



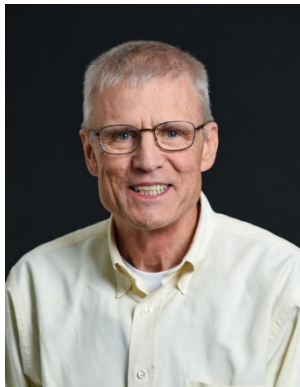
# CIPP and Styrene Emissions: Best Practices

Presented by Members of NASSCO's Technical Advisory Council and  
Health and Safety Committee





## CIPP and Styrene Emissions: Where We've Been; Where We're Headed



Lynn Osborn, P.E.

Owner, LEO Consulting

Member of NASSCO's Technical Advisory Council





## Defining the Challenge

### Concerns with CIPP emissions

- Specifically steam-cured CIPP
- Volatile organic compounds (VOCs)
  - Styrene

### NASSCO formed an industry-wide workgroup

### The workgroup recommended

- NASSCO commission a multiphase, third-party investigation
- NASSCO agreed and the work began in late 2017





## CIPP Technology

### Method

- Pipeline rehabilitation
- A tube is saturated with resin, inserted into a pipe and cured to form a pipe-within-a-pipe

### Tube

- Thermoplastic coating
- Fabric
- Reinforced or unreinforced







## CIPP Technology

### Resins

- Polyester (styrene)
- Vinyl ester (styrene)
- Epoxy (no styrene)
- Styrene free vinyl ester

### Curing by

- Heat, light or ambient temperatures

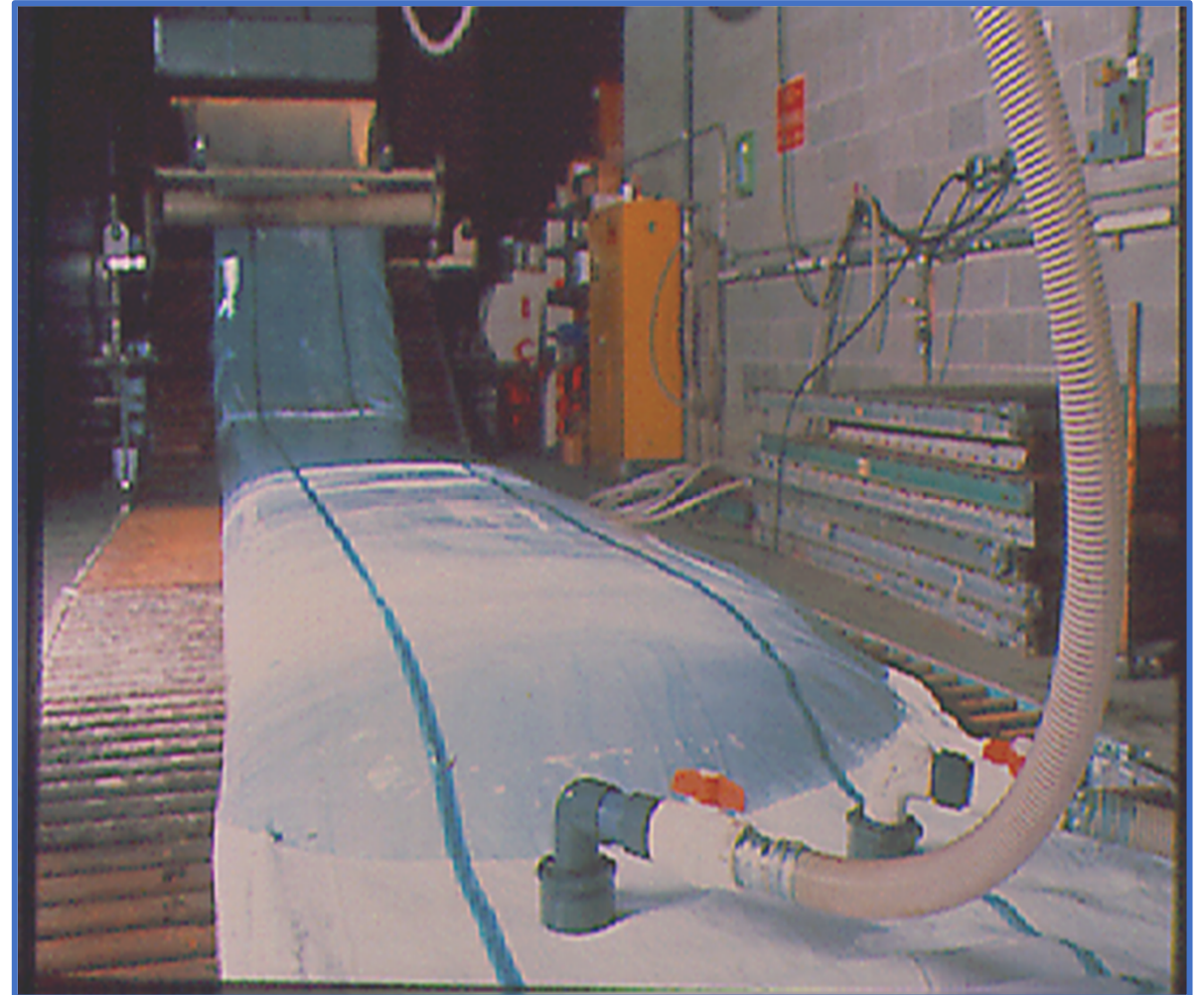




## CIPP Technology

### Styrenated Resins

- Used for 50 years with CIPP
- Can contain up to 40% styrene
- Most of the styrene becomes part of the CIPP
- Low odor threshold ( $\approx 0.1$  ppm)







## Phase 1 Emission Study



## University of Texas – Arlington

- Center for Underground Infrastructure Research & Education (CUIRE)
- Dr. Mohammad Najafi

## Completed in 2018

## Consisted of

- Literature review of previous CIPP emission studies – 21 studies
- A scope of work for Phase 2 study

## CUIRE Study Finds CIPP Reports Non-Conclusive



NASSCO



The University of Texas at Arlington Research Team Found Existing Literature on Chemical Emissions of Styrenated CIPP Non-conclusive

(Arlington, Texas, April 30, 2018) -- A four-month study on the review of published literature pertaining to chemical emissions of styrene-based resin used in the cured-in-place pipe (CIPP) process found that existing studies do not adequately capture worker exposures or levels in the surrounding areas to which workers or citizens may be exposed. The study started last December and completed on April 6, 2018 by researchers at the University of Texas at Arlington (UTA)'s Center for Underground Infrastructure Research and Education (CUIRE), and the Institute for Underground Infrastructure (IKT) in Germany. The team determined that spatial variation of concentrations, and variations in concentrations with different meteorological conditions, are not well determined.

Most of the steam-cure studies captured temporal variation in emissions, by measuring concentrations before, during and after curing. The studies were less complete in capturing spatial variation in concentrations. Most studies measured styrene around the termination manhole, or inside the manhole or sewer pipe itself. Maximum values at the outlet point and inside the terminal manhole ranged from 20 to 1,070 ppm, which are levels that exceed some exposure limits. However, since workers and certainly the public should not typically enter or stand directly at the termination manhole in the exhaust plume, this information is not very helpful.

At the steam-cured sites, additional field measurements of styrene concentrations surrounding the terminal manhole are needed. Only four of the steam-cure studies measured concentrations at locations surrounding the terminal manhole (at least 3 ft. (1 m) away), not in the manhole itself or in the exhaust plume. On one project, employees walked the construction area periodically but spent most of the time in their work trucks due to the cold weather. Hence, these measurements were likely not typical of worker exposures. Additional worker exposure data should be collected to capture variability in source emission rate, meteorological conditions, and the worker's location with respect to the terminal manhole.

Atmospheric concentrations of compounds are functions of the source emission rate, meteorological conditions, and the receptor location. Since concentrations are expected to vary as a function of distance from the manhole, measuring at few locations gives an incomplete picture. In addition, concentrations are expected to vary with wind speed and wind direction, so measuring on one day does not capture what levels may be under differing meteorological conditions.

These earlier studies also do not adequately capture variations in emission rates from different kinds of pipes (different diameters, lengths, etc.). The overall results of the project at UTA/CUIRE/IKT indicated that the 21 papers reviewed have questionable methodologies, and therefore, the results presented are not conclusive. The researchers recommended additional sampling and data evaluation and analysis as a second phase of this study, as proposed in their final report.

### Project Team

Dr. Mo Najafi supervised this project. Dr. Najafi serves as Director of the Center for Underground Infrastructure Research and Education at



## Phase 1 Emission Study



### Results

- Concluded that previous studies were inconclusive
  - Quantify VOCs
  - Health effects
- Developed a scope of work to address issues
- Good list of previous studies/papers addressing emissions from CIPP job sites
- Report available at [NASSCO.org](https://nassco.org)

## CUIRE Study Finds CIPP Reports Non-Conclusive



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## Phase 2 Emission Study



2020

### Louisiana Tech University

- Trenchless Technology Center (TTC)
- Dr. Elizabeth Matthews
- U.S. Army Corps of Engineers – Engineer Research and Development Center (ERDC)

Quantified worker and public exposure to steam-cured CIPP emissions

NASSCO CIPP Emissions Phase 2:  
Evaluation of Air Emissions from Polyester Resin CIPP with Steam Cure  
  
Final Report

#### PREPARED FOR

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Executive Director, NASSCO Inc.

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Marriottsville, MD 21104

#### PREPARED BY

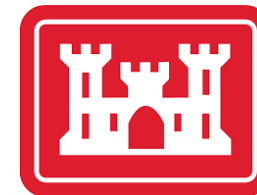
*Principal Investigator:*  
Elizabeth Matthews, PhD

*Co-Principal Investigators:*  
John Matthews, PhD  
Shaurav Alam, PhD  
Sven Eklund, PhD

*Student Researchers:*  
Ashlesh Banjara  
Hawa Hassan  
Gazi Hossain  
Jason Howell  
John Kraft

Jan. 2020

#### RESEARCH REPORT



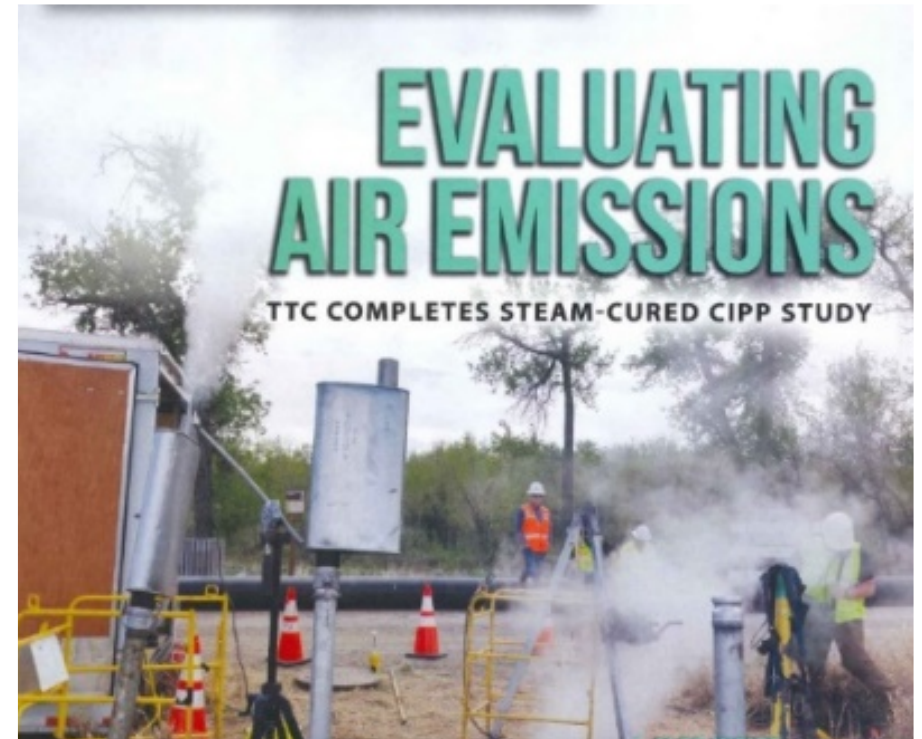


## Phase 2 Emission Study



Testing and samples collected at nine CIPP jobsites

- Varying diameters, lengths, weather conditions and geographic location
- Modeled air dispersion of emissions
- Evaluated potential health risks to workers and public
- Report available at [NASSCO.org](https://www.nassco.org)







## Phase 2 Emission Study

### Results

- Styrene was the only VOC at concentrations with the potential to pose health risks
- Two locations on steam-cured CIPP jobsites at risk to styrene exposure:
  - Exhaust discharge
  - Liner transport truck





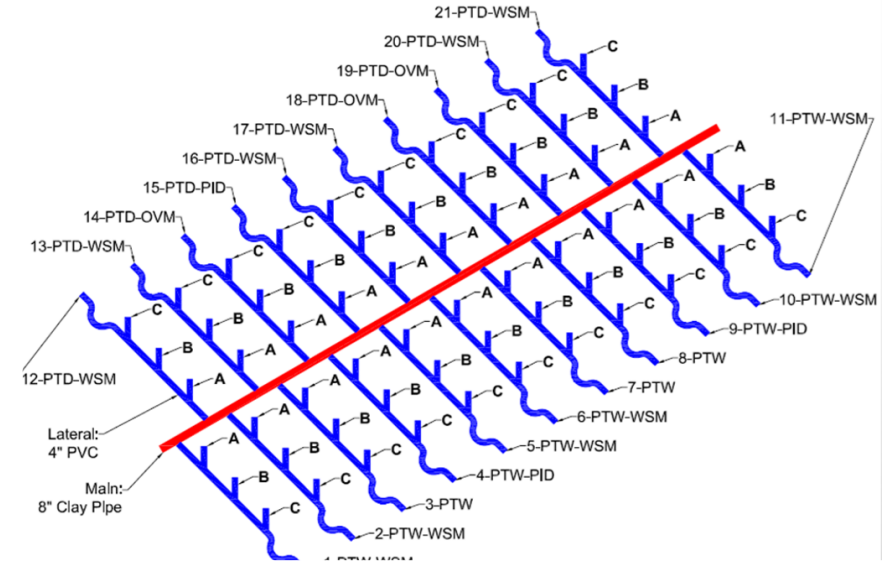
## VOCs in Laterals



University of Waterloo & Aegion

- Centre for Advancement of Trenchless Technologies (CATT)
- Completed in 2020
- Dr. Mark Knight

## FIELD STUDY DESIGN



VOCs in laterals with wet & dry P-traps

Evaluated VOC measurement equipment

Soon to be published in a peer-reviewed, scientific journal





## NASSCO CIPP Installation Recommendations

### Styrenated Resins Safety

- Exhaust discharge
  - 15-foot radius perimeter
  - Stack minimum 6 feet high
  - Inside perimeter < 5 minutes
  - Over 5 minutes, proper PPE
- Protect the public by maintaining a work zone perimeter around the job site
- Styrene Guideline
  - Contains best practices for installing CIPP with styrene-based resins



### Guideline for the Safe Use and Handling of Styrene-Based Resins in Cured-in-Place Pipe



October 2020

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#### 2008 & 2009 Editions

Norman E. (Ed) Campbell- Principal Author- National Liner  
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## NASSCO CIPP Installation Recommendations

### Styrenated Resins Safety

- Liner transport truck
  - Wear proper PPE when opening door and entering truck
- Styrene Guideline
- Steam-cured CIPP should be acceptable and safe if installed properly



### Guideline for the Safe Use and Handling of Styrene-Based Resins in Cured-in-Place Pipe



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## Phase 3 Emission Study



Further work regarding the liner transport truck is ongoing at TTC

- Dr. John Matthews

Further define

- Dispersion of styrene from the liner transport truck
- Correlate site-specific liner information with styrene concentrations





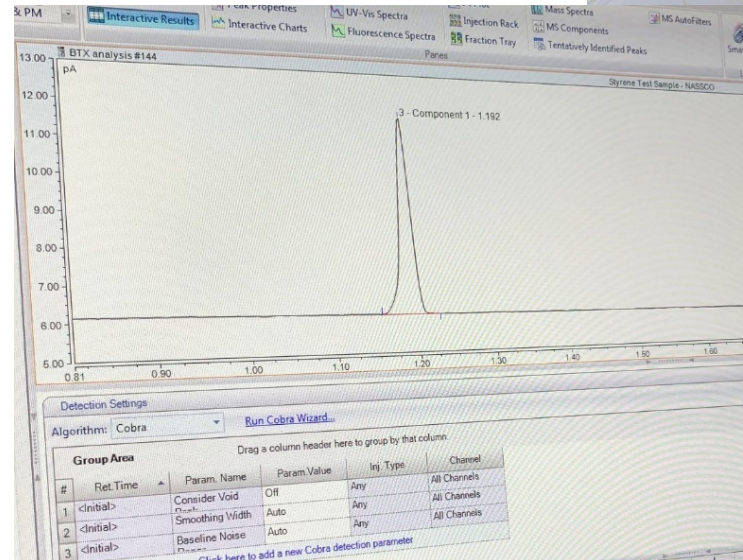
## Phase 3 Emission Study



Via the following methods

- Styrene breakthrough studies through common thermoplastic coatings
- Lab scale simulations and modeling
- Field testing with loaded refrigerated trucks

Update Styrene Guideline document







## Possible Remediation Methods



Kaleel Rahaim

Principal Engineer, CIPP Consulting

Member of NASSCO's Technical Advisory Council



## Defining the Challenge

### Concerns with CIPP emissions

- Steam-cured CIPP
- Hot Water-cured CIPP
- Volatile organic compounds (VOCs)
- Styrene

### Methods for reducing emissions

- Must be effective
- Must be economical
- Must occupy a small footprint
- Must be portable







## Available Technologies

- Chemical Scrubbers
- Activated Carbon Units
- Catalytic Conversion Units
- Biological Scrubbers
- Thermal Oxidation
- Combined Technologies





## Removal Objectives

- Remove Styrene to levels below regulated levels
- Units for removal of styrene from air and/or water
- Use equipment that is effective
- Use equipment that is economical
- Use equipment that is site accessible







## Scrubber Units

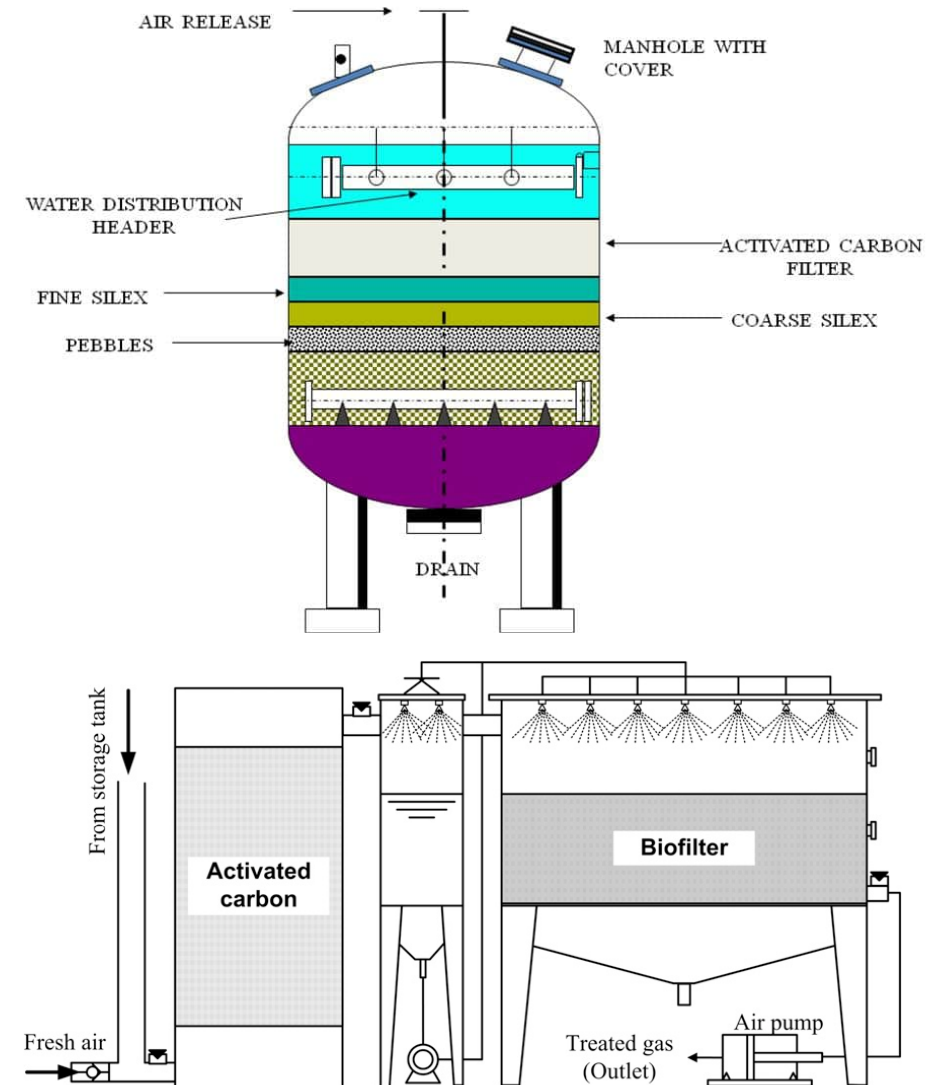
- Most used are packed bed scrubbers
- Generally large and bulky
- Economical to use – water is the scrubbing media
- Must have an easily accessible water source
- Difficult to move around, but may be made portable





## Activated Carbon Units

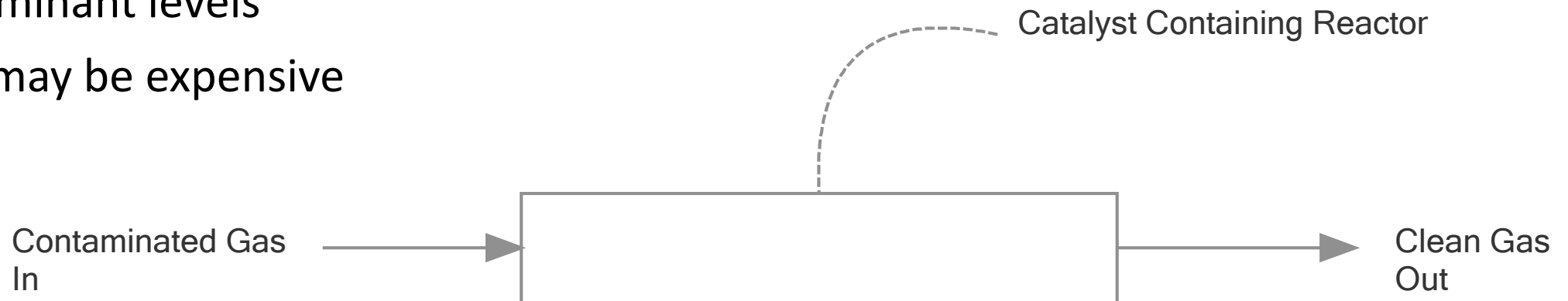
- Carbon must be replaced frequently for heavier concentrations of contaminants
- Units may be compact and portable
- Removes levels of contaminants to acceptable range
- May be used for air or water treatment
- Moderately expensive to use
- Air stream must be cooled and dehumidified





## Catalytic Conversion Units

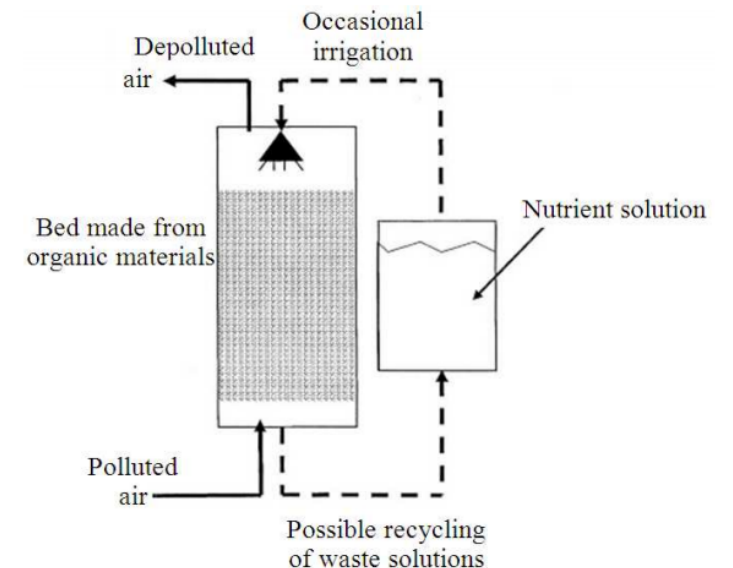
- The most portable of available technologies
- Easy to use
- Removes styrene to acceptable levels
- Newer Technology – not fully developed
- Catalyst needs replacement – frequency depends on contaminant levels
- Catalyst may be expensive





## Biological Treatment Units

- Difficult to be made portable
- Microbes need replacement
- Replacement frequency depends on contaminant levels
- Economical to use
- Relatively expensive to purchase



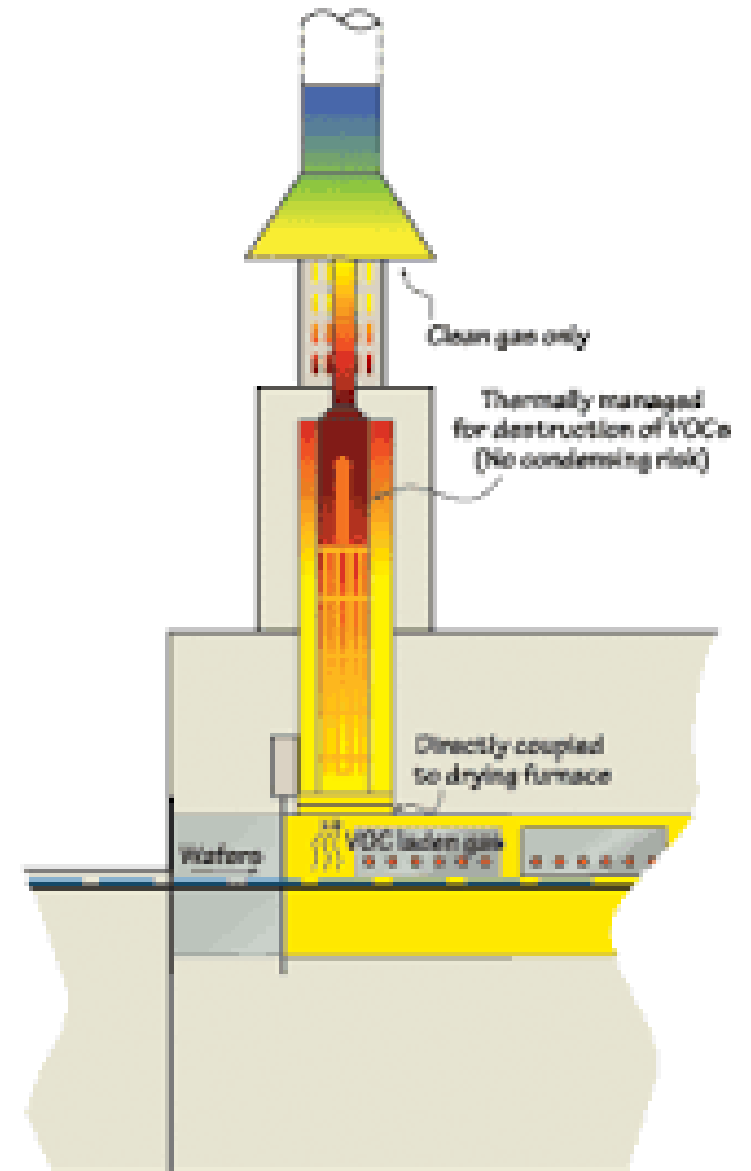
Aydin Berenjian, <sup>1</sup>Natalie Chan and <sup>2</sup>Hoda Jafarizadeh Malmiri, Volatile Organic Compounds Removal Methods: A Review, American Journal of Biochemistry and Biotechnology, 2012, 8 (4), 220-229





## Thermal Oxidizers

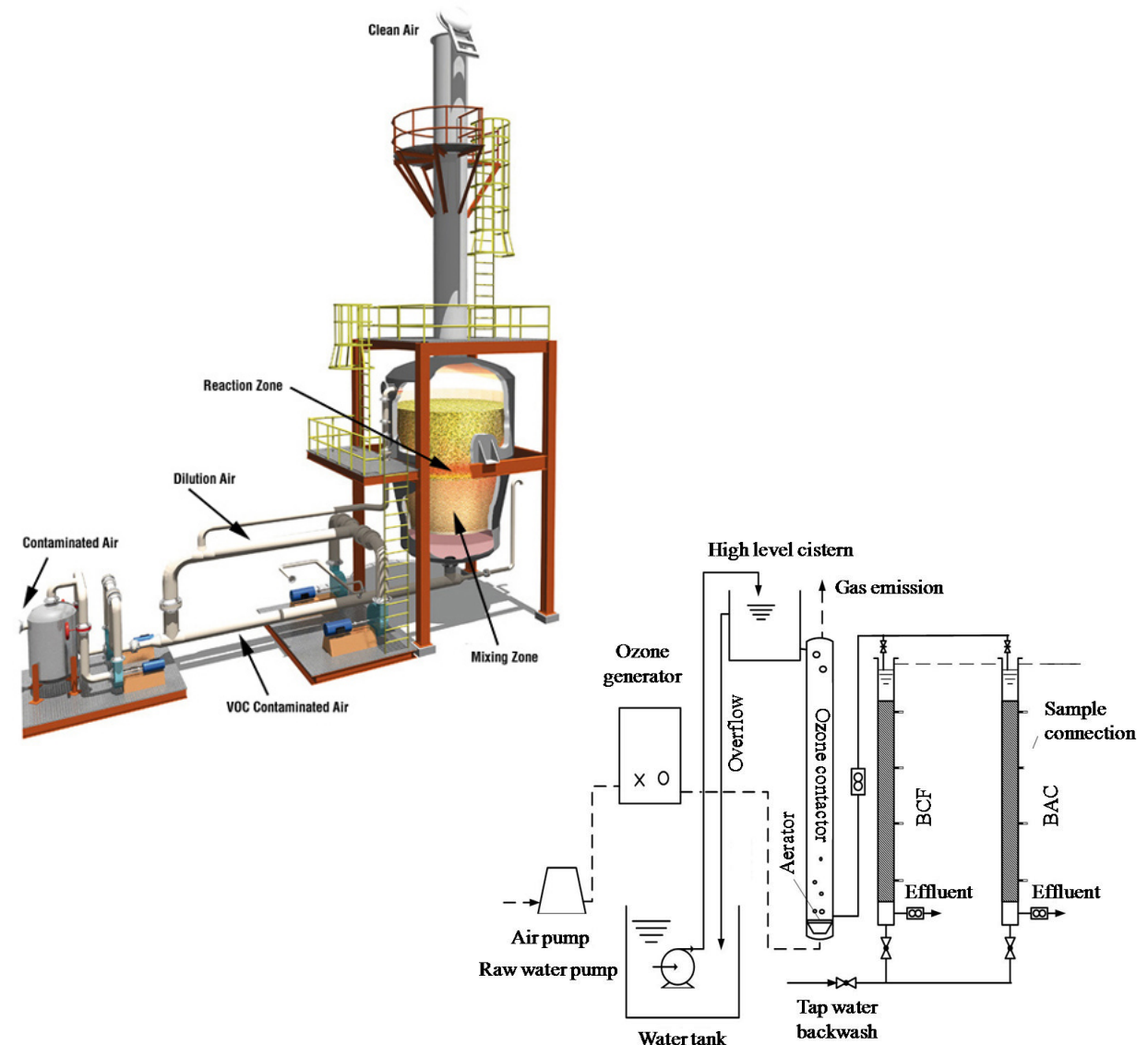
- Bulky – difficult to make portable
- Needs frequent calibration
- Subject to have high maintenance costs
- Reduces styrene levels to acceptable range





## Technology Combinations

- Provides the possibility of more effective removal
- Opportunities to reduce costs
- Possibly increased maintenance costs
- May be made compact and portable







## Cost Comparisons

Technology	Estimated Costs
Wet Scrubber	\$95,000
Activated Carbon	\$15,000 +*
Biological Scrubber	\$120,000
Catalytic Converter	\$35,000
Thermal Oxidizer	\$200,000 +

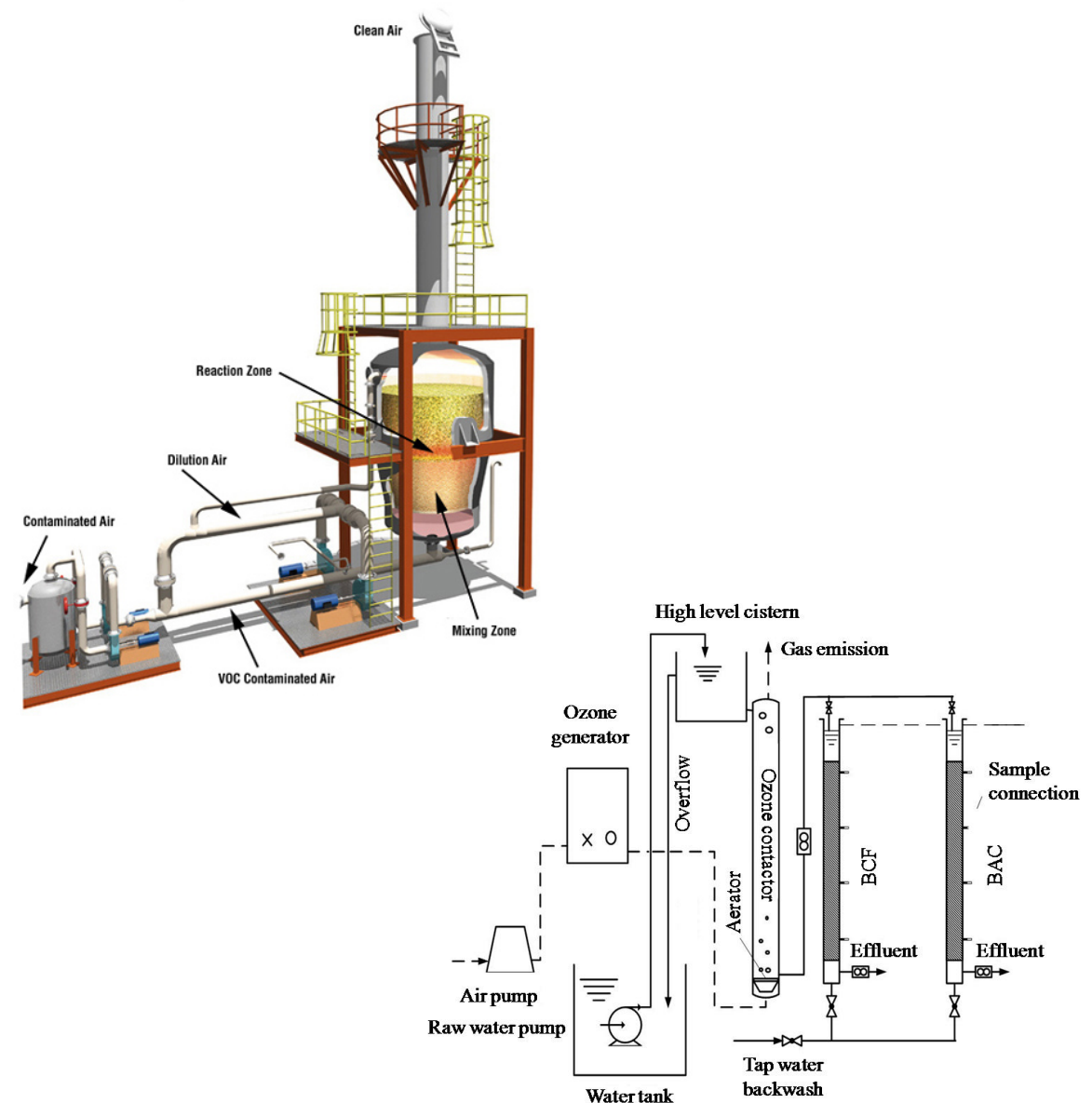
\*Possible high carbon replacement costs





## Conclusions

- Today's most commonly used method is Activated Carbon
- The newest technologies of catalytic conversion and a combination of activated carbon and bioremediation may prove more effective and more economical
- These options may be made compact and portable





## Summary

- Several available technologies
- Limited number of proven technologies commercially for this process
- Several potentially economical technologies



**NASSCO**



## Research Findings, Safety Recommendations and PID Requirements



Dennis Pivin, CSP, CHST, CIT

Vice President, Environmental Industrial Hygiene, Safety and  
Security, Aegion

Co-Chair, NASSCO Health and Safety Committee



Which of the following does NOT contain styrene?

1. Food packaging
2. Corvette
3. Strawberry
4. Toilet paper



# What's that odor?

And why can I smell it in my house?

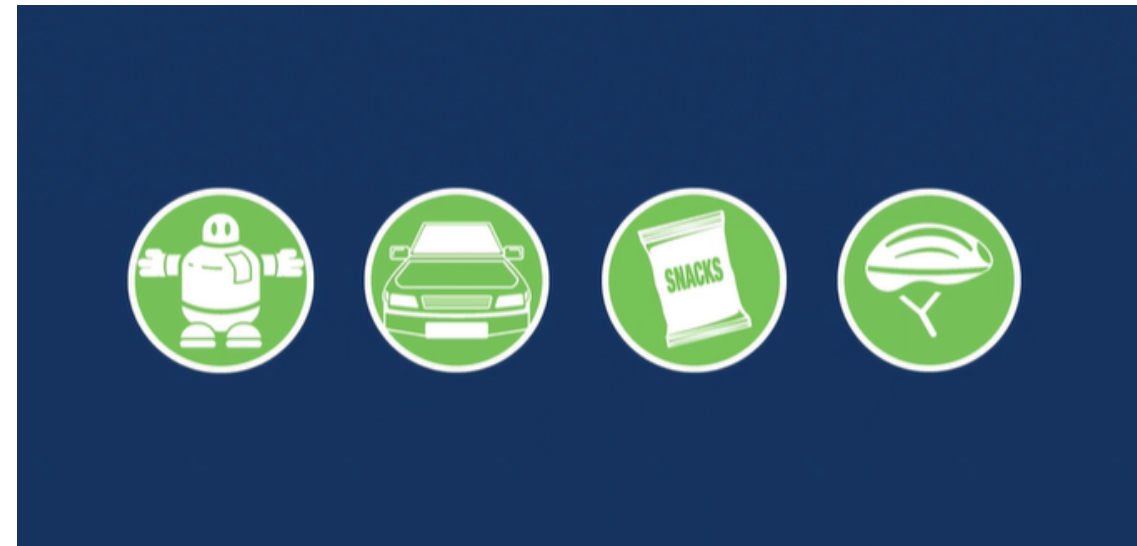
- Styrene has a distinct glue-like odor
- Detected at extremely low levels of 0.1 ppm





## Common Question: “Do I come in contact with styrene?”

- People are exposed to styrene every day in tiny amounts that may occur naturally in items such as tobacco smoke and food.
- Recognized by its distinctive odor – used in products like paints, patching materials and resins.





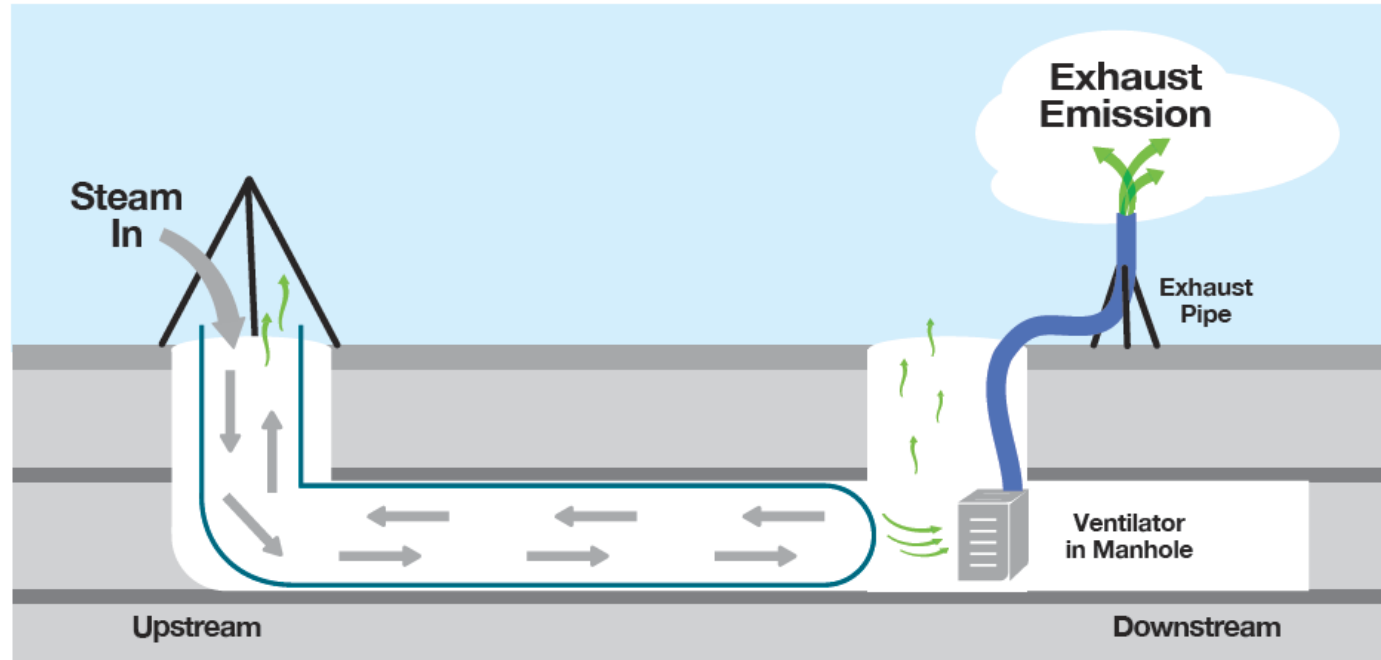
## Styrene and CIPP Liners

- Sewer CIPP liners typically use Polyester or Vinyl Ester resins.
- Uncured Polyester resin can contain 30 to 40% percent styrene that is a reactive diluent.
- Most of the styrene is locked into the cured CIPP liner however some styrene can be released during and post liner cure.
- Styrene has a low odor threshold so you can smell low concentrations.

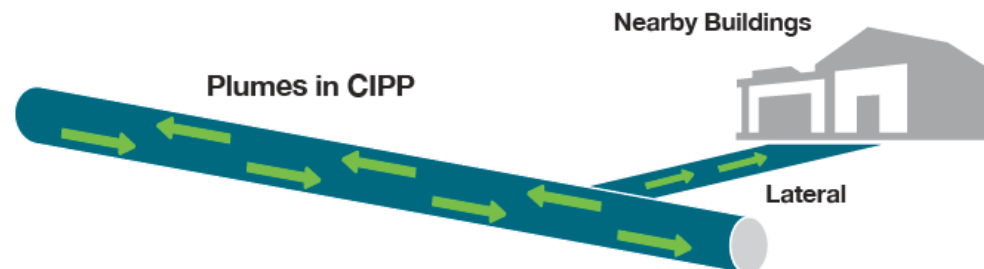




## Exposure Points on CIPP Job Site



**Plumes generated by CIPP can escape the pipe being repaired.**





## Acceptable Styrene Health Limits

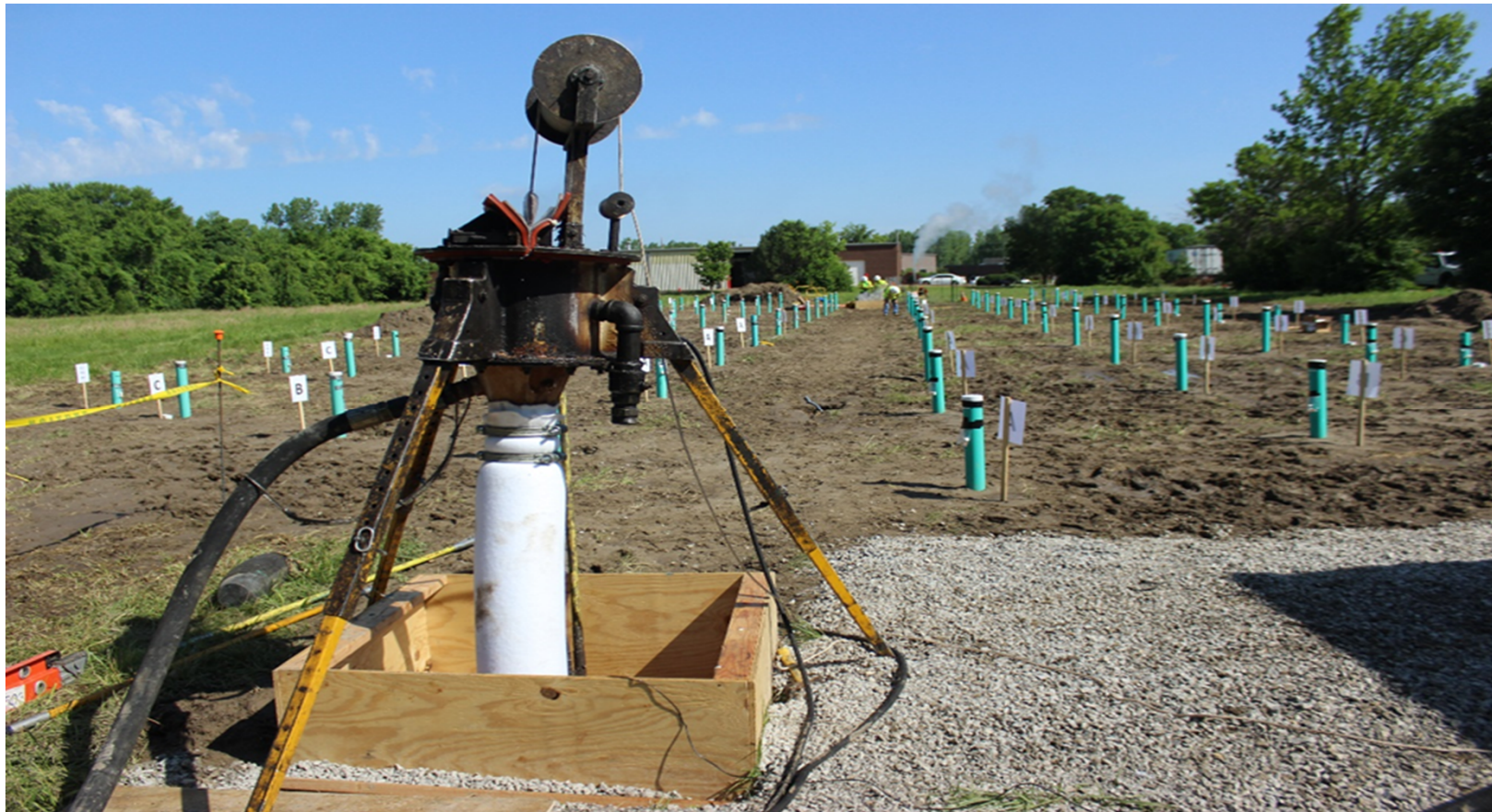
Many different guidelines by different regulatory agencies:

- **ACGIH** currently listed its TLV at 10 ppm for an 8-hour workday.
- **EPA** assigns Acute Exposure Guidelines for Hazardous Substances as set forth in the Acute Exposure Guideline Levels (AEGLs)
- **NIOSH** has a Recommended Exposure Limit (REL) at 50 ppm for a 10-hour workday.
- **OSHA** uses a Permissible Exposure Limit (PEL) at 100 ppm for an 8-hour workday but in addition cites a Ceiling level at 200 ppm and 600 ppm (5-minute maximum peak in any 3 hours)





## Waterloo University/ Aegion Styrene lateral migration field study





## Key Study Findings

- PIDs detect VOCs. Proper calibration for styrene per the manufacturer's guidelines is required.
- Water in a P-Trap will stop styrene from migrating out of the lateral.
- NASSCO has issued safety guidelines for workers as outlined in the TTC Phase 2 study available at [NASSCO.org](https://www.nassco.org).







## NASSCO CIPP Installation Recommendations

### General Safety

- Site-specific Health and Safety Plan
  - Covers all aspects of CIPP work
  - Flow Control
  - Confined Space Entry
  - Traffic Control and Access
  - Emission Controls
  - Cure Water and Condensate Management







## NASSCO CIPP Installation Recommendations

### Styrenated Resins Safety

- Exhaust discharge
  - 15-foot radius perimeter
  - Stack minimum 6 feet high
  - Inside perimeter < 5 minutes
  - Over 5 minutes, proper PPE
- Protect the public by maintaining a work zone perimeter around the job site

### Guideline for the Safe Use and Handling of Styrene-Based Resins in Cured-in-Place Pipe



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Common Question: “How can I prevent the odor from getting into my home?”

- See Video at [www.nassco.org](http://www.nassco.org)



## Measuring Devices for CIPP Industry

- Photoionization Detectors
- Direct Read Devices
- Passive Dosimetry



## What is a PID?



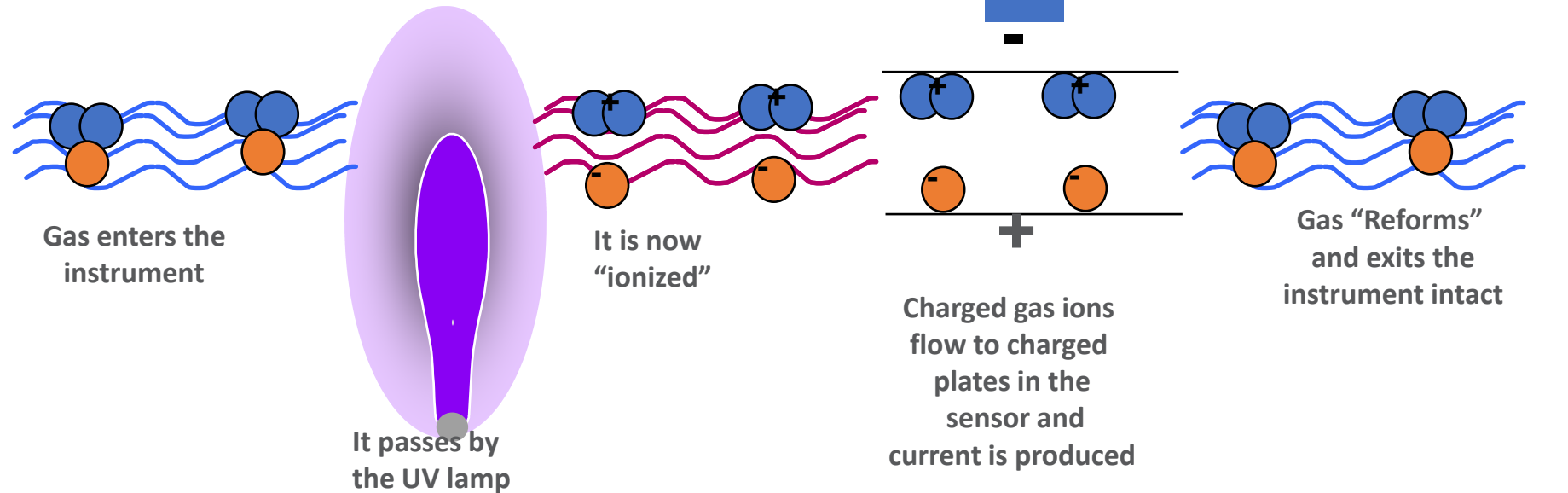
- ✓ PID = Photo Ionization Detector
- ✓ Detects VOCs (Volatile Organic Compounds) in low concentrations of 0.1 to 2000 ppm
- ✓ A PID is a very sensitive broad-spectrum monitor, like a “low-level LEL”





## How does a PID work?

An optical system using Ultraviolet lamp to breakdown vapors and gases for measurement





## What Does a PID Measure?

### Organics: compounds containing carbon (C)

**Aromatics:** compounds containing a benzene ring

- BETX: benzene (9.24), ethyl benzene (8.76), toluene (8.82), xylene (8.56)

**Ketones and aldehydes:** compounds with a C=O bond

- Acetone (9.71), methyl ketone or MEK (9.54), acetaldehyde (10.22)

**Amines and amides:** carbon compounds containing nitrogen

- Diethyl amine (8.01)

**Amines and amides:** carbon compounds containing nitrogen

- Diethyl amine (8.01)

**Chlorinated hydrocarbons:** trichloroethylene (TCE)

**Sulfur compounds:** mercaptans

**Unsaturated hydrocarbons:** C=C and C C compounds

- Butadiene (9.07), isobutylene

**Alcohols:** Ethanol (9.51)

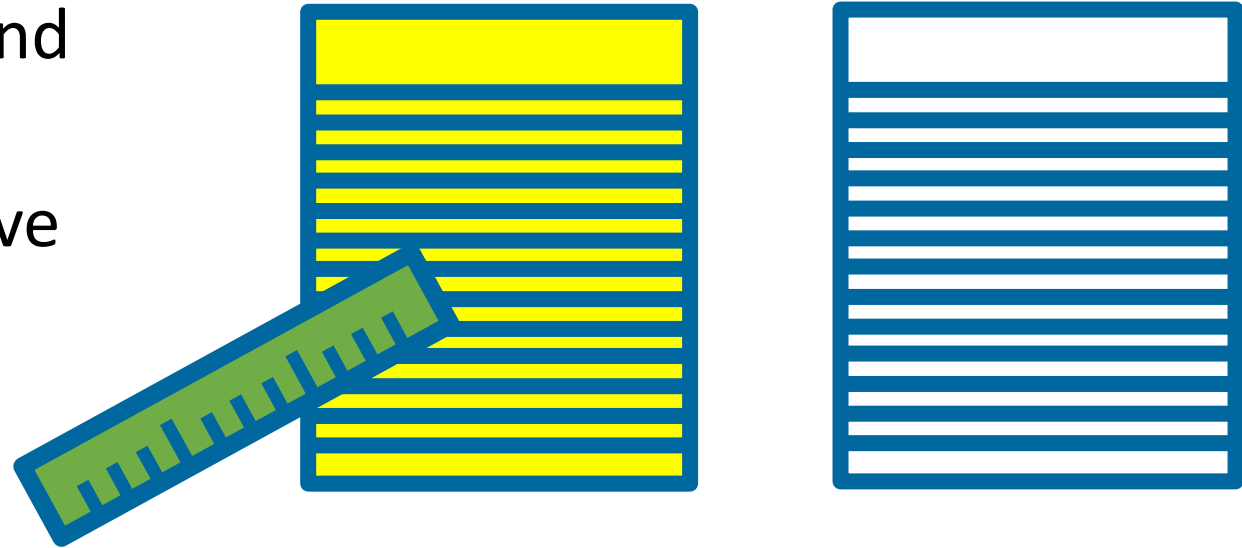
**Saturated hydrocarbons**

- Butane (10.63), octane (9.82)



## What can a PID not do? (Selectivity vs. Sensitivity)

- PID is very sensitive and accurate
- PID is not very selective



A ruler cannot tell the difference between yellow and white paper!





## What is Colorimetric Detection?

- Glass graduated tube filled with a chemical reagent that produces a color change when exposed to that specific vapor
- Detector tube used is specific to the vapor detected and is used one time.
- Each tube has specific number of pump strokes
- Challenges: Accuracy and storage guidelines





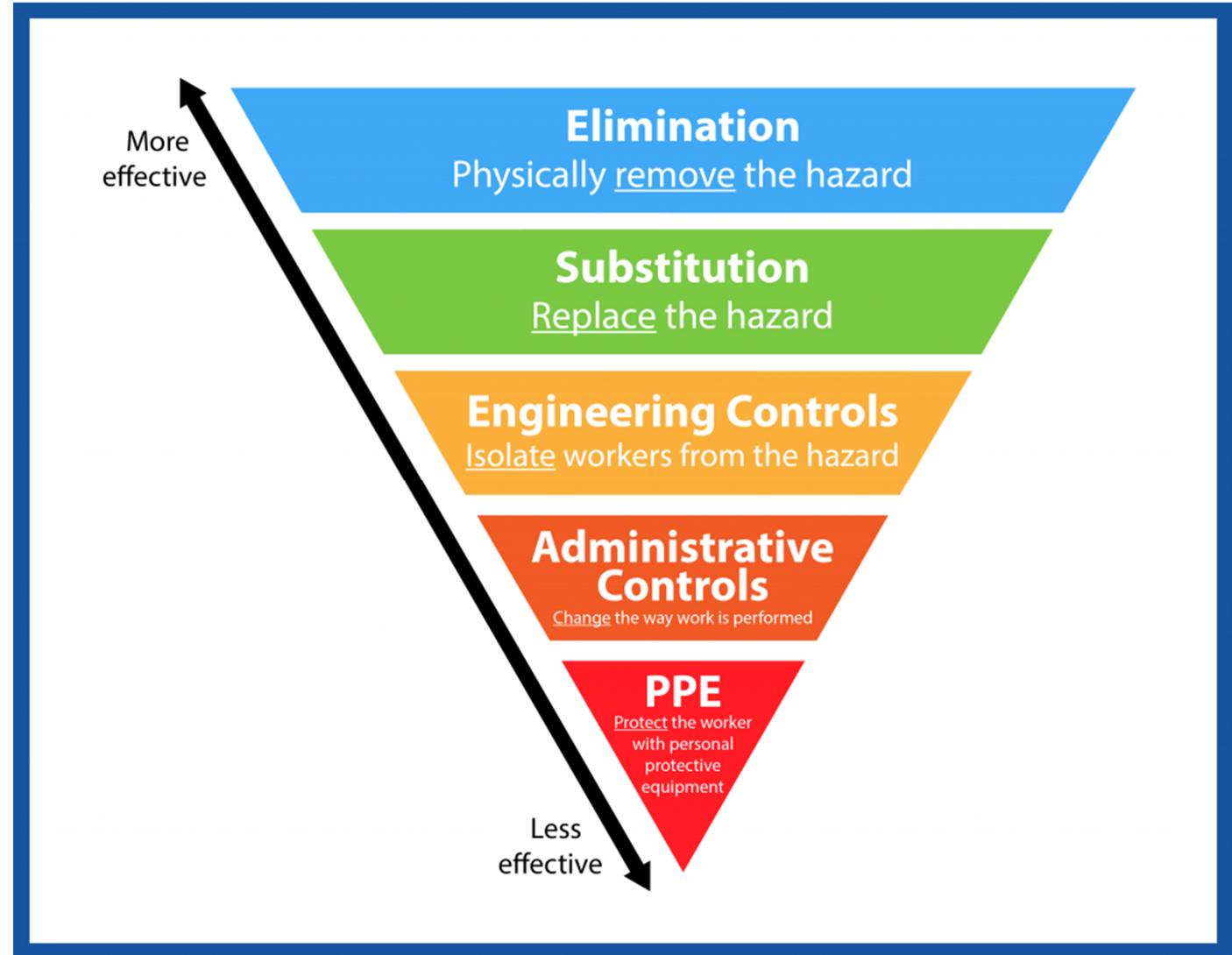
## What is an Organic Vapor Diffusion Monitor?

- Simplest employee sampling technique
- Carbon layer will be digested and analyzed in a laboratory using Gas Chromatography and Mass Spectrometer instrumentation.
- Laboratory will provide the level of VOC compounds collected during that sample period
- Sampling a full work shift (TWA) is recommended in order to best determine the daily exposure that a worker may have to an organic vapor.





## Styrene Safety & Health Hierarchy of Control







## Technical Resources

### Guideline for the Safe Use and Handling of Styrene-Based Resins in Cured-in-Place Pipe



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- Facts about Styrene
- Specification Guidelines for CIPP
- Research Findings and Recommendations
- Webinars
- Videos
- Industry Resources

Available at [NASSCO.org/resources](https://nassco.org/resources)





# UNDERGROUND CONSTRUCTION TECHNOLOGY

THE UNDERGROUND UTILITIES EVENT | JANUARY 25-27, 2022 | FORT WORTH, TEXAS

## Informational Resources and Support

### What's that odor?

The sewer pipe is being replaced with Cured-In-Place Pipe (CIPP)

#### What is CIPP?

CIPP is a method used to replace damaged or deteriorated sewer pipe without digging up the existing pipe or disrupting roads, driveways, sidewalks, or landscaping. Since 1971, CIPP has been used to safely reduce construction time, cost and disruptions in sewer service, while minimizing the impact on homes, businesses, traffic, and the environment.

#### CIPP Installation Process

The process involves installing a resin-saturated felt tube into an existing sewer pipe. Once in place, the tube is inflated to fit tightly inside the original pipe and cured or hardened to create a new plastic pipe within the old pipe. During the process, a steam cloud coming from a 6-foot (minimum) vent stack at a manhole may be visible in the air and will dissipate quickly when the process is complete.

#### What is that odor and why can I smell it inside my house?

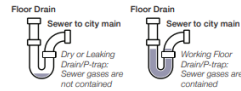
On occasion, there may be a "glue like" odor during the curing process that arises from the styrene component in the resin used in CIPP. Once the CIPP is fully cured or hardened, the odor will be eliminated.

If you detect an odor in your home, it is likely entering through the pipe that connects your home to the public sewer main. A "U" shaped pipe called a P-trap is located at all drains/plumbing fixtures and is designed to keep sewer gas and other vapors out of your home or building. Floor drains/plumbing fixtures may dry out at the P-trap and allow sewer vapors to enter your home or building.



#### How to prevent or stop?

In all plumbing fixtures and prior to the start of the odor in your home, ventilate rooms and doors. Adding ps and using a fan may help it. If the odor persists after project superintendent.

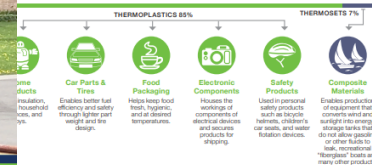


#### What is Styrene?

Styrene is a colorless, flammable liquid that is synthesized for commercial use from petroleum and natural gas by occurs naturally in the environment and is an inherent component in small concentrations in many foods and beverages, such as coffee, strawberries, and cinnamon.

frequently used for thermoplastics, and also latex and thermosets

Source: Styrene Information and Research Center



#### Why is the odor so strong?

Styrene has a very intense, distinctive odor and is detectable by the human nose at very low concentrations (0.1 parts per million). The presence of a styrene odor does not necessarily indicate a dangerous level.

#### Question: Is the odor harmful to my family and me?

For the general population in normal circumstances, measured environmental styrene concentrations from CIPP in the air are at levels too low to cause health effects. However, short-term exposure may cause eye irritation, headache, and discomfort. The EPA guideline for such an airborne concentration would list this as an Acute Exposure Guideline Level -1. EPA defines this as the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. In most cases, however, the effects are reversible upon leaving the area of exposure.

#### To learn more about:

- CIPP visit [NASSCO.org](http://NASSCO.org)
- Styrene visit [styrene.org](http://styrene.org), [nassco.org](http://nassco.org), [youknowstyrene.org](http://youknowstyrene.org), [epa.gov](http://epa.gov)



- NASSCO Tech Tips (published in *Underground Construction Magazine*)
- The NASSCO Pipeline
- “What’s that odor?” flyer and video
- Safety questions? Email [safety@NASSCO.org](mailto:safety@NASSCO.org)
- Technical questions? Email [TAC@NASSCO.org](mailto:TAC@NASSCO.org)

Available at [NASSCO.org/resources](http://NASSCO.org/resources)





# UNDERGROUND CONSTRUCTION TECHNOLOGY

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Q&A



# Thank you.

For additional questions, please contact [TAC@NASSCO.org](mailto:TAC@NASSCO.org)

