



Tighe&Bond

Engineers | Environmental Specialists



CURED IN PLACE PIPE (CIPP) PROCESS, RISKS, & CONTROLS

Dr. Scott Smith CSP
Safety & Health Director
Tighe & Bond

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Discussion Outline

■ **Cured in Place Pipe**

- A History
- The Process
- Applications and Benefits

■ **Standards**

- EPA
- OSHA
- Sampling Methods
- OSHA Enforcement and Inspection Guidelines

■ **Exposure Relationships**

- Environmental
- Community
- Worker

■ **Exposure Monitoring**

- Compounds Isolated
- Steam and Non-steam
- Study Results

■ **Best Practices on Exposure Prevention**

- Environment
- Community
- Worker

A History

- Pipe maintenance is critical to an infrastructure
- PVC, Acrylonitrile Butadiene Styrene (ABS), Steel, Cast Iron / Galvanized (Hexavalent Chromium), Copper, Clay, Concrete (Silica), Orangeburg (hot pitch and wood pulp)
 - Warps in heat
 - Loud
 - Expensive
 - Limited to indoor use
 - Toxicity concerns
- Install in most cases requires trenching
 - Working around existing infrastructure
 - Roadways, traffic, structures
 - Pedestrian safety
 - Impacts to customers and water plant operation
 - Replacing pipes requires trenching and creates greater risks
 - All add costs



CIPP – A History

- CIPP is designed to be a trenchless system
- Invented in London England in 1971
- Implemented in Europe across the 70s
 - Eric Wood invented the CIPP process to control a leaky pipe in his garage
 - He didn't want to pull up the flooring
 - He called his product Insit U Form (form in place)
 - Applied for patent January 29, 1975
- Insituform Technologies commercialized the product
 - Brought it to the United States

- It is estimated the 50% or more of pipe repair is now done with CIPP methods
- Generally, < 60 min cure time



CIPP – Process

The process involves inserting a flexible liner (felt or fiberglass) inside an existing pipe. Inflating the liner, then exposing it to heat (hot water / steam) or ultraviolet light to harden. The liner creates a smooth surface restoring it to near-new condition.



CIPP – Applications and Benefits

- Can be used in sewer, water, gas, chemical, and heating pipelines
- Limits impacts on surface traffic, pedestrians, and facilities
- Allows existing infrastructure to remain in place
- No or limited trenching work needed
- Fast process with rapid hardening
- Used in short and long pipe runs
- 50+ years lifespan

CIPP – Process

Emissions have been historically communicated as only steam, sampling shows the emission from the process contains multiple compounds and high heat released throughout the process.

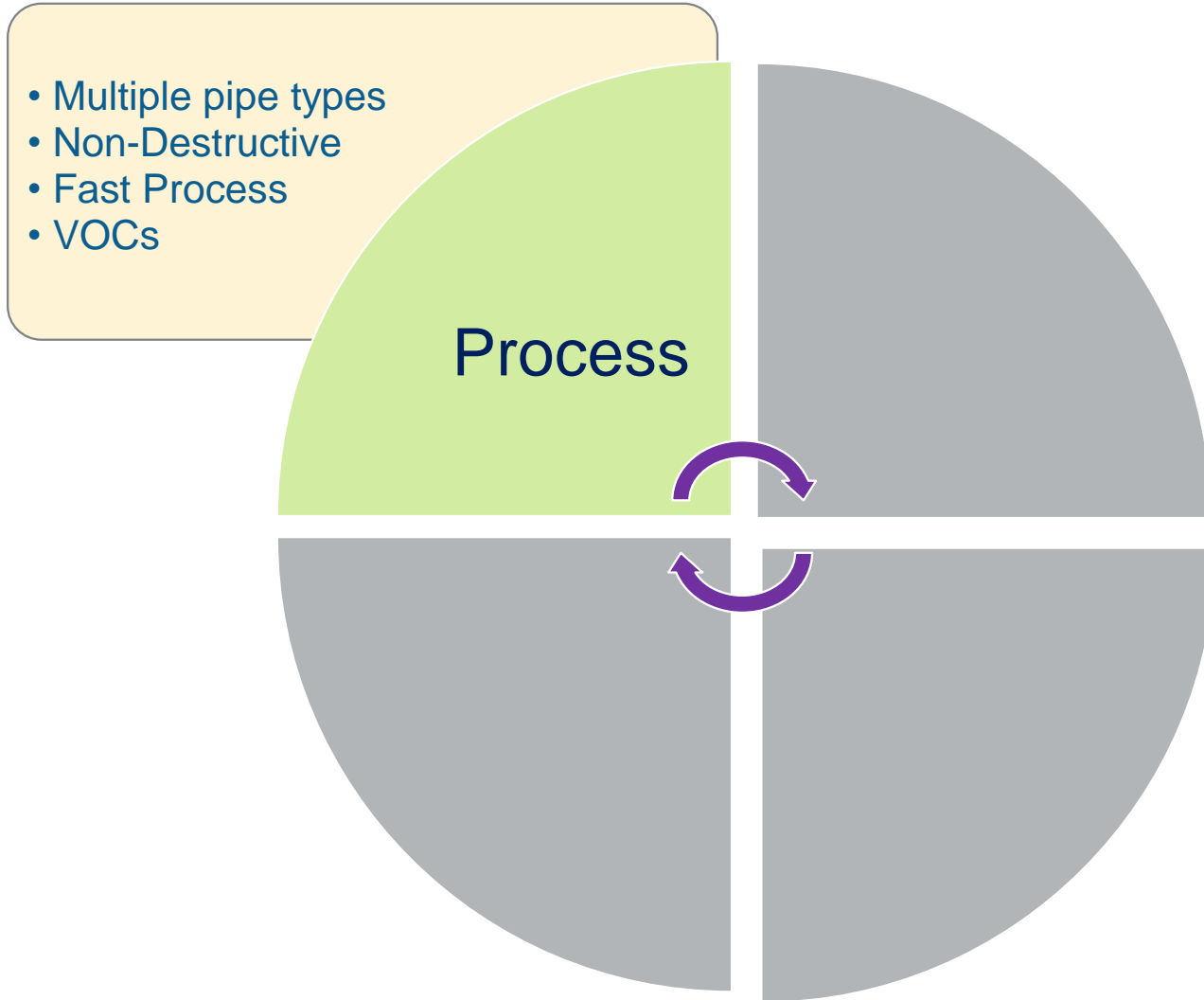
Discharges May Contain

Volatile organic compounds (VOC)
Semi-volatile organic compounds (SVOC)
Particles
Liquid droplets

Most Common Resins Used Today:

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

CIPP – Circle of Safety



Let's move on to existing standards.....

Risk Pathways



EPA – Environmental, Community

Boat manufacturing is a major source of HAPs, including styrene, methyl methacrylate (MMA), methylene chloride (dichloromethane), toluene, xylene, n-hexane, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and methyl chloroform (1,1,1-trichloroethane). Facilities are point sources. Easy to find.

California Department of Public Health issued a “Safety Alert” on the issues of CIPP work, based on their research. Updated that alert asking community members to **call their medical provider** if they detect odors.

Canton Connecticut sent a notice out prior CIPP work stating odors “may get into the building through improper or clogged venting, dry traps, or, in some older homes, floor drains that are connected to the sanitary sewer. If you detect an odor, please ventilate your home by opening a window.” They also stated, “The **odor is not harmful** and will dissipate quickly.”

CIPP projects are pop up operations, very difficult to monitor and control. EPA has standards on chemicals in the environment, but not on how CIPP should prevent it.

EPA – Environmental, Community

Chemicals, in varying amounts, are released into the air throughout the process.

Into the worksite, through nearby pipes, residential pumping, open windows, doors, foundation cracks. Sometimes community members are notified of work, other times not.



OSHA – Worker Safety

- Standards on Exposure levels
- Workplace Hazards Training
- Confined Space Standards
- PPE Requirements
- LOTO Standards
- Fall Protection

Nothing specifically on CIPP.

Deaths have occurred.....



OSHA – Worker Safety

Accident Report Detail

Accident Summary Nr: 100333.015 - EMPLOYEE IS WORKING IN CONFINED SPACE AND BECOMES UNRESPONSIVE

Accident Summary Nr: 100333.015 -- Report ID: 0524200 -- Event Date: 10/25/2017

Inspection Nr	Date Opened	SIC	NAICS	Establishment Name
1274028.015	10/25/2017		237110	Benchmark Construction Co., Inc.

Abstract: At 6:30 p.m. on October 25, 2017, an employee was working with a crew that was engaged in sewer line rehabilitation work using a cured-in-place-pipe (CIPP). The CIPP process is a trenchless method for the sewer pipe repair which involves a resin-impregnated fiberglass liner inverted into the damaged sewer pipe. The employee crawled into a 24-inch horizontal sewer line and was in approximately 30 feet, cutting ropes and lying flat hot water circulation hoses. The employee began to mumble and became unresponsive. Emergency Services responded and the employee's body was recovered by the Fire Department Rescue Team and the employee was pronounced at the scene. Drowning with styrene toxicity was listed as a significant contributing factor.

OSHA – Worker Safety

The OSHA citations state that Benchmark did not train its workers to do the job safely, that workers did not monitor air in the pipe for styrene, and two employees working underground were not connected to a retrieval line.

Violation Summary

Violations/Penalties	Serious	Willful	Repeat	Other	Unclass	Total
Initial Violations	6					6
Current Violations	6					6
Initial Penalty	\$77,604	\$0	\$0	\$0	\$0	\$77,604
Current Penalty	\$55,000	\$0	\$0	\$0	\$0	\$55,000
FTA Penalty	\$0	\$0	\$0	\$0	\$0	\$0

What about enforcement – it's easy right?

OSHA Enforcement & Inspection - 1910

General Industry (1910) Standards Triggered:

- 1910.1200 - Hazard Communication (2)
- 1910.147 - The Control of Hazardous Energy (6)
- 1910.134 - Respiratory Protection (7)
- 1910.146 - Permit-Required Confined Spaces

Top 1910 Citations issued 2023-2024

- 1910.1200 Hazard Communication, general industry (2)
- 1910.147 Control of Hazardous Energy (6)
- 1910.134 Respiratory Protection, general industry (7)

OSHA Enforcement & Inspection - 1926

Construction (1926) Standards Triggered:

- 1926.21 - Safety Training and Education
- 1926.29(b) - Boilers
- 1926.56 - Illumination
- 1926.95 - Criteria for Personal Protective Equipment
- 1926.102 - Eye and Face Protection (9)
- 1926.103 - Respiratory Protection
- 1926.501 - Duty to have fall protection (1)
- 1926.651 - Specific Excavation Requirements
- 1926 Subpart AA - Confined Spaces in Construction

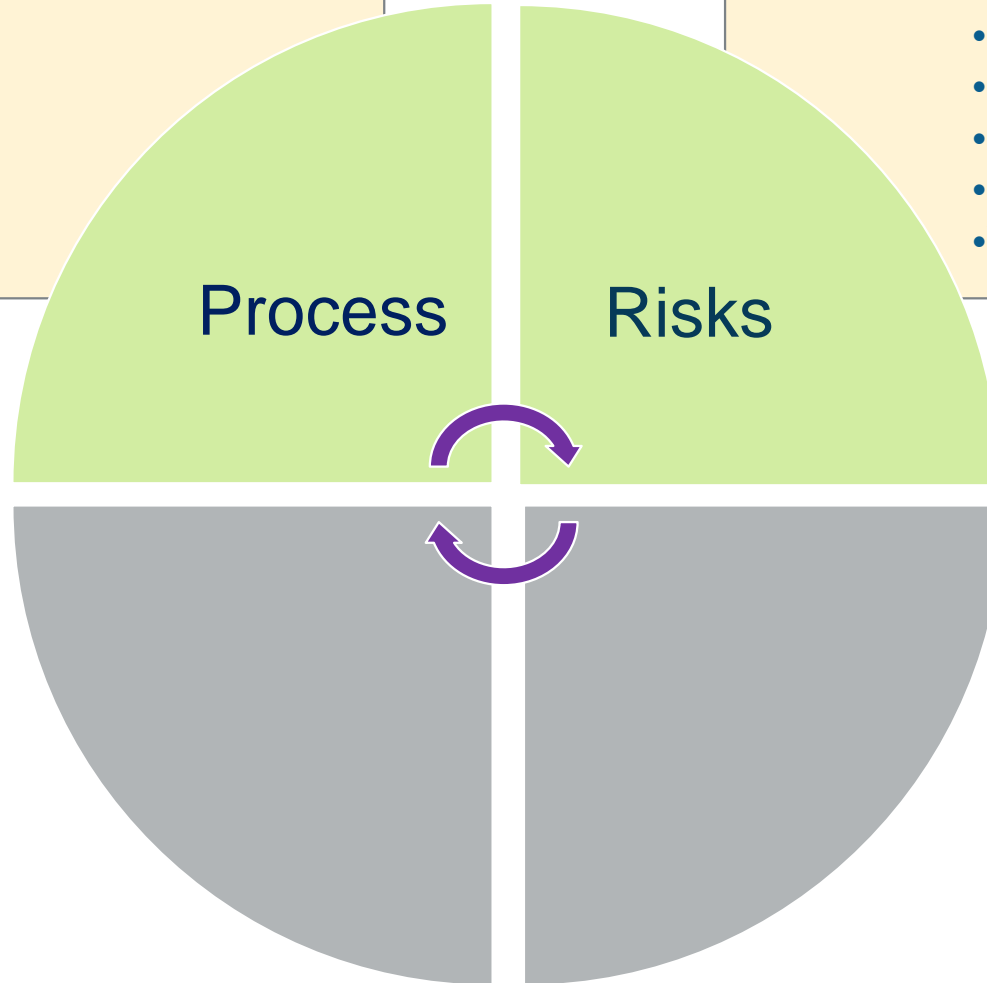
Top 1926 Citations issued 2023-2024

- 1926.501 - Fall Protection (1)
- 1926.102 - Eye and Face Protection (9)

CIPP – Circle of Safety

- Multiple pipe types
- Non-Destructive
- Fast Process
- VOCs

- Inspection Difficulty
- Minimal Regulations
- Environmental
- Community
- Worker



Let's move on to exposure relationships.....

Exposure Relationships



Purdue Study



Compounds Isolated

While styrene is the primary compound collected in samples above exposure levels, all these compounds have been identified in air samples during CIPP operations.

- Acetone
- Acetophenone
- Benzaldehyde
- Benzene
- Benzoic acid
- Butylated hydroxytoluene (BHT)
- 4-*tert*-Butylcyclohexanol
- Carbon disulfide
- Carbon tetrachloride
- Chloroform
- Cyclohexane
- Dibutyl phthalate (DBP)
- 1,4-Dioxane
- 1,4-Ethanol
- Ethyl acetate (Vinyl acetate)
- Ethylbenzene
- Hexane
- Isopropanol
- 2-Methylbutane
- Methylene chloride
- Methyl ethyl ketone (MEK)
- Phenol
- Styrene
- 1-Tetradecanol
- Toluene
- 1,2,4-Trimethylbenzene
- 1,3,5-Trimethylbenzene
- m,p-Xylene
- o-Xylene

How were they collected.....

Sample Methodologies

NIOSH 1501: Sorbent tube – Gas Chromatography

- Used for peak, ceiling, and TWA
- High humidity may reduce breakthrough volumes

NIOSH 3800: Portable direct-reading instrumentation Extractive Fourier Transform Infrared Spectrometry (FTIR)

- General characterization of workplace air
- Overlap of infrared absorption may affect quantification

Photo-Ionization Device (PID)

- 0.1 TO 2000 PPM range (Various VOCs)
- Must be calibrated to determine VOC of interest
- Not selective

Tedlar Bag Sampling

- Hold times for analysis are short
- May lose some VOC in transport and sampling

Organic Vapor Monitors

- Passive sampling
- Active sampling

Exposures – Symptoms

Changes in color vision

Slow Reaction Time

Balance Problems

Eye Irritation

Nausea

Concentration Problems

Nasal Irritation

Feeling Drunk

Hearing Loss

Headache

Vomiting

Tiredness

Breathing difficulties

Exposure Routes, Symptoms, Target Organs

Styrene (Reasonably Anticipated to be a Human Carcinogen)

Exposure Route: Inhalation, Absorption, Ingestion, Skin and Eye Contact

Symptoms: Irritation of eyes, nose, respiratory system, headache, malaise, dizziness, confusion, drowsiness, unsteady gait, possible liver and teratogen

Target organs: Eyes, skin, respiratory system, central nervous system, liver, reproductive system

PEL: 100 ppm

Benzene (Carcinogen)

Exposure Route: Inhalation, Absorption, Ingestion, Skin and Eye Contact

Symptoms: Irritation of eyes, nose, respiratory system, headache, nausea, dizziness, staggered gait, drowsiness, anorexia, weakness - exhaustion, bone marrow depression

Target organs: Eyes, skin, respiratory system, central nervous system, liver, reproductive system

PEL: 1 ppm

Methylene Chloride (Potential Occupational Carcinogen)

Exposure Route: Inhalation, Absorption, Ingestion, Skin and Eye Contact

Symptoms: Irritation of eyes and skin, weakness - exhaustion, drowsiness, numbness, nausea

Target organs: Eyes, skin, cardiovascular system, central nervous system,

PEL: 25 ppm

Exposures: Environmental (water)

Water **contamination** has been found in US and Canada **after installation**. A Virginia study found styrene **concentrations in drinking water** at 5 study sites were **higher than the EPA maximum limits (0.1 mg/L)**. High levels were found from 5 to 72 days after installation.

Sampling after a 3000-gallon CIPP wastewater discharge directly to a creek in Georgia identified **1,300 ug/L** of styrene 1000 feet downstream **19 hours after the event**. Other VOC were identified as well.

After a spill incident in Connecticut, **219 ug/L** of styrene was found downstream **12 days later**.

In Alabama roughly 70,000 gallons of CIPP wastewater was released to a dry creek bed. Traveling downstream, concentrations in the flow were **143 mg/L**. The waste would eventually **contaminate a drinking water well** where concentrations were **4 mg/L**.

Exposures: Community (odor)

In 2011, daycare centers in Worcester Mass and Port Huron Michigan were evacuated when emissions from CIPP work overcame children and staffers. The same year, CIPP work sent five students and high school staff in Birmingham Michigan to the hospital.

In 2014 a family in Prairie Village, Kansas had to vacate their home due to odors. The father called the exposure experience “ghastly.” Later that year, a retiree moved out of her townhouse in Baltimore for three and a half weeks to escape fumes and odors associated with a CIPP project in front of her home.

In September 2017, 36 elementary students reported nausea, coughing, or headaches after exposure to CIPP emission in San Diego.

2020 a Puget Sound Seattle family was overcome with the odor causing multiple symptoms. They were out of their home for 2 months + pending cleaning actions.

Exposures: Worker

- Emission are not only steam as originally proposed
- Multiphase mixture of organic vapor, water vapor, particulate and liquid droplets
- Styrene >86.4ppm and Methylene Chloride >1.56 PPM identified
- EPA identifies styrene as a known carcinogen
- Styrene was the only compound consistently found at levels posing health risk

- | | | |
|--|--|--|
| <input type="checkbox"/> Acetone | <input type="checkbox"/> Cyclohexane | <input type="checkbox"/> Methyl ethyl ketone (MEK) |
| <input type="checkbox"/> Acetophenone | <input type="checkbox"/> Dibutyl phthalate (DBP) | <input type="checkbox"/> Phenol |
| <input type="checkbox"/> Benzaldehyde | <input type="checkbox"/> 1,4-Dioxane | <input type="checkbox"/> Styrene |
| <input type="checkbox"/> Benzene | <input type="checkbox"/> 1,4-Ethanol | <input type="checkbox"/> 1-Tetradecanol |
| <input type="checkbox"/> Benzoic acid | <input type="checkbox"/> Ethyl acetate (Vinyl acetate) | <input type="checkbox"/> Toluene |
| <input type="checkbox"/> Butylated hydroxytoluene (BHT) | <input type="checkbox"/> Ethylbenzene | <input type="checkbox"/> 1,2,4-Trimethylbenzene |
| <input type="checkbox"/> 4- <i>tert</i> -Butylcyclohexanol | <input type="checkbox"/> Hexane | <input type="checkbox"/> 1,3,5-Trimethylbenzene |
| <input type="checkbox"/> Carbon disulfide | <input type="checkbox"/> Isopropanol | <input type="checkbox"/> m,p-Xylene |
| <input type="checkbox"/> Carbon tetrachloride | <input type="checkbox"/> 2-Methylbutane | <input type="checkbox"/> o-Xylene |
| <input type="checkbox"/> Chloroform | <input type="checkbox"/> Methylene chloride | |

Exposures: Worker

- Researchers in California were required to wear full-face carbon filtered masks
- Wind direction, speed, and worker location affects exposures
- There are differences between sites using the same methods and contractor

- | | | |
|--|--|--|
| <input type="checkbox"/> Acetone | <input type="checkbox"/> Cyclohexane | <input type="checkbox"/> Methyl ethyl ketone (MEK) |
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CIPP – Circle of Safety

- Multiple pipe types
- Non-Destructive
- Fast Process
- VOCs

- Inspection Difficulty
- Minimal Regulations
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- Community
- Worker

Process

Risks

Exposures

- Confirmed VOCs
- Limits to Sampling
- Carcinogenic Potential
- Variations from site to site

Let's move on to best practices on exposure prevention.....

Best Practices on Exposure Prevention



Exposure Prevention: Community

Community:

Odors detected: Recommend to avoid breathing in compounds by leaving home until cleared. Nose can detect Styrene at 0.4 - .75 ppm (very low).

House:

Keep water in P traps, fill sinks with water, keep windows and doors closed during CIPP events. Place plastic bags over faucets. When completed, open to refresh air. Studies have shown P-Trap use will prevent high styrene emissions entering buildings. Risk of exceeding high concentrations is very low.

Communication: Provide communities, businesses, and public areas notice of work being performed to allow for risk planning.

Exposure Prevention: Worker

Personal:

- Respirator usage (Carbon Filter Full Face) – Inhalation / Occ Asthma,
- Skin covering – Epoxy Resins are Skin Irritants
- Nitrile Gloves, skin cream barriers – Contact Dermatitis
- Hardhat, vests, safety glasses, safety shoes – General site safety

Technology:

- NOAA Weather App - Weather had a larger impact on site exposures
- NIOSH Heat App - High heat keeps particulate low
- EAA Air Now App - Air Quality creates health issues alone

Education:

- **TRAINING!** - Confined Space, LOTO, PPE, Exposure....
- HAZCOM - Emission exposures, risks, heat issues....
- CIPP - Training on industry standards and process

Exposure Prevention: Employers

- Ensure clear separation between work areas and rest areas.
- Ensure workspaces are well-ventilated.
- Monitor air quality and ventilation before workers enter confined spaces and while they are in the confined space.
- Conduct personal air monitoring on workers to ensure styrene concentrations remain below occupational exposure limits.
- Provide personal protective equipment (PPE) and PPE training to workers, including as respirators with organic vapor cartridges
- Use non-styrene-based resins, if possible.
- Provide workers education on chemicals they work with and potential health effects of exposure.

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Process

Risks

Best Practices

Exposures

- PPE Usage
- Communication
- Proper Training
- Limit Exposure Pathways

- Confirmed VOCs
- Carcinogenic Potential
- Limits to Sampling
- Variations from site to site

Let's review

Discussion Summary

Process:

CIPP: non destruction pipe repair process
Used extensively throughout the US
Fast process with rapid hardening

Risks:

Steam, hot water, process safety risks
Emission into environmental systems
VOC emissions into ambient air

Standards:

OSHA has limited protections
EPA minimum standards
Not a lot of data

Protection:

Communication
Education
PPE





THANK YOU!

CURED IN PLACE PIPE (CIPP)

PROCESS, RISKS, & CONTROLS

Safety & Health

Dr. Scott Smith CSP
ssmith@tighebond.com

Partial Reference List

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