Sewer Pipe Repair Sites—Anticipating the Hazards

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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.

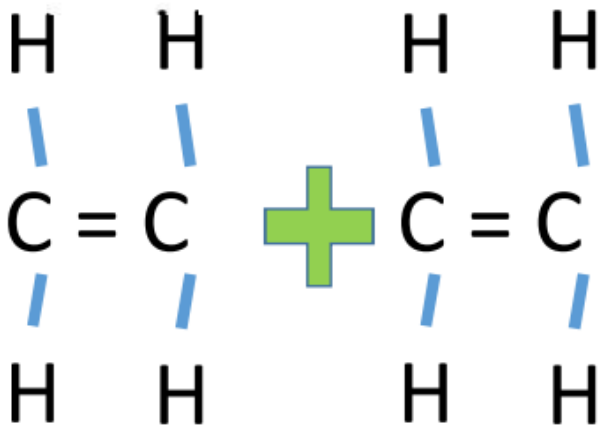
Mechanical pipe failures can be catastrophic

(traffic disruption, public safety, $$$)

Plastics are ....Polymers = *Many...Unit...compound*

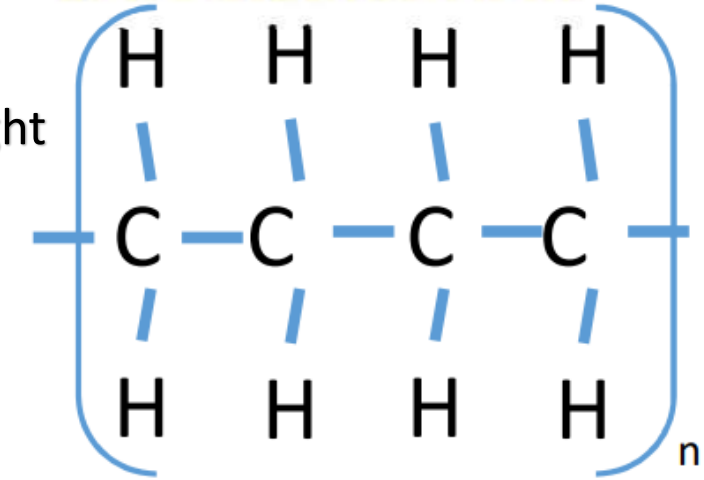
Long-chain molecules of very high molecular weight (n = tens of thousands)

MER UNITS



Initiator(s)
+heat or UV light

POLYMERIZATION



POLYMER CHAINS ... THINK SPAGHETTI !

Linear

Branched

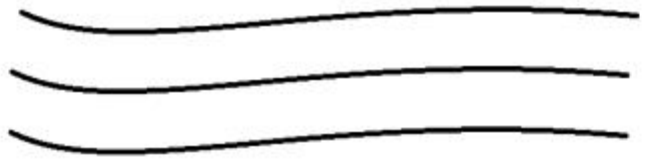
Place of Manufacture

Before onsite
HDPE, PVC, cPVC, PEX,etc.

Inside the water system
Coatings and CIPP liners

How to Make Plastics (*Think Spaghetti*)

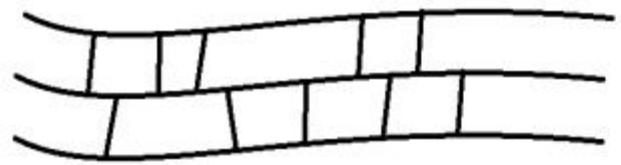
Straighten the spaghetti strands



Not crosslinked

HDPE, PVC, etc.

Bond the spaghetti strands



Crosslinked

CIPP, gaskets, coatings, PEX

Flexible: HDPE vs. LDPE (LDPE has more free volume/space between chains)

Flexible: HDPE vs. PEX (HDPE has greater chain mobility)

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

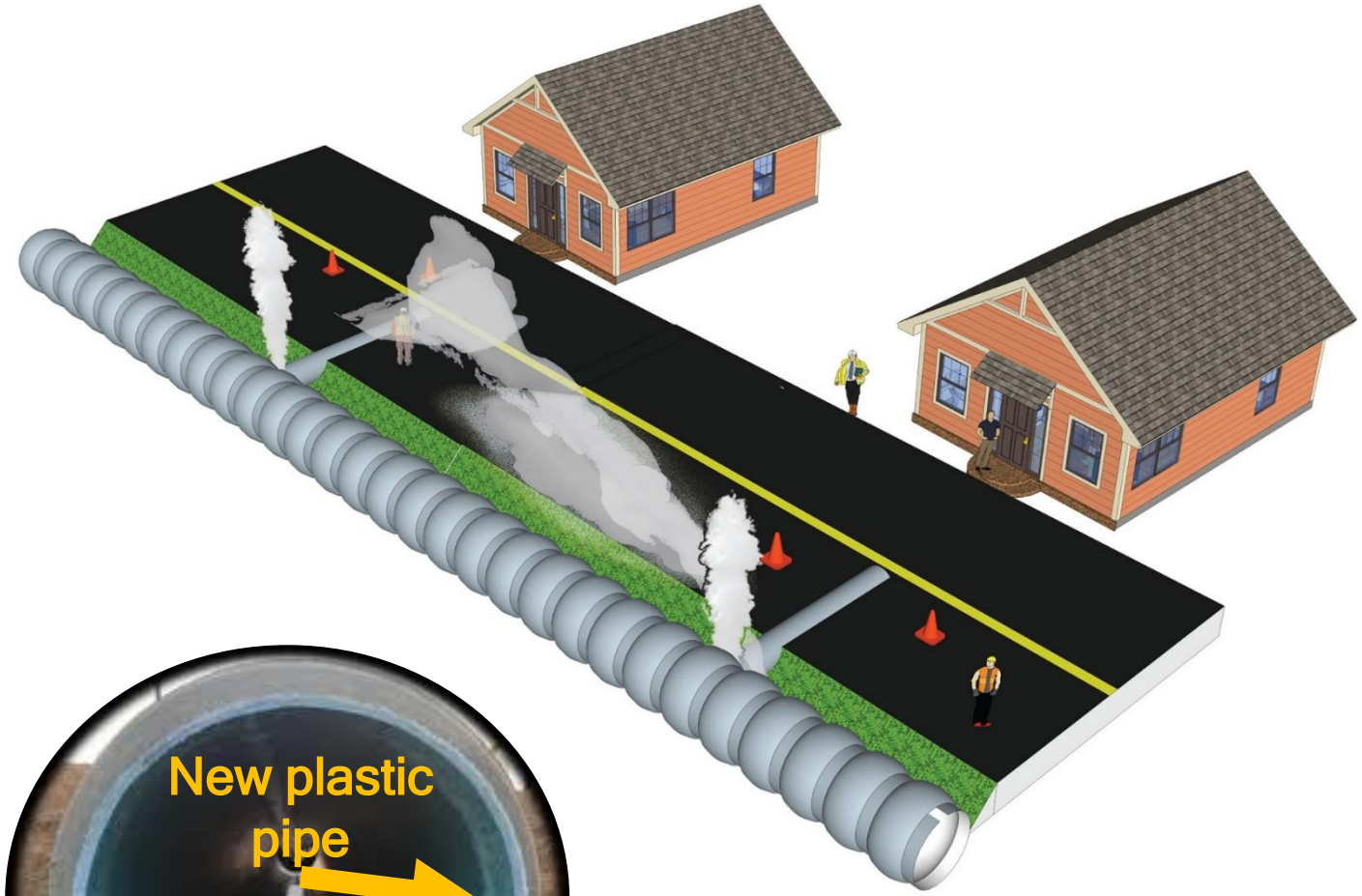
“Trenchless” pipe repair method preferred by communities nationwide

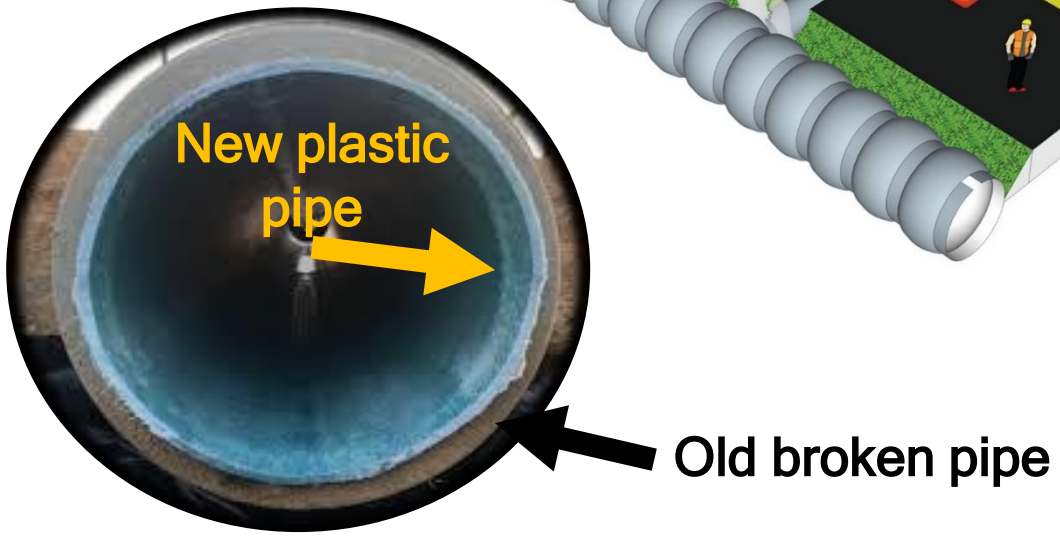
1975: Arrived in the USA.

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

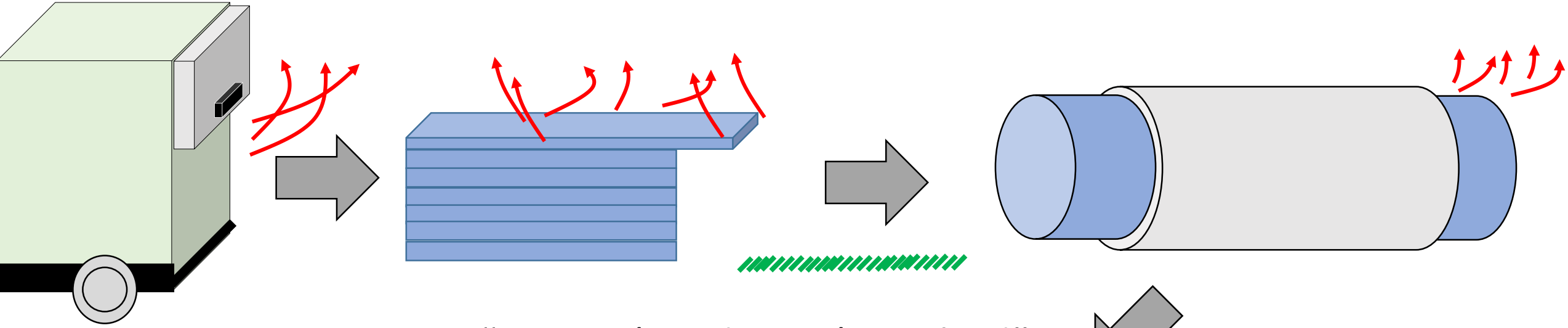




Uncured **RESIN** tube delivered on a truck

Uncured **RESIN** tube inserted into damaged pipe (raw chemicals)

Uncured **RESIN** tube inflated with air inside host pipe

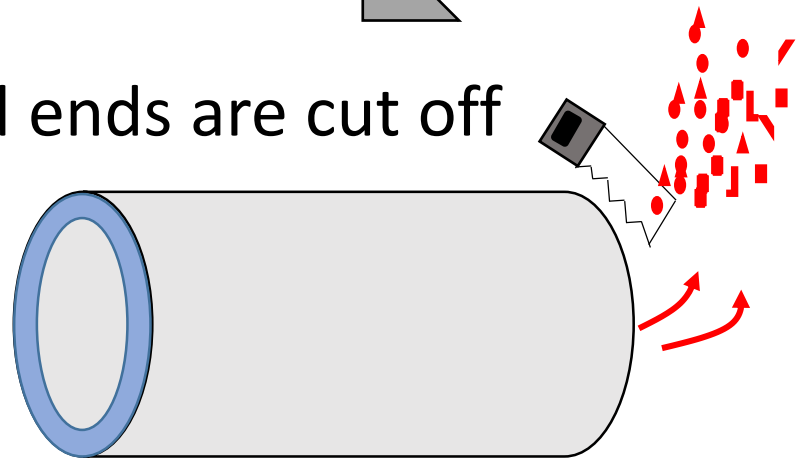


"Curing (Hardening) Method"

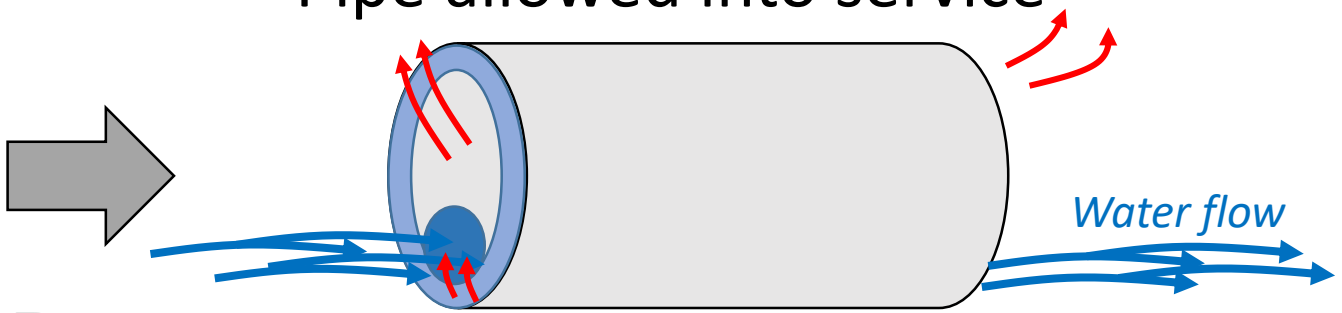
Hot Water or Steam or UV Light

(industry encourages waste discharge to air)

Hard ends are cut off



Pipe allowed into service



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Resin Types

- **Polyester (est. most popular)**
- **Vinyl ester (est. > cost of polyester)**
- **Epoxy (est. >> cost of polyester)**

People also say “Styrene resin” vs. “Non-styrene based” resin

Resin + Solvents + Fillers + Catalysts + Initiators are added to create an uncured resin tube

Method to insert uncured resin tubes

- **Air inversion**
- **Water inversion**
- **Pull in place**

Sometimes resin may leave the tube and flow into cracks and sewer laterals. May not cure.

Tubes sometimes have a plastic coating. Plastic “preliners” sometimes used.

Method to polymerize resin

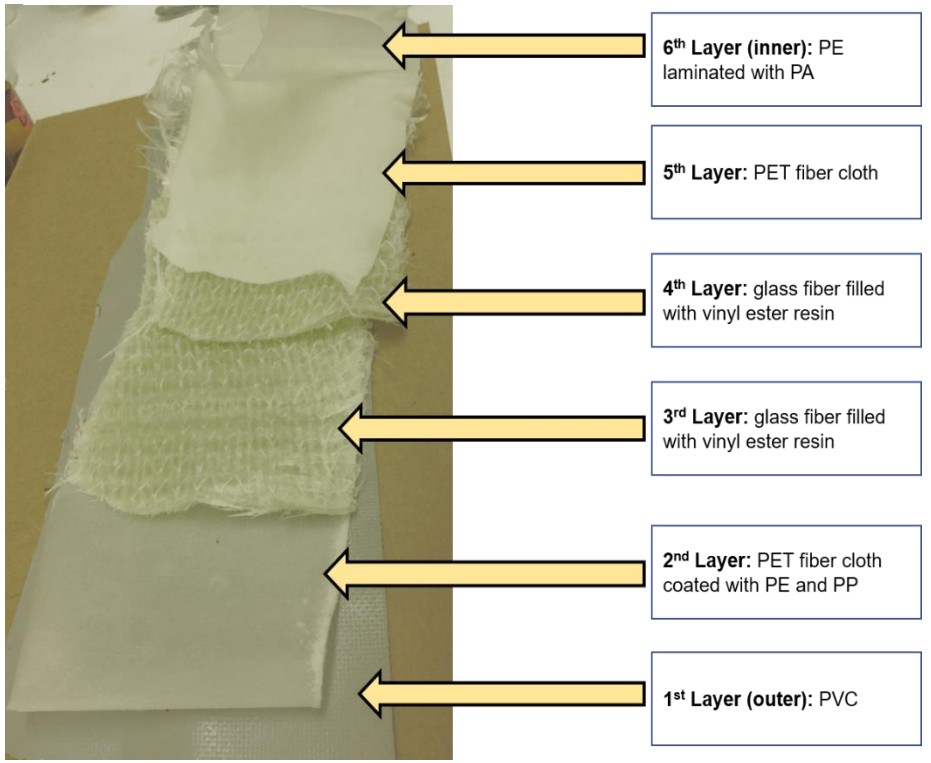
- **Thermal – Steam injection (most popular)**
- **Thermal – Hot water recirculation**
- **UV – Light exposure (est. most growth)**

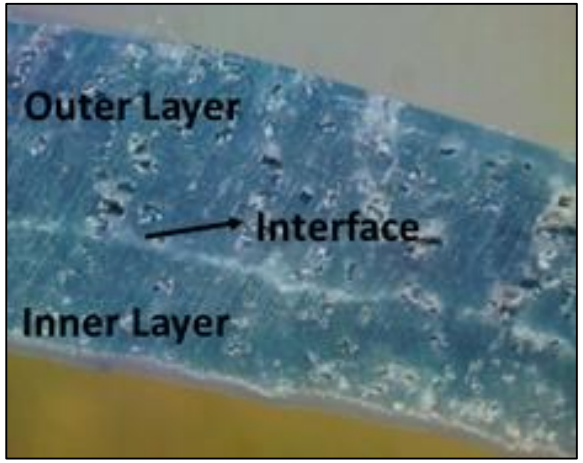
Cooldown method

- **Forced hot air**
- **Forced ambient air**
- **Recirculated water**

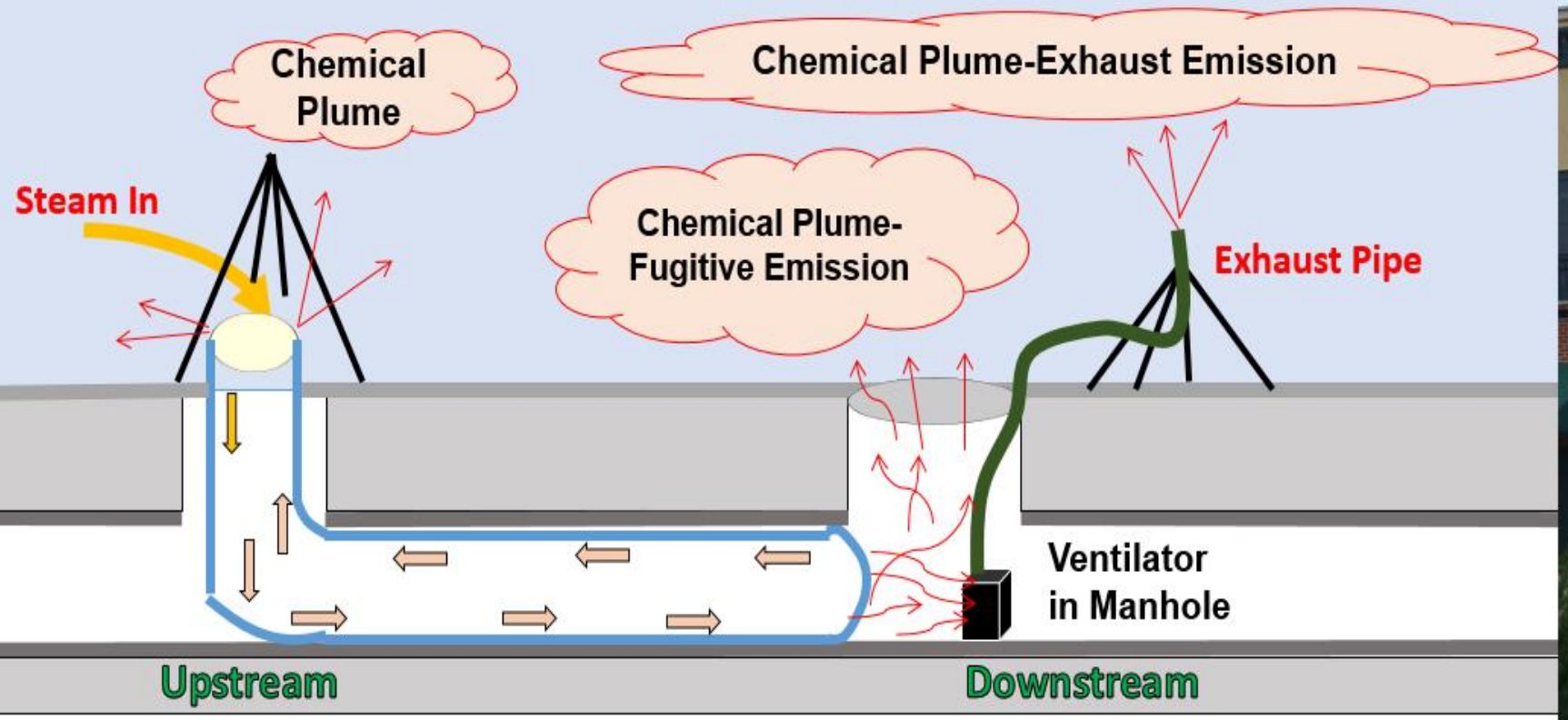
Uncured PET felt resin tube before steam curing

Cross-section of new UV cured CIPP with fiberglass layers



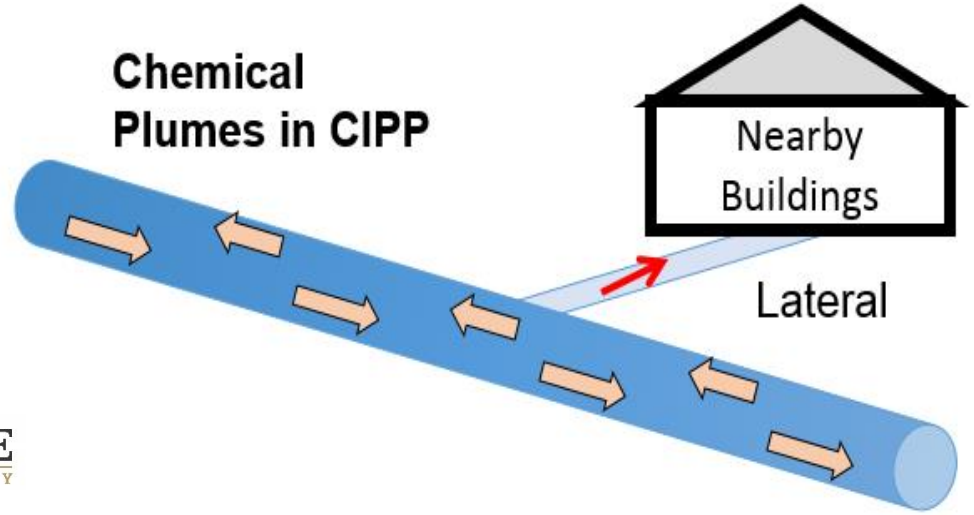


Cross-section of new thermally cured CIPP with PET felt layers



Chemical plumes can be discharged into nearby areas

Chemical Plumes Generated by CIPP can Escape the Pipe Being Repaired



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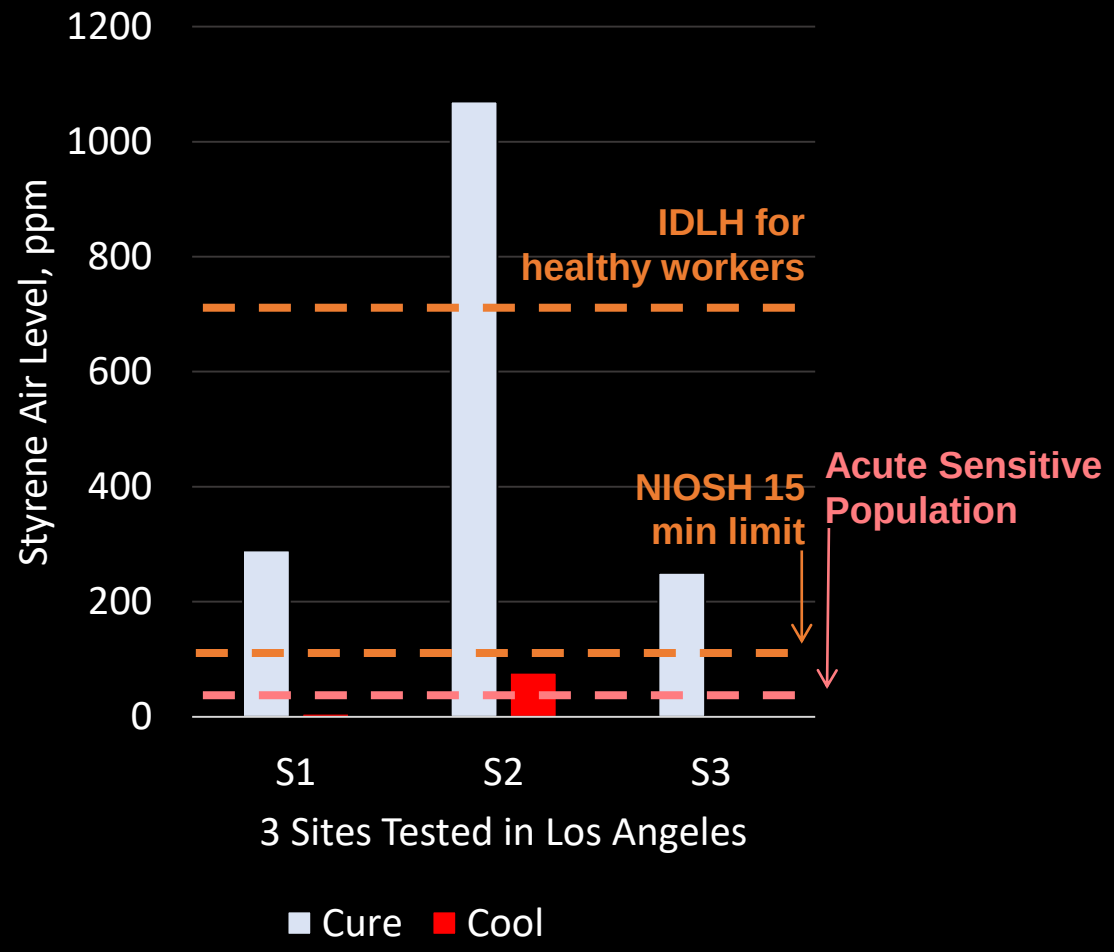
Reinstate lateral connections by robot cutting

Sewer laterals that connect to the pipe being repaired are not sealed off from the property. The uncured resin tube can bulge into the sewer lateral.

Uncured resin slugs in laterals that off gas: CIPP companies add 3-15% excess resin by volume per ASTM F1743 “to allow for the change in resin volume due to polymerization, the change in resin volume due to thermal expansion or contraction, and resin migration through the perforations of the fabric tube and out onto the host pipe.”

2015 – A University of New Orleans PhD student uncovered imminent safety risks: Styrene exiting a Los Angeles sewer exceeded the IDLH



Elena Adjari, Ph.D. (2016)

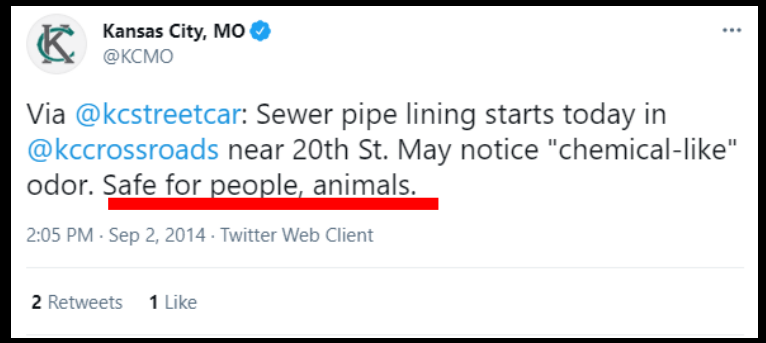
Chemical waste reaches bystanders nearby
Image: Proctor (2022)

In 2005, An Office Building was Contaminated through the Foundation, Lingered for Months

Date	Total VOC, ppm	Styrene, ppm
12/10	Evacuation	Evacuation
12/13	Evacuation	Evacuation
12/13-22	nd – 1.45	Not tested
12/22	nd – 199.0	Not tested
1/12	0.5 – 30.0^{+}	Not tested
1/13	nd – 1.77	nd – 0.30
1/18	nd – 1.60	Not tested
1/21	nd – 0.86	nd – 0.22
2/4	nd – 0.21	nd – 0.15
2/7	nd – 0.57	nd – 0.04
3/28	nd – 0.22	nd – 0.01

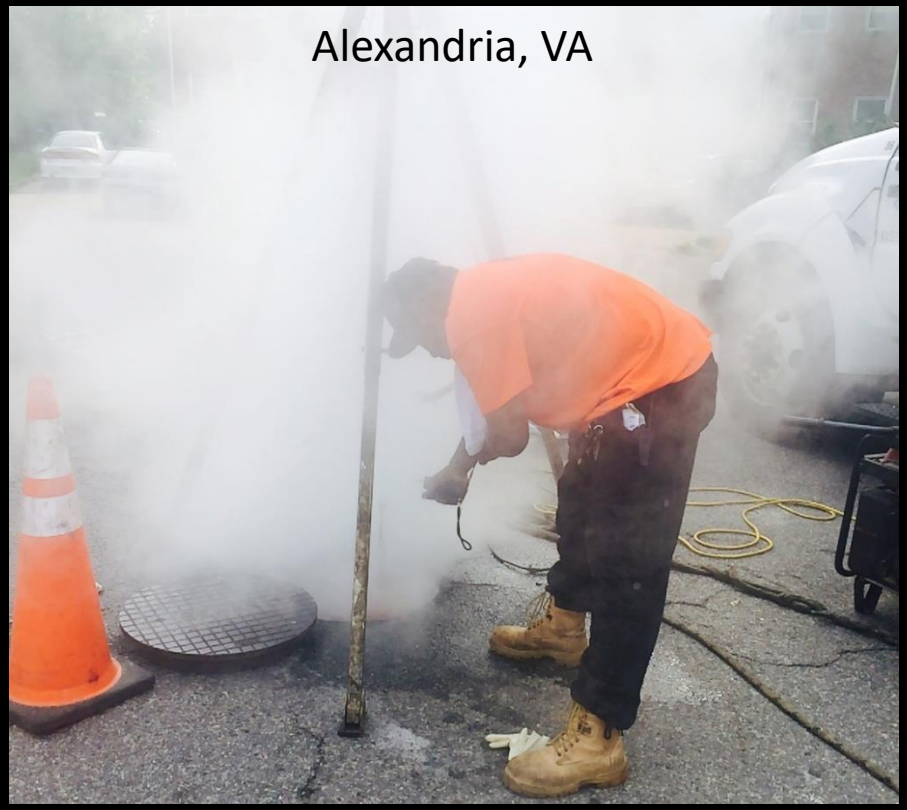
ATSDR Conclusion: "…airborne styrene levels above guidelines for long-term exposure as well as other VOCs…past conditions at the site are classified as a public health hazard"

Milwaukee, WI Health Department: odor in buildings associated with some re-lining projects in the past, but typically would last only a couple of days.



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

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2001, Canada: 3.2 ppm styrene maximum

2004, Canada: PID 110 ppm

2004, Germany: Draeger tube 20 ppm styrene

2004, Canada: PID 120 ppm styrene

2005, Wisconsin: PID 199 ppm

2006, The Netherlands: PID 87 ppm styrene

2007, Virginia: 9.9 ppm styrene

2016, California: 200-1,070 ppm styrene discovered

Q: Does emission pose a healthy and safety risk to workers or bystanders (i.e., children)?

Odor Threshold Concentration = 0.016 ppm

General Public:
CA OEHHA (2017) Acute Ref. Exposure Level = 4.9 ppm

ATSDR (2005) Acute Level = 2.0 ppm

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

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NSF

Teimouri et al. 2017. *Environ. Sci. Technol. Letters.* https://doi.org/10.1021/acs.estlett.7b00237

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:

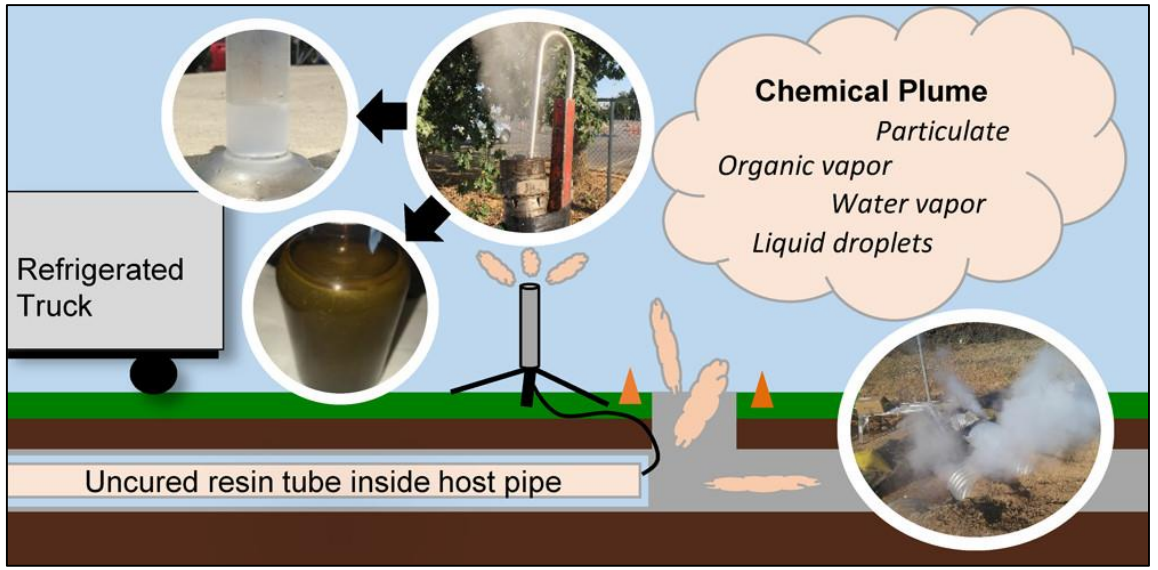
https://doi.org/10.1021/acs.estlett.7b00237

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

1,800 to 4,300 ppm 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

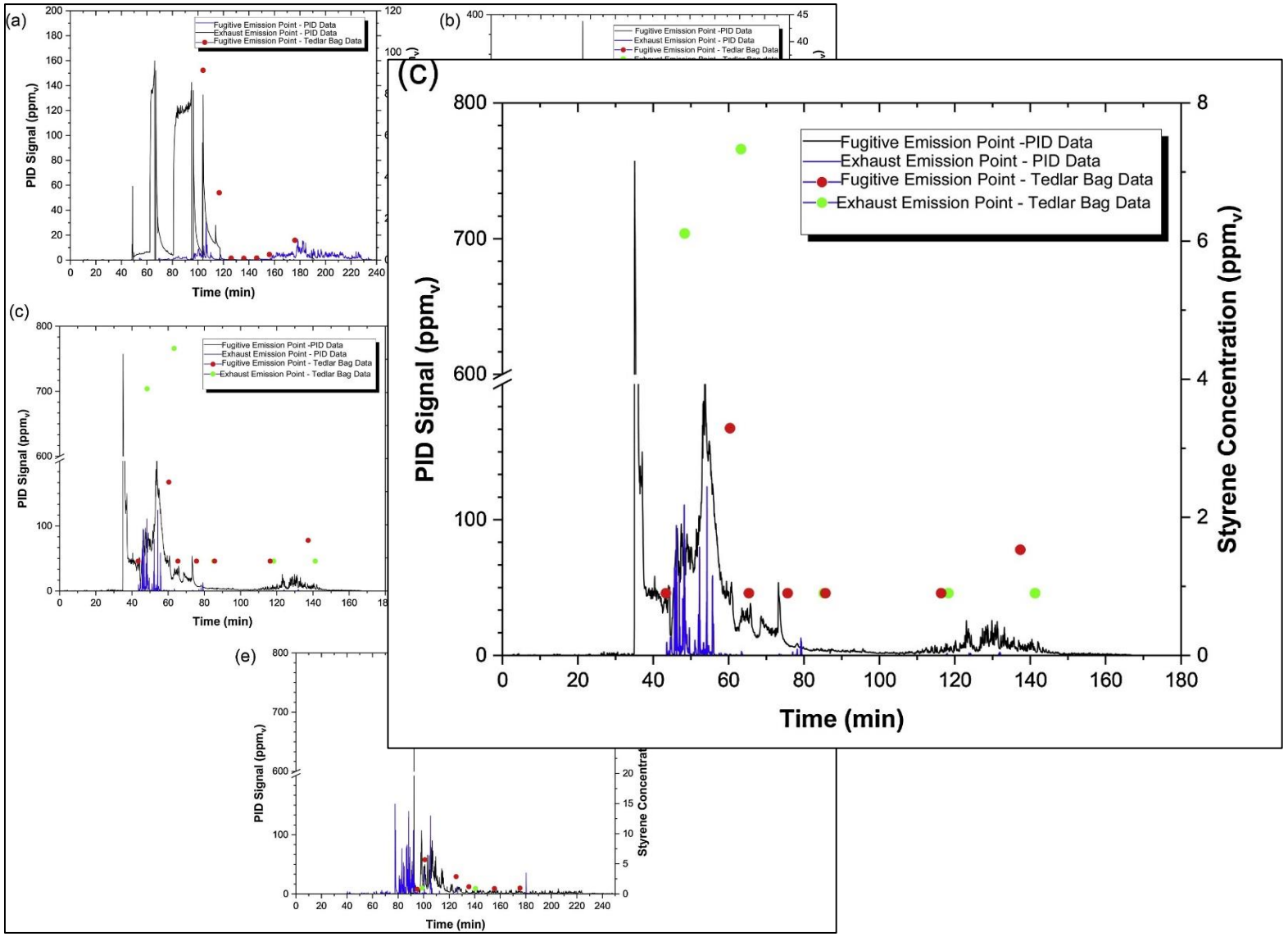


Response…

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

Teimouri et al. 2017. *Environ. Sci. Technol. Letters*. https://doi.org/10.1021/acs.estlett.7b00237

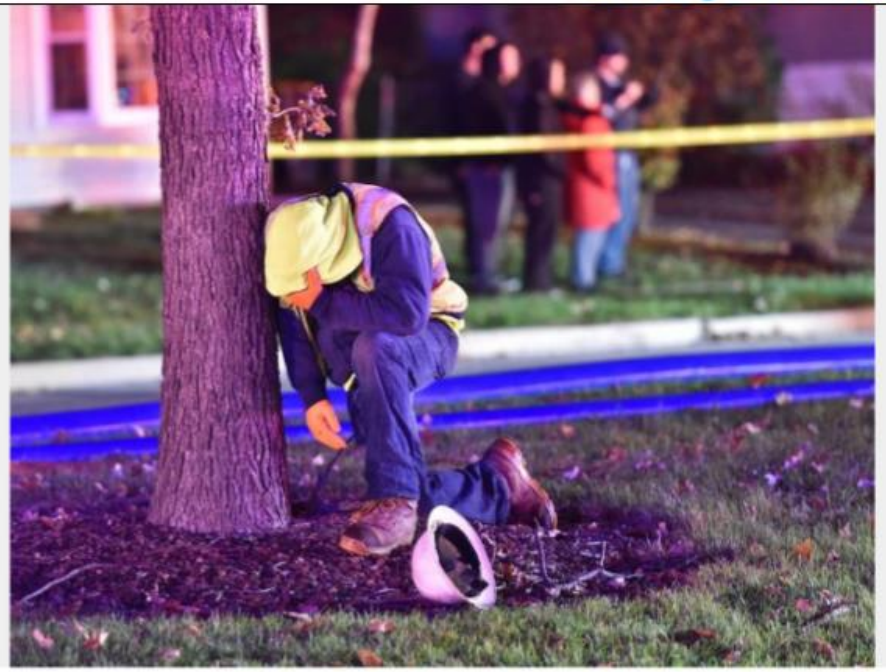
Calibrated PIDs at CIPP worksites *do not* predict health risk. PID under and overestimated styrene levels by 10x to 1000x



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

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

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

As we started looking more closely at exposures….

The material safety data sheets…
did not list all the chemicals that

…were present in the resin brought onsite,
…were created during CIPP manufacture,
…were released into air during manufacture,
…remained in the new CIPP after manufacture, or
…were released after CIPP manufacture.

Product/ingredient name	Identifiers	%	Classification	
styrene	REACH #: 01-2119457861-32 EC: 202-851-5 CAS: 100-42-5 Index: 601-026-00-0	35-50		STOT RE 1, H372i Asp. Tox. 1, H304
phenyl bis(2,4,6-trimethylbenzoyl)-phosphine oxide	EC: 423-340-5 CAS: 162881-26-7 Index: 015-189-00-5	0.1-25	R43 R53	Skin Sens. 1, H317 Aquatic Chronic 4, H413
2,2-dimethoxy-1,2-diphenylethan-1-one	EC: 246-386-6 CAS: 24650-42-8	<0.25	N; R50/53	Aquatic Acute 1, H400 Aquatic Chronic 1, H410
			See Section 16 for the full text of the R-phrases declared above.	**See Section 16 for the full text of the H statements declared above.**

Onsite UV CIPP Resin MSDS: 3 Chemicals reported

Chemicals we found in the resin

Chemical loading varied by layer of the uncured resin tube

Compound	Compound loading (mg/kg)						
	Whole	1st (PVC)	2nd	3rd	4th	5th	6th
BADGE[O]	1110 ± 40	–	1,730 ± 180	1,010 ± 71	1,010 ± 60	2,610 ± 30	–
Benzaldehyde	130 ± 11	–	295 ± 28	195 ± 11	89 ± 5.7	253 ± 12	–
BHT	86 ± 4.0	–	162 ± 4.0	70 ± 2.0	92 ± 2.6	237 ± 6	44 ± 2.3
DBP[EDC, HAP]	388 ± 60	7,700 ± 380	62 ± 16.7	30 ± 3.5	–	18 ± 1.6	41 ± 3.5
Decane	60 ± 4.7	–	109 ± 6	62 ± 1.5	68 ± 5.0	74 ± 4.1	34 ± 2.5
1-Dodecanol	156 ± 15	743 ± 96	–	–	–	–	–
Ethylbenzene[HAP]	5.0 ± 0.5	–	8.2 ± 1.0	8.0 ± 1.0	7.0 ± 1.2	8.2 ± 1.6	3.3 ± 4.6
Irgacure® 184[PI]	2,270 ± 80	–	4,330 ± 150	2,290 ± 30	2,160 ± 120	6,090 ± 96	936 ± 72
Isopropylbenzene[CAR, HAP]	21 ± 1.4	–	31 ± 1.8	24 ± 0.7	26 ± 1.7	33 ± 0.7	–
Maleic anhydride[HAP, M]	280 ± 2	–	550 ± 40	273 ± 40	314 ± 13	811 ± 42	94 ± 2.6
Phthalic anhydride[HAP, M]	124 ± 12	–	274 ± 36	175 ± 21	176 ± 17	402 ± 0.3	–
N-Propylbenzene	40 ± 1.8	–	58 ± 2.5	42 ± 0.6	46 ± 3.8	57 ± 2.6	5.9 ± 1.6
Styrene oxide [CAR, HAP]	56 ± 6.3	–	60 ± 1.3	138 ± 10	47 ± 3.4	63 ± 4.9	–
Styrene[CAR, HAP, M]	108,000 ± 12,000	22,200 ± 4500	144,362 ± 10,135	112,000 ± 4000	134,000 ± 8900	125,000 ± 2600	10,400 ± 3300
1-Tetradecanol	98 ± 11.7	988 ± 180	–	–	–	–	–
1,2,3-TMB	19 ± 0.7	–	32 ± 1.5	18 ± 0.5	19 ± 0.5	38 ± 1.9	1.2 ± 1.7
1,2,4-TMB	113 ± 3	–	175 ± 9	105 ± 3	115 ± 4	186 ± 5	11 ± 5.2
1,3,5-TMB	36 ± 0.6	–	52 ± 1.9	53 ± 2.7	38 ± 0.8	56 ± 1.6	4.4 ± 0.5
Xylenes[HAP]	15 ± 1.2	–	22 ± 1.2	20 ± 0.4	21 ± 2.1	22 ± 1.0	7.1 ± 10.1
Est. Total ΣMass	**113,007**	**31,631**	**152,312**	**116,513**	**138,246**	**135,958**	**11,581**

Some chemicals found were from initiators, meant to react and facilitate polymerization, but also formed new chemicals

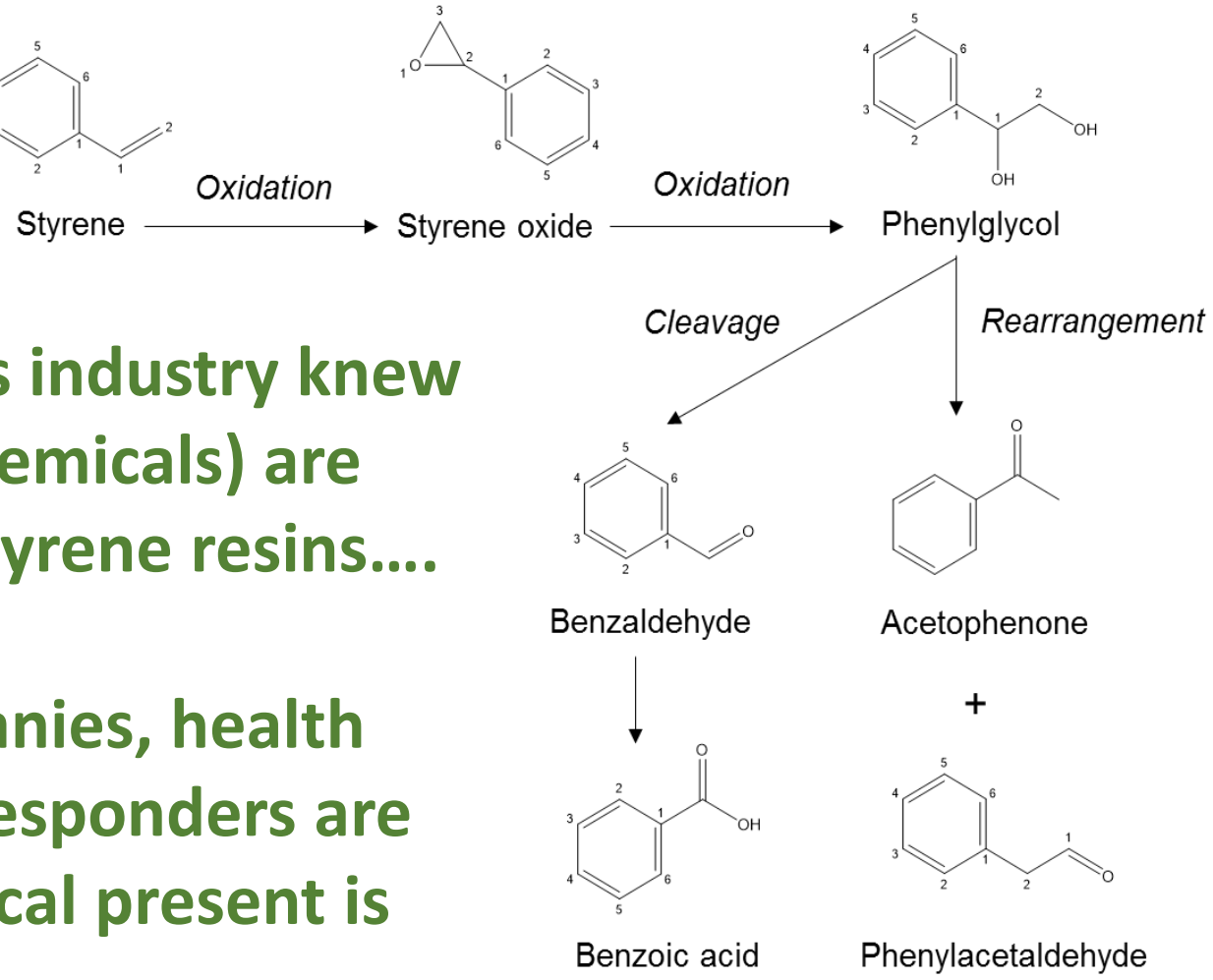
Trigonox®
Acetone
Acetophenone
Benzene
Benzoic acid
tert-Amyl alcohol
tert-Butanol
3-*tert*-Butoxyheptane
2-*tert*-Butyloxy-24,4-trimethylpentane
Carbon dioxide
3-(1,1,Dimethylpropoxy) heptane
Ethane
2-Ethylhexanoic acid
Heptane
Methane
2-Phenylisopropanol
3,3,5-Trimethylcyclohexanone

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 the composites industry knew that byproducts (new chemicals) are produced when you cure styrene resins….

But CIPP workers, companies, health officials, and emergency responders are often told the only chemical present is styrene.

Pfäffli et al. 1979. Styrene and styrene oxide concentrations in the air during the lamination process in the reinforced plastics industry. *Scandinavian J. Work, Environ. & Health*, 158-161.

Our 2019 Study: Styrene, Other VOCs Present, PIDs, 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 alterations in operational procedures to mitigate emissions and to understand potential 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

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1 UV CIPP company completed a free and confidential NIOSH health hazard evaluation

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.

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PROBLEMS: Most CIPP studies 100% reliant on PID data and styrene vapor 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

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Remember the CIPP industry who stated our discoveries were unfounded?

4 years later… their report

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)

But several issues with sampling locations, data interpretation, representativeness, etc.

1 Steam/Hot Water CIPP company completed a free and confidential NIOSH health hazard evaluation

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.

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HHE HealthHazard® Evaluation Program

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

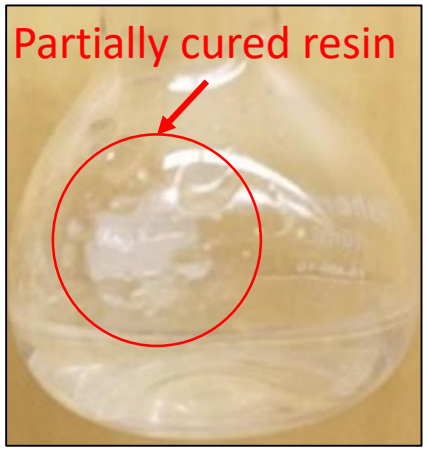
CDC NIOSH Centers for Disease Control and Prevention National Institute for Occupational Safety and Health

Concentrations differ by activity: Setup vs. Curing vs. Cooldown vs. Mechanical cutting

Example: Steam cured CIPP waste discharge

Organic Vapors from Resin Truck
Styrene+ vapor 1,820 ppm
(NIOSH Limit: IDLH 700 ppm worker)
(CDPH Limit: 4.9 ppm public)

Organic Vapors are Pushed Out
Styrene: 250 to 1,070 ppm, 3.6 to 76 ppm, 200 to 300 ppm, >86 ppm, 3.2 ppm
Methylene chloride >1.5 ppm
Others: Acetone, Benzene, Benzaldehyde, MEK, Chloroform, Ethylbenzene, Toluene, TMBs, Xylenes and more



3 to >20+ psi artificial pressure applied

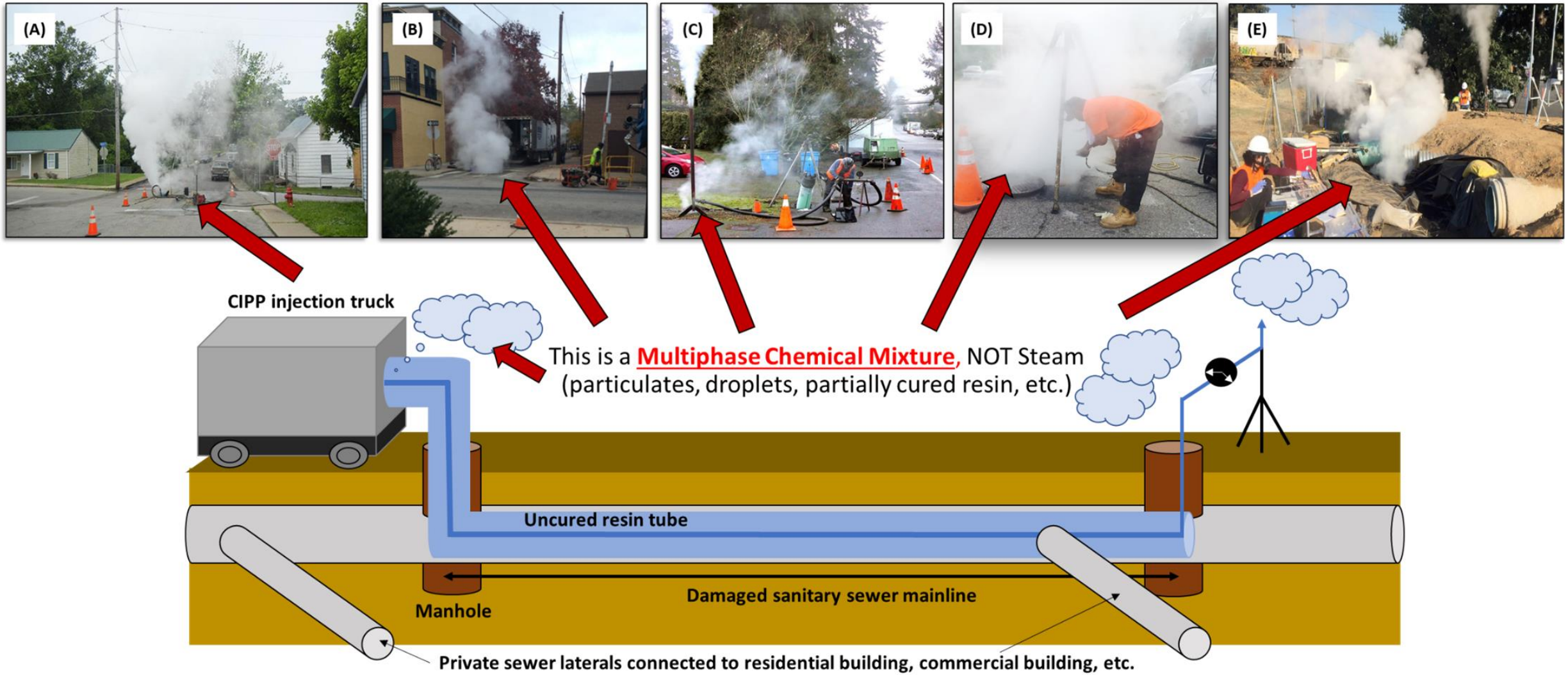
Steam hose from boiler

Exhaust Emissions **NOT STEAM**

Fugitive Emissions

A Multiphase Mixture is Discharged
Styrene: **1,800 to 4,300 ppm**
Phenol, DBP, TPGDA, Tetradecanol, Benzaldehyde Benzoic acid, Acetophenone

Sewer lateral to building


(A)
(B)
(C)
(D)
(E)
CIPP injection truck
This is a Multiphase Chemical Mixture, NOT Steam
(particulates, droplets, partially cured resin, etc.)
Uncured resin tube
Manhole
Damaged sanitary sewer mainline
Private sewer laterals connected to residential building, commercial building, etc.

From 2017 to 2020:

Evidence we obtained debunked 20+ years of safety claims spread by contractors, municipalities, and consulting engineers

"Styrene vapor of at most few ppm" - False
"is not a human health risk" - False
"is safe for people and animals" - False
"it is harmless steam" - False
"no hazardous conditions posed" - False
"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" – It may in fact be harmful.

2019, New York City, NY

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The failure to contain plastic manufacturing waste has had significant bystander health consequences

Cancer Care Center of Decatur evacuates due to odor caused by city sewer project

Illinois: Feb 20, 2020

Spooner Middle School reopens, identifies 'chemical exposure' that sickened 64 students and staff

Some parents aren't comfortable sending children back, saying district hasn't been open about what caused Nov. 10 evacuation

By Rich Kremer

Published: Tuesday, December 21, 2021, 6:10pm

Fumes Sicken 28 Pupils at Zamorano Elementary

California: Sept 21, 2017

fall ill at Riverview Elementary School

Washington: Oct 10, 2018

Evidence: CIPP caused chemical exposure incidents for the general public (info below not yet updated since 2019, more have occurred.)

2017 study (59)

Alexandria, Virginia
Antigo, Wisconsin
Arlington, Virginia
Baltimore, Maryland
Bellevue, Washington
Bethlehem, New York
Boston, Massachusetts
Botany Village, New Jersey
Brooklyn, New York
Cambridge, Massachusetts
Cheektowaga, New York
Clear Creek, Colorado
Des Moines, Iowa
Fayetteville, New York
Good Hope, Illinois
Helena, Montana
Kensington, Maryland
Lincoln, Nebraska
Lorain County, Ohio
Madison, Wisconsin
Milwaukee, Wisconsin
Nashville, Tennessee
North Tonawanda, New York
Philadelphia, Pennsylvania
Picayune, Mississippi
Pittsburgh, Pennsylvania
Port Huron, Michigan
Prairie Village, Kansas
Rensselaer, New York
Saint Louis, Missouri
Saint Petersburg, Florida
Saugus, Massachusetts
Snellville, Georgia
Southfield, Michigan
West Lafayette, Indiana
Willamette River, Oregon
Williams Co. Village, Ohio
Worcester, Massachusetts
Unidentified, Illinois
Unidentified, Minnesota

Teimouri et al. (2017) *Environ. Sci. Technol. Letters.*
https://doi.org/10.1021/acs.estlett.7b00237

2019 study (45)

Andersen, Indiana
Aurora, Colorado
Austin, Texas
Alexandria, Virginia
Arlington, Virginia
Arlington, Kentucky
Barnet, Vermont
Bend, Oregon
Bolivar, Missouri
Bronxville, New York
Burlington, Kentucky
Charlotte, North Carolina
Chattanooga, Tennessee
Columbia, Missouri
Darlington, Wisconsin
Dublin, California
Effingham, Illinois
Falls Church, Virginia
Hattiesburg, Mississippi
Honolulu, Hawaii
Lees Summit, Missouri
Midland, Michigan
Milwaukee, Wisconsin
North Attleboro, Massachusetts
Nyack, New York
New York, New York
Richmond, Virginia
Salem, Virginia
Sarasota, Florida
Saint Louis Park, Minnesota
Saint Paul, Minnesota
San Diego, California
South Heights, Pennsylvania
South Pasadena, California
Tampa, Florida
Terra Haute, Indiana
Vancouver, Washington
Weymouth, Massachusetts
Whitesboro, New York

Ra et al. (2019) *J. Haz. Materials.*
https://doi.org/10.1016/j.jhazmat.2019.02.097

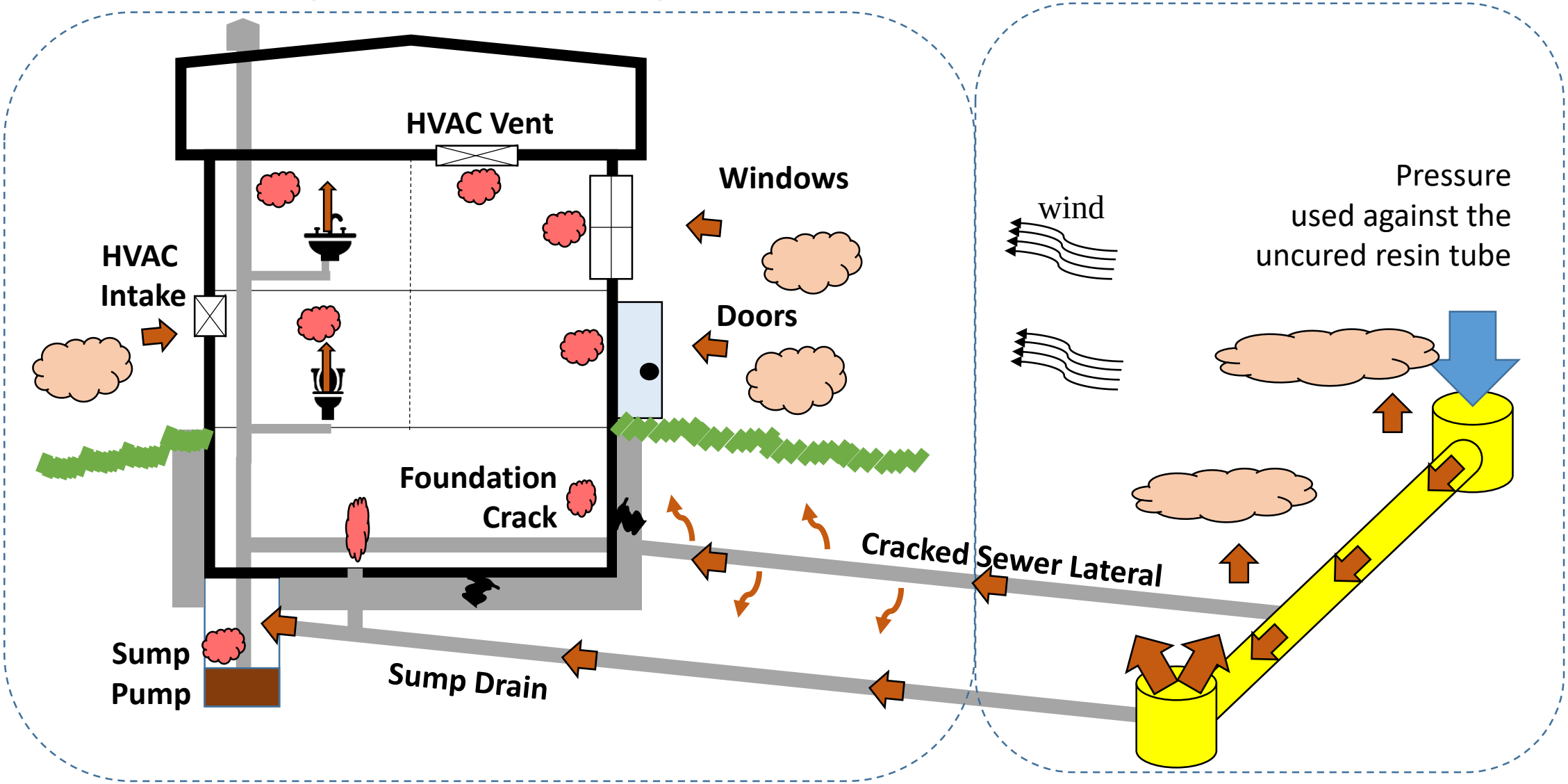
OCONUS (11)

Brisbane, AUS
Birmingham, UK
Cornwall, UK
Manchester, UK
Somerset, UK
Surrey, UK
Montréal, CAN
Ontario, CAN
Ottawa, CAN
Québec, CAN
Toronto, CAN

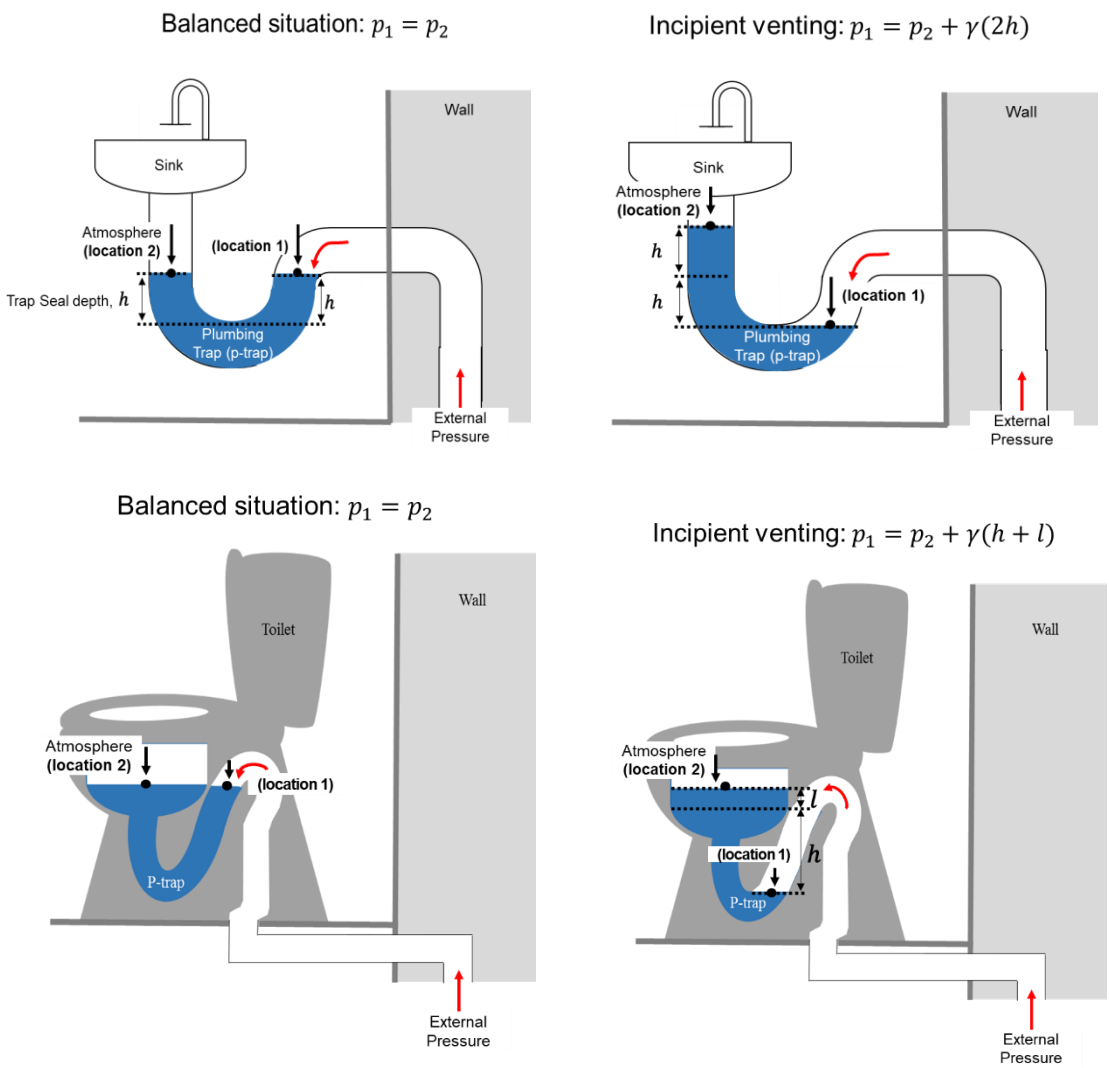
Known Exposures in 30+ States
California, Colorado, Connecticut, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Vermont, Virginia, Washington, Wisconsin

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



https://doi.org/10.1016/j.jhazmat.2021.126832

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

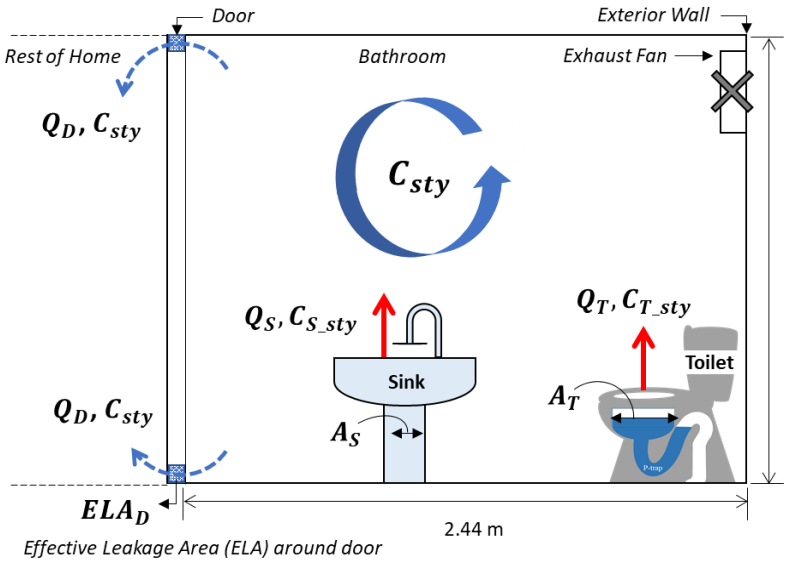
Reported pressure applied by contractors during sewer lining:
3 psi to 28 psi

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

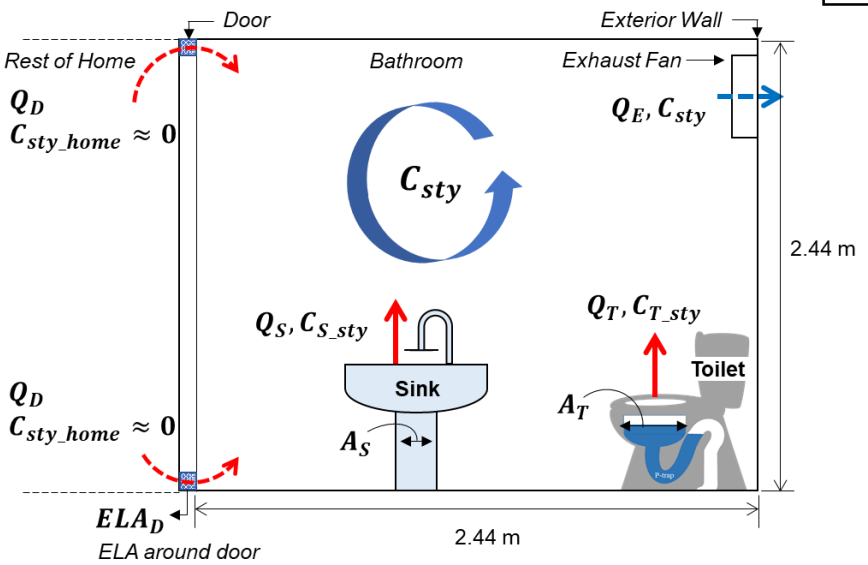
Bathroom chemical air contamination and decontamination model simulation

Non-ventilation Condition



Effective Leakage Area (ELA) around door

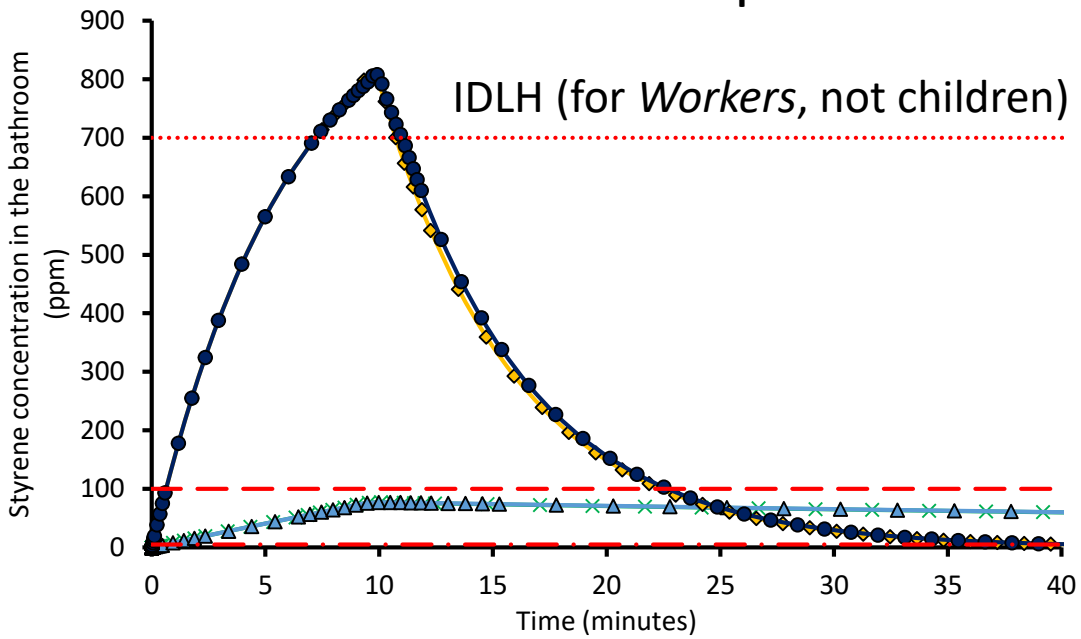
Ventilation Condition

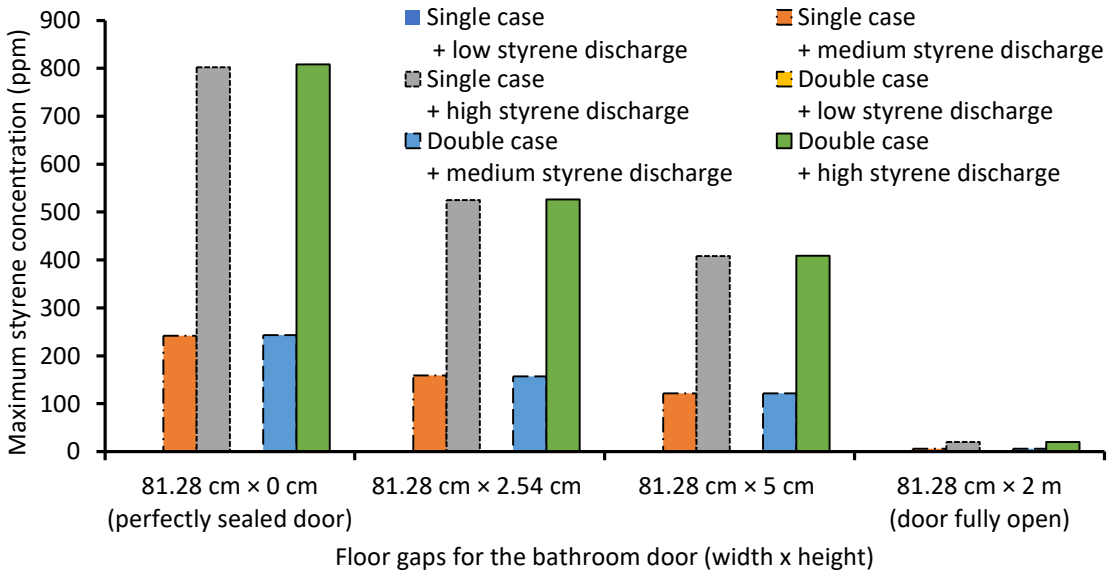


ELA around door

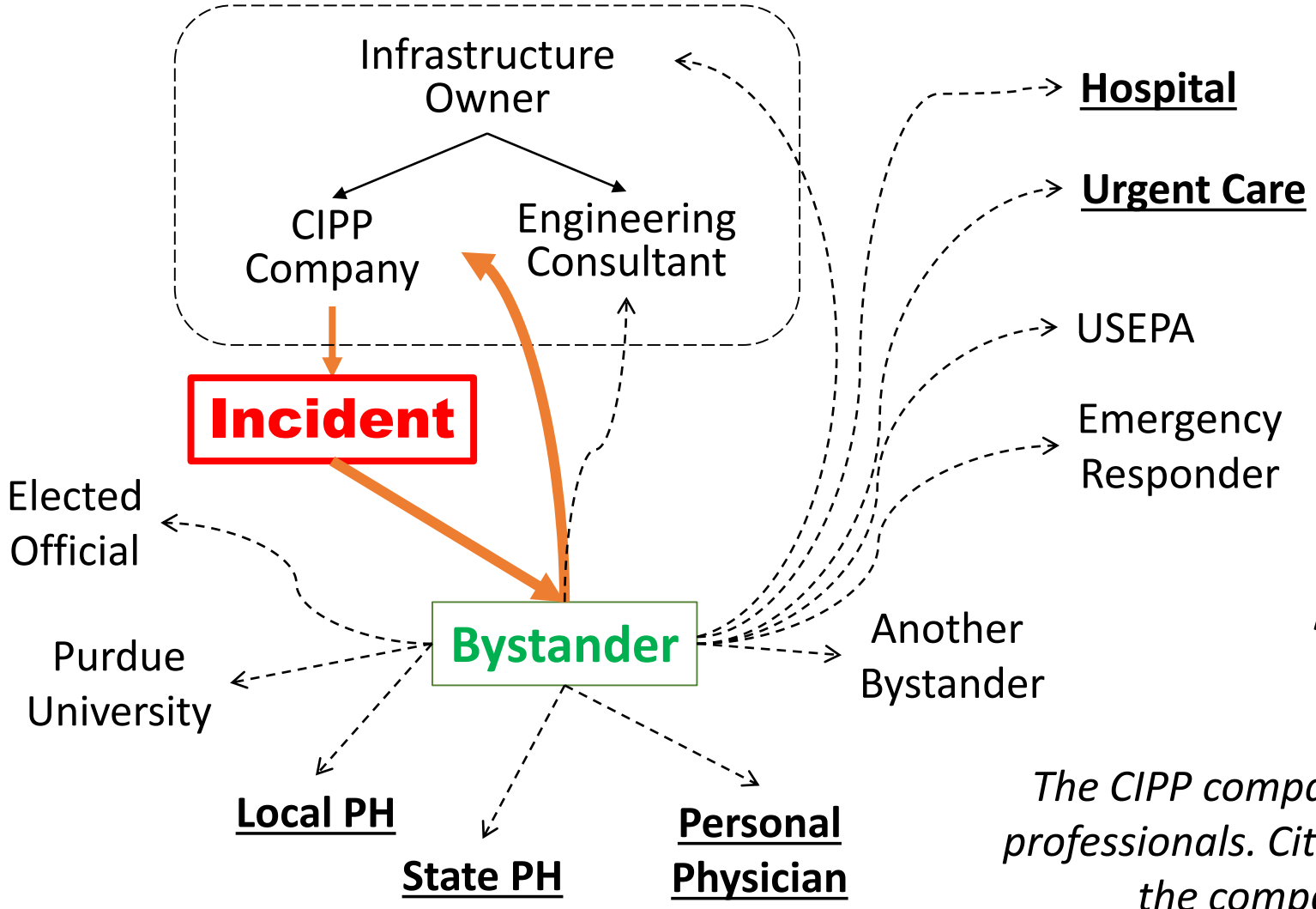
Indoor styrene concentration change after constant inflow (1,000 ppm$_v$ for 10 min) into the bathroom

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





What's the extent of the problem?



The CIPP company notifies bystanders, not medical professionals. City encourages bystanders to contact the company. None have medical experience.

Technology and system awareness: The California Department of Health and Florida Department of Health have taken initiative to warn health officials, municipalities, and the public

Safety Alert
Cure-In-Place Pipe (CIPP)
Vapor Migration into Buildings

CDPH California Department of Public Health

Background

The use of CIPP for sewer line and culvert rehabilitation is widespread throughout the country and abroad. Styrene-based resins are the most widely used.

There is a possibility for chemical releases with CIPP processes. In addition to styrene, recent studies have shown numerous volatile chemicals being released during CIPP installations that have previously been repo

Migration of vapors fro tile ca t indoor result exposure to building occupants.

There have be over 130 ex re den d in 30 states.

A project involv a larg er line installation resulted in styrene vapors migrating into an office bu g. eeded acceptable exposure levels. Building occ ants experienced health symptom rene was measured for up to three months follo the P installation.

Styrene is not th ly chemical emitted, but it may as for ntifying vapor intrusion impacts.

Styrene healt ffects

- Central nervous sy depres
- Mucous membrane ant (ract, eyes, nose and throat).
- Nervous system effe nclu eadache, fatigue, changes in color vision, concentration and balance problems.
- Potential to cause cancer.

Concerns during CIPP installation

- Styrene and other toxic vapors can migrate during **cure-in-place pipe (CIPP)** installation into buildings through windows, doors, cracks in foundations, laterals, compromised plumbing connections, and subsurface voids, resulting in potentially harmful exposure to occupants.
- Vapor migration is highly variable due to subsurface conditions, job size, and building characteristics.

May 2020 (update)

[2017]
[2020]

Mission: To protect, promote & improve the health of all people in Florida through integrated state, county & community efforts.

Florida HEALTH

Vision: To be the **Healthiest State** in the Nation

Ron DeSantis
Governor

Scott A. Rivkees, MD
State Surgeon General

CURED-IN-PLACE-PIPE [CIPP]

Cured-in-place-pipe (CIPP) installation is a relatively new method used for sewer line and culvert rehabilitation. Recently, concerns were raised regarding the possibility of residual chemical releases during the installation process and related harm to human health.

This factsheet will help you to learn more about the CIPP process — what it is, how it may harm your health and how to protect yourself and your family from possible health effects.

General Facts
CIPP Regulation and Advisories
Biomonitoring and Blood Testing

General Facts

What is CIPP?

Cured-in-place-pipes (CIPP) are ntless, seamless, flexible plastic pipe liners chemically installed within an existing sewer, water, gas or pipe.

CIPP is used during the repa ocess of lines, culvert and drinking water pipes. The process involves the insertion an uncure ting, defective pipe. Hot air and/or water or ultraviolet light are u expan be creating a liner to fit against the wall of the "broken" pipe

The purpose of the curing ess is to hat would otherwise allow rainwater and roots to enter the pip cause ns such as stoppages and overflows. The new liner can also help prevent

Why is CIPP used?

CIPP is used to repair pipes without disturbance to surface structures or other utilities broken pipes. It is advertised by some contractors to be a more efficient and cheaper process to re pipes. Some, new CIPPs are designed to have an estimated 50-year lifespan.

What does CIPP consist of?

A new CIPP is created using a number of materials: a resin, a chemical initiator package, a reinforcement material and other additives. The most popular resins today include:

- Styrene-based polyester
- Styrene-based vinyl ester
- Vinyl ester (styrene free)
- Epoxy (styrene free)

Why is the CIPP process a concern?

Chemicals are released into the air during a CIPP project setup, while the CIPP is made and after the plastic liner has been created. The tube of uncured resin as well as its delivery and handling can release chemicals into the air. In addition, forced air, steam and hot water use also releases chemicals into the air and can potentially transfer the chemicals from the process into a worksite, nearby pipes, nearby residences through plumbing, open windows, doors, cracked foundations and in the environment causing

UPDATED: 09-28-2020

[2020]

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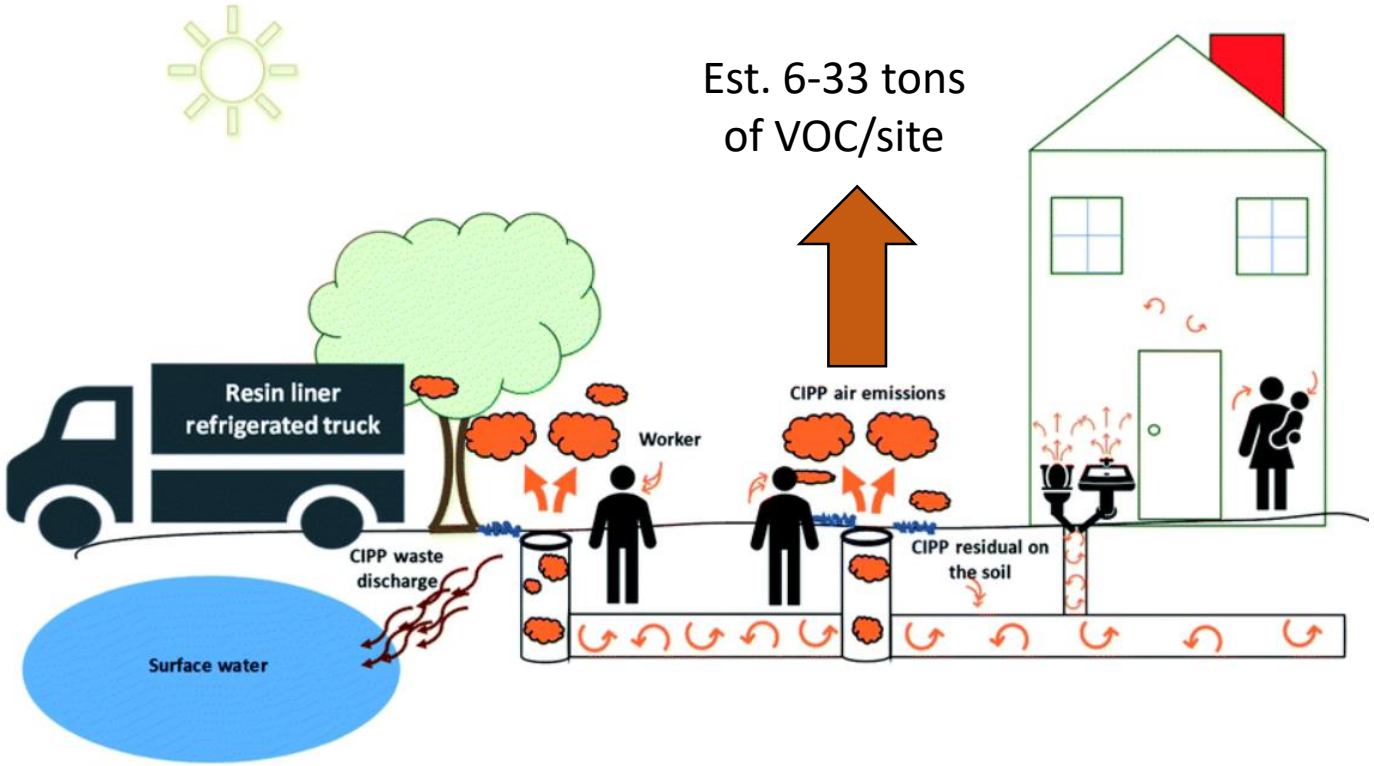
Environmental impacts have been less studied

61,000 to 454,000 kg of resin sometimes used per project

Resin VOCs evaporate and are discharged into the environment during curing (est. 8.87 wt% lost)

[[Est. 6-33 tons per CIPP project]]

Can ventilating the new CIPP fix the use phase styrene release problem? - No

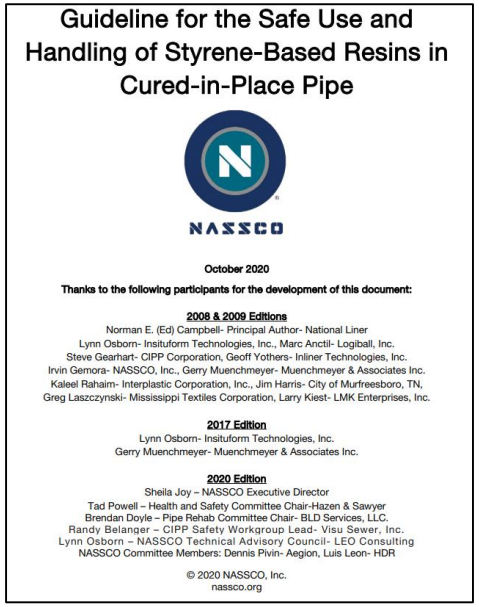


Perspective: Under section 112 of the Clean Air Act, the plastic pipe and pipe fitting manufacturing industry [NAICS code 326122] must follow a permit limit of less than 100 tons per year of HAP emission.

Teimouri et al. 2020. *Env. Sci: Proc. Impacts* https://doi.org/10.1039/D0EM00190B

CIPP companies *and* engineering consultants have encouraged CIPP companies to discharge the untreated hazardous air pollutant waste into the air by

"…maximizing the flow of air through the curing CIPP…"



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

NASSCO

October 2020

Thanks to the following participants for the development of this document:

2008 & 2009 Editions

Norman E. (Ed) Campbell- Principal Author- National Liner
Lynn Osborn- Insituform Technologies, Inc., Marc Anctil- Logiball, Inc.
Steve Gearhart- CIPP Corporation, Geoff Yothers- Inliner Technologies, Inc.
Irvin Gemora- NASSCO, Inc., Gerry Muenchmeyer- Muenchmeyer & Associates Inc.
Kaleel Rahaim- Interplastic Corporation, Inc., Jim Harris- City of Murfreesboro, TN,
Greg Laszczynski- Mississippi Textiles Corporation, Larry Kiest- LMK Enterprises, Inc.

2017 Edition

Lynn Osborn- Insituform Technologies, Inc.
Gerry Muenchmeyer- Muenchmeyer & Associates Inc.

2020 Edition

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Tad Powell – Health and Safety Committee Chair-Hazen & Sawyer
Brendan Doyle – Pipe Rehab Committee Chair- BLD Services, LLC.
Randy Belanger – CIPP Safety Workgroup Lead- Visu Sewer, Inc.
Lynn Osborn – NASSCO Technical Advisory Council- LEO Consulting
NASSCO Committee Members: Dennis Pivin- Aegion, Luis Leon- HDR

nassco.org

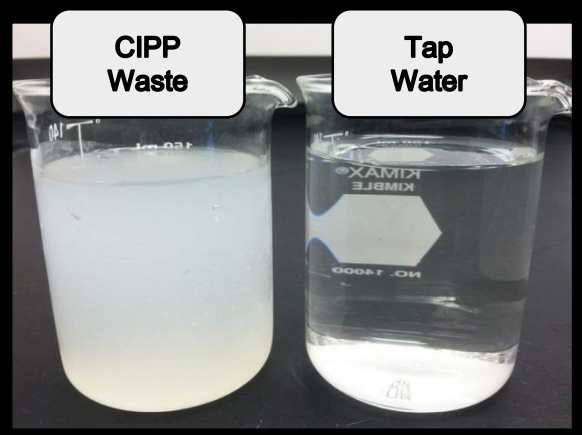
An estimated 6 to 33 tons of VOC is discharged into the air *per project*

- CIPP companies seem to be discharging HAP/EDC/CAR air pollution at scales classified under the *Clean Air Act*
- Environmental Assessments under NEPA should consider this air pollution

New CIPPs release VOCs into the air *after* being placed into service

Styrene-free, VOC-free CIPPs release pollution too

To date…USEPA has been relatively unaware of the pollution.



Until 2020, the CIPP industry encouraged companies to dump their waste into “streams and ditches”

Fish kills, drinking water contamination, wastewater treatment plant upsets, waste dissolves organisms at room temperature

August 2019 in Carlisle, PA

1 of the top 10 U.S. trout streams: 200+ fish kill caused by CIPP waste

Styrene found, temperature not high

NOV issued to city; Criminal/law enforcement, and environmental enforcement investigations opened

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Our 2022 Study: Change the resins to reduce pollution

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

Download FREE here:

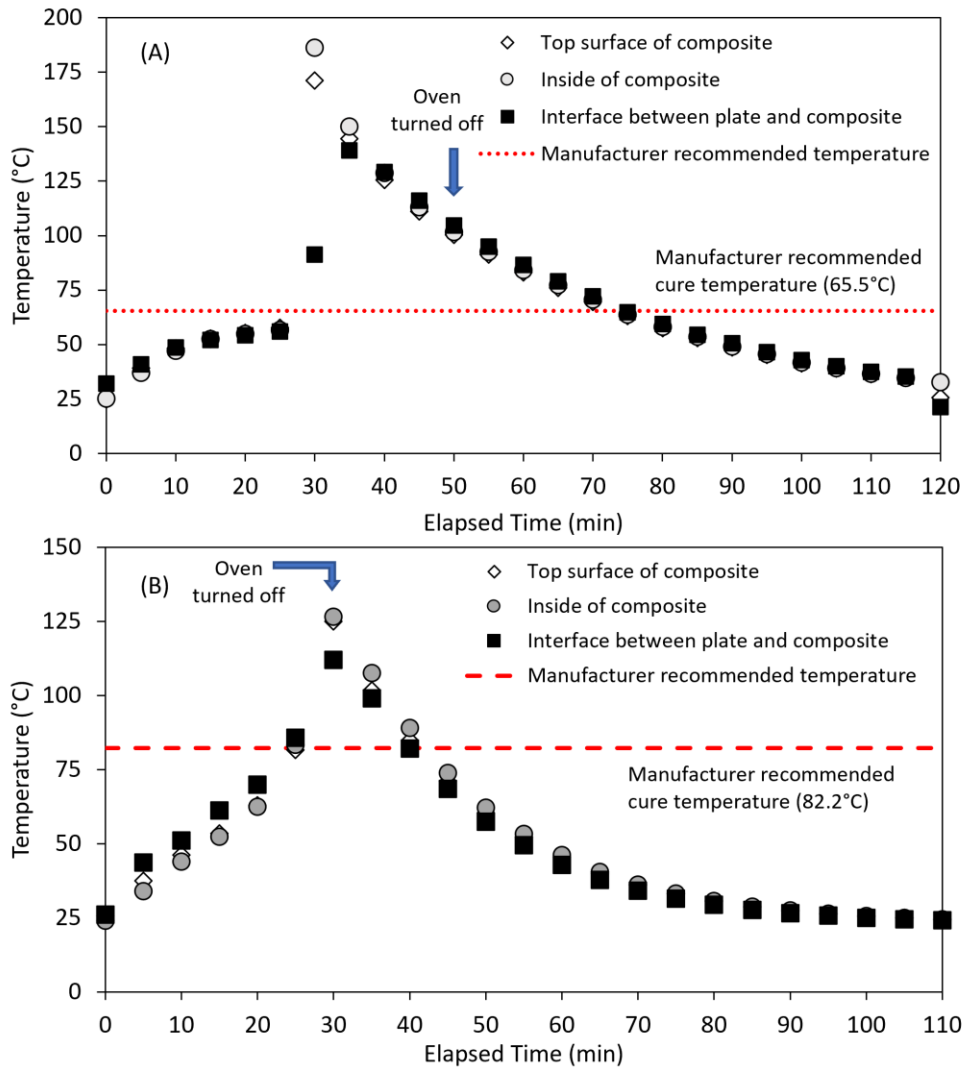
https://doi.org/10.1016/j.jclepro.2022.131803

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 MSDS, but 8 chemically identified



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Noh et al. 2022. *J. Cleaner Prod.* https://doi.org/10.1039/D0EM00190B

RISKS OF INFRASTRUCTURE RENOVATION: BYSTANDER INJURIES DUE TO SEWER PIPE REPAIR EMISSIONS

1. The primary health concern is the chemical waste. Styrene has exceeded levels where acute harm occurs for the general public (4.9 ppm), the IDLH concentration (700 ppm), and where NIOSH recommends –*worker*– respiratory protection (500 ppm).
2. Chemicals other than styrene are emitted and can cause harm.
3. SDSs do not list all resin chemicals, those being created and discharged into the air. New chemicals are created that can cause acute health impacts.
4. Do not use odor to determine whether or not the exposure is safe for children, adults, and pets.
5. Popular 4-gas meters cannot detect the chemicals discharged at CIPP worksites.
6. PID meters do not reliably quantify chemicals of concern at CIPP sites, 10 to 1,000 times off.
7. Chemical waste enters buildings multiple ways. CIPP pressures can displace plumbing trap water seals.
8. Neighboring buildings may have starkly different contamination levels.

RISKS OF INFRASTRUCTURE RENOVATION: BYSTANDER INJURIES DUE TO SEWER PIPE REPAIR EMISSIONS

9. First responders should

   - Halt the CIPP process to gain control of the incident. (Waste left containment)
   - Remove exposure victims from the area and provide medical attention.
   - Ventilate the building and conduct testing to determine contamination is fully removed
   - Prepare the incident report and include description of site observations and discussions with contractors, general public, etc.

10. In building chemical levels …

    … may be drastically lower than the initial exposure IF ventilation starts before emergency responders arrive.

    … can increase DUE to ventilation.

CIPP can likely be used without endangering human health if appropriate controls were implemented.

To reduce risks posed to emergency responders & bystanders…

1. Petition Public Works and Pipe Owners to require lesser polluting CIPP, capture the waste and/or use of other pipe repair practices

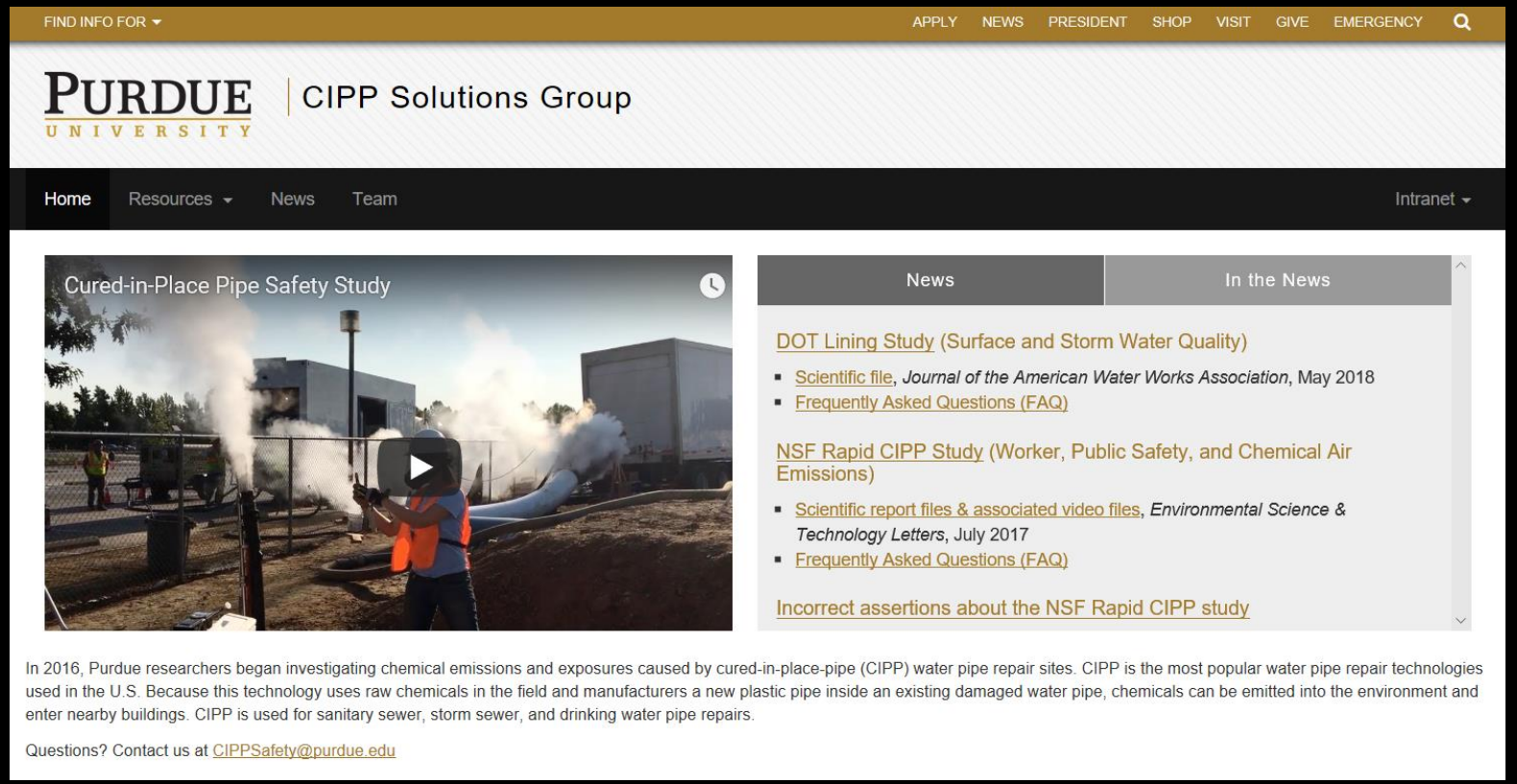
2. Require the Public Health Department be notified before projects begin

3. Request a free NIOSH health hazard evaluation for worksites and buildings

4. Request NIOSH evaluate rapid air testing devices for CIPP incident response

Thank you. Questions?

Andrew Whelton, Ph.D. awhelton@purdue.edu



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