

“Quality Assurance/Quality Control, Testing & Inspection of Polymer Coatings”

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Abstract

“As federally mandated programs result in the successful removal of Infiltration/Inflow from existing sewerage systems, in cities, around the country, the resulting higher concentration of sewage will present an elevated corrosion problem at wastewater treatment plants and in collection systems. This paper will discuss the proper preparation, application of epoxy coatings but more importantly the quality assurance and testing requirements which must be included in all specifications. Good verifiable quality controls and testing documentation during construction are critical components for the long term success of corrosion protection coating. Warranties will be discussed and how regular project inspections will further insure that the customers’ desired results are met.”

Introduction

The need for protection of concrete and steel structures against corrosion has been recognized for many decades. The type of coatings and their capabilities have varied, ranging from aesthetic and architectural to severe service protective coatings. Emphasis by federal programs and local government awareness has opened up opportunities in a variety of industries with infrastructure rehabilitation being a fast growing area. A huge inventory of concrete and steel infrastructure in underground systems, including manholes, pipelines, pumping stations, wet wells, reservoirs, storage tanks and others, are regularly protected with polymer coating systems extending their useful life. In addition to water and wastewater, corrosion protection needs exist in power plants, industrial facilities, pulp and paper, food and beverage, pharmaceutical, aquariums, zoos, theme parks, marine and offshore and many other markets where a corrosive environment threatens to shorten the life expectancy of the existing infrastructure.

Background

Polymer coating systems and application technologies have evolved and improved significantly over the last 20 years. Through trial and error industry standards have been developed, but in some cases performance expectations are not being met. Three basic reasons for lack of expected performance include: 1) incorrect or improper installation; 2) improper or incomplete specification; and 3) product defect. In addition, the coating applicator may have minimal skills or training in proper installation practices but still was the successful low bidder. As a result customers occasionally suffer the inconvenience resulting from poor performance, accepting inferior installed systems and then face the expense of subsequent repair or replacement.

Failure Prevention

Failures occur with virtually every system offered on the market today. Sheet lining systems may fail from improper installation or improper seam welds. Pipe liners may fail from excessive grouting pressures, improper liner sizing and incorrect curing procedures. Coating systems may fail due to improper surface preparation, mix ratio, incomplete coverage or wrong product selection.

Coating failures can be minimized and prevented through development and implementation of a Quality Assurance and Quality Control Program which includes proper product selection, strong performance specifications including applicator qualifications and institution of testing and quality control measures during construction.

Discussion of Topic or Purpose

Coatings provide solutions. They protect new and provide the means to rehabilitate deteriorated structures. A properly selected coating can provide a barrier to a structure protecting against corrosion, abrasion and/or successful containment of substances or prevention of undesirable substances from entering a structure (infiltration/exfiltration). Properly applied coatings will extend the service life of the structure and can provide improved maintenance characteristics.

Adherence to basic product selection standards, the development of quality assurance program requirements during project design followed by a quality control plan implemented during and after construction fulfills the purpose and ultimate success of any protective polymer coating for restoring, protecting and/or extending the service life of the infrastructure.

Coating Selection

In selecting a polymer coating system it is necessary to understand the current condition as well as the potential future service of the structure. The intended service of the coating needs to be accurately defined to choose the correct coating, including:

- Type of service: submersion, intermittent splash and spill, gaseous or vapor
- Temperature variants
- Chemical or mechanical attack mechanisms

The specified coating product should have a proven history similar with the intended application and service environment, as well as data that reflects third-party testing, to substantiate physical property and chemical resistance claims by the manufacturer.

The structural condition should also be evaluated and the need for repairs identified. Multiple, but compatible systems may be evaluated and subsequently specified. Since all coating systems are not alike, accessibility, service environment, temperature and humidity, moisture filled substrates and surface condition must be evaluated to determine proper coating and repair system selection.

Identification of the correct product for the anticipated service and qualification of the contractor are two very important steps towards succeeding with polymer coatings in underground infrastructure. However, there are many application challenges that the contractor faces when applying coatings in this environment.

Accessibility issues including traffic control, backyards, wooded areas, access points covered by pavement, depth of structures or access shafts to reach pipeline to be coated, bypass or diversion of flow, etc. can prohibit the application of certain products. Likewise, moisture related issues such as low temperature (50 deg F), high humidity (>80%), moisture filled substrates, infiltration and live flow may prevent the use of otherwise desirable products including solvent-borne epoxies, urethanes, polyureas and other products with moisture sensitivities or those requiring evaporation to cure.

The use of equipment selected for application both with the chosen product and within the underground environment identifies another key component for coating success. Most polymer coatings used in underground applications are designed for spray or spincast application with a plural component pump system. The polymer coating manufacturer can generally provide general information on its recommendations, and many times will actually approve specific equipment for use with their products, especially for underground applications.

Contractor Qualification

Historically, more than 90% of all coating failures result from improper installation. The Contractor (or Applicator) must be educated and/or experienced in the proper procedures of preparation, application and inspection of the polymer coatings to be installed. Polymer coating manufacturers may have institutionalized certification programs and require Applicators to become certified. NACE and SSPC also offer training and certification courses for contractors and inspectors. Requirements listed throughout the project specifications should include verification of the Applicators training and experience related to the product specified.

Aside from the fact that the fundamentals of coating success begin with correct product selection and specification writing, the contractor's ability to successfully execute the application of the coating is by far the most difficult task. Specifiers have a responsibility to include contractor qualification and submittal requirements to verify coating experience at all levels. Specifications should be written to qualify the contractors, their personnel and require their use of proper equipment which results in ultimate successful performance.

Surface preparation is the most common step specified or performed improperly or incompletely causing failure of a coating system. Since there are many methods of surface preparation that have been established and proven successful, the coating contractor must be current in their knowledge of these various techniques. Adequate and properly maintained equipment and materials for surface preparation enable a trained contractor to succeed in this crucial step.

Surface preparation of a substrate, to receive a protective coating, should be such that a clean, sound surface with adequate profile and porosity to promote good adhesion of the coating to the prepared substrate is achieved through the most efficient and productive manner as selected by the applicator of the coating. Inspection criteria included in the specifications provide a mechanism to ensure good, quality surface preparation. Surface preparation and inspection methods are detailed through standards of the Society of Protective Coatings (SSPC) and the National Association of Corrosion Engineers (NACE). (reference specific standards NACE 5, SP 13).

Actual application of a spray applied polymer coating in underground structures is almost anti-climatic ... most of the time consuming work has been accomplished. However, continuance of inspection during application remains important, including:

- Crews ability to operate and troubleshoot equipment
- Management of safety & environmental issues and changes
- Conformance to quality assurance steps, based on project variables, to eliminate potential application problems such as off ratio material, pinholing, proper coverage, recoat windows, etc.
- Inspection and documentation of material usage and surface coverage

Once the application of the polymer coating is completed, inspectors verify the integrity of the installed system. The methods used for inspection are best accomplished when detailed in the quality assurance section of project specifications.

Performance Specifications

Performance specifications strive to adopt the best commercial practices and provide the means to attract the most qualified contractors, encourage greater technology innovations, maximize competition and obtain the best value for the customer. They are designed to deliver the end result and allow the bidders to be innovative in their approach subject to assessment of performance, as clearly spelled out in the specifications.

Performance specifications are a statement of the project requirements in terms of the anticipated results including:

- Criteria for verifying compliance without stating the methods for achieving the results
- Functional requirements for the specified product and the environment that it must function operate or function
- Encouraging Contractor's to seek innovations to meet the specification performance criteria

Key Elements of Performance Specifications

Performance Work Statement describes the contractual requirements in terms of measurable rather than prescriptive performance. Required product performance in the required environment is defined and a reasonable timeframe for performance is specified. Quality assurance/quality control requirements and specific testing and inspection during construction are outlined and representative of the final performance and quality expected by the customer.

- Materials provided, by the contractor, shall be as specified and verified through submittals and third party testing and evaluation.
- Equipment used to perform the tasks required must comply with the manufacturer's recommendations for the technology chosen.
- The product shall perform as claimed by the manufacturer.
- Documentation of contractor, and subcontractor, experience including project and crew level personnel.
- Verification of contractor training and certification programs.
- Third party inspection during construction.
- Warranty requirements.

Measurable Performance Standards defines acceptable levels of performance. The levels of performance should be determined on the minimum objectives of the customer and specific technology capabilities.

Remedies are specific procedures for addressing unacceptable performance. Specific identification of levels of failure are identified with the remedies including required repair criteria the level of failure whereby total replacement will be required. Monetary adjustments may be negotiated when performance and quality is below the specified contract requirements and re-performance in cases where the installed system is unacceptable.

Incentives encourage performance that exceeds specification standards including projects completed ahead of schedule, below project estimates and projects with zero safety related incidences.

Quality Assurance

A quality assurance plan outlines in detail how contractor performance will be measured and assessed. Performance is typically judged against the plan submitted by the contractor and should be measurable and verifiable. Quality assurance criteria should be incorporated in the specifications; it should be relative to the technology and outline the nature of and minimum testing required. The data should be meaningful and serve to set the standard for determining whether or not a technology is installed properly. Quality control should focus on project outcome, not contractor processes.

A Quality Assurance Plan for a polymer coating project could include:

- A complete description of the project site and structure condition specifying precautions if applicable.
- Defined quality assurance criteria.
- Defined quality control verifications during construction.
- A proposed safety plan for the execution of the work.
- Schedule for product sampling.
- Required submittals and certifications for the project and on the products to be used.
- Training certifications for the Applicator.

Quality Controls during the installation or application of a polymer coating could include:

- Written verification that all quality assurance requirements have been met.
- Documentation that all safety requirements have been implemented and followed.
- Verification of coating materials submittals, delivery and use, documented in writing.
- Pre-construction inspection of surfaces specified to receive the coating documenting their condition and submitting any requirements for alteration in the execution portions of the specifications based upon new findings.
- Inspection of all equipment to be utilized during surface preparation and coating application for applicability, operational condition and manufacturer approval when required.
- Documentation of environmental and service conditions that may affect the outcome of the coating project. ie. temperature, humidity, surface pH, live flow, infiltration, etc.
- Inspection and documentation of surface preparation implemented by the Applicator.
- Inspection of the prepared surfaces for cleanliness and soundness per the specification prior to the application of the coating material.
- Film thickness measurements of the applied coating performed and documented. Based upon the type of polymer coating these measurements may be wet or dry film readings.
- Inspection to determine film continuity – visual and holiday detection – with documented findings.
- Adhesion testing as specified with documented results presented for evaluation in accordance with the project specifications.
- Inspection and documentation of post-inspection repair procedures.
- Re-testing requirements of areas found to be deficient and repaired.
- Other test requirements as appropriate, recorded and verified by the inspector.

Inspectors who are charged with verification and implementation of quality control during the execution of a polymer coating project must be knowledgeable of the products specified, their handling, surface preparation, application and testing requirements and limitations. They should know the key components of the project specifications well enough to immediately recognize when project requirements are not being met. They must document all quality assurance requirements using the quality control tools provided for in the specifications.

Findings:

- Industry contract specifications are varied, general in content and tend to be vague on performance requirements.
- Customers using performance specifications including QA/QC requirements, relevant testing and trained inspectors are reaping the benefits of successful, quality work.
- Coating specifications typically do not motivate applicators to perform beyond requirements which are usually limited by low bid parameters.
- As new coatings and new applicators emerge in the underground infrastructure industry, performance specifications that include quality assurance guidelines, quality controls during construction, timely third party testing results and trained inspector evaluation throughout the application process are needed to ensure positive project results.

- Customers, engineers and contractors all prefer a successful quality installation where subsequent warranty repair and/or replacement are not required.
- Ongoing education and training, at all levels, is key to consistent, quality coating applications.
- Customers are typically extending warranty periods beyond terms that are common to the industry, primarily to encourage contractors to a higher level of performance.

Conclusion

Quality polymer coatings, quality in workmanship, and overall successful coating projects are attainable and are a benefits to all parties. Key specifications issues and customer acceptance criteria should include:

- Clearly determine what issues or project problems exist and need to be addressed. No single coating or coating technology will fit all situations. In some cases, compatible products used as a composite system may provide the solution desired.
- The engineer or specifier must consider all variables in choosing the polymer coating system to ensure that the product or process will solve the existing needs without creating other problems.
- Specifications should clearly outline the project performance requirements and final goals.
- Specifications must accurately define product requirements, Contractor qualifications and required equipment submittals for pre-acceptance and approval by the Project Manager/Engineer.
- A Quality Control and Safety Plan that details performance criteria should be a required submittal by the Contractor.
- Quality assurance requirements, testing, inspections and quality control documents during construction, must be specified, outlining the consequences and penalties.
- Incentives, if any, for completing the project ahead of schedule and under budget must be clearly spelled out within the project specifications.
- Contract completion requirements must be included in the project specifications including applicable testing and inspection, installation and product warranties.
- Installation warranty provided by the applicator and product warranty from the coating manufacturer.
- Include periodic inspections of the complete project in conjunction with warranty periods. The longer the warranty, the more project inspections should be required.
- Repair or replacement requirements for defects discovered during warranty inspections must be adequately defined within the project specifications and reiterated in warranty documentation.
- Extended application warranties will raise applicator risk resulting in higher project costs.
- Well written performance specifications, including QA/QC, testing and inspection requirements during construction will go significantly further in accomplishing quality coating applications.

A positive working relationship between the applicator, the customer and the customer representative is critical to achieving quality work. The relationship should promote a strong business alliance to achieve the contractual goals to the benefit of all parties. The relationship should encourage open communications, teamwork and good performance to resolve conflicts and achieve the overall objectives of the contract.