Underground Coatings And Linings:? Evolution or Revolution

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Underground Conditions Tougher and Unique - Today's infrastructure is subject to more corrosion than ever before.? In sewer systems, the Clean Water Act induced efforts to reduce unwanted inflow and infiltration into collection systems have reduced the dilutive effects on sewers.?? Additionally, the more concentrated sewage with heavy metal and industrial pollutants is no longer present to kill bacteria resulting in much more prolific microbial activity and aggressive microbiologically induced corrosion problems.? Combine these challenges with rehabilitation issues found in wet underground, confined space environments and the primary influences leading to the development of today's most successful underground coatings have been identified.

Although corrosion has been an axiom of life since the dawn of man, the science of corrosion engineering has evolved only within the past 50 years. Infrastructure replacement was the primary solution to corrosion until the 20th century's advent of the modern paint, and later, protective coating industries.? "*While World War I marked the beginning of what is now the paint industry, World War II provided the impetus behind the development of the protective coating industry.? The need to conserve labor, to lengthen the time a ship could be at sea without returning to dry-dock, to protect structures against corrosion that developed from rapidly expanding chemical and fertilizer industries ... all pushed the development of the protective coating industry*."[1]

Accelerated corrosion problems in today's infrastructure, as well as greater awareness of corrosion issues, have led to the development and use of solvent free coatings to increase infrastructure life expectancies.?? Due to inherent safety, performance and quick return-to-service attributes, professionally applied solvent free or "100% solids" epoxy, urethane and urea coatings have proven unique advantages for successful rehabilitation and corrosion protection. These 100% solids coatings should require application by manufacturer trained applicators using custom spray equipment to achieve optimal performance.? Such products now dominate the underground infrastructure protection and rehabilitation industry because many can cure and bond to concrete, brick, steel and iron? in damp underground environments while requiring no evaporative processes.? Because there is no evaporation, they can also be formulated for thicker, structurally enhancing applications.

Safety and Confined Spaces - Pipelines, tunnels, lift stations, manholes and tanks are typical confined spaces where coatings have proven successful applications.? Worker safety and environmental concerns are unquestionably best satisfied in such structures with 100% solids coatings. Because 100% solids coatings have no solvents and therefore no evaporative curing process like the vast majority of coatings, flammability and breathability issues are greatly reduced.? The 100% solids epoxies, urethanes and ureas are all inert plastics once fully mixed and cured.? All require protective clothing and good hygiene prior to and during mixing.? Provided the air in the confined space is safe, solvent free epoxies produce little odor and generally require air purifying respirators for confined spaces. Urethanes and ureas utilize isocyanate catalysts while polyesters and vinylesters contain styrene monomers which can sometimes also require air supplied respirators in confined spaces.

Cardinal Corrosion Protection Rule: Impermeable Monolithic Barrier  **-** As more aggressive corrosion takes its toll on our infrastructure, rehabilitation techniques have evolved to offer better protection. The key to superior long term performance is the concept of providing "a barrier without fault" ... an impermeable monolithic coating. According to the Los Angeles County Sanitation District's Coating Evaluation Program, old industry norms of thin 20 mil applications of coal tar have proven inadequate at protecting concrete in corrosive environments. Other recognized experts[2] have extensively studied concrete coating failures in corrosive wastewater environments and concluded that minimum 50 mil thick coating systems with low permeability and good chemical resistance were required to provide effective long term protection. Lower coating permeability generally offers better chemical resistance and suitability for immersion service. Furthermore, this research points out that thicker systems generally improves film integrity, reduces pinholing and allows for better coverage over rough, irregular and porous concrete.

As surfaces go from moderate to heavy corrosion leaving deeper profiles after cleaning, thicker coating applications will be needed to achieve the monolithic requirement. Typical industry recommended specifications range from 80 to 250+ mils for moderate to extremely corroded substrates. At the extreme, in other words, it may take 250+ mils nominal coverage to achieve a 40 to 50 mil minimum thickness on top of the highest peak of a rough corroded surface. For reliable data in these circumstances, testing for holidays and thickness should be calibrated to the minimum and not average thickness.

Ideal Underground Coating Attributes - In conjunction with chemical resistance and monolithic coverage, adhesion is generally regarded as a co-primary attribute of coatings. Other attributes vary greatly between epoxies, urethanes and ureas ... the most prevalent types used in underground infrastructure protection and rehabilitation. Some may be excellent for bridging moving cracks in concrete structures but have low chemical resistance due to inherently higher porosity, others may exhibit excellent long term strength but poor adhesion in damp environments. True project needs should matched with proven product attributes.

Moisture can wreak havoc on a coatings curing process and ability to bond to the host substrate. Although moisture is relatively easy to mitigate in above grade structures, it can not be completely avoided below grade, especially in concrete and masonry structures. Therefore, a coating with a high moisture tolerance offers an adhesion advantage for below grade coating projects. Epoxies generally offer the best moisture tolerance, although some urethanes and ureas also offer moderate tolerance or utilize an epoxy primer. Other attributes to analyze could include:

- Structural enhancement
- Flexibility/elongation
- Quick return-to-service
- Visibility

Surface Preparation - It is well accepted that most coatings fail because they were either inadequately applied or improperly specified. Assuming the engineer has properly specified the right product at the right thickness leaves only the application variable to complete a successful application. Unfortunately, coating of underground infrastructure is routinely specified site unseen. This presents unanticipated difficulties ranging from

infiltration to various contaminants. There are several resources available to assist both specifier and trained coating applicator in selecting the right surface preparation method(s). In particular, National Association of Corrosion Engineers (NACE) and the International Concrete Repair Institute (ICRI) have prepared extensive guidelines including visual guides for determining profile of prepared concrete. The purpose of surface preparation remains the same for most underground infrastructure to receive a protective coating: to produce a sound, clean, uncontaminated surface with sufficient profile and porosity to promote a good bond between the coating and the substrate.

Handling Difficulties of Solvent Free Coatings - Solvents are utilized in the vast majority of paint and coatings to dilute the blended resins making them simpler and easier to stir, hand apply or spray with conventional spray equipment. Once applied, the solvents evaporate, the resins react and set leaving a dry film thickness proportionately thinner than its wet film based upon solvent content (i.e. 40% thinner if 40% solvent content or 60% solids). Numerous coats are therefore required with solvent-based coatings to achieve the high build specifications necessary for monolithic application to rough underground concrete and masonry surfaces. The Clean Air Act has greatly reduced the use of solvents over the past twenty years and, coincidentally, forced manufacturers to focus on high solids and solvent free coatings. 100% solids coatings are comprised of multiple components that are mixed just prior to application. Because 100% solids coatings contain no solvents, the mixed product generally has a very quick reaction time ... thus the requirement for plural component spray. The resulting high build, quick return-to-service production advantages prove more than worthwhile.[3]

Qualifications - When introducing the use of sophisticated plural component spray equipment in combination with high performance coatings, manufacturer support and contractor qualifications become even more significant. Coating manufacturers and contractors committed to fighting underground corrosion participate in professional associations such as NACE, ASCE, SSPC, WEF, ASTM, NASTT and NASSCO that study coating failures, develop tests and help write industry accepted specifications and standards that help ensure long term successful underground coating applications. Many municipalities have initiated product review committees that evaluate coatings in many ways. The Los Angeles County Sanitation District's Coating Evaluation Program has tested over 100 coatings in a simulated corrosive underground environment and has received widespread industry acclaim. The University of Houston in conjunction with the then Greater Houston Wastewater Program evaluated the effect of hydrostatic pressure on coatings, as well as adhesion and chemical resistance. The EPA and the National Sanitation Foundation are working together to adopt an evaluation program specifically for the use of coatings in wastewater structure rehabilitation and protection. Designers, specifiers and owners should choose proven successful products with attributes that match their project needs and require application by trained and experienced applicators.

Underground Experienced Products and Applicators - 100% solids coatings unquestionably offer superior safety and performance for protecting new and rehabilitating old corroded underground structures. Such structures offer many unique coating challenges for products and applicators. The need for special application equipment as well as initial and ongoing training, necessarily suggests a close relationship between proven coating manufacturers and their trained applicators. Users should not underestimate the interdependent need for proper equipment, trained and experienced applicators and good manufacturer support. These attributes are inseparable for consistent coating success with 100% solids coatings.

Case Histories - Cementitious products have been used in underground rehabilitation for centuries. The use of thermoplastic sheet liners, cured-in-place liners and spray-applied polymers began over 50 years ago.[1] However, only in the past 15 years, has there been a significant increase in the specification and use of those products exhibiting greater chemical resistance and longer life expectancy. This can be attributed to accelerated corrosion problems in today's infrastructure, as well as a greater awareness of corrosion issues. In general, what has been learned and why are these systems lasting longer and achieving greater success in these difficult environments? The following case histories provide insight into the world of underground infrastructure rehabilitation and structural rebuild providing increased life expectancy through cost effective installation of coatings and linings.

If you have any questions, please contact **Dr. C.Vipulanandan**

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[1] Munger, Charles G. "Corrosion Prevention by Protective Coatings" NACE, 1984