Should I be concerned with Stryrene Releases During CIPP Pipe Lining?

Dr. Mark Knight
University of Waterloo, Ontario

Raise your hand if you have Pumped Gas?

Raise your hand if you have smelled Gasoline?

Raise your hand if you know that gasoline is a known cancer-causing chemical?

Why are you allowed to Pumped Gas?

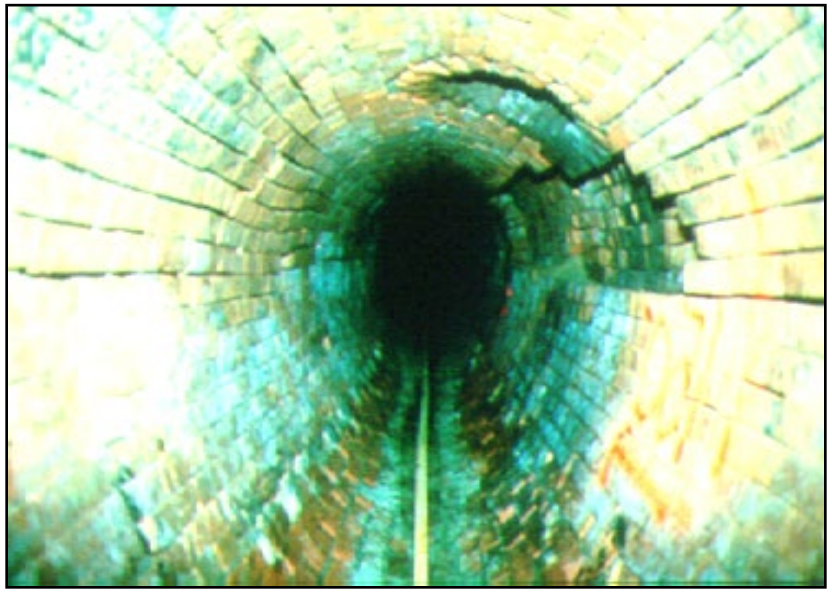
Why are You Allowed to Pumped Gas?

Health risk = Exposure Time X Chemical Concentration

Colored Cells are the Risk Categories	Low Risk	Medium Risk	High Risk

Frequency of Scenario	Severity of Consequences		
	Low Severity	Medium Severity	High Severity
High Frequency	Medium	High	High
Medium Frequency	Low	Medium	High
Low Frequency	Low	Low	Medium

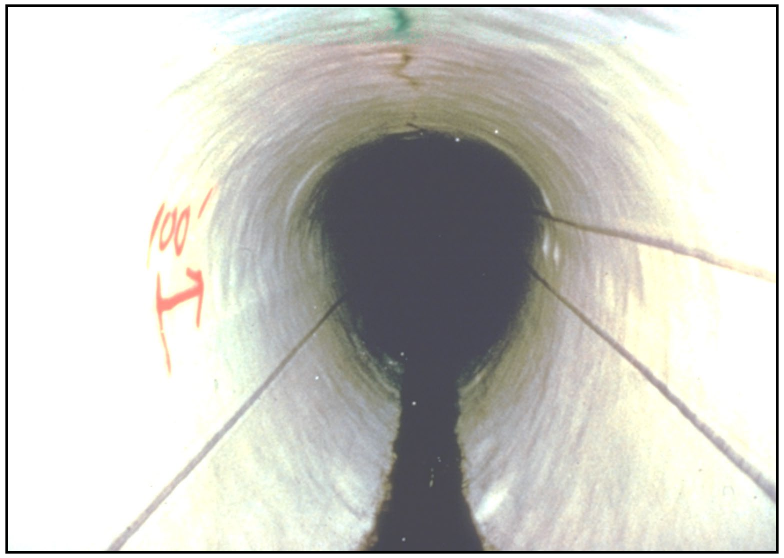
CURED IN PLACE PIPE (CIPP)



Before

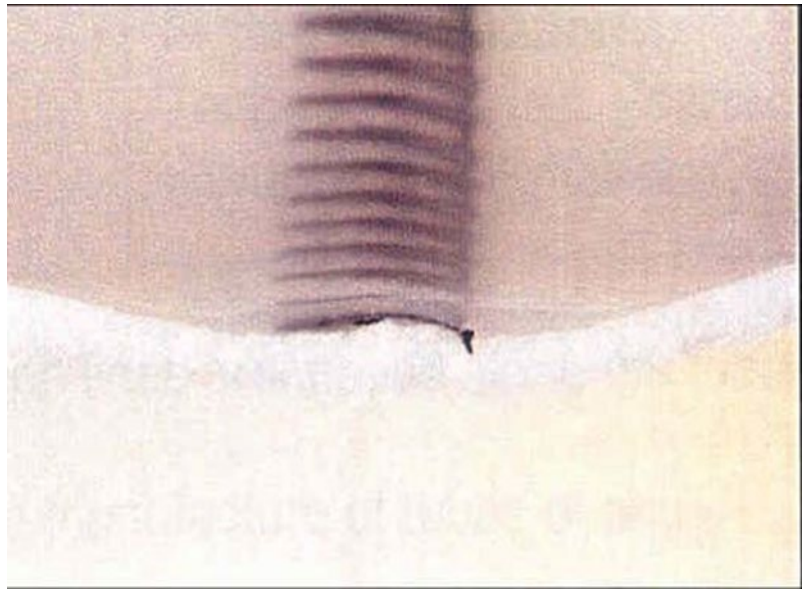
Developed in the 1970s and over 40-year track record of success

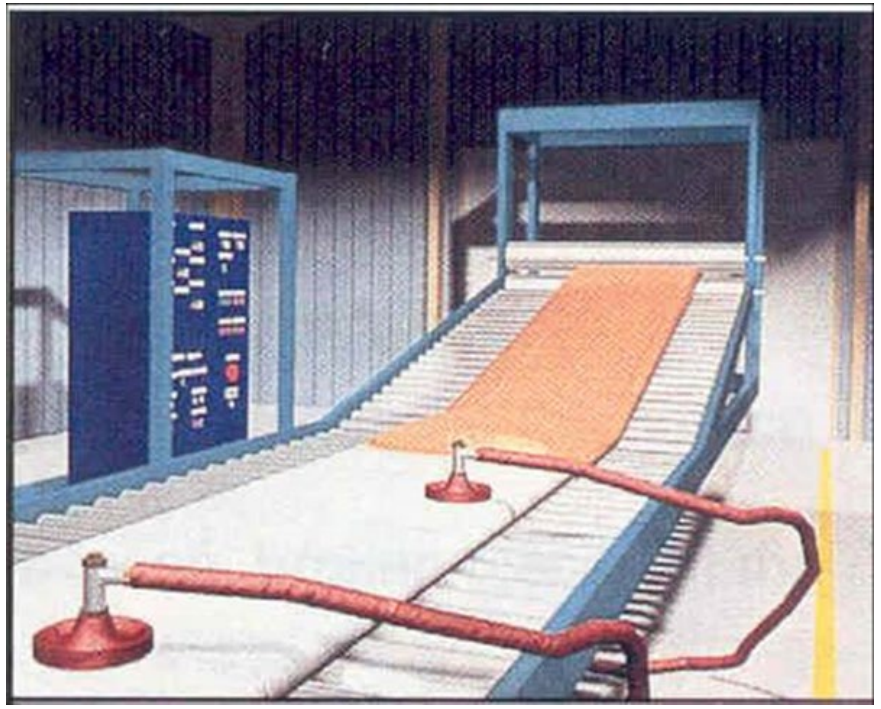
After



Alternative to Opencut Construction

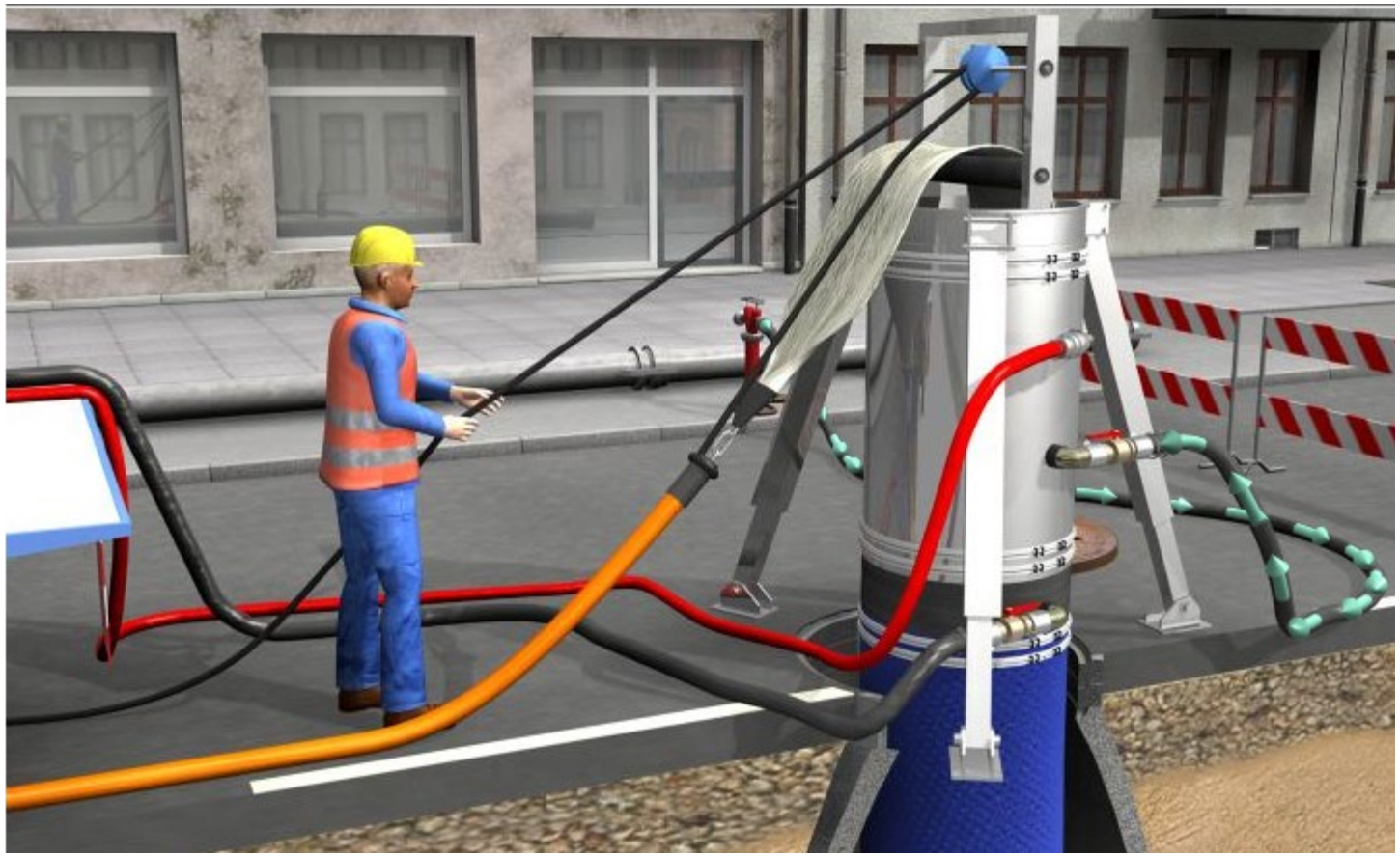
CIPP Liner Tube is Saturated with Liquid Resin





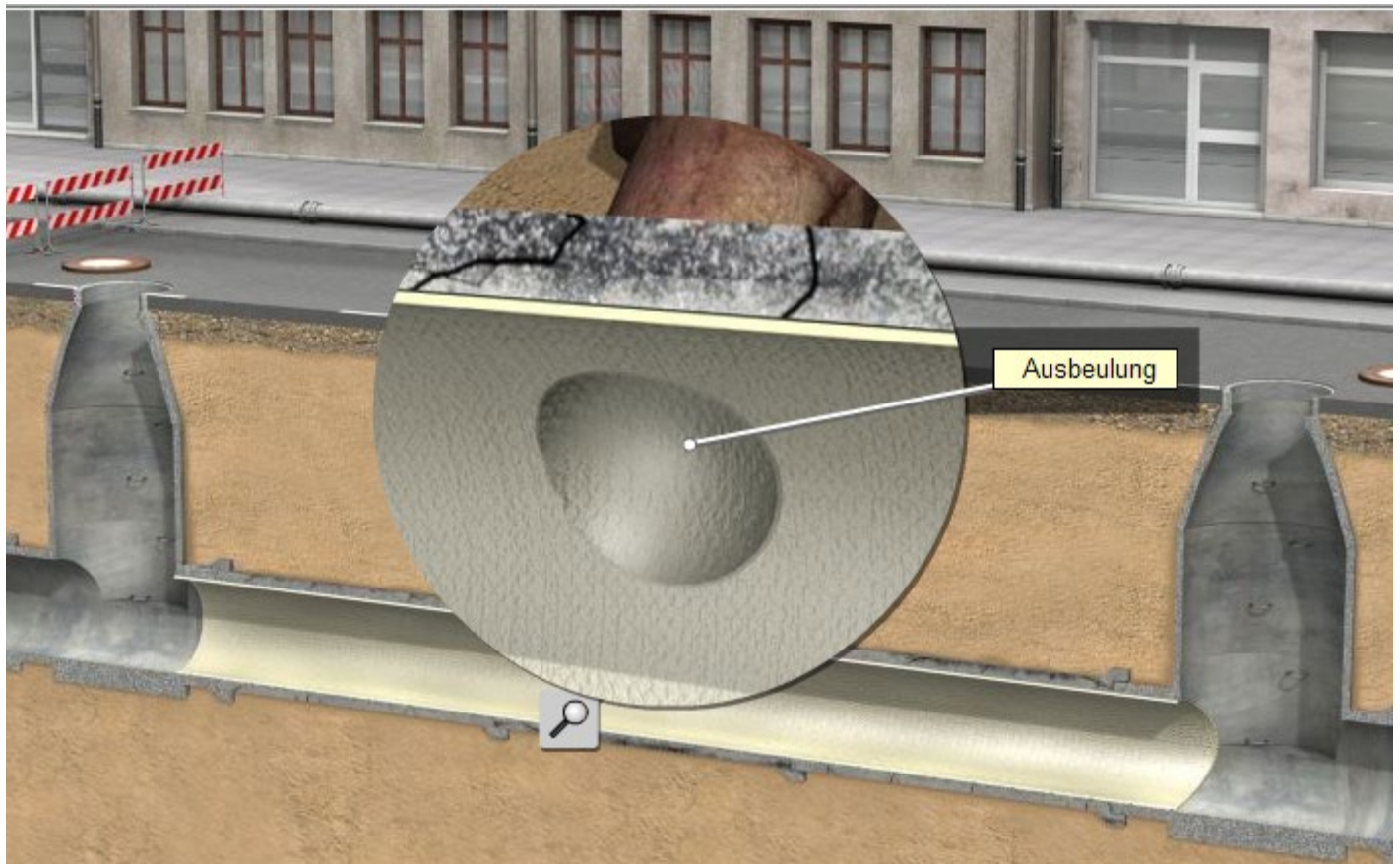
CIPP Installation Process

Flatline connected to end of liner



CIPP Liner is Cured In Place to form a solid hard liner

Liner dimpling at service connection



CIPP Liners

Different resin compositions exist for different applications

- Potable Water
- Force Main Sewers
- Gravity Sewers

CIPP Resins for Potable Water

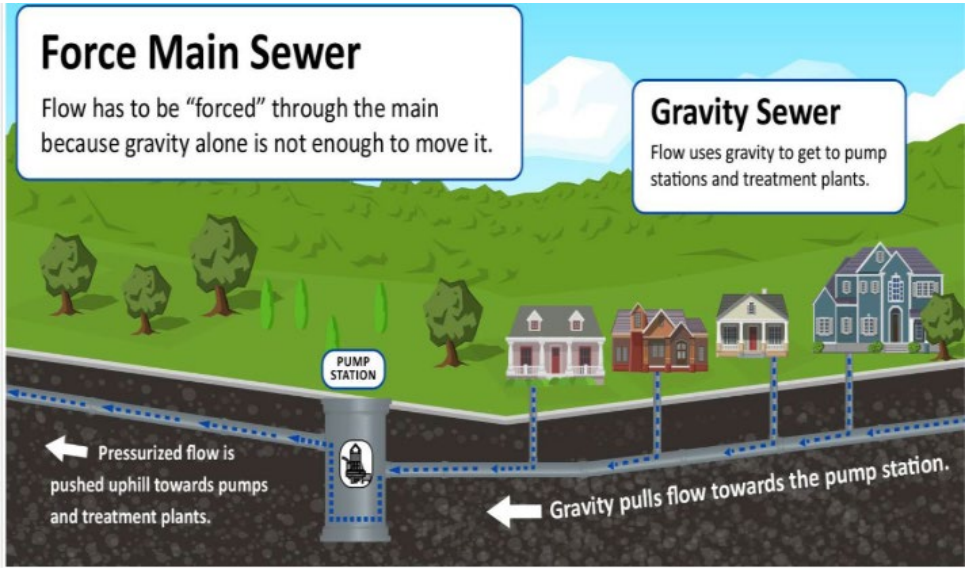
- Must meet very strict NSF/ANSI/CAN 61 drinking water testing requirements
- Mostly 100 percent solids epoxy thermoset resins are used.
- Epoxy resins do not have styrene…..
- Most expensive CIPP resins to buy and use…

CIPP Resins for Force Main Sewers

- Most CIPP products for Forcemain use Vinyl Ester (VE) resins as it has great fatigue resistance to handle the pressure cycles

- VE resins may or may not have styrene…..

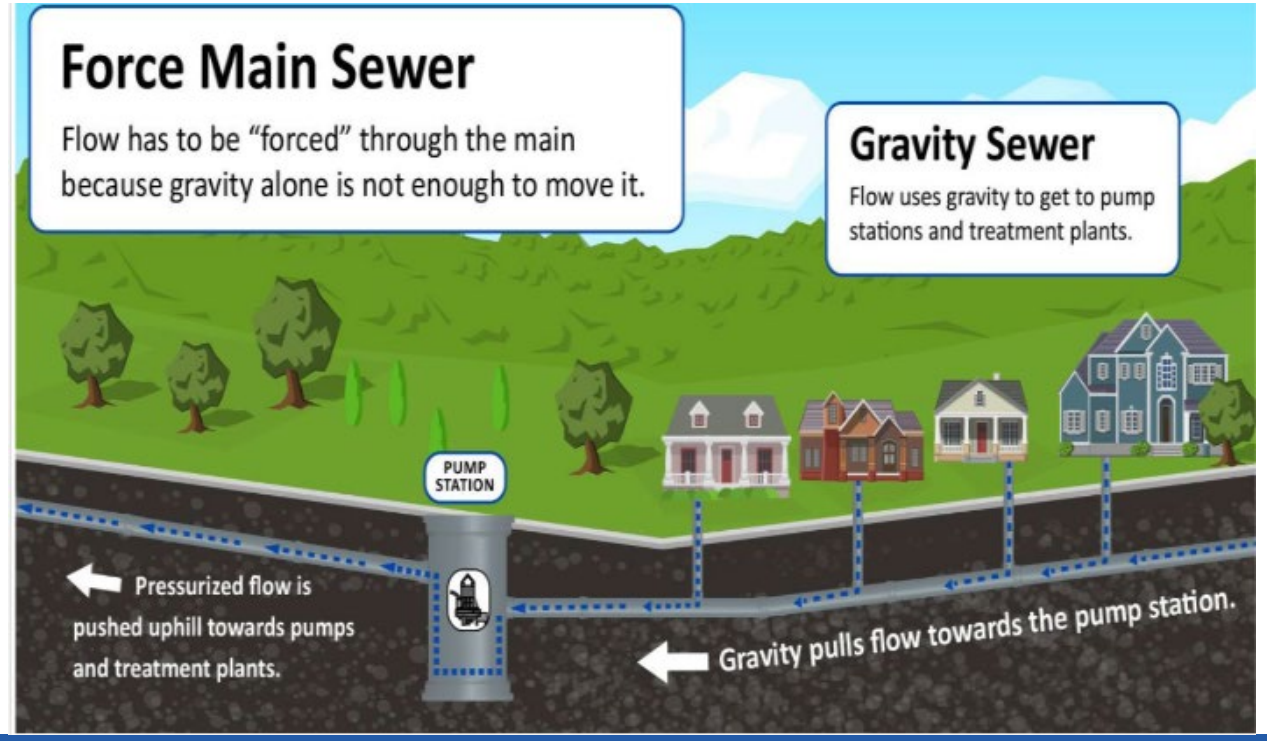
- Second highest cost resins



CIPP Resins for Gravity Sewers

Unsaturated Polyester (UPE) Resin

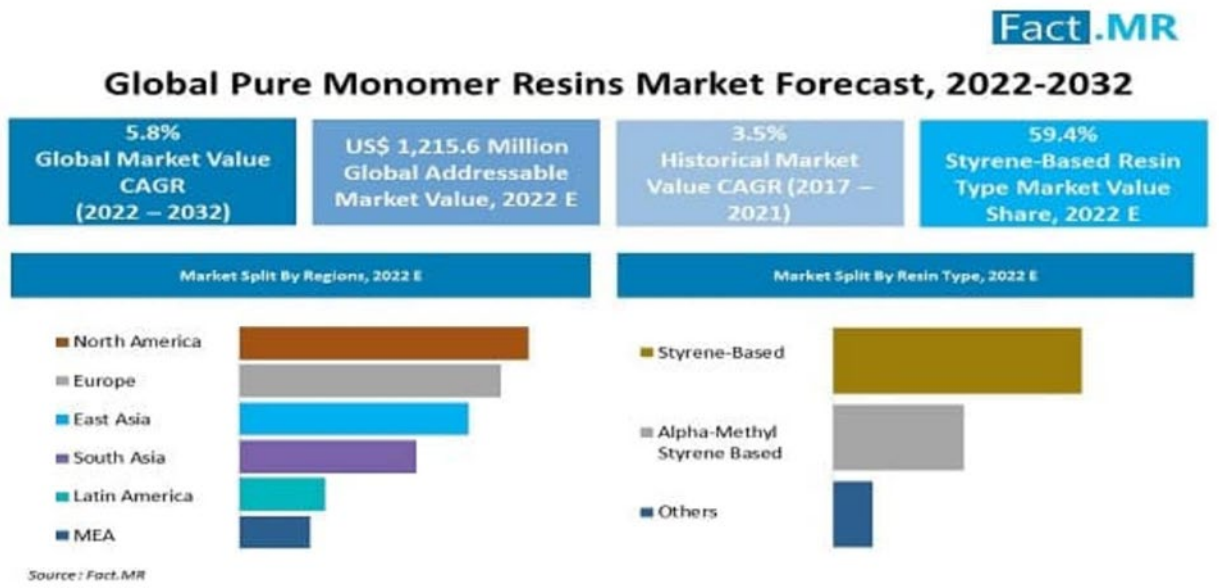
- Styrene is a critical component to cure the liquid resin to form a solid…
- Styrene can be replaced with other VOC's with unknown health effects



Unsaturated Polyester (UPE) Resin

Third largest class of polymer resin that has many industrial applications:

- Sanitary-ware: Bathroom sinks, showers, toilets
- Composite Pipes
- Tanks
- Automotive parts
- Shirt buttons
- Fibreglass boats



CIPP Resins for Gravity Sewers

UPE often has 30 to 40 percent styrene in the liquid resin:

- Provides the low resin viscosity needed to wet out the liner
- Creates excellent consistent mechanical properties
- Stable and consistent cure reaction
- Lowest cost resin and most common

Styrene in CIPP Resins

Styrene in CIPP

- polymer cross linking creates the solid CIPP LINER
- Styrene is used up during the cross-linking process
- Residual styrene will be locked into the solid CIPP plastic liner

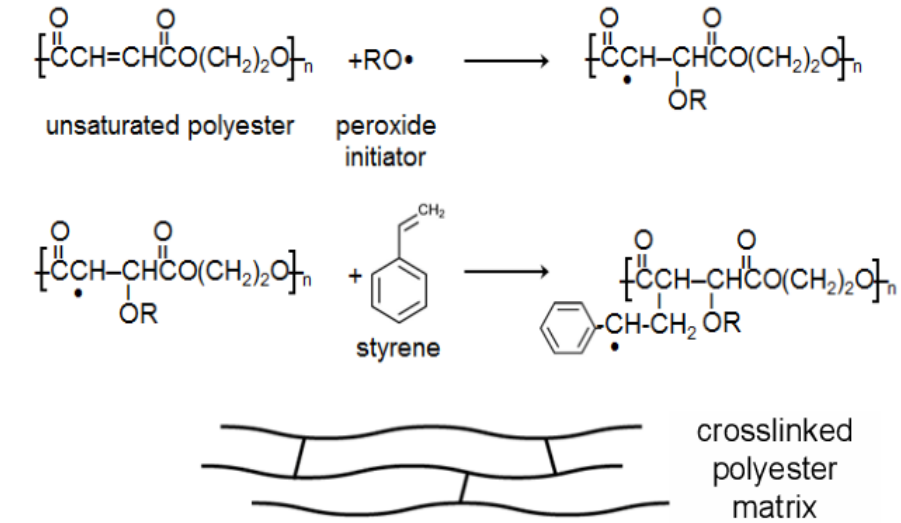
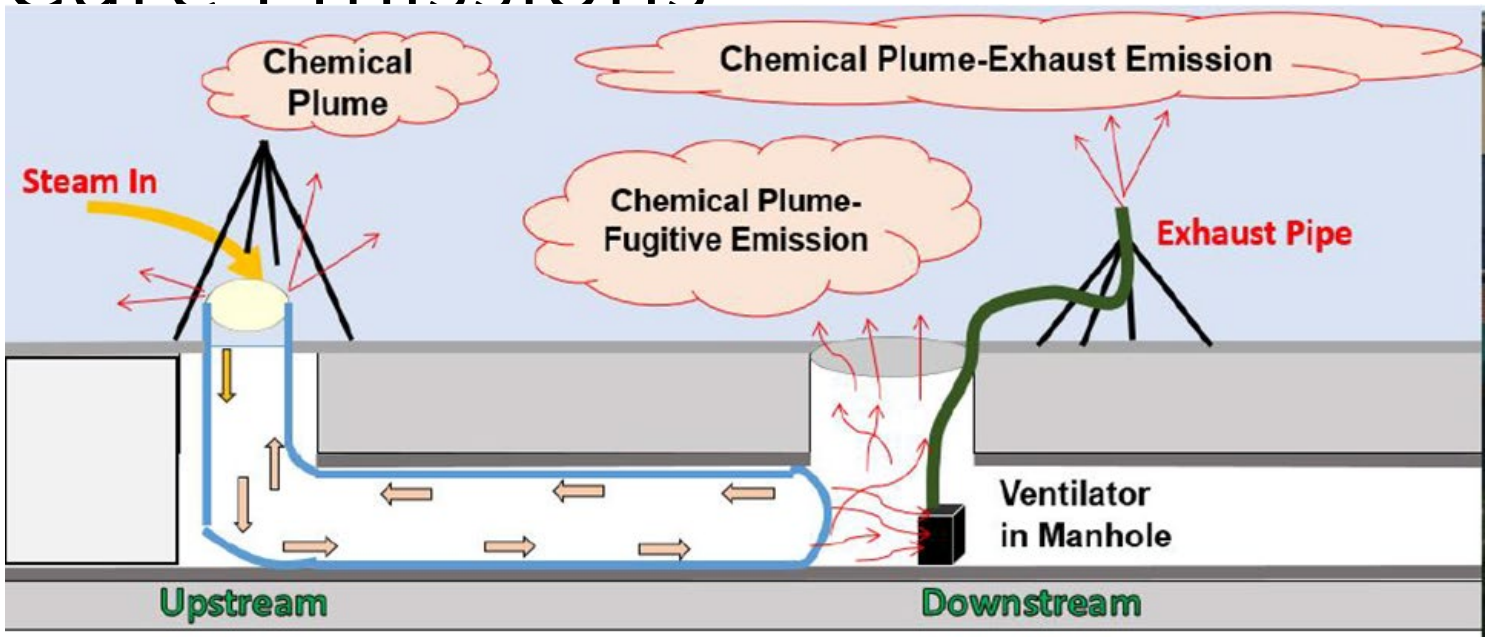


Fig. 1. Crosslink formation within a polyester resin.

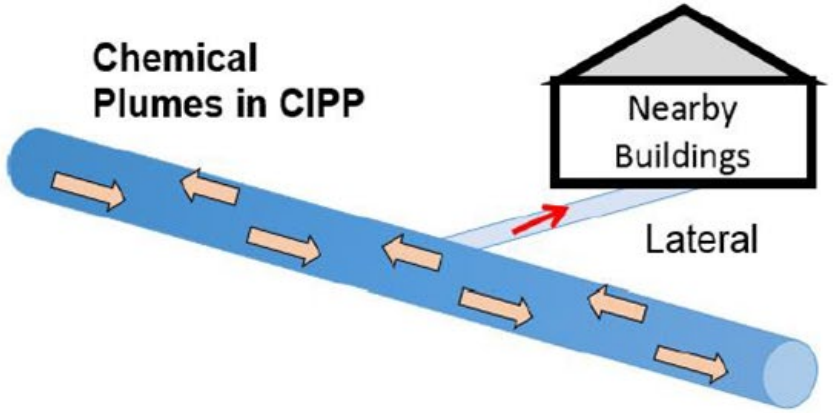
Styrene is the catalyst the creates crossing when energy is added…

- Hot water heat cure
- UV light cure
- **Hot steam cure - has been the focus of health concerns….**

Steam Cure Emissions



Chemical Plumes Generated by CIPP can Escape the Pipe Being Repaired



EPA Styrene Acute Exposure Guideline Limits

AEGL 1 general population, including susceptible individuals,could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the **effects are not disabling and are transient and reversible upon cessation of exposure.**

AEGL 2 general population, including susceptible individuals, could **experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.**

AEGL-3 general population, including susceptible individuals, could **experience life-threatening health effects or death**

Styrene

- Styrene has a distinct odor
- Can smell at **extremely low levels 0.1 PPM**
- National Toxicology Program (NTP) classification: ***Reasonably anticipated to be a humans carcinogen.***

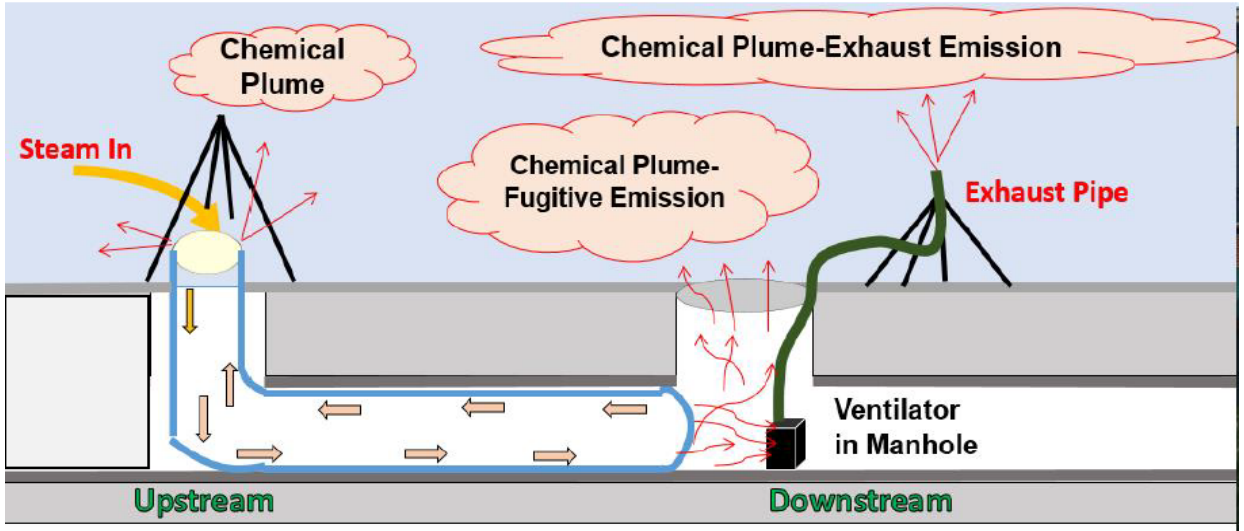
Styrene is the Canary In the Mine

Distinct smell at 0.1 ppm

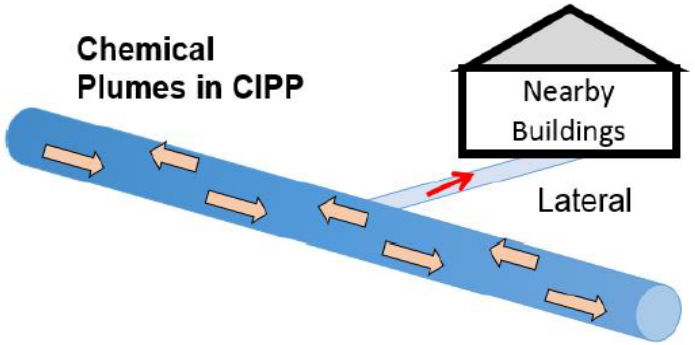
AEGL 1 = 20 ppm
AEGL 2 = 230 ppm for 10 minutes
AEGL 3 = 1900 for 10 minutes

Styrene at or near 20ppm will smell so strong you will want to leave….

CIPP STYRENE Exposure Risks?



Chemical Plumes Generated by CIPP can Escape the Pipe Being Repaired



Liner Curing which is typically less than 120 minutes - NASSCO/TTC Studies

Styrene migration through sewer lateral connections - City of Toronto and Uwaterloo/AEGION Study

A Report on the Monitoring of Styrene in Toronto Homes During the Cured in Place Pipe (CIPP) Process for Sewer Pipe Rehabilitation by Insituform

PROJECT NO. 041-6742

Prepared for
Toronto Works & Emergency Services
2700 Eglinton Avenue West
Toronto, Ontario
M6M 1V1

Prepared by

AirZOne Inc.
2240 Speakman Dr.
Mississauga, Ontario
L5K 1A9

Toronto Study

While the CIPP process is a potential source of styrene, it does not appear to be a significant source of any of the other VOCs that are typically of concern in occupational or indoor air quality studies. Most of the levels of these VOCs were consistent with concentrations measured indoors in several studies in North America conducted over the last 20 years.

Styrene levels in homes were elevated significantly only in homes with dry sewer traps (engineered specifically for this study) during the CIPP installation. The levels, although elevated, were not of health concern.

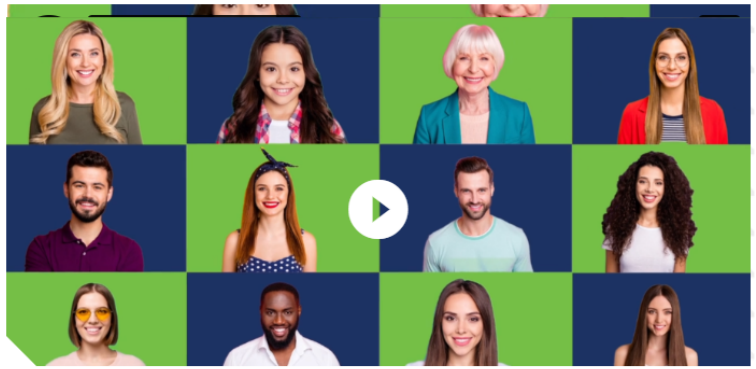
NASSCO.ORG

nassco.org/safety/styrene-safety/?scLang=en

NASSCO > Safety > Styrene Safety

STYRENE SAFETY

Since 2016, when concerns regarding styrene emissions used in the CIPP process first emerged, NASSCO and other industry organizations jumped into action to learn everything they could to keep our workers safe. Now, five years later, and after three phases of independent research, NASSCO has used those findings to continually and transparently update our industry on best practices in the safe use and handling of styrenated resins. Full reports are available below. We encourage all contractors and public agencies to read, understand, and follow the critical safety recommendations found on this simple, one-page document and to utilize NASSCO guidelines and specifications on safe and effective CIPP installations.



INDEPENDENT STUDIES

PHASE 1 CIPP EMISSION STUDY

Published reports have questioned the safety of emissions from the CIPP process when using styrenated resin. NASSCO has gone to great lengths to ensure our workers and communities stay healthy through the funding of objective research. In Phase 1, the Center for Underground Infrastructure Research and Education (CUIRE) found previously published reports to be NON-CONCLUSIVE.

READ THE FULL REPORT

PHASE 2 CIPP EMISSION STUDY

Field studies in a variety of geographic locations – testing various liner dimensions, conditions, and worker exposure – were conducted by the Trenchless Technology Center at Louisiana Tech University (TTC) and resulted in specific recommendations for refrigeration/storage trucks and emission stacks including active air monitoring in trucks, 15-foot perimeters around exhaust manholes, and more.

PHASE 3 CIPP EMISSION STUDY

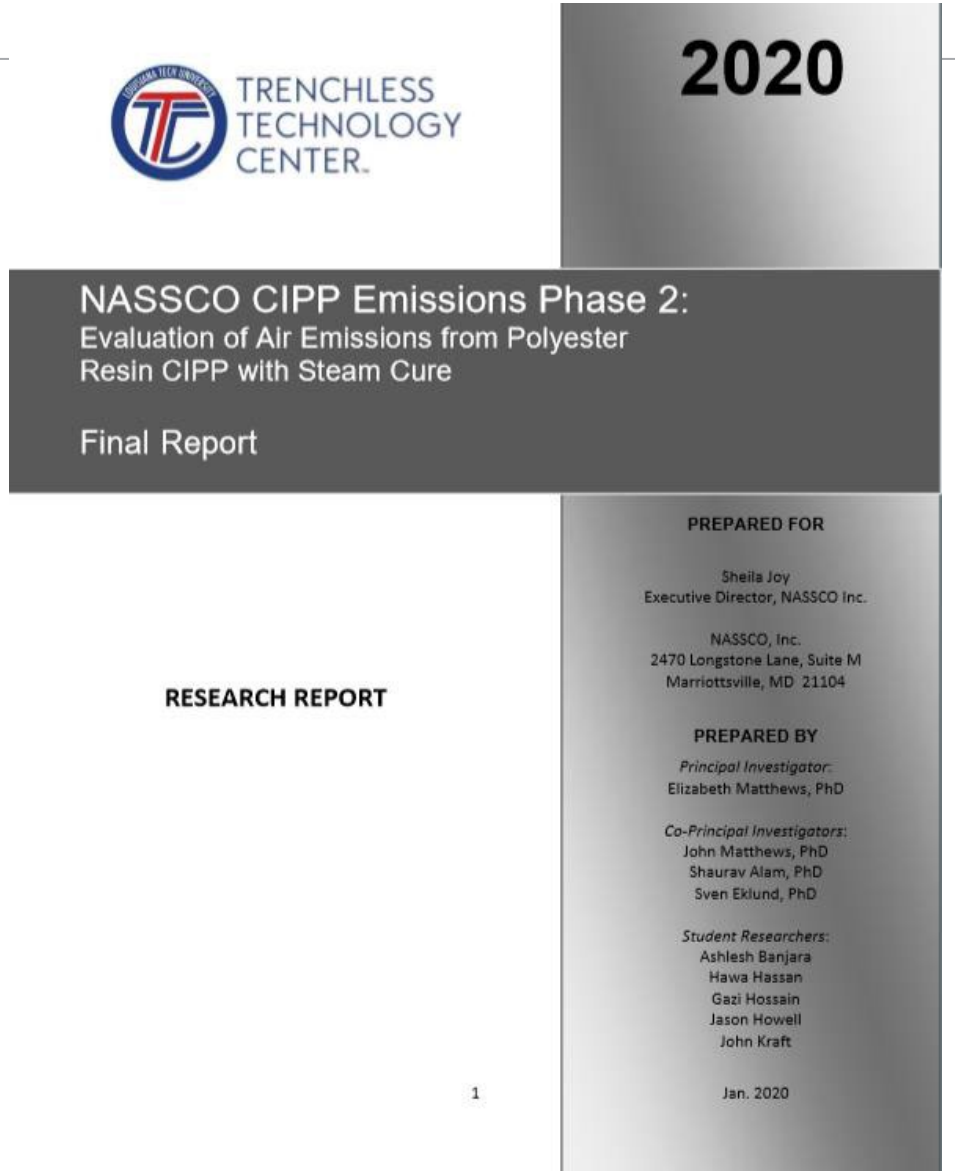
In Phase 3, TTC evaluated the breakthrough time of various coating/resin combinations. The final report suggests that once doors are opened and styrene thresholds reduce to below regulatory agencies' limits for planned exposure time of workers, the truck can safety be entered for that amount of time with minimal PPE. If durations must be exceeded, however, manufacturers could consider using thicker coatings, more impermeable coatings,

- University of Texas Arlington
  - Center for Underground Infrastructure Research and Education (CUIRE)
  - Dr. Mohammad Najafi
- Completed in 2018
  - One year study
- Scope
  - Literature review of previous CIPP emission studies -21 studies
- Results
  - Concluded that previous studies were inconclusive
  - Developed a scope of work to address issues – Phase II study
  - Report is available at NASSCO.org

Phase 2 Emission Study

Recommendations

- Maintain a 15-foot zone around manholes and exhaust points
- Where PPE if within the 15-foot zone for more than 5 minutes
- Need to monitor and study the refrigeration truck for worker safety



Key Findings

- Once doors are opened and styrene thresholds reduce to below regulatory agencies' limits for planned exposure time of workers,
- The truck can safety be entered for that amount of time with minimal PPE.

Journal of Pipeline Systems Engineering and Practice / Volume 14 Issue 1 - February 2023

Editor's Choice Collection

Health Risks Assessment from Cured-in-Place Pipe Lining Fugitive Styrene Emissions in Laterals

Mark A. Knight, M.ASCE; Marios A. Ioannidis; Faten Salim; Tadeusz Górecki Show all authors

Abstract

The aim of this study was to improve the understanding of styrene emissions in sewer laterals, resulting from the installation and steam curing of a resin impregnated cured-in-place-pipe (CIPP) liner, within a sanitary sewer. The study

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Tadeusz Górecki

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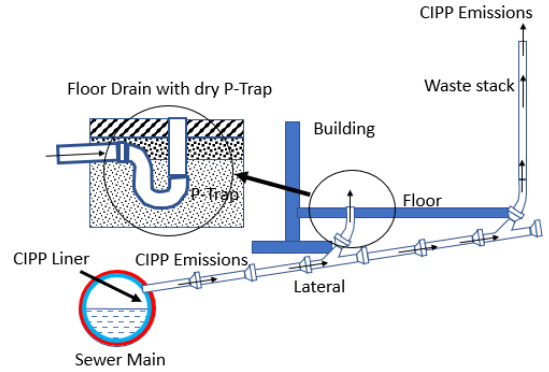
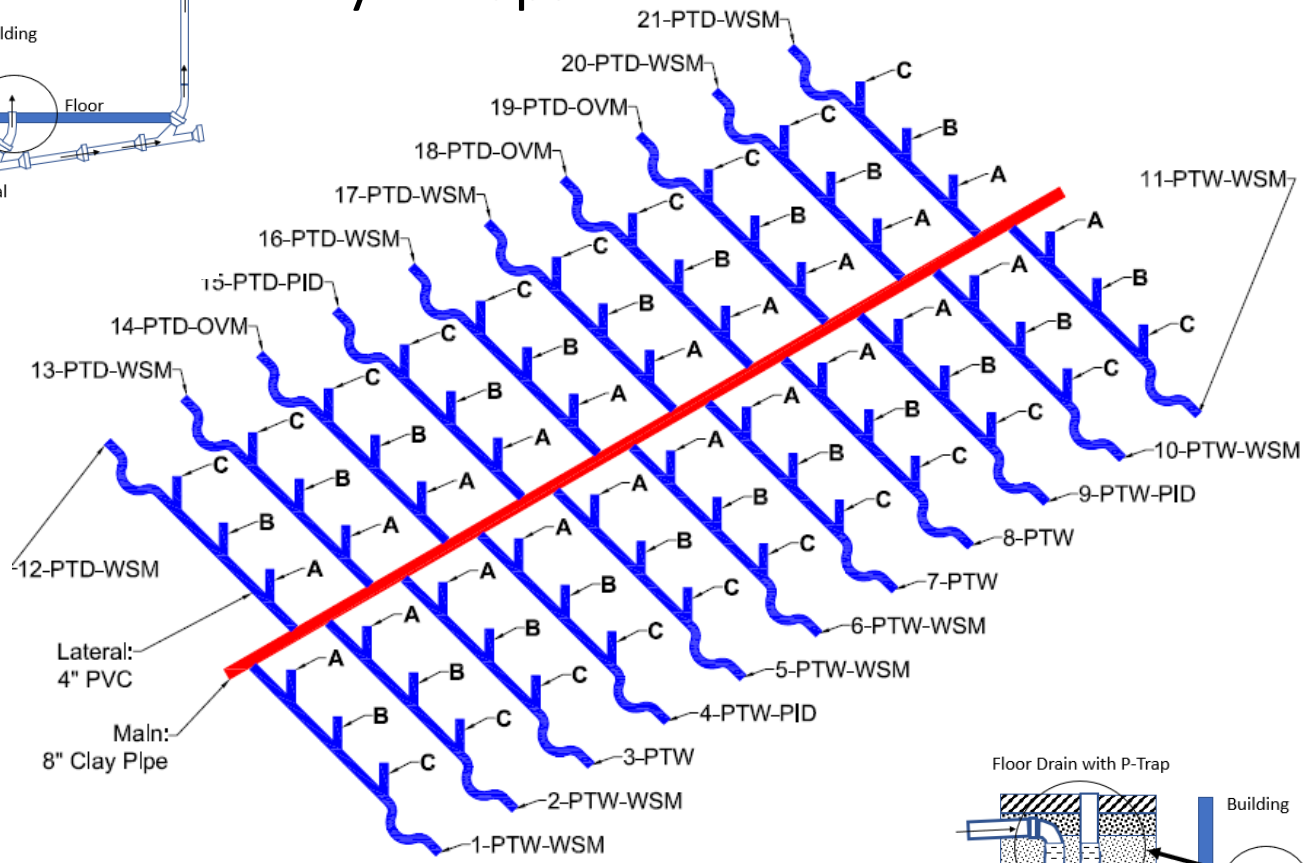
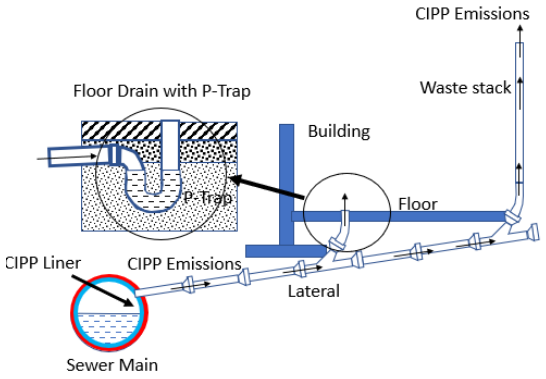
Field Study Design



Dry P-traps



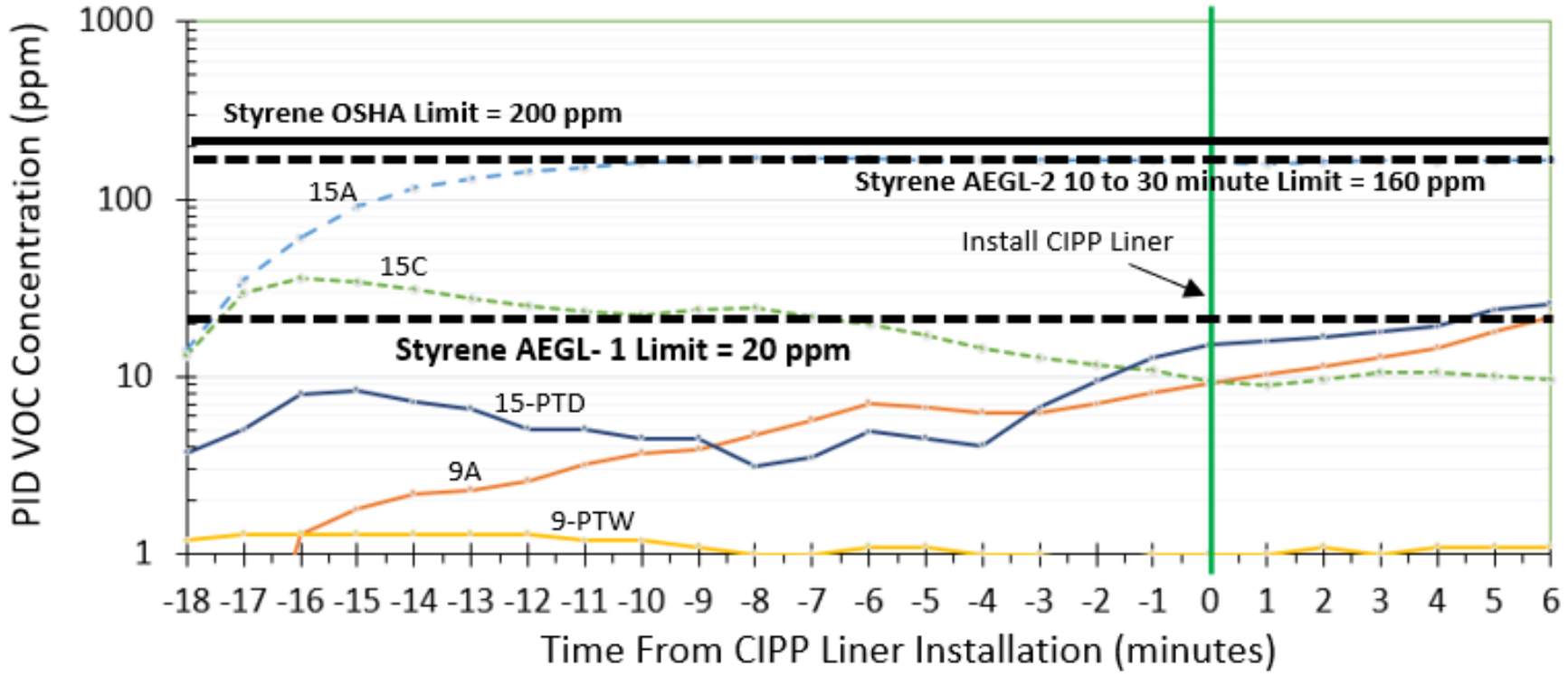
Water filled P-traps



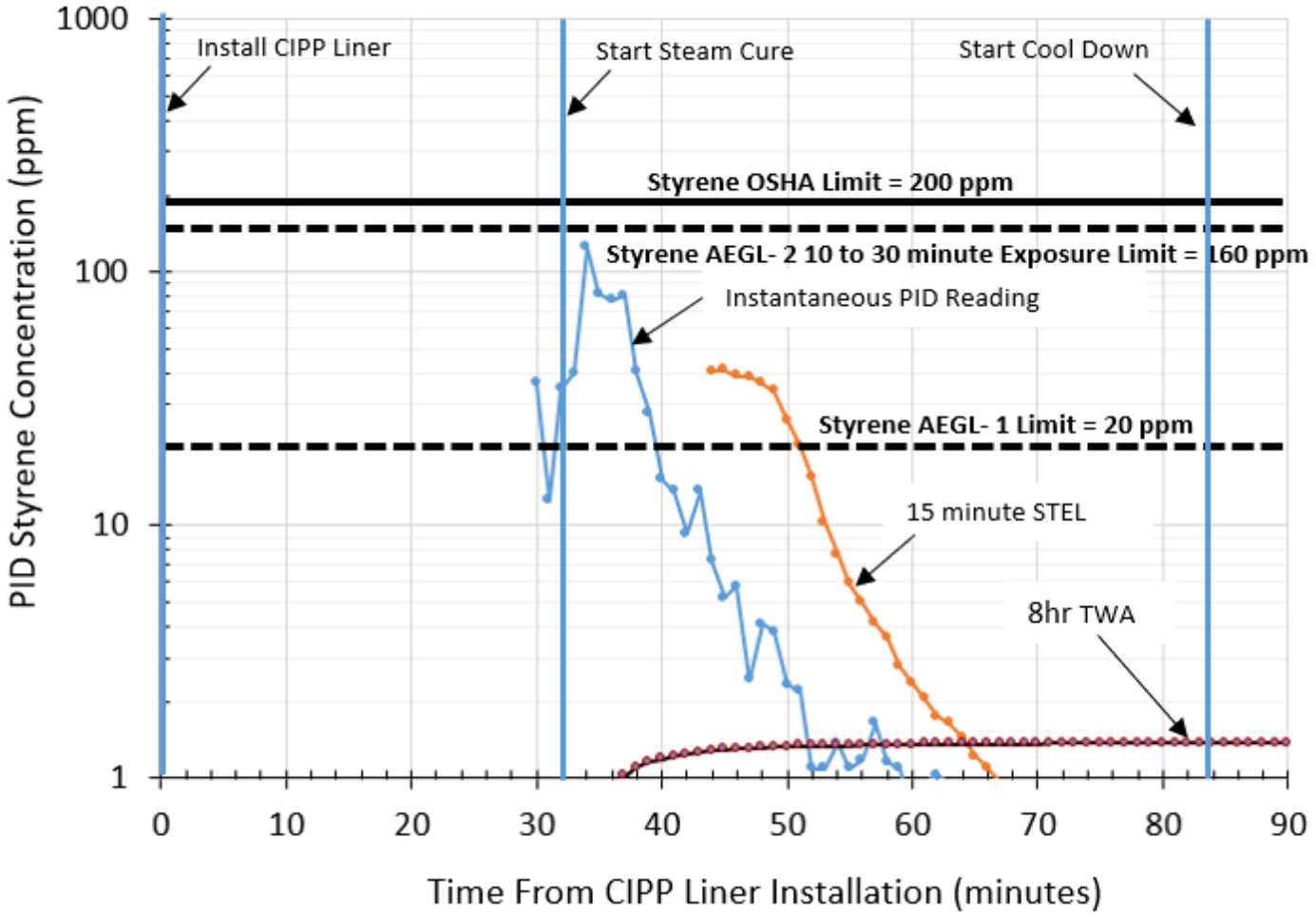
Back Ground Pre-Lining Monitoring

High PID VOC's can exist prior to the liner installation.

These high VOC's are not due to styrene



CIPP Liner Installation and Curing



Styrene release is at the beginning of the Liner Steam Cure and then decrease quickly after 8 minutes

Other Key Findings

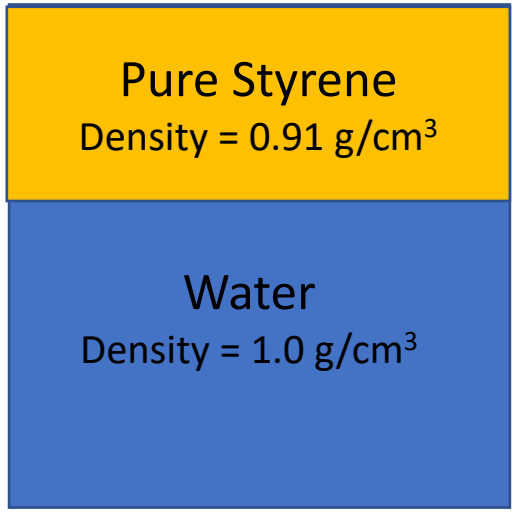
1. Water in a P-Trap will stop styrene from migrating out of the lateral.

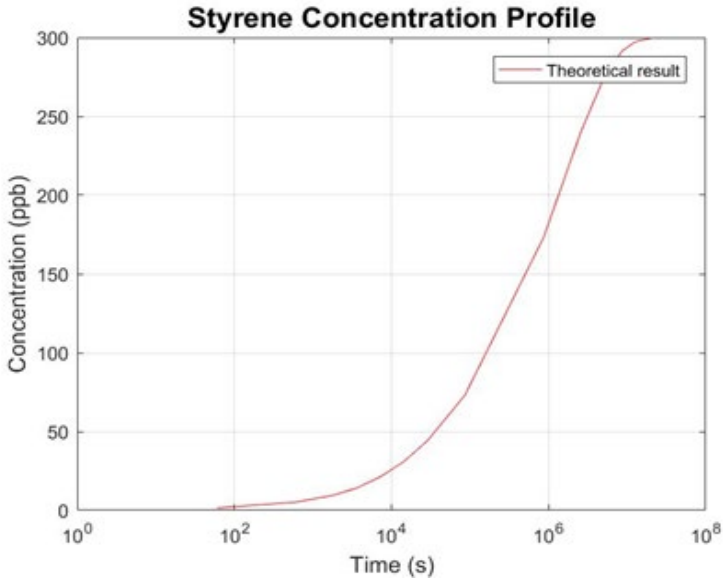
2. Styrene is released early in the CIPP steam cure process.

3. Styrene is the canary in the mine – Alerts you that a plumbing problem exists, and that home residents have an exposure risk to dangerous sewer gases

Styrene Concentration into Water

- If static water and constant source of pure Styrene, then styrene concentration will increase over time to 300 ppb (ug/L)

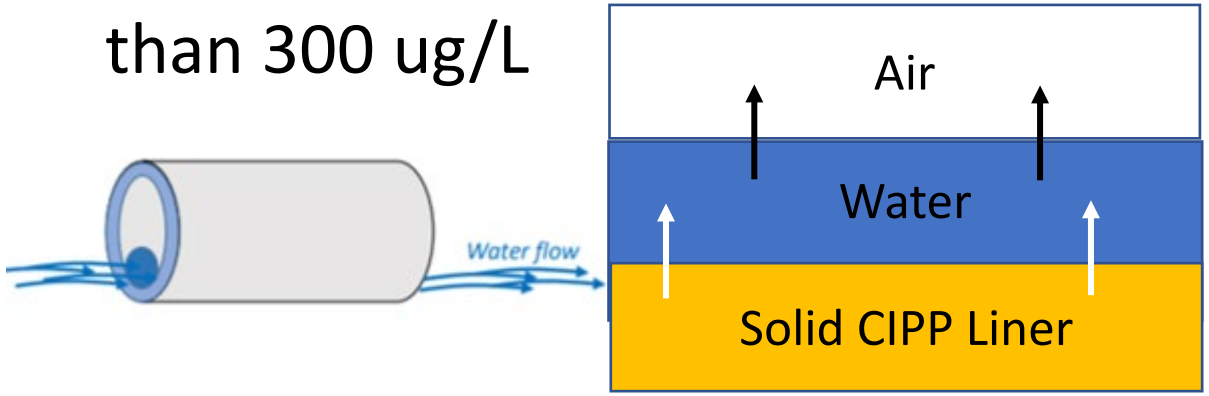




Styrene Leaching Transport into Water

- In a culvert the water is flowing and CIPP Liner is not pure styrene.

- Thus it is not pure styrene with a constant source therefore the max. concentration will be much lower than 300 ug/L



Styrene will partition out of the water into the air

Styrene will leach out of liner into the water

Note: Styrene has a lower in density than water and will want to leave the water

Waste TreatMENT Plants

1. It has been suggested that CIPP styrene releases have impacted treatment plants and killed fish

2. No evidence that this is true

3. Hot water releases not styrene can result in fish kills due to low oxygen levels

4. Phase IV NASSCO Study underway

Conclusions

1. No styrene in potable water CIPP

2. Styrene is released early in the CIPP steam cure process.

3. Styrene is the canary in the mine – Alerts you that a plumbing problem exists, and that home residents have an exposure risk to dangerous sewer gases

4. Exposure risk to home-owners and the public is extremely low

5. CIPP is a cost effective and safe way to renew your aging and deteriorated underground infrastructure.

Have you Heard of this Ban?

"We must stop Iran and North Korea from stockpiling DHMO before it is too late!"
Secretary of State Jim Kerry: United Nations, New York (June 17, 2014)

Coalition to Ban DHMO: http://BanDHMO.org

Ban DHMO: Dihydrogen Monoxide!

"The United States will not weaponize DHMO as long as I am President. You have my solemn word on this.
Beware of Conservative Republicans though. Some of them are pro clean DHMO."
President Barack Obema: Washington, DC (January, 2010)

The Invisible Killer

Dihydrogen monoxide (DHMO) is colorless, odorless, tasteless, and sickens over 4 billion and **kills** over 2 million people every year (United Nations World Health Organization, 2008: www.WHO.Int). Most of these deaths are caused by accidental inhalation of DHMO, but the dangers of dihydrogen monoxide do not end there. Prolonged exposure to its solid form causes severe tissue damage. Symptoms of DHMO ingestion can include excessive sweating and urination, and possibly a bloated feeling, nausea, vomiting and body electrolyte imbalance. For those who have become dependent, DHMO withdrawal means certain death.

"Recreational DHMO illness can have a significant impact on public health not only
because of the severity of the illness but also the number of people who die."
Department of Health, State Of Washington (www2.DOH.WA.Gov)