



PROGRAM OFFICE  
210 25th Avenue North, Suite 1104  
Nashville, Tennessee 37203  
Phone (615) 915-0384 • Fax (615) 891-2508

## Memorandum

**Date:** August 21, 2015

**To:** Ron Taylor, P.E., Director  
Clean Water Nashville Overflow Abatement Program

**From:** Wayne Miles, P.E., Manager  
Clean Water Nashville Overflow Abatement Program

**RE:** Discussion of Risk Mitigation for Styrene Releases associated with Cured-in-Place Pipe (CIPP) Lining Installation

**cc:** Greg Ballard, P.E., CWNOAP Deputy Director  
Kimberly Martin, P.E., CWNOAP Deputy Manager  
Michael Krabacher, P.E., CWNOAP Controls Manager  
Paul Stonecipher, P.E., CWNOAP Design Manager  
File

**No. of Pages:** 5

**Attachments:** None

### Background

As part of the *Risk Management Plan* development for the Clean Water Nashville Overflow Abatement Program (CWNOAP), the issue was raised about the potential risks related to styrene releases associated with the installation of cured-in-place pipe (CIPP) lining. This memorandum explores the potential risks associated with this process, describes potential mitigation measures to address this, and makes recommendations for consideration by the CWNOAP to mitigate these risks.

At present, styrene is a primary ingredient used to manufacture most of the thermoset resins used in CIPP lining. Styrene is used because it is an ideal monomer for the cross linking of polyester and vinyl ester resins. Styrene is the most popular formulation diluent because of its copolymerization efficiency, affordability, and availability, and it may represent up to 50% by weight of the CIPP lining resin. Other CIPP lining ingredients include sodium metasilicate, ethylene glycol, and diphenylmethane diisocyanate.

While styrene utilization remains commonplace within our industry, concerns have been raised about its impact on sensitive receptors and whether or not application should include additional precautions such as containment, absorption, and/or shielding methodologies.

Of particular concern to CWNOAP are the styrene releases and concentrations in the air as a result of the CIPP lining curing process. Significant research has been done about the styrene concentrations in the process water used during the curing process of CIPP lining. Process water disposal is not, however, a major concern for the CWNOAP because the process water is discharged to the sanitary sewer and sent to the wastewater treatment plant (WWTP). Information about this issue is included in this memo, however, because of the potential for confusion by the public who may not be familiar with this distinction.

## Studies

CDM Smith has reviewed several studies on use of styrene in CIPP lining. Some highlights from referenced studies are summarized below:

- The European Centre for Ecotoxicology and Toxicology of Chemicals concluded that “the carcinogenic potential of styrene, if one exists at all, is rated so low that occupational or environmental exposure is unlikely to present any carcinogenic hazard to man.”<sup>1</sup>
- The Virginia Department of Transportation (VDOT) research suggests that high concentrations of styrene can pose a health threat to waters used for municipal purposes, but styrene is highly biodegradable. There is also evidence to suggest that high concentrations of styrene can have a potential impact on aquatic life forms but that may be mitigated by both its volatility and biodegradability. Additionally, high concentrations may pose a brief but acute “localized ecological threat” to aquatic life forms at the point of application.<sup>2</sup>
- Gerry Muenchmeyer, P.E., technical director of NASSCO (National Association of Sewer Service Companies) said there appears to be no evidence that styrene, as it is currently used in the CIPP lining process, poses any health hazards to the workers installing the CIPP lining or to the general public.<sup>3</sup>
- During the past 5 years, a few California Department of Transportation (CALTRANS) regions, New York State Department of Transportation (NYSDOT) regions, and VDOT instituted moratoriums on CIPP lining use in stormwater applications. Moratoriums were issued because of documented and suspected environmental contamination incidents, but specific details were not available.<sup>4</sup>

## Exposure Levels

The voluntary occupational exposure level limit for airborne styrene levels is 50 parts per million (ppm) over an 8 hour work period. Process water for liner curing, once the liner temperature reads 100°F, will generally have a styrene concentration in the range of 20-25 ppm. By comparison, the mixing room within a CIPP lining wet-out facility typically has concentrations of 17 ppm or less.

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<sup>1</sup> NASSCO

<sup>2</sup> NASSCO

<sup>3</sup> NASSCO

<sup>4</sup> Tabor, Newman, and Whelton

Typical levels of styrene are 0.1-0.2 ppm in dry traps inside houses, 0.16-3.2 ppm at the liner insertion/extraction manholes, and 0.08 to 0.5 ppm near installation personnel.

Putting this in perspective, the human nose can detect styrene at levels of 0.4 to 0.75 ppm, depending on one's ability to detect odors (NASSCO, 2008). Therefore, styrene odors can be detected at levels much lower than the concentrations that could cause health effects. For this reason, much of the concern around styrene is related to customer complaints.

The Occupational Safety and Health Administration's (OSHA) guideline for the "Time Weighted Average" for exposure is 50 ppm during a forty (40) hour work week. The "Immediately Dangerous to Life and Health" exposure limit tops 5,000 ppm. Given this insight, it is safe to say that odors associated with styrene in and around the CIPP lining process as we presently know it may represent more of a nuisance than hazard. However, certain individuals may possess sensitivities to this or other solvents.

In limited studies, exposure of pregnant animals to styrene at levels of 250-300 ppm did not cause birth defects but did indicate the potential for impacts to developing fetuses early in pregnancy. We do not know whether styrene can affect human reproduction. Results from studies conducted so far have been inconclusive about the effects on human reproduction. However, styrene inhaled by a pregnant woman can reach her developing fetus. Styrene may also enter breast milk. Whether it can affect the fetus or the nursing infant is uncertain. Pregnant and nursing women should avoid overexposure to styrene just as they should minimize their exposure to alcohol, tobacco, and other drugs.<sup>5</sup>

When considering styrene concentrations in the liquid phase, styrene exposure can impair or be lethal to aquatic organisms, and studies have shown its toxicity for select freshwater organisms. However, styrene breaks down in the atmosphere due to hydroxyl radical and ozone reactions and is also degraded through microbial action. CIPP lining process water also contains various heavy metals at levels greater than those typically found in stormwater. Aluminum is present and likely originating from aluminum silicate, which is used as the water absorption filler in polymer matrices. Zinc is present in the form of zinc oxide because the zinc oxide is used as a polymer matrix reinforcement. Copper is also present and likely originates from the CIPP lining formulation's blue colorant, "phthalocyanine blue" or "phthalocyanine blue," a known component of polymer coating systems.

Based on the above discussion and from the studies reviewed herein, it appears that releasing CIPP lining process water to a sanitary sewer is an acceptable solution. Using standard installation procedures does not appear to put the public or installation crews at risk for exposure. Additionally, if adequate dilution is available in the sewer system it is unlikely that styrene or these other compounds will cause toxicity concerns with the activated sludge system at the WWTP. The CWNOAP's standard specifications prohibit the release of CIPP lining process water to a storm drain or waterbody.

### **Alternative Methods of Curing without Styrene or to Minimize Impact**

Because of questions in the trenchless industry about the use of styrene, alternative methods of curing have been developed. The use of ultraviolet (UV) light curing and non-styrenated curing such as

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<sup>5</sup> Florida Department of Health

remote impregnated epoxy resins sidesteps this debate while still offering a close fit, full structural, and pressure rated CIPP lining. While there are benefits to the UV light curing and non-styrenated curing processes, there are other concerns with these processes including increased costs.

UV light curing reduces the amount of styrene released into the environment because the quick cross-linking of the resin effectively binds up the styrene. UV light curing has some advantages regarding strength, but it can also be more costly to use for installation than traditional curing. Other potential issues of UV light curing include compatibility with lateral lining systems and the ability to make traditional lateral connections to the liner.

In the southeastern United States, Tri-State Utilities (Chesapeake, VA) uses a custom polyester felt liner system from CIPP Corp., which incorporates CoREZYN styrene-free vinyl ester resins from Interplastic Corp. Tri-State has installed more than 150,000 lbs. of this resin and liner in storm drain pipes along Virginia's environmentally fragile eastern shore.

Another alternative to styrene-based systems is epoxy. Epoxy is almost entirely free of airborne compounds, and its minimal odor and low shrinkage (3 percent, compared to 7 percent for polyester and vinyl ester resins) make it suitable for CIPP lining applications. Because epoxy is inherently HAP-free (hazardous air pollutant) and VOC-free (volatile organic compound), some manufacturers and contractors are specifying epoxy despite several disadvantages. Notable disadvantages include cost and, unlike vinyl esters that can be catalyzed and applied off-site, epoxy must be mixed and applied on-site just before installation. Perma-Liner Industries (Clearwater, FL) uses epoxy for its liners to eliminate emissions in the densely populated areas it typically serves.

The estimated increased costs (based on CDM Smith experience) of the above technologies used for curing CIPP lining can be summarized as follows:

1. Non-styrenated resin application: 10-50% increase
2. UV light cured application: 10-50% increase
3. Remote epoxy impregnated: 50-100% increase

### Conclusions and Recommendations

Based on the above discussion and from the studies reviewed herein the release of airborne styrene during the CIPP lining curing process is not expected to result in undue exposure to the public and/or construction workers when properly monitored and managed. Also, it appears that releasing the CIPP lining process water containing styrene to a sanitary sewer is a generally accepted practice and one that will generally have little or no negative public or environmental impact. At this time, installation concerns and the additional cost of curing with non-styrenated processes do not warrant changing the current CIPP lining process.

For CWNOAP projects, some general steps to minimize possible exposure risks and negative public perceptions include the following:

- Continue the use of the door hangers prior to CIPP lining installation to notify the homeowner that they may notice the smell of solvents during the installation process and that the odor should not be present for long
- Continue to note on the door hangers prior to liner installation that the homeowner should ensure that all plumbing traps are full of water
- Modify the specification language to allow the Construction Management Team to require additional styrene mitigation measures of the Contractor when necessary based on observed styrene levels. These measures could include plugging laterals, additional ventilation, or other measures. This may add some additional cost to future lining contracts. Revise specification language to include a requirement for the contractor's submittal of an *Odor Control Plan* that ensures that project-specific odors will be minimized at the project site and surrounding area based on field directions from the Construction Management Team and the Construction Management Team's assessment of field conditions. Revise specification language to include a requirement for the contractor to vent or exhaust noxious odors to an acceptable level in accordance with OSHA requirements and at the direction of the Construction Management Team.
- Gather local monitoring data during CIPP lining processes for several representative conditions to establish that styrene levels on CWNOAP projects fall within typical industry standards
- Provide reference information on the CWNOAP website regarding styrene and provide links to NASSCO and EPA websites
- When CIPP lining is conducted on large diameter sanitary sewers in close proximity to one of the WWTPs, require contractors to notify the WWTP operations staff of the process water release times so that operators can monitor for process impacts
- If CIPP lining is conducted on storm drains or culverts, other precautions for handling the process water may be warranted. These measures are yet to be determined.

## References

NASSCO, September 2008, *Guideline for the Use and Handling of Styrenated Resins in Cured-In-Place-Pipe*

Matthew Tabor, Derrick Newman, and Andrew Whelton, *Stormwater Chemical Contamination Caused by Cured-In-Place-Pipe (CIPP) Infrastructure Rehabilitation Activities*

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Fred Tingberg, Jr., *"Green" Cured in Place Pipe Utilization, Styrene Free Emerging Methods and Resin Systems*