

# The Engineered CIPP System

Designing for long-term performance while considering the social affects to residents, business owners and the general public

By

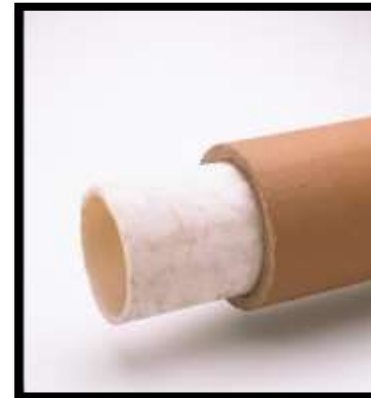
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# Introduction

- Rehabilitation methods have changed in the last 50 years
- Excavation & replacement has changed from disruptive & costly to fast, low cost, very effective, Cured-in-place pipe (CIPP)
- The process of rehabilitating a sewer pipe includes:
  - Preparing the existing pipe
  - Using the existing pipe as a form
  - Installing a flexible fabric, resin saturated liner into the existing pipe
  - Curing the liner into a new pipe within the existing pipe

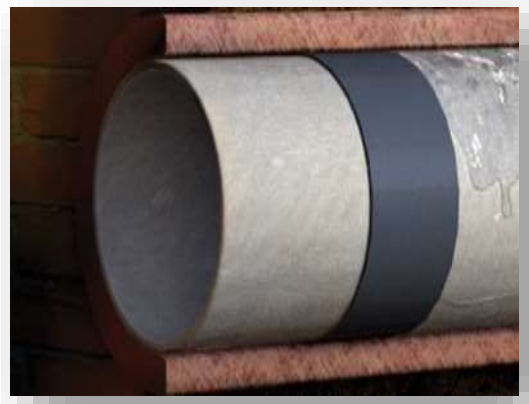


# Understanding CIPP Technology Concepts

- The existing pipeline is the Mold for the CIPP installation
- The existing pipeline is not always consistently the same size or configuration
- Standard pipe sizing does not apply to many installed materials
- The CIPP must be designed to a positive curved circumferential surface
- Negative curved circumferential surfaces, in the pipeline, may not be a candidate for installation of long term structural CIPP
- A CIPP does not bond either chemically or mechanically to the existing pipeline

# Understanding CIPP Technology Concepts

- CIPP does not eliminate Infiltration from entering the existing pipeline
- CIPP must be installed in conjunction with proven sealing techniques such as engineered gaskets to stop Infiltration
- The cured resin, unless installed with reinforcement materials, is the final CIPP structure
- Resins installed and cured in the presence of active flow may not cure as expected or wash-out during the installation



*End Seal Gasket ASTM F3240*

# Technology Development

- Since inception, the technology has been improved including:
  - New innovations
  - Improved material
  - More efficient delivery systems
  - Faster and diversified curing techniques including UV
  - Lower cost
  - Experienced and knowledgeable contractors and crew personnel



*Light Curing Device*

# Product Manufactured

- Most pipe products, used in the industry, are manufactured in a factory, under strict quality controlled procedures & requirements
- CIPP is manufactured in the field under less than ideal quality conditions producing less than ideal results
- However what is minimally acceptable for one buyer may not be acceptable for another buyer
- This results in significant opportunity to improve the results and overall quality of the CIPP product and providing quality choices for the industry



*Manufactured Pipe*

# CIPP Product Quality Choices

**What will be the Choice???**

CIPP installed that only meets minimum specified requirements

Or CIPP installed that meets maximum product potential?

**The difference between minimum acceptability and maximum product potential is the requirements & quality as defined in the contract specifications and enforced through trained inspection**



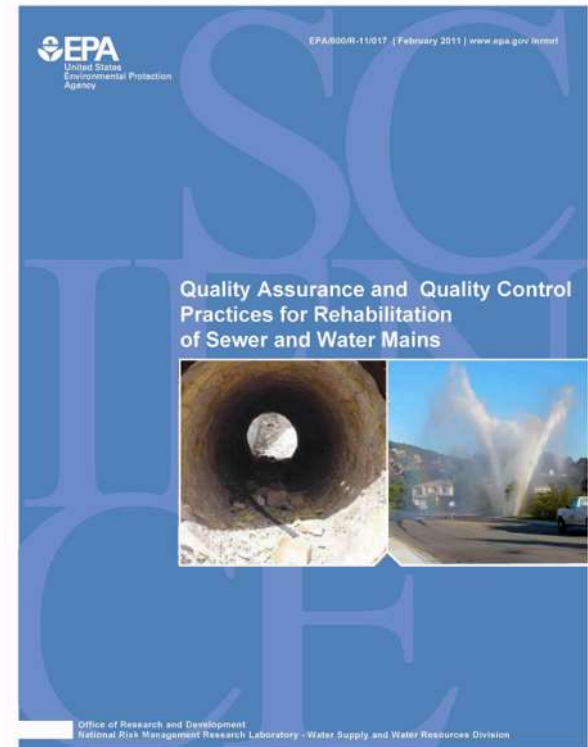
*Quality Cured CIPP*



*Blistered CIPP*

# What the EPA Says

Good QA/QC practices promote a healthy bid environment and ultimately lead to higher performing installations of trenchless technologies. Practitioners of a well executed QA/QC program benefit from the overall lower cost of these improvements and the lower in-house costs of managing these assets over time. Contractors and technology vendors will respond accordingly to this call for quality once in place.

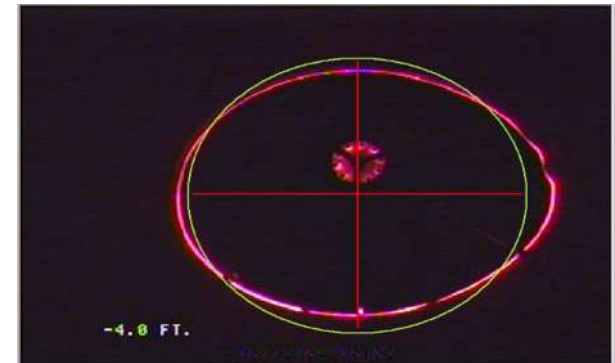


**Reference: EPA/600/R-11/017 February 2011 Quality Assurance and Quality Control Practices for Rehabilitation of Sewer and Water Mains**



# Existing Pipeline Evaluation

- The existing size, shape, length, condition and material must be verified & documented both during design and also before materials are fabricated by the Contractor.
- This may include CCTV inspection (PACP & LACP) and laser profile
- The flow content and characteristics need to be determined
- The pipeline's structural capabilities need to be determined
- Existing ground conditions, including soil and groundwater depth need to be determined



**Best Quality**

Verify and Document

# Pipeline Access

Access points generally include manholes, cleanouts, main/lateral connections, and house traps

- Access points must be installed when unavailable
- Mainlines are typically rehabilitated between existing manholes
- Lateral lines are typically rehabilitated from the main/lateral connection to the house, from the trap inside the house or from an existing cleanout outside of the building (if available) either located at the private or public property
- Proper access is not only key to proper CIPP installation but also for repairing, preparing, stopping water infiltration and cleaning of the pipeline before a new liner is installed

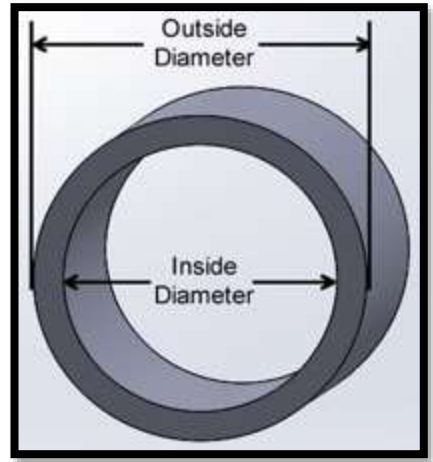
## **Best Quality**

Design accounts for proper access allowing best available means and practices

# Pipeline Measurement

## Inside diameter of pipeline in the field

- Standard pipe sizing does not apply to many installed materials
- Must be physically measured and certified before liner materials are fabricated
- Measurements listed on as-built or contract plans not acceptable alternative for measuring the pipe in the field



*Fin in the CIPP*

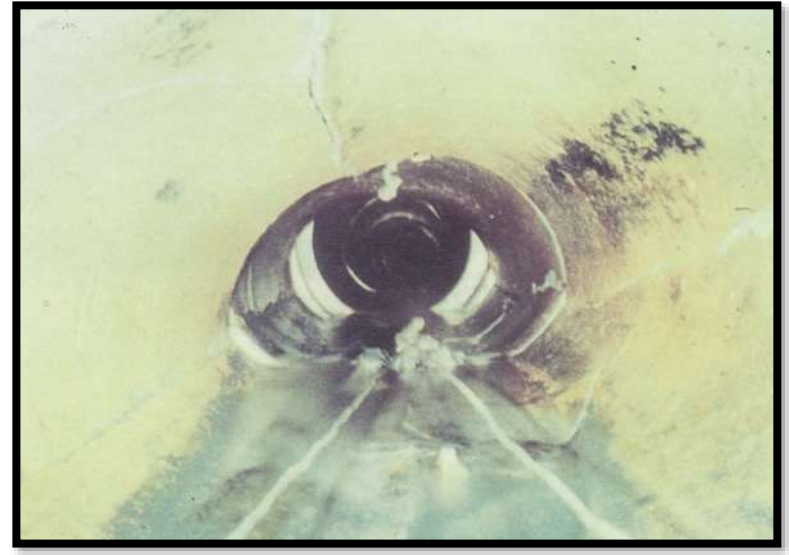
## Best Quality

Liner fabricated to field verified pipeline measurements will reduce unwanted wrinkling or excessive stretching & thinning

# Pipeline Shape

## Existing Pipeline Shape

- Confirmed through visual inspection and/or laser measurement
- Existing Pipeline may vary in circumferential shape from round to broken
- Engineer must determine whether the distortion has a sufficient curved surface to support the load



*Broken Distorted Pipe*

## Best Quality

Visual inspection & measurement of the pipeline will result in a more accurate design CIPP fit in the existing pipeline

# Pipeline & CIPP Length

Existing pipeline measured in the field, in the pipe, from Manhole to Manhole

- Calculate length of liner based on pipe length and estimated stretch
- Installation in accordance with manufacturers recommended minimum & maximum pressures
- Confirming the exact length of pipe and stretch is critical for installing a lateral liner from a main pipe ensuring the liner doesn't overrun the cleanout



*Excess CIPP Liner*

## Best Quality

Liner installed correctly, being neither under stretched resulting in unwanted wrinkles or overstretched resulting in reduced CIPP thickness & excess liner material

# Conditions That Affect Installation Methods

## Pipe Conditions:

- Good pipe with no leakage - smooth some cracks or fractures - **inversion, pull-in methods**
- Good pipe - active leakage – **inversion method**
- Poor condition pipe, leaking or not leaking, broken, distorted – **inversion method**
- Leaking pipe with dips – **water inversion best**
- Non-leaking pipe with dips – **inversion or pull-in methods**, if the dips can be dewatered

## Best Quality

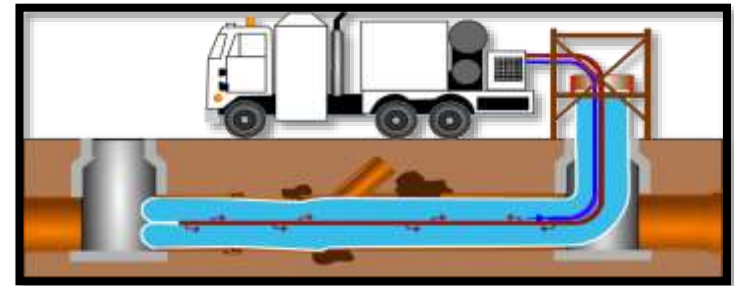
Specifications define delivered quality. Contractor provides best installation means and methods to accomplish required results



# CIPP Curing Methods

**Methods include, Water, Steam and Light Cure**

**Water Curing** – Successful quality history. When manufacturers recommended installation, speed, pressure and cure time schedule is followed



**Steam Curing** – Faster high temperature cure. Successful quality history when manufacturers recommendations are followed, preventing high heat blisters and condensate build-up in CIPP

**Light Curing** – Low temperature light cure, lower cure shrinkage. Successful quality when manufacturers recommendations are followed

**Best Quality**

Follow Manufacturers Recommendations

# Proper Cure Design

The Cure Schedule may vary depending on the type of pipe and adjustment of the cure temperatures may be applicable

- Materials such as clay, concrete, asbestos cement and other materials that allow heat to uniformly dissipate through the pipe and into the surrounding soil. ***Water, steam or UV curing***
- Materials such as CIPP, PVC, Polyethylene and other insulating materials that will retain excessive heat during the curing process. ***Water, well controlled steam or UV curing***



*Steam Cured Blistered CIPP*

## Best Quality

Tight fitting, no bulge or blistering or pin-holing in the CIPP



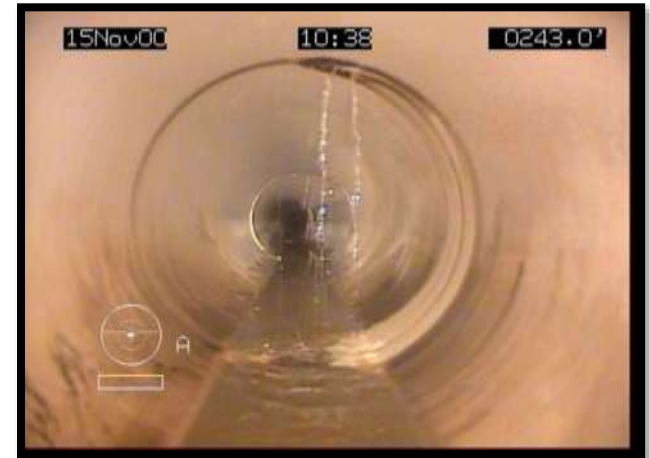
# Flow & I/I Conditions Affecting CIPP Curing

Typical water flow into a sewer pipeline includes the following:

- Pipe flow from upstream basins
- Infiltration through joints and service connections
- Inflow from stormwater connections & home roof leader
- Wastewater flow from home and businesses

## Best Quality

Prevent infiltration and system flow from mixing with the CIPP



*Groundwater Infiltration*

# Current Flow Management Practices

Not all flows are currently stopped

- Pipeline flows are temporarily by-pass pumped around the pipe being rehabilitated
- Infiltration/inflow is not normally stopped except for extreme flow such as gushers
- Flows from residential homes are normally allowed to continue to flow during CIPP installation including the hidden sump pump



*Plugging Equipment*

## **Best Quality**

Stopping the main flows and service pipe flows during liner installation and curing

# Diverting System Flow

## Correctly sized pumping systems

- Pipeline Flow – properly sized redundant by-pass systems are designed for pumping normal flows and peak storm event flows
- Commercial, industrial high flow connections are temporarily interrupted and bypass pumped
- Flow from lateral connections are temporarily stopped or bypassed



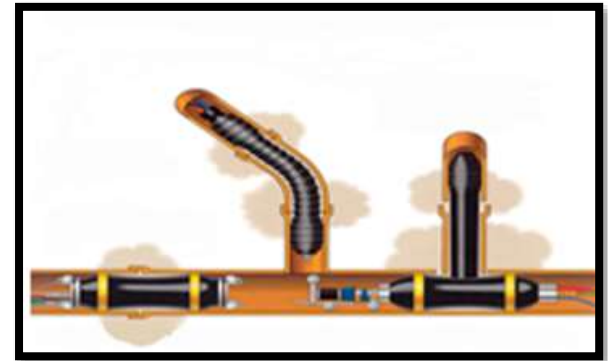
*By Pass Pumping Equipment*

## **Best Quality**

CIPP installed and cured without influence from system flows

# Stopping Infiltration

All Infiltration through joints and other pipe defects that will affect the proper installation and curing of the CIPP is temporarily stopped using available grouting techniques



*Chemical Grout Injection*

- Although grouting can stop active leaks from entering the pipe, it does not address flow from homeowners and businesses
- Grouting does not address CIPP odors or toilets blown up from jetting

## **Best Quality**

Prevent active water leaks, resin wash out and soft spots

# Prevent Resin Washout

A pre-liner can be used to protect the resin from Infiltration through joints and other pipe defects and flow from service pipes



*Pre-Liner Tubes*

- A pre-liner protects the resin but does not address flow from lateral pipes
- Laterals continues to flow between the main pipe and a pre-liner until the liner is inflated where water can be trapped in pipe sags
- A pre-liner may reduce CIPP odors but does not address toilets blown up from jetting

## **Best Quality**

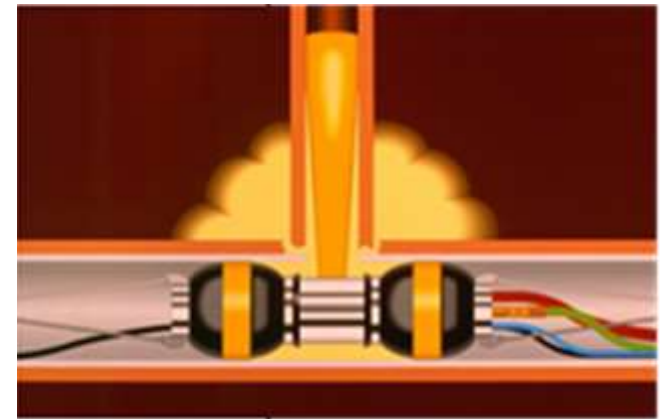
Prevent active water leaks and lateral pipe flow from washing resin out and causing soft spots

# Stopping Flow From Laterals

## Flow from Lateral Connection

### Techniques

- Plugging the main/lateral connection
  - Specialty robotic equipment required
- Plugging the lateral connection at the existing cleanout or new cleanout
  - Existing flow entering from the home
  - Grouting active leaks in the lateral pipe



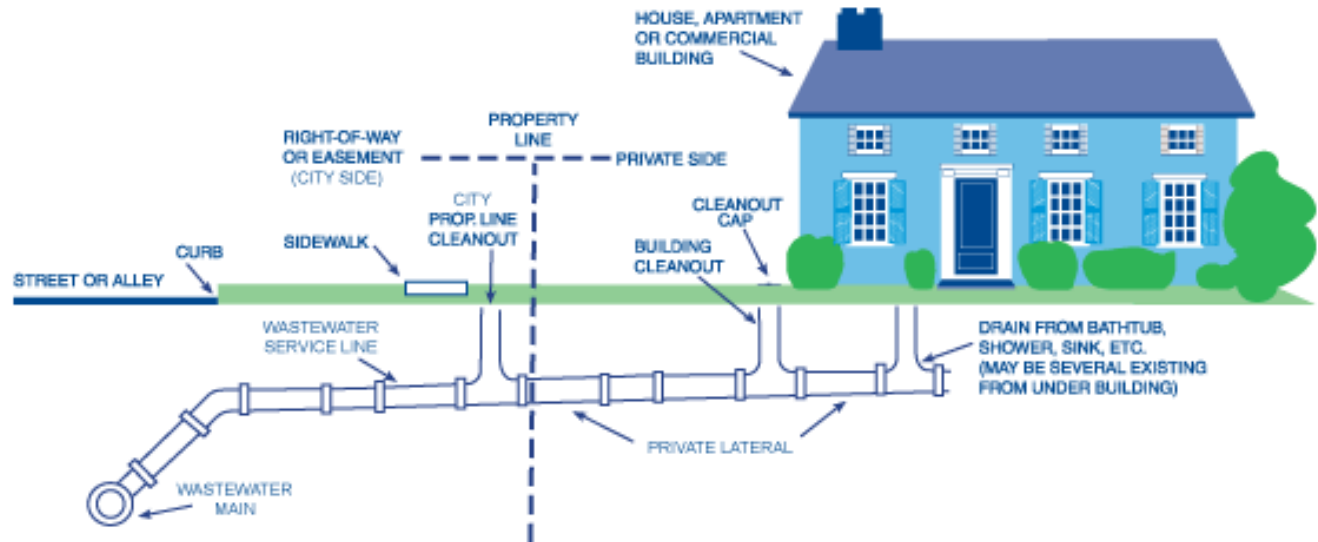
*Chemical Grouting Packer*

### Best Quality

Prevent active water leaks and lateral pipe flow from washing resin out and causing soft spots

# Why a Clean-out is Important

- Is an asset for the public utility sewer collection system
- Provides access for cleaning, measuring and plugging to effectively take the pipeline out of service
- Provides access to maintain the system for at least another 50-years



## Best Quality

Take the pipeline out of service when forming the new CIPP

# A Cleanout Provides Success

The ability to access the service from a cleanout provides access to perform further investigation through inspection and dye testing

Often there is confusion on which service should be reinstated

Too often, inactive service pipes are reinstated because lateral investigation is typically performed after mainline CIPP

There's always the decision without adequate investigation to not open a service pipe which often leads to a sewer backup

Although with sewer innovative tools like Picote products, a CIPP liner can be reinstated from a clean-out

## **Best Quality**

The best option is to know for certain if the pipe is active or nonactive





# A Cleanout Provides Access

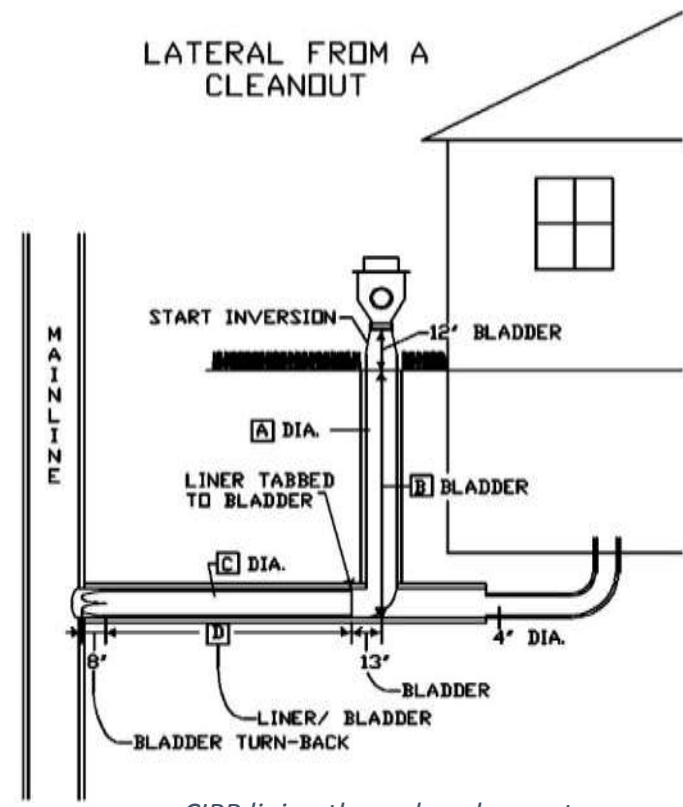
A proper Cleanout Provides Access in both the upstream and downstream direction

Homeowners can have a plumber line their private sewer lateral by inverting a liner through a cleanout without blocking flow and without any open cut excavation.

The ability for homeowners to rehabilitate private side laterals and remove more I/I from the system is also a big plus for municipalities.

## Best Quality

Investigate and confirm if the pipe is active or nonactive



*CIPP lining through a cleanout*

# Plumbing Codes

## Cleanouts Are Necessary

- Plumbing codes like the IPC (International Plumbing Code) and the UPC (Universal Plumbing Code) require cleanouts in a waste drainage system
- Plumbing codes require a maximum total length of 100' between cleanouts
- For the same reason a cleanout is required by law on waste drains, the same practical reasons apply to a sewer service pipe, especially when rehabilitating a sewer collection system expected to last another 50-years.
- Many municipal projects now require a cleanout to be located in the ROW (right of way) near the property line, typically adjacent to the water service valve box.

## Best Quality

Apply practical plumbing principles to the service lateral pipe

# The Proper Order of Operations

It has been common practice to first rehabilitate a mainline and then rehabilitate the service pipes.

- Cleanouts are typically installed by the lateral lining contractor and are generally not in-place when the mainline CIPP liner is installed.
- Public health concerns ranging from toilets blown up from sewer jetting, to homeowners complaining of paint smell and a headache.
- This has happened in cities everywhere and when it does happen, it causes great concern for Utility Owners and Contractors alike.
- No contractor wants a fire truck on his jobsite!

## **Best Quality**

The proper order of operations defines the quality of a sewer renovation project by following a step by step process to produce an engineered CIPP



***“The Proper Order of Operations controls the quality of the CIPP.”***

# Advantages of Proper Order

There are significant advantages by simply changing the order of operations and installing service cleanouts, on all service pipes before lining the main pipe.

- The contractor has good access to the service pipe, that feeds the main, pipe when the cleanout is installed prior to lining the main pipe.
- Proper cleanout access, both in the upstream and downstream directions provides means for inserting an inflatable plug on the upstream side of the cleanout.
- This prevents odors from travelling up the pipe where dry fixture traps or defective vent piping can allow CIPP odors to enter a resident's home.

## **Best Quality**

It's really all about the order of operations in the process providing for a higher quality CIPP and ensuring residents are protected from unpleasant CIPP odors, that could be harmful.

# Taking the Pipe Out of Service

The process of temporarily plugging the service pipe also provides a primary requirement for producing an engineered pipe; that is to take the pipe out of service during the process of forming a new pipe within the old pipe.

- It might seem unnecessary to take the pipe out of service but it is a practical requirement.
- Did you know it is an OSHA requirement to lockout and tagout machinery so it can't function and is safe for technicians to make repairs?
- In current day CIPP practices there are no measures taken to ensure flow from residents and businesses do not continue to discharge waste into the pipe while inverting and curing the resin saturated liner.



## Best Quality

For a 50-year liner keep sewage off the resin saturated liner

# Sewage Mixed With The Liner

This practice does not promote quality and could hinder liner performance in several ways:

- Sewage mixed with the resin saturated liner may cause reduced physical properties and chemical resistance
- Flow from service pipes can cause the CIPP to not fully cure at service connections. The gooey resin can make it difficult to reinstate the service properly
- Flow from a service with head pressure could cause a lift in the liner



## Best Quality

No Sewage in the CIPP - Keep Resin Clean and Undiluted

# Sewage Between Liner & Pipe

Mainline liners that are air inverted typically drop air pressure when the liner is inverted in-place.

- Processing cans are connected to the liner ends and the liner is inflated a second time potentially trapping flow from service pipes between the liner and the old pipe.
- A “lift” is an uncured section of a liner which is caused by water in contact with the liner; the water is a heat sink that prevents the heat from curing the resin in that certain area.
- The uncured section can lift from hydraulic pressure driving water between the liner and the pipe, thereby lifting the liner.

## **Best Quality**

Maintain Inversion/Inflation Pressure Until Cured & Cooled



# Lifts or Bulging Sections of CIPP

Condensation, a result of steam curing produces water that collects inside of the liner

- The water that collects in the pipe sag is an insulator preventing the resin from fully curing
- The photo to the right is a section of pipe where a “lift” had to be robotically cut out
- A CIPP patch will be installed, and this sort of repair is occurring every day in America



*Lift in CIPP Robotically Cut Out*

## **Best Quality**

Stop Flows, Maintain Inflation Pressure and Proper Air Flow

# The Sewer Service Cleanout

“A cleanout is a cleanout”, that is not so much the case for an engineered sewer rehabilitation project today

- The old school of thought is a cleanout needs to be directional
- However, trenchless technologies have advanced allowing inspection, cleaning, and liner inversion from a T-shaped cleanout.
- Having a two-way (2) cleanout allows for an inflatable plug to be positioned on the upstream side of the cleanout.



*ASTM F3097 Sewer Cleanout*

## **Best Quality**

Stop Flows, Maintain Inflation Pressure and Proper Air Flow

# The Two-Way Service Cleanout

The two-way cleanout also provides access to prepare, rehabilitate and maintain the service pipe in the public ROW as well as the homeowners private lateral side. This can all be accomplished from one single cleanout.

- The two-way cleanout as described in ASTM F3097 utilizes a trenchless (or minimally invasive) installation method
- Another option is to install two wye shaped cleanouts “back to back” to allow access in both upstream and downstream directions
- This option requires open cut excavation pulling up concrete sidewalks which is can negatively impact residents and businesses



*Two Way Back to Back Wye Cleanout*

## **Best Quality**

Provide Access to the Pipe both Upstream & Downstream

# The Two-Way Service Cleanout

Many municipal utilities today prefer less disruption and fewer complaints from residents.

The process described in ASTM F3097 incorporates a small diameter vacuum excavation to remotely connect a special cleanout saddle.



*Vacuum Excavated Cleanout*

This process is fast, safe for surrounding utilities, is minimally disruptive to homeowners and allows for SDR (Same Day Restoration) meaning the sidewalk, driveway, or yard is completely restored all in the same day to its original condition.

## **Best Quality**

Provide Proper Pipe Access Using Minimal Disruptive Methods

# The SDR Process

- In order to achieve SDR, the contractor must be outfitted with the necessary tools and materials to completely compact the trench fill placed in the bore hole.
- Sidewalks are reinforced with dowels; a mobile cement unit and an asphalt hot box are used to make final restoration onsite the same day.
- Homeowner complaints are drastically minimized, and the contractor does not have to return to that location again.



*Compacting Trench Fill*

## **Best Quality**

Trench Fill Compacted In Lifts Ensures No Settling & SDR

# Residents Information Pamphlets

- It is important to provide quality informational pamphlets to homeowners; the better residents are informed of what is going on out in front of their home, the better chance they will be cooperative.
- Good information and communication with the residents about when to refrain from using any water is also a critical step in the process of forming a quality CIPP.
- Although, there are no assurances that homeowners will cooperate. For this reason, the service pipe must be temporarily taken out of service.

## **Best Quality**

Includes Satisfied Customers and No Complaints

# Maintaining Service Pipe Flows

Multi-story buildings, restaurants, hospitals, schools

- Install two (2) cleanouts approximately 18-inches apart
- An inflatable sewer plug is positioned in the pipe section between the two cleanouts
- Prevent flow from mixing with the resin saturated liner
- Protect building occupants, provide access from the cleanout to the main pipe for pipe preparation, CIPP rehabilitation and maintenance
- The second cleanout provides access to maintain uninterrupted service by inserting a suction hose into the upstream cleanout and pumping the flows to a designated downstream manhole

## **Best Quality**

Maintain Necessary Flows and Keep the Resin Clean

# The Proper Order of Operations

The proper order of operations is critical to achieving the highest quality CIPP possible.

The proper order of operations for a sewer rehabilitation project can be defined as follows:

- **INITIAL INSPECTION, MEASURING & LOCATING**
- **CLEANOUT INSTALLATION**
- **CONTROLLING GROUNDWATER INFLUENCE ON CIPP**
- **PREPARING THE MAIN PIPE FOR LINER INSTALLATION**
- **INSERTING AND CURING THE MAIN LINER**
- **PREPARING THE LATERAL PIPES FOR LINER INSTALLATION**
- **INSERTING AND CURING THE LATERAL LINER**



# INITIAL INSPECTION, MEASURING & LOCATING

Mainline are inspected using PACP

- The upstream and downstream ends of the main pipe are measured (physically or by laser measuring device)

Service laterals are inspected using LACP

- The lateral launch CCTV is outfitted with pan/tilt and have various methods for pinpoint locating sewer lateral pipes
- The lateral pipe is measured at the main connection and at the termination of the inspection where a cleanout is or is to be located

**Best Quality**

Adhere to Proper Order of Operations

# CLEANOUT INSTALLATION

- The cleanout installed by open cut excavation or by minimally invasive method ASTM F3097
- Restoration can be scheduled based on the utility owner's requirements, or Same Day Restoration



*Minimally Invasive Cored Sidewalk*

## **Best Quality**

Minimally Invasive/Trenchless Technologies are a Significant Social Incentive

# Same Day Restoration (SDR)

- SDR provides faster return to service
- Driveways, sidewalks, yards are restored the same day the cleanout is installed
- Provides a safe worksite with no missing flags of sidewalk
- No piles of dirt in residents yard



*Concrete Restoration*

## **Best Quality**

Same Day Restoration is a Significant Social Incentive

# CONTROLLING GROUNDWATER INFLUENCE ON CIPP

- Chemical grouting in accordance with ASTM F2304 is a good tool to stop active leaks that can cause resin washout.
- In some locations there is so much water entering the pipe that well point pumping becomes another option for controlling groundwater.



*Well Point Pumping Equipment*

**Best Quality**  
Adhere to Proper Order of Operations

# PREPARING THE MAIN PIPE FOR LINER INSTALLATION

Take the pipeline out of service

- Bypass pumping the flow from an upstream manhole to a designated downstream manhole
- Inserting a plug on the upstream side of service pipe cleanouts
- Clean the main pipe removing all debris including water collected in sags (low lying pipe sections)

## **Best Quality**

Keep the Resin Clean and Flow off the Liner

# INSERTING AND CURING THE MAIN LINER

- The liner is typically inverted into the pipeline. Glass liners are pulled-in-place.
- When a resin saturated liner tube is inverted, the rate of inversion and the 19.5 pressure applied must be calibrated to ensure the liner is pressing tightly against the pipe wall
- Engineered End Seals must be used at the terminating ends of the liner to ensure Watertightness



*Steam Curing Mainline CIPP*

## **Best Quality**

Use Engineered Gaskets for Watertightness ASTM F3240

# PREPARING THE LATERAL PIPES FOR LINER INSTALLATION

- Take the main and lateral pipelines out of service
- Clean the main and lateral pipes removing all debris
- Take measurements from the cleanout to the main pipe necessary to order a custom-tailored liner that will connect to the main CIPP



*Measuring Lateral Pipe for Exact Liner Length*

**Best Quality**

Measure Twice Order Once

# INSERTING AND CURING THE LATERAL LINER

- The lateral liner is inverted from the main
- The rate of inversion and pressure applied must be calibrated
- Remove excess resin through the cleanout before the resin is cured
- Engineered End Seals are used at the main connection and at the terminating ends of the liner to ensure long-term Watertightness



*ASTM F2561 Gasket Sealed Lateral Connection*



# Conclusion

**The proper order of operations described in this paper, improve CIPP quality, reduce liner defects, reduce public health concerns associated with CIPP, and greatly minimize social impact on residents and business owners.**