area exhibited mechanical damage that was coated over at the plant, as shown in Fig. 4.

The mechanical damage occurred prior to the coating process and appeared to have been missed during inspection. Another location exhibited coating damage during the installation process, as show in Fig. 5.

A properly applied FBE system would be tightly adherent and should resist delamination. It should only be scratched by probing with a knife. This investigation showed that the FBE was lifted by knife probing with the surface beneath the FBE exhibiting mill scale and surface corrosion, as shown in Fig. 6.

After the field investigation, it was discovered that client did, indeed, have a third-party inspection at the plant during the coating application process. A cursory review of the inspection records showed that the inspection team onsite did not reject a single section of pipe during the entire run of over 35,000 linear feet.

In any manufacturing process, a certain percentage of defects are found. The fact that no defects were found, and that the coatings were all identified as applied within the specified range of dry film thickness, without a single section being rejected, called into question the skills of the inspection personnel assigned to the project. Further investigation revealed that the inspectors had no formalized training in coatings inspection. If there are no identified discrepancies with any of the materials, it is likely that they did not undergo meticulous inspection.

Clients need a trusted partner to spot errors and verify the coatings are applied correctly during the procurement process. Without qualified coating inspectors, coating failures and mechanical defects are about the only "guarantee" the purchasing agent can bet on. PSP

Fig. 6: View of disbonding FBE

ABOUT THE AUTHOR

Pond & Company is a technology-driven full-service engineering, architecture, planning, and construction firm providing design solutions to defense, government, corporate and private clients worldwide. With locations throughout the U.S. and overseas, Pond is one of the fastest growing A/E/C firms in the country.