

New scientific discoveries have made reducing environmental, occupational, and public health risks for polymer composite sewer pipe repairs possible

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Water Infrastructure Needs

USEPA: \$200 billion for drinking water pipe repairs

USEPA: \$600 billion for sanitary sewer pipes

FHWA: Millions of feet of culverts require repair

Private water and sewer pipes require repair. In-building plumbing require repairs.

Mechanical pipe failures can be catastrophic
(traffic disruption, public safety, \$\$\$)



What is cured-in-place-pipe (CIPP)?

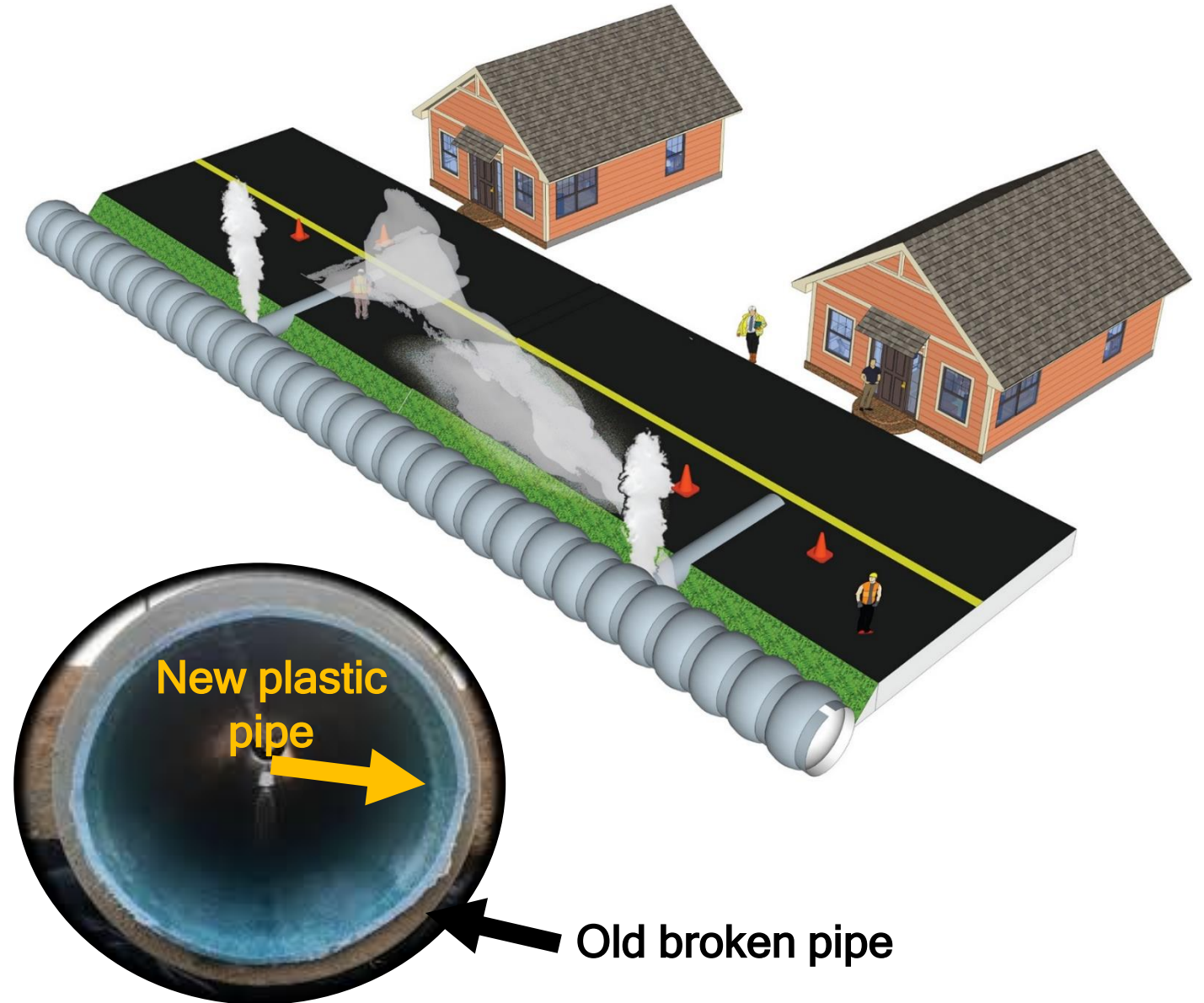
“Trenchless” pipe repair method
preferred by communities nationwide

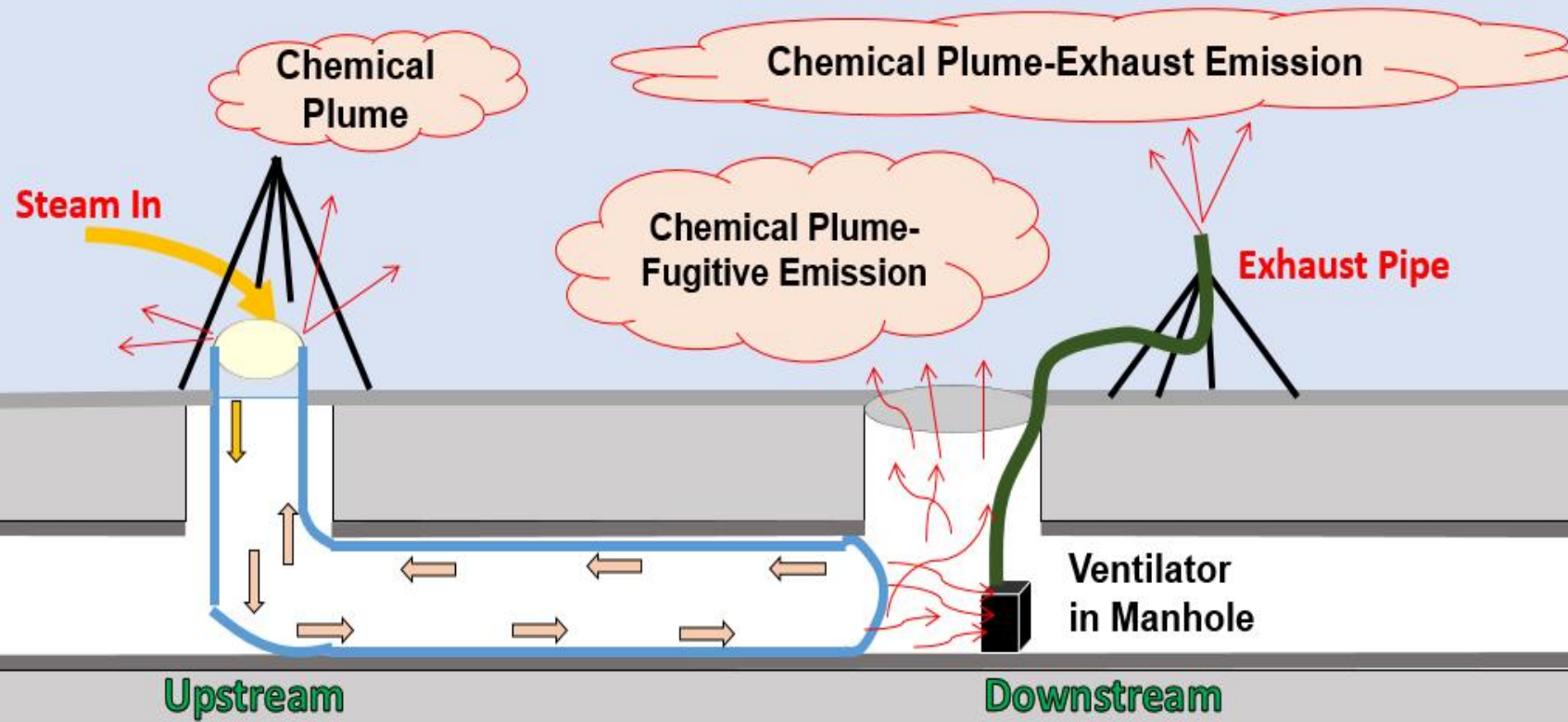
1975: Arrived in the USA.

Sanitary sewer, storm sewer, drinking
water pipes (4-100” diam.)

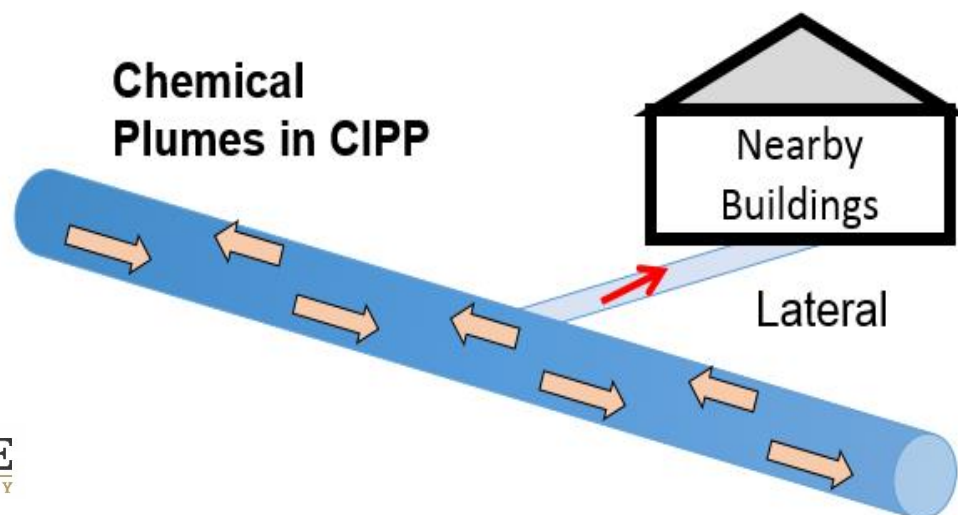
Up to 60-80% less expensive than other
pipe repair options.

Pipes can be typically repaired in 1-3
hours instead of days or weeks

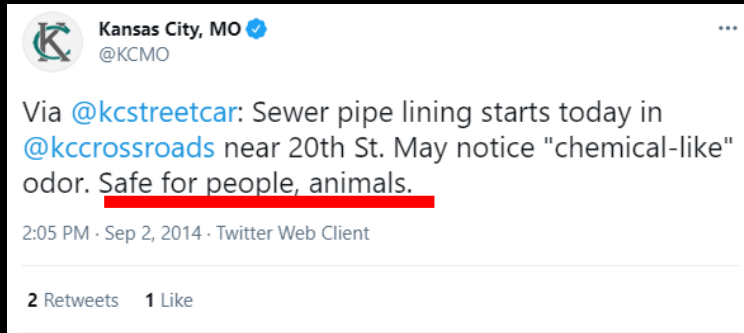




Chemical Plumes Generated by CIPP can Escape the Pipe Being Repaired



**Chemical plumes can
be discharged into
nearby areas**



Circa 2016 Industry Safety Claims

“Styrene vapor of at most few ppm”

“is not a human health risk”

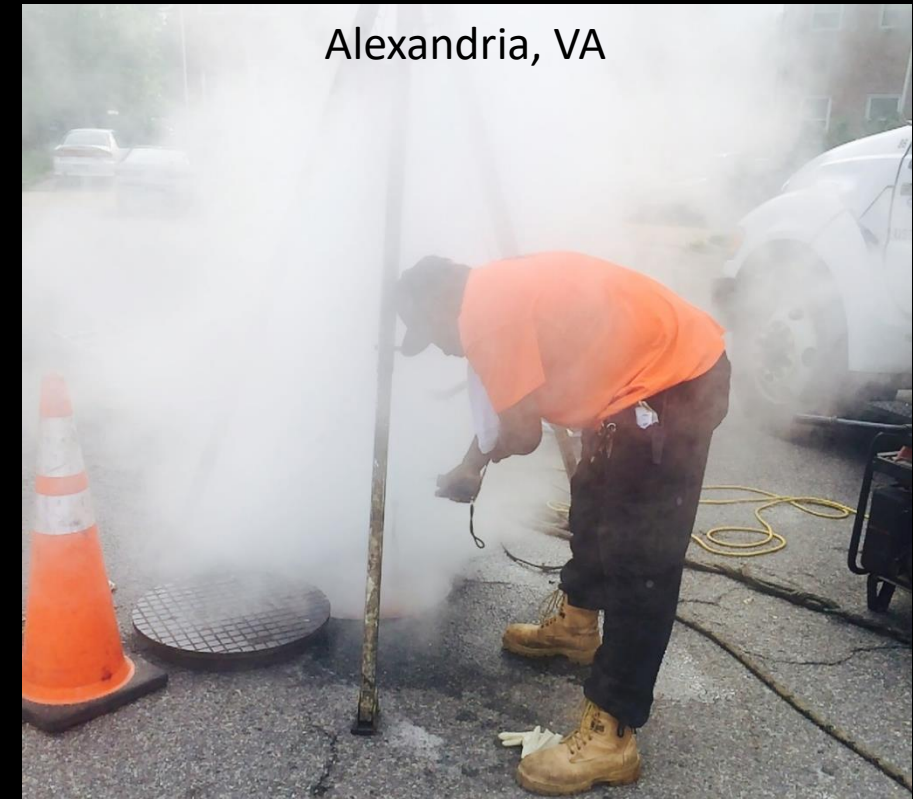
“is safe for people and animals”

“it is harmless steam”

“no hazardous conditions posed”

“don’t be alarmed”

“some people are offended by this odor and are fearful of it; even though the concentrations they smell present no harm”



Common in the US

No waste capture

No formal setback distances

No formal respiratory protection

No formal air monitoring



NSF RAPID Study: The plastic manufacturing waste was a multiphase chemical mixture, NOT Steam (vapors, particulates, droplets, partially cured resin, etc.)

Our 2017 Study: Plastic manufacturing waste emissions were quite complex ... not what people were being told

Worksite Chemical Air Emissions and Worker Exposure during Sanitary Sewer and Stormwater Pipe Rehabilitation Using Cured-in-Place-Pipe (CIPP)

Download FREE here:

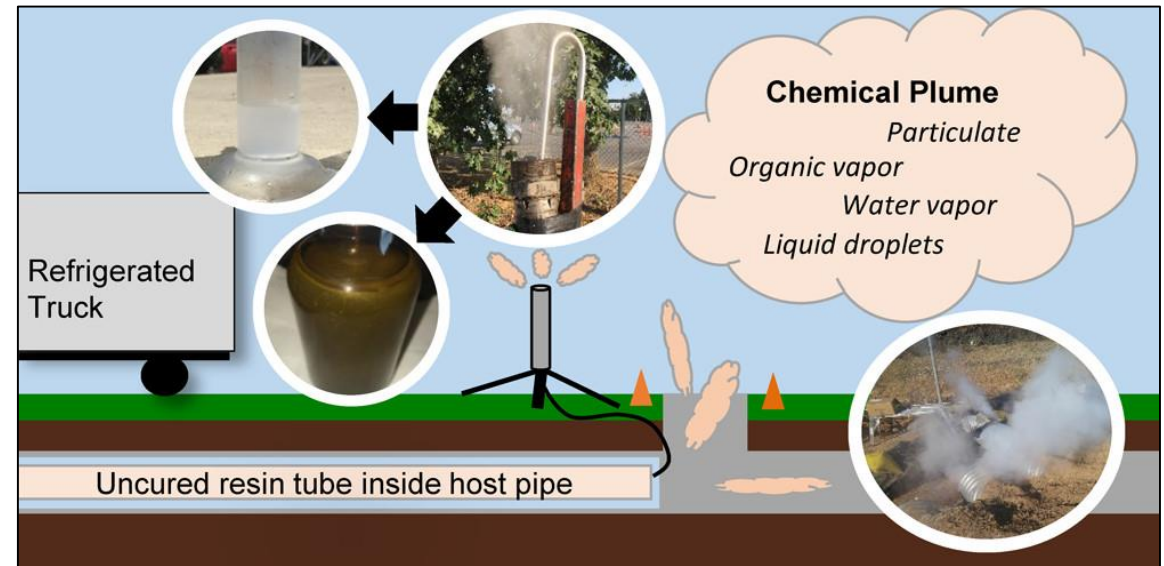
<https://doi.org/10.1021/acs.estlett.7b00237>

Exhaust is a multi-phase mixture, *not* steam

1,800 to 4,300 ppm (total) styrene in condensed material + other carcinogens and EDCs

Acute toxicity differed by worksite to mouse lung cells

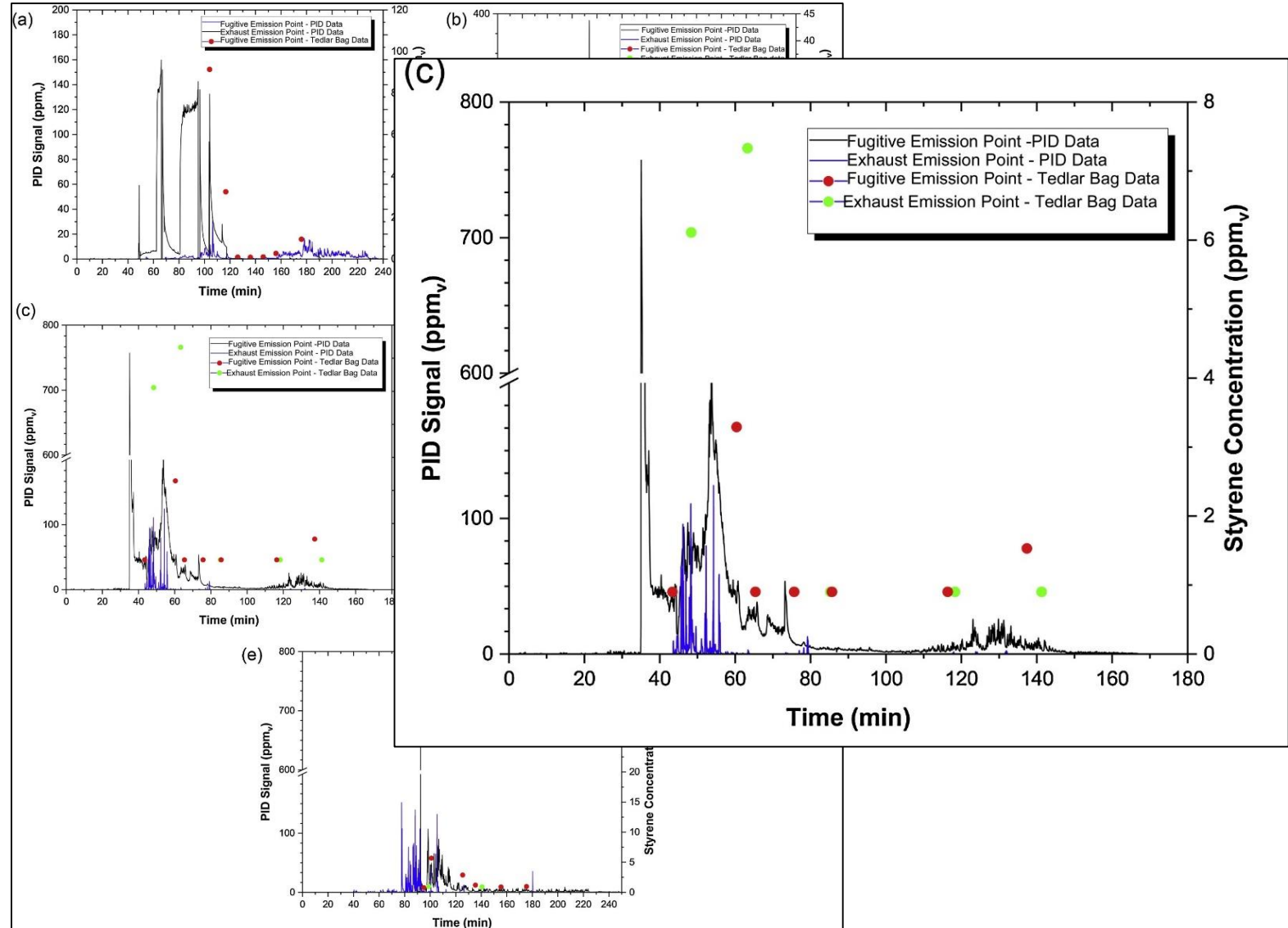
Some workers were handling resin with barehands and had no respiratory protection



Response...

- CIPP industry said results were unfounded, no safety risk. Urged municipalities not to jump to conclusions. Sent letters threatening lawsuits.
- CIPP industry funded their own study.
- Some companies reached out and we helped.
- NIOSH began helping workers (confirmed the issue).
- Workers reached out to us for help and advice

Calibrated PIDs at CIPP worksites underestimated and overestimated styrene levels by 10x to 1000x



News | updated: 10/26/2017 11:28 AM

Worker killed in Streamwood sewer line

Daily Herald



Illuminated by emergency lights and rescue lights, a man reacts after rescue crews pulled the body of a worker from a sewer line on South Park Boulevard in Streamwood Wednesday night.

John Starks | Staff Photographer

A few months later a 22 year old healthy CIPP worker was killed

Worker entered the new CIPP (like others had elsewhere)

Victim exposed to 225-275 ppm_v styrene for 4 hours according to post-mortem blood analysis [OSHA]

\$3M wrongful death settlement.
Village of Streamwood, Consulting engineer, CIPP company, CIPP safety company, CIPP resin company

Reporters: Jake Griffin, Eric Petersen
Photo: John Starks, Daily Herald

We've identified chemicals in resins, composites, as well as gleaned them from material SDSs

Trigonox®

Acetone

Acetophenone

Benzene

Benzoic acid

tert-Amyl alcohol

tert-Butanol

3-*tert*-Butoxyheptane

2-*tert*-Butyloxy-2,4,4-trimethylpentane

Carbon dioxide

3-(1,1-Dimethylpropoxy) heptane

Ethane

2-Ethylhexanoic acid

Heptane

Methane

2-Phenylisopropanol

3,3,5-Trimethylcyclohexanone

Perkadox®

Benzene

Benzoic acid

4-*tert*-Butylcyclohexanone

4-*tert*-Butylcyclohexanol

Carbon dioxide

Diphenyl

Phenylbenzoate

Tetradecanol

Butanox®

Acetic acid

Carbon dioxide

Formic acid

Propanoic acid

Methyl ethyl ketone

N,N-Dimethylaniline

Aniline

Carbon oxides

Nitric oxides

Ra et al. (2018) Critical Review: Surface Water & Stormwater Quality
Impacts of Cured-In-Place-Pipe Repairs. JAWWA.
<https://doi.org/10.1002/awwa.1042>

40 years ago composite manufacturers knew that byproducts (new chemicals) were produced when you cure styrene resins, but new (CIPP) composites contractors seemingly did not.

Our 2019 Study: Styrene, Other VOCs Present, Workers can Cross-Contaminate their Equipment

Considerations for emission monitoring and liner analysis of thermally manufactured sewer cured-in-place-pipes (CIPP)

Download FREE here:

<https://doi.org/10.1016/j.jhazmat.2019.02.097>

Vapors found: Styrene (>86 ppm),
methylene chloride (>1.5 ppm), phenol

Many people using PIDs, but styrene vapor by PID can have 10x to 1000x error on worksite! - Unreliable.

1 to 2 wt% of final CIPP is VOC residual

Many VOCs and SVOCs in the new CIPP.

Workers contaminated non-styrene CIPP with styrene.



***In vitro* toxicity assessment of emitted materials collected during the manufacture of water pipe plastic linings**

Lisa Kobos, Seyedeh Mahboobeh Teimouri Sendesi, Andrew J. Whelton, Brandon Boor, John Howarter, **Jonathan Shannahan**

2019. *J. Inhalation Toxicology* <https://www.tandfonline.com/doi/full/10.1080/08958378.2019.1621966>

1. CIPP emissions likely should **not be regulated based on styrene alone** and exposure assessments of worksites would benefit from more comprehensive evaluation of emission components
Benzaldehyde, benzoic acid, phenol, 1-tetradecanol were all highest in Site 4 emissions
2. Efforts should be made to adequately **inform workers and the public** regarding emissions as there is a potential for toxicity following inhalation exposure
3. Minimize exposure, utilize proper **personal protective equipment (PPE)**
4. Investigate operational procedures to mitigate emissions and understand adverse health effects
5. Based on our findings future studies should examine **cytotoxicity and cell injury, immune responses, fibrosis, and cancer** as these were pathways determined to be modified significantly in representative pulmonary cells following exposure

Evaluation of Exposures to Styrene During Ultraviolet Cured-in-place Pipe Installation

Ryan F. LeBouf, PhD, CIH
Dru A. Burns, MS

NIOSH (2019)

Exposure to styrene (140 ppm) exceeded the 15-min short-term exposure limit of 100 ppm

Styrene and total VOC worker exposure concentrations were reduced when manhole ventilator blower fans were used.

They now could fix their problems.

Report No. 2018-0009-3334
January 2019



U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health



NIOSH (2021)

Exposure to styrene (105 ppm) exceeded the short-term 15-min NIOSH exposure limit of 100 ppm and ACGIH limit of 20 ppm; Styrene levels downwind were higher than upwind. The uncured liners released styrene into the air even though they were wrapped in polyethylene.

Evaluation of Exposures to Styrene during Cured-in-place Pipe Liner Preparation and during Pipe Repairs using Hot Water and Steam

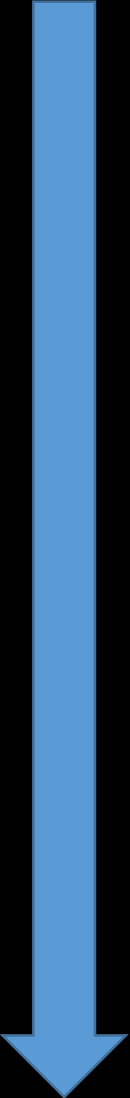
HHE Report No. 2019-0080-3379

July 2021



Centers for Disease Control
and Prevention
National Institute for Occupational
Safety and Health

PROBLEMS: Most CIPP studies have been 100% reliant on PID data and styrene vapor was only considered



2001, Canada: 3.2 ppm styrene
2004, Canada: PID 110 ppm
2004, Germany: Draeger tube 20 ppm styrene
2004, Canada: PID 120 ppm styrene
2006, The Netherlands: PID 87 ppm styrene
2007, Virginia: 9.9 ppm styrene
2016, California: 1,070 ppm styrene
2017, PURDUE: Multiphase mixture, not just styrene vapor (1800-4300 ppm styrene + others)
2017, Virginia: PID 104 ppm styrene max.
2017, OSHA: 225-275 ppm styrene
2018, Alaska: PID >100 ppm styrene for 15 min
2018, New Zealand: 12 ppm styrene
2018, Oregon: PID 1,050 ppm styrene
2019, NIOSH: 140 ppm styrene and divinyl benzene
2019, PURDUE: >86 ppm styrene, >1.5 ppm methylene chloride. Multiple other VOCs: acetophenone, benzaldehyde, benzoic acid, phenol, tetradecanol

2023: The CIPP industry

Detected styrene vapor in air but also other VOCs including benzaldehyde, benzene, acetone, MEK, methylene chloride, phenol, toluene, and more...

The captured condensed material was not just styrene.

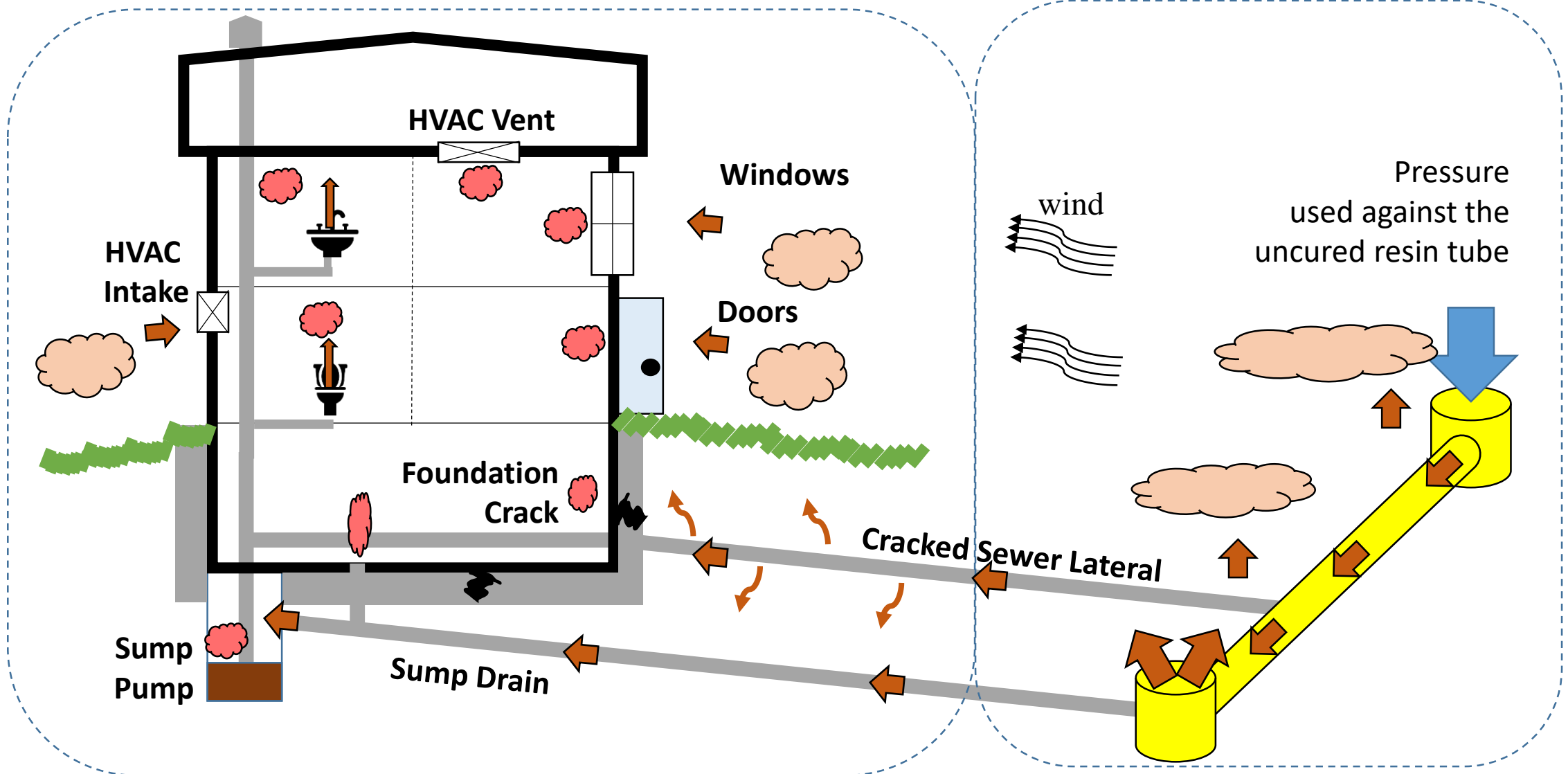
Styrene levels *up to 1,820 ppm* (in resin truck) and 316 ppm (exhaust pipe)

Several issues with sampling locations, data interpretation, representativeness, etc.

Recommended setback distances

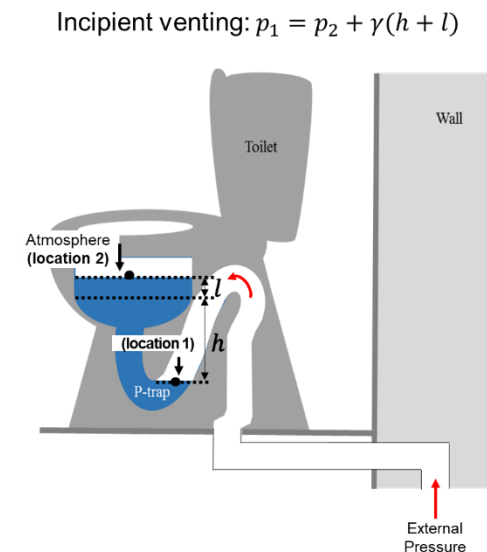
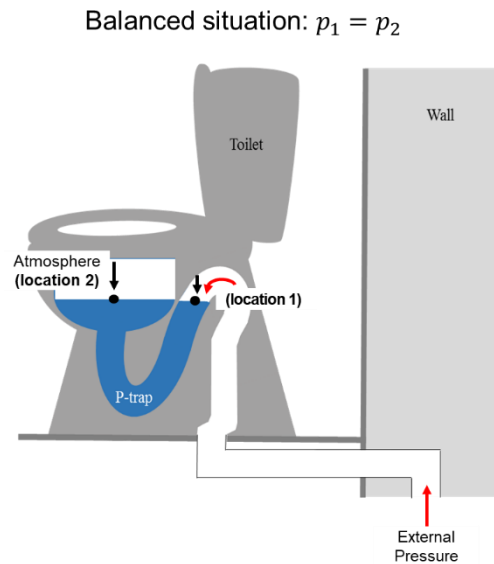
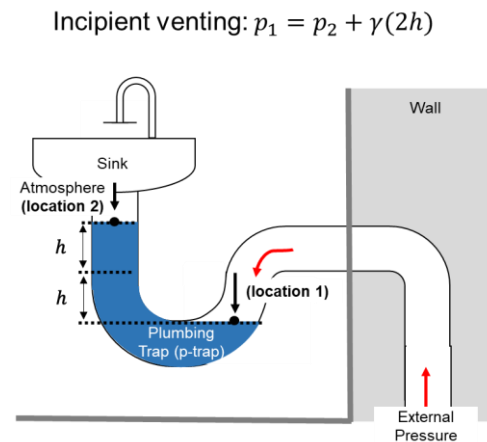
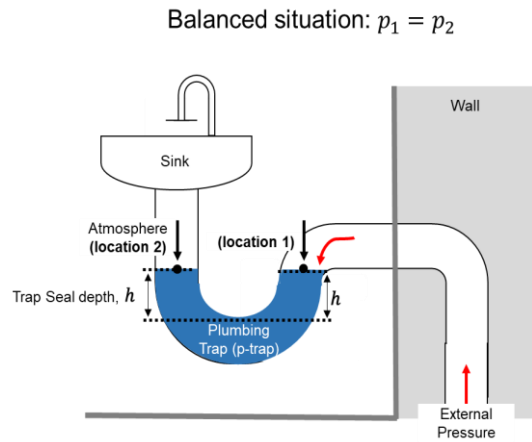
Private Property
(not for contractors)

Utility/City Property
(Worksite only for contractors)



Emergency responder and public health considerations for plastic sewer lining chemical waste exposures in indoor environments

Plumbing traps (p-traps) are required on all plumbing fixtures, including toilet, sink, bathtubs, shower, and floor drain *to prevent transient gases, insects, and rodents from entering the room*



Reported pressure applied by contractors during sewer lining:

3 psi to 28 psi

The relative (gage) pressure needed to displace the water seal

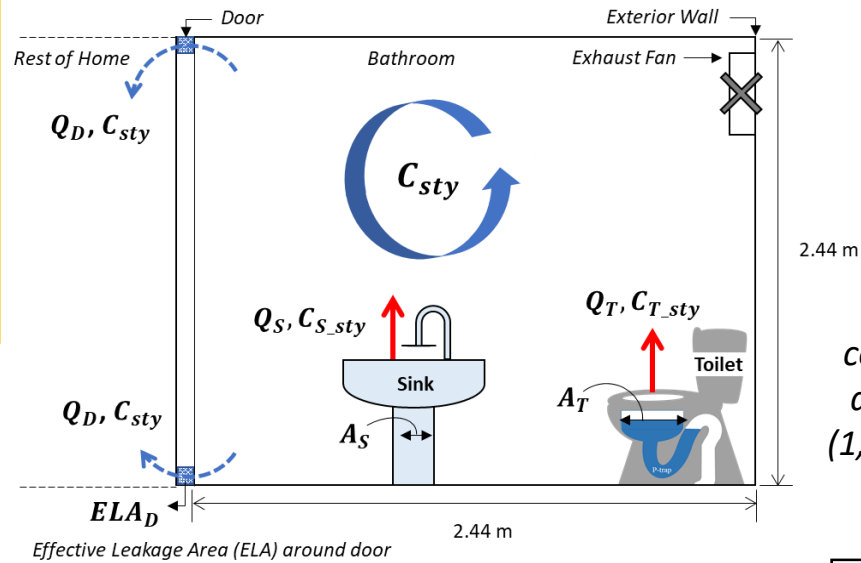
Sink= 0.14 psi

Toilet= 1.28 psi

Only 0.5% to 43% of the total pressure applied by the contractor would be needed to prompt wastewater blowback

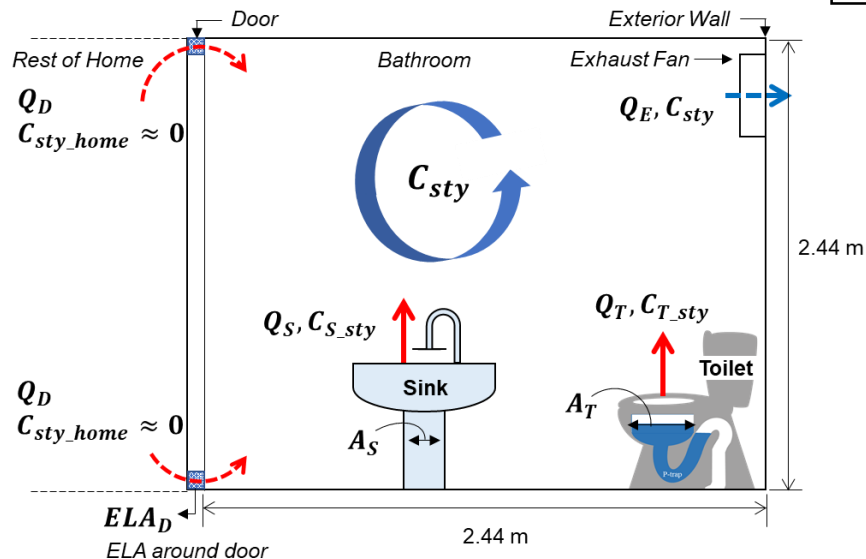
Bathroom chemical air contamination and decontamination model simulation

Non-ventilation Condition

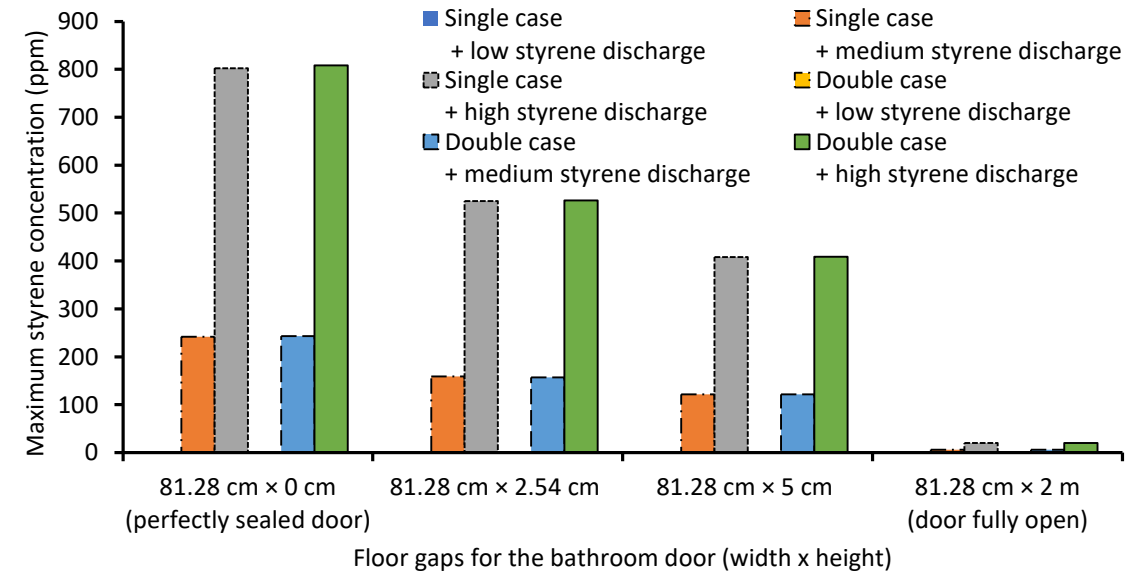
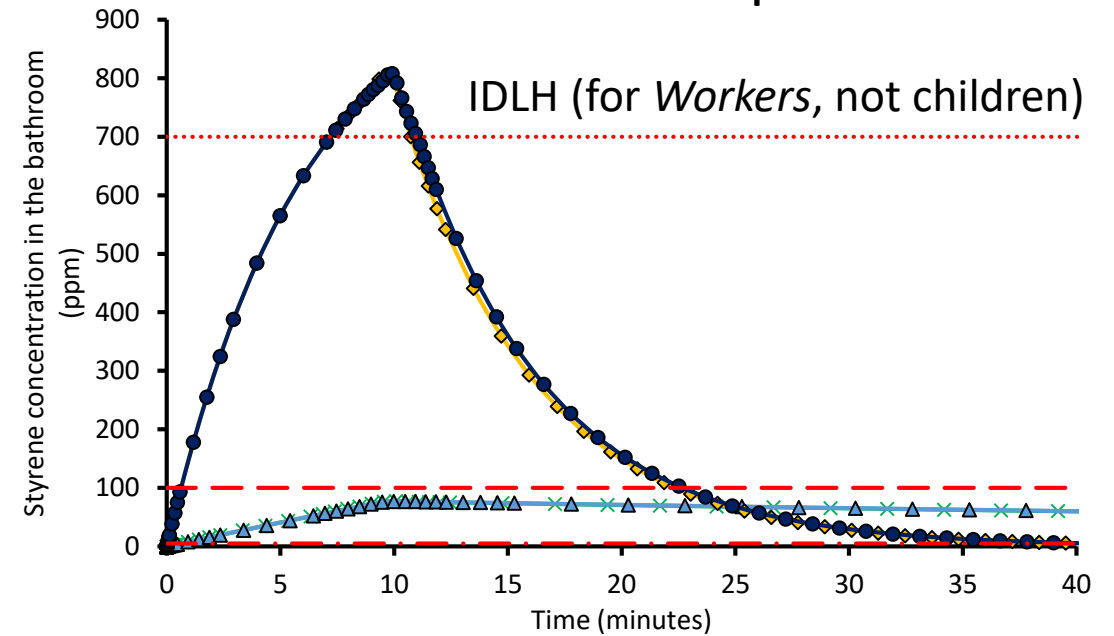


Indoor styrene
concentration change
after constant inflow
(1,000 ppm_v for 10 min)
into the bathroom

Ventilation Condition



The bathroom air styrene concentration was influenced by
bathroom exhaust fan operation



Our 2022 Study: Change the resins to reduce VOC pollution

Environmental and Human Health Risks of Plastic Composites can be Reduced by Optimizing Manufacturing Conditions

Download FREE here:

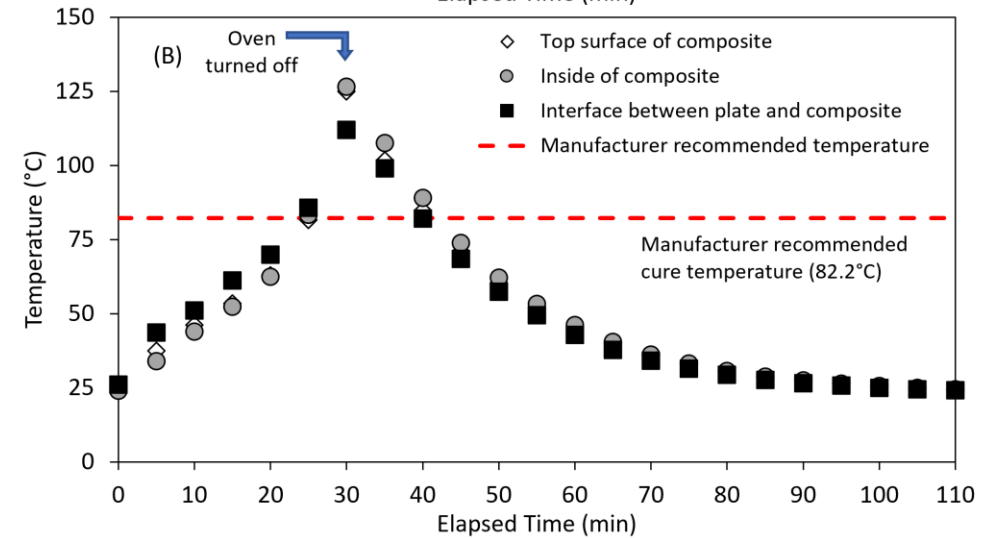
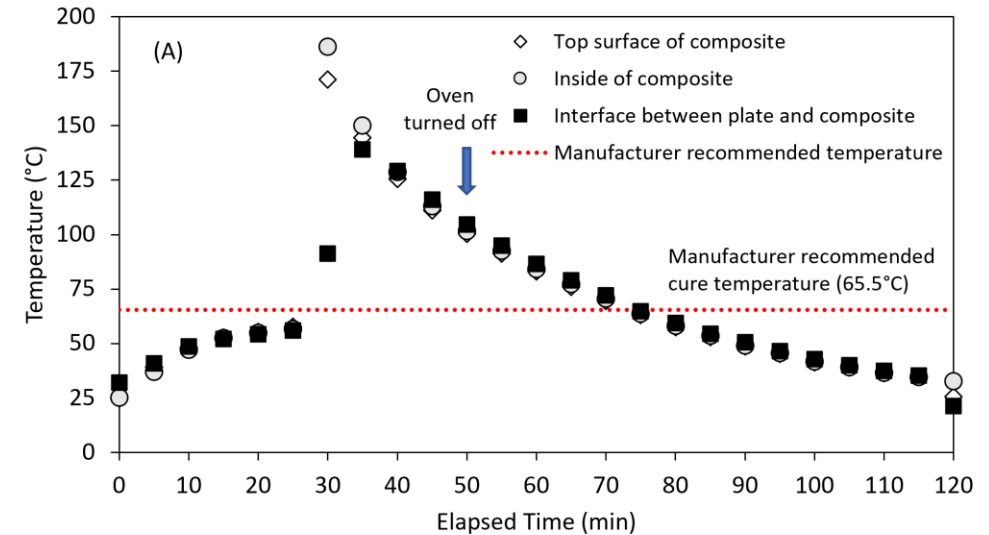
<https://doi.org/10.1016/j.jclepro.2022.131803>

Styrene resin (39% VOC) vs. Nonstyrene resin (4% VOC)

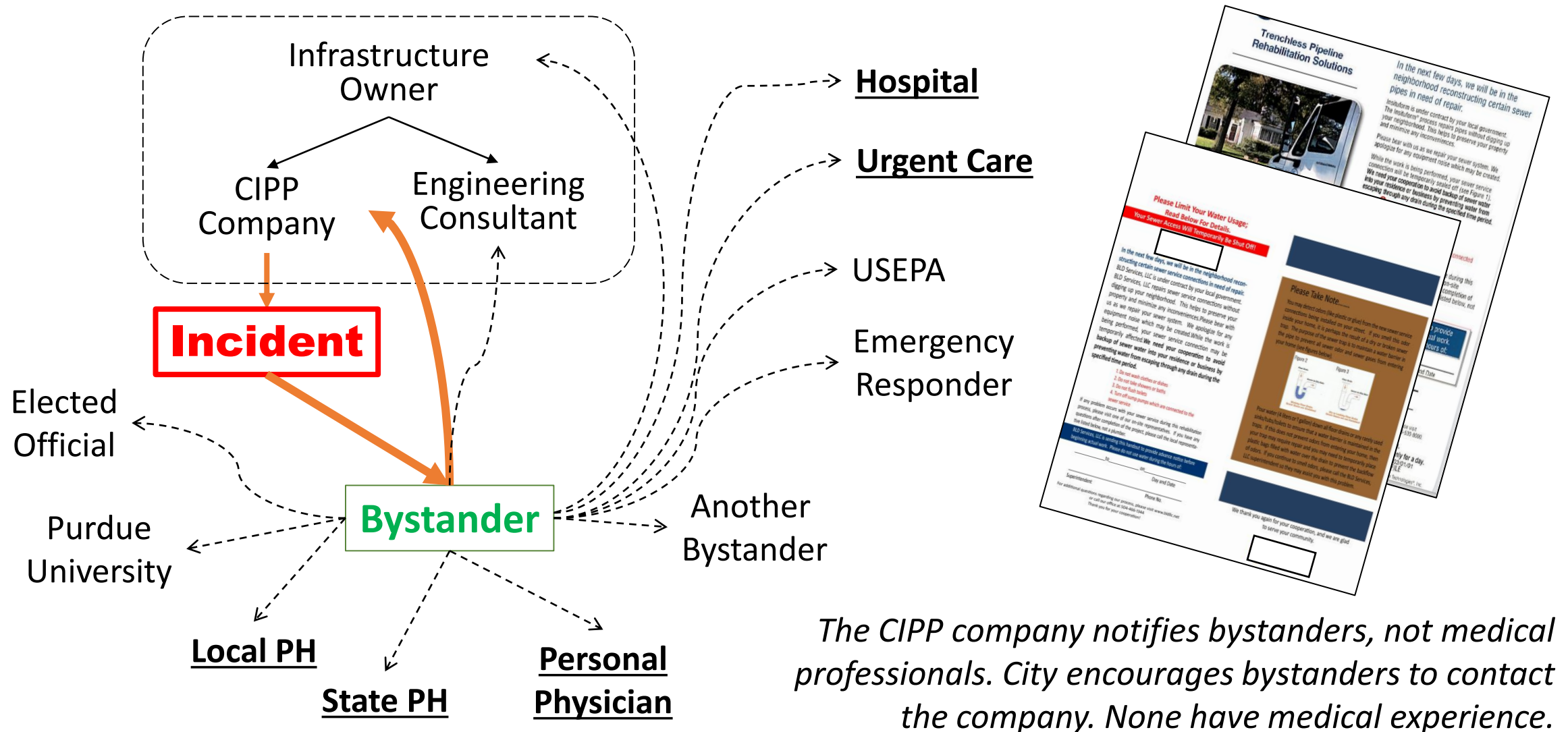
Resin manufacturer contaminated their Nonstyrene resin with a Styrene resin (*Companies do not test before installation*)

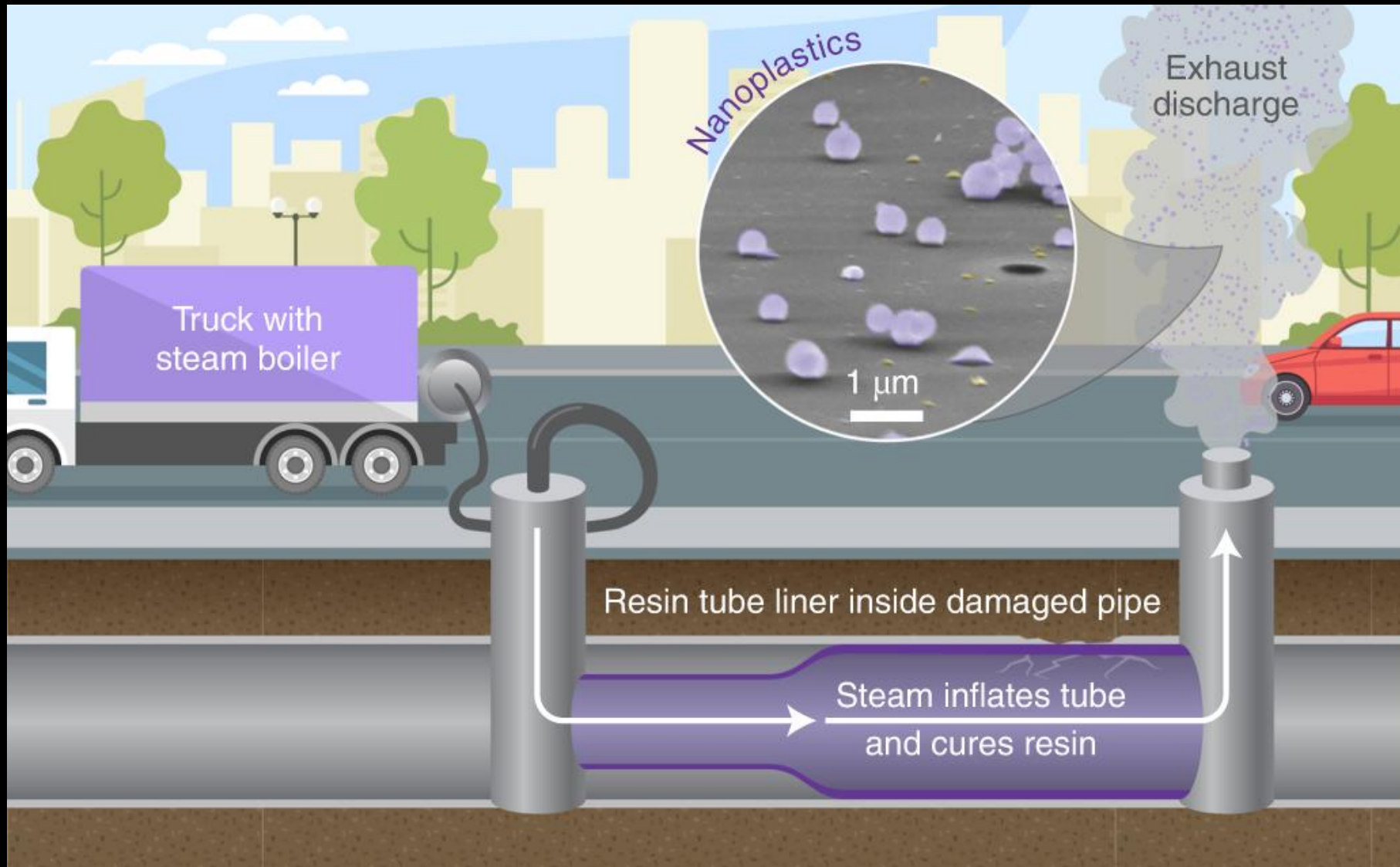
By increasing the initiator loading we reduced styrene (-42%) and styrene oxide (-32%) residuals.

Only 2 compounds listed on material SDS, but 8 identified

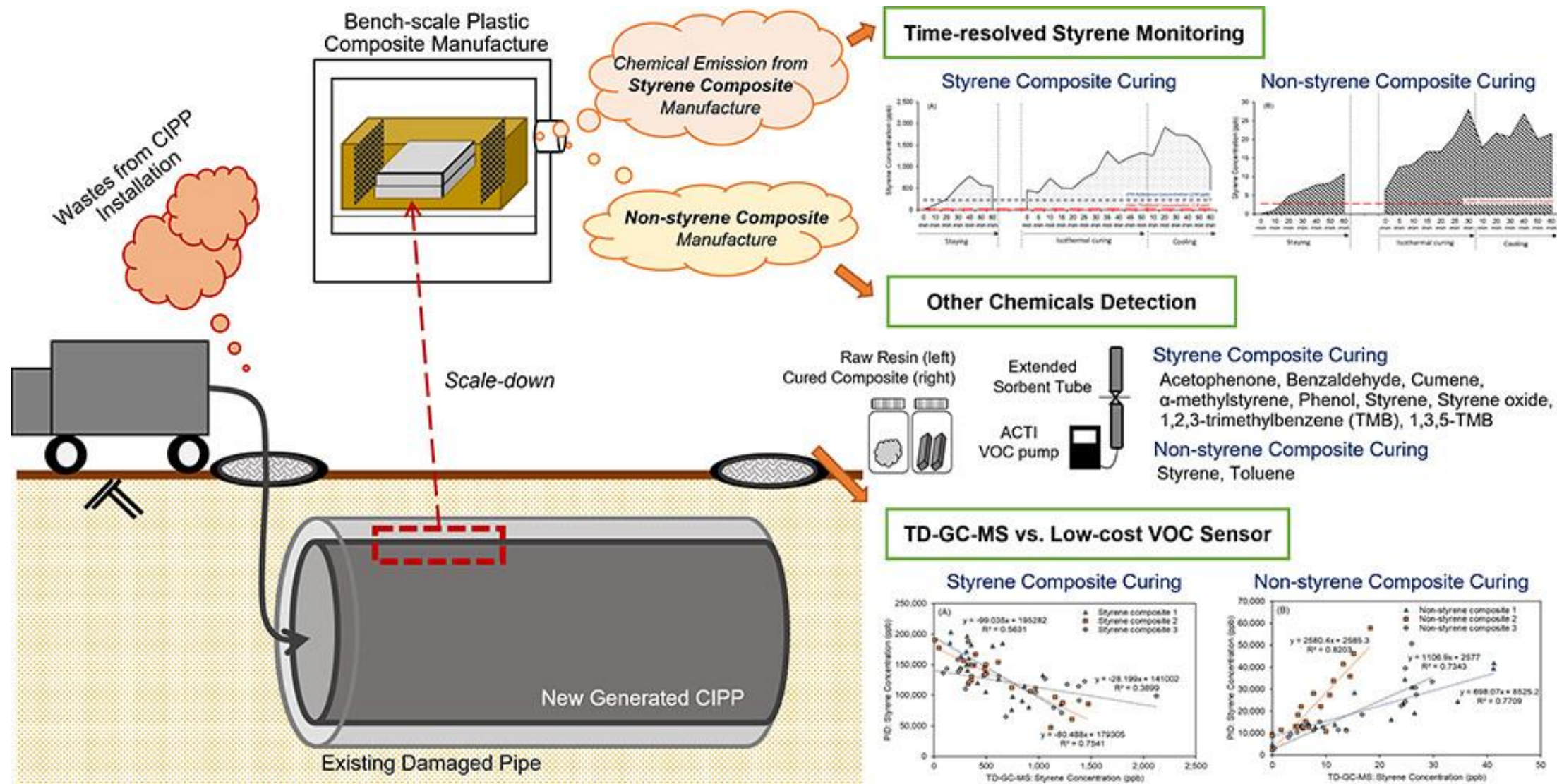


What's the extent of the problem?





Regulatory Significance of Plastic Manufacturing Air Pollution Discharged into Terrestrial Environments and Real-Time Sensing Challenges



New scientific discoveries have made reducing environmental, occupational, and public health risks for polymer composite sewer pipe repairs possible

Risks to workers, emergency responders, bystanders...

1. Require lesser polluting CIPP resins and processes
2. Capture waste
3. Notify the Health Department before projects begin. Potential exposure victims should contact the health department for help –not– pipe contractors or public works.
4. Request a free NIOSH health hazard evaluation for worksites and buildings.
5. Request that NIOSH further evaluate rapid air testing devices for CIPP incident response.
6. Conduct long-term worker exposure health study.



CIPP is an innovative technology that can be used without endangering the safety of workers, public, and the environment if appropriate actions were taken.

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Cured-in-Place Pipe Safety Study

News In the News

[DOT Lining Study \(Surface and Storm Water Quality\)](#)

- [Scientific file](#), *Journal of the American Water Works Association*, May 2018
- [Frequently Asked Questions \(FAQ\)](#)

[NSF Rapid CIPP Study \(Worker, Public Safety, and Chemical Air Emissions\)](#)

- [Scientific report files & associated video files](#), *Environmental Science & Technology Letters*, July 2017
- [Frequently Asked Questions \(FAQ\)](#)

[Incorrect assertions about the NSF Rapid CIPP study](#)

In 2016, Purdue researchers began investigating chemical emissions and exposures caused by cured-in-place-pipe (CIPP) water pipe repair sites. CIPP is the most popular water pipe repair technologies used in the U.S. Because this technology uses raw chemicals in the field and manufacturers a new plastic pipe inside an existing damaged water pipe, chemicals can be emitted into the environment and enter nearby buildings. CIPP is used for sanitary sewer, storm sewer, and drinking water pipe repairs.

Questions? Contact us at CIPPSafety@purdue.edu

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USEPA XA00E02898

FHWA TPF-5(339)

NIEHS R03ES030783

Crowdfunding

Purdue University

Learn more at:

www.CIPPSafety.org

www.PlumbingSafety.org



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