“Green” Cured in Place Pipe Utilization, Styrene Free Emerging Methods and Resin Systems

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ABSTRACT: This paper compares Non Styrenated, UV Light, Remote Epoxy CIPP, and Sequential Wrapped Carbon Fiber/ Epoxy technology in applications where the presence of VOC’s, fumes, vapors, is unacceptable, undesirable or impractical. Several recent case histories of successfully installed CIPP applications are presented where the application did not allow for Styrene emissions either in the Vapor Phase during Cure or during the release of liquid Styrene laden process water during commissioning of the pipeline. UV cure technology is also compared which, while styrenated, requires no process water resulting in styrene concentrations well below those realized during typical CIPP installation. Finally in NSF 61 Certified Application there is no room for introduction of solvents, reagents, and residuals into the distribution side of the municipal water stream.

The practical limits of Styrene usage in the trenchless industry has become controversial citing environmental, exposure, and safety issues. The use of non-styrenated, UV Cure, and Remote Impregnated Epoxy Resins in CIPP installation sidesteps this debate while offering the benefits of close fit, full structural, and pressure rated cured in place pipe.

Issues associated with styrene usage, such as cycle water contamination and airborne odor concentration has been largely eliminated in Europe through the evolution of UV, as well as, Remote impregnated epoxy technologies.
While it remains to be seen as to the timing of this change within the US; both sides along with the economics of this issue will be presented within this paper.

The movement towards more “Green” materials in construction has been largely accepted in concept while the Owner/End users must weigh the economic impact of such materials as compared with alternative means of using styrenated products and more common technologies. While styrene utilization remains commonplace within our industry; Green or sensitive application requires containment, absorption, and/or shielding methodologies. This paper shall demonstrate the successful installation of CIPP without Styrene in applications where Odors, Exposures, or Contamination could not be tolerated.

INTRODUCTION

The issue of styrene utilization in CIPP installation is recently become controversial within the United States stirring debate within and outside of the Trenchless Construction Industry [1]. Experts point to the five year lag in technology implementation between Europe and the United States arguing that today’s snapshot overseas would demonstrate less usage of styrenated resins in favor of UV and Remote Impregnated Epoxy Technologies. In this country the increasing use of CIPP has been an adaptive process while solving the gamut of trenchless application ranges from small to large and non-circular diameter, pressure rated, storm drain, industrial sewer and process pipes has largely been accomplished with little or no effect being attributed to the use of a common, inexpensive, and in CIPP, practical solvent known as styrene.

On the other hand; as we strive to become more environmentally responsible; what were once novel process are coming under increased scrutiny for the monitoring, exposure to, installation and transport of VOC laden constituents.

Additionally; the need to contain, shield, absorb or eliminate solvents needs to compare with cost to provide the user with an end result that is both cost effective and practical.

Exhibit #1: Non Styrenated Gravity Sewer Rehabilitation at Indoor Casino:

(Figure#1 Trappers Alley, Detroit Michigan)

Greek town was selected for downtown survival and revival in the seventies. Part of this effort was the development of Trappers Alley as a brick mall encasing of a street whose history dated back to the fur trading days of the eighteenth century.

Seemingly unconsidered in this development was the existence of a one hundred (100) year old 18" to 15" transition sewer some twenty feet below the surface of what was now a full service gaming casino and restaurant complex.

When numerous complaints emanating from ongoing backups, odor issues, and flow restrictions failed to be satiated with routine and ongoing cleaning and plumbing efforts; CIPP became the solution of choice.

One of the parameters made necessary was the zero tolerance for Casino Closing during the rehabilitation effort. Additionally, the two hundred plus foot installation with an inline transition and multiple service reinstatements would require an around the clock installation schedule. The issue of styrene emissions were discussed and deemed by the management company to be unacceptable.

A styrene free resin was selected and approved based on its property where during exotherm it remained virtually odor free. Fully deteriorated structural properties along with common cycle times and installation method made the selection an easy one to make.

Exhibit 2: Non Styrenated Pressure Pipe in Water Fountain Application at Detroit's Renaissance Center:

(Figure #2 Renaissance Center Fountain overlooking the Detroit River)

At the same time the Casino Project was being constructed a call came in from the Management Company responsible for the Renaissance Center in Downtown Detroit. A pressure pipe beneath the plaza facing the Detroit River had become deteriorated causing shutdown of a critical and decorative centerpiece of the complex also the focal point of each summer's Downtown Detroit's multi heritage festival schedule.

While there was no declaration of NSF 61 water main requirement; the fact that children commonly come in contact with this water during the summer festivities gave the owner cause to seek a "green resin". In fact, the styrene free resin used at the Greek town Casino project had recently been submitted to NSF 61 for leach testing in accordance with the UL/NSF 61 certification process. This rendered substantial chemical analysis available for submission to Engineers reviewing the project offering comfort with regard to the fountain application.

The project required CIPP lining of twin twelve (12") inch water transmission lines rated at 100 psi. The ASTM F 1743 (pull and invert) method implemented during installation allowed for a successful installation, pressure test and return to service within one week of project commencement.

Exhibit 3: UV Cured Trunk and Collection Sewer Interceptor:

(Figure #3 Light Train inserted into a 30" Trunk Sewer on Division Street)

UV cured CIPP utilizes resin which while styrenated allows only minimal emissions since:

- There is no Process Water release upon conclusion of the lining process
- The tube is encapsulated in a protective black plastic which acts as a UV shield
- Fully deteriorated design relies more heavily on Tube Reinforcement than resin during wall selection [2]

During installation of the Division Street Interceptor Project for the City of Dover over five (5,000') thousand feet of trunk transmission and residential collection sewers were lined on an extremely tight schedule within and around the Downtown area. Cycle time to install was significantly reduced in that the typical inflate/ cure/cool/ process water release was sidestepped in favor of the Air inflate/UV Cure steps used with UV methodology. Additionally; there were no residential complaints or calls from residents concerning the matter of Styrene Odors which may be ordinarily be expected during the implementation of standard styrenated polyesters and vinyl esters.

Exhibit # 4: Remote Impregnated NSF 61 Certified Epoxy Water main:

Remote Impregnated Epoxy looms as a highly desirable CIPP methodology. This method allows for the transport of the entire wet out procedure to the respective jobsite; while using the beneficial properties of 100% solids, 0 VOC's, structural epoxy which has tremendous structural, adhesion, and life span benefits. The process is applicable to Gravity, Pressure, High Corrosion, and NSF 61 Potable Water application. This process enjoys widespread acceptance within Europe and has proven to be an Engineers favorite since it is so repeatable, recordable, and controllable.

A 3,000 lf NSF 61 Residential Distribution Water main of 8" through 12" was installed tested at 100 psi on Theodore in Clinton Township, Michigan and using this technology [3]. Remote Impregnated Epoxy methods include products such as Norditube, Aquapipe, and Blue Line Citi Liner by RS Tecknik.

Exhibit #5: Non Styrenated Gravity Storm Sewer Culverts in Environmentally Sensetive Wetlands:

A styrene free resin was selected and approved based on its property that no styrene could be released into the environment which might pose a risk to Fish and Wildlife. Fully deteriorated structural properties and a fifty (50) year service life expectation were desired using the direct inversion methods described in ASTM F 1216. No styrene was released since none existed in the products delivered to this environmentally sensitive Wetland application. On another note in the wetland application thermal shock must also be considered prior to process water release. While ASTM F 1216 discusses cooling to 100'F prior to release, process water might be cooled further, transported out, or pumped onto adjacent ground in an effort to eliminate any chance for Fish kills or other undesirable environmental effect. Several installations of 36" & 48" Non Sytrenated CIPP were installed in culverts throughout the Loxahatchee Water Reclamation District during this project

Exhibit #6: NSF 61 Certified Carbon Fiber/ Epoxy Matrix Sectional Lining in Cylinder Pipe Watermains:

In the late Seventies (70's) and Early Eighties (80's) a large quantity of defective Prestressed Concrete Cylinder Pipe became distributed to major municipalities throughout North America. This pipeline product became depended on for Potable Water distribution in High Pressure Transmission Mains. Only recently have these utilities become "condition assessed" for potential to allow catastrophic line break and failure. The utilization of a space age process involving sequential Carbon Fiber wrapping technology allows for the implementation of NSF 61 certified internal sleeving to preempt line breaks given pressure ratings of 150psi or more. One such installation of this technology was a 54" 150 psi Water Transmission Line in Metro Dade County. The strict UL certified NSF guidelines allow for no harmful solvents to remain residual in what will become the rehabilitated water supply. This technology shows great promise for growth as the Nation prepares to forge forward with new Federal mandates for Water Infrastructure Rehab and Renovation.

Other means and methods:

A reagent known as "Sty Redux" has also been utilized on certain projects where strict limits have been placed on concentrations of styrene in the process water released. This compound, when added to the process water within a water cured inversion column, causes the styrene present to polymerize for easy collection upon release of the cooling water that was utilized. The implementation of a Pre Liner should be added if the concerns include Styrene emissions in a gas phase up through the lateral stacks of the sanitary applications being rehabilitated.

Frac Tank water collection, Pre liner utilization, and closed system containment are all ways which can be utilized to diminish any levels of styrene which ultimately become released into the environment.

The Numbers:

Regarding Styrene; the author of this paper has been associated with over eight Million (8,000,000) lineal feet of CIPP installation using styrenated resins during which time we are not aware of one individual whose health has been directly impacted by exposure to the styrene emissions prevalent using conventional methods described in ASTM F 1216 or F 1743. Styrene concentrations as they pertain to recognized levels are:

Human recognition	2ppm
Monitored during Wet out	17ppm
TWA (NIOSH)	50ppm [4]
IDLH (NIOSH)	5000ppm

Putting this in perspective then; the Human Nose can detect 2 parts per million of styrene while in accordance with OSHA guidelines the "Time Weighted Average" for exposure is 50 parts per million during a forty (40) hour workweek. The Immediately Dangerous to Life and Health exposure limit tops 5000 parts per million. While in the mixing room within a CIPP wet out facility it is uncommon to monitor concentrations greater than 17 parts per million. Given this insight; it is safe to say that odors associated with styrene in and around the CIPP process as we presently know it; may represent more nuisance than hazard. However; certain individuals may possess sensitivities to this or any other solvent which is perhaps why the potential for eliminating its use is compelling. Additionally, the implementation of Styrene laden resins in wetlands and waterways may pose risk to wildlife if one or more of the methods listed in this paper are not utilized.

Cost:

The bottom line is that what we as a society are willing to pay to "go green", eliminate solvents, or minimize sensitivities. When so many millions of feet have been successfully installed within The United States and elsewhere; using an efficient, cheap, and proven styrene based material such as iso polyester and vinyl ester resins; those leading us into the next generation of Rehab methodology or toward the European Model will need to provide persuasive guidance.

Estimate Cost of comparative technologies eliminating or minimizing Styrene Exposure

Conventional Styrenated Resin Application	$ 4 - $ 8	per diameter inch [5]
Non Styrenated Resin Application	$ 6 - $10	per diameter inch
Remote Epoxy Impregnated Application	$ 8 - $12	per diameter inch
UV Light Cured Application	$10 - $16	per diameter inch
Sequential Wraped Carbon Fiber / Epoxy Matrix	$75-$100	per diameter inch

Many factors must be weighed along with these crude estimates such as site specific information, access, cycle time allowable and others.

Conclusions:

The intent of this paper was to discuss and compare methods where the use of styrene emissions needed to be sidestepped, minimized or eliminated. The use of styrene continues in the face of Federal initiative suggesting against its use along with the persistent nuisance represented by emissions of odors and release of chemicals within our environment and at the home sites of the unsuspecting public at large.
For purposes of this presentation the facts surrounding the applications listed; made selection a non styrenated or a reduced emission styrenated product, as opposed to solvent styrene based product forthright and justifiable.
Simply adding these products to the specifications will no more insure their utilization than the specification of "silver plating" as an equal alternate to "galvanized" in storm drain culvert manufacture.
Objectives such as the removal of styrene, elimination of the nuisance and risks associated with solvents, or the desire for properties such as reduced cycle time and higher physical properties; will only be achieved by direct specification of the Owner/Engineer.

References:

[1]Guideline for the Use and Handling of Styrenated Resins in Cured in place Pipe
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[2] Lee, Robert. "Risks associated with CIPP lining of storm water pipes and the release of styrene."
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[4] US Department of Health and Human Services. NIOSH pocket guide to chemical Hazards: Cincinnati, 1990. Print.

[5] Lanzo Lining Services Engineering Design Guide 2nd addition, 2010. Print