

Overview of Lateral and Main/Lateral Connection Lining and Sealing Technologies

Prepared by the NASSCO Lateral Committee
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1.0 INTRODUCTION

The intent of this document is to provide information to the public on lateral rehabilitation and sealing options. In some areas, the use of lateral lining and sealing technologies are not specified in plumbing codes. These codes did not anticipate the use of lining or grouting for lateral pipes, resulting in the only alternative being costly excavations and disruption to private property and the public.

The NASSCO Lateral Committee has decided to develop educational documents for the purpose of advancing lateral technologies by working with local and state health departments and plumbing boards. This effort is being advanced through education and dissemination of information in an effort to convince these agencies to accept these technologies and include them into the code books.

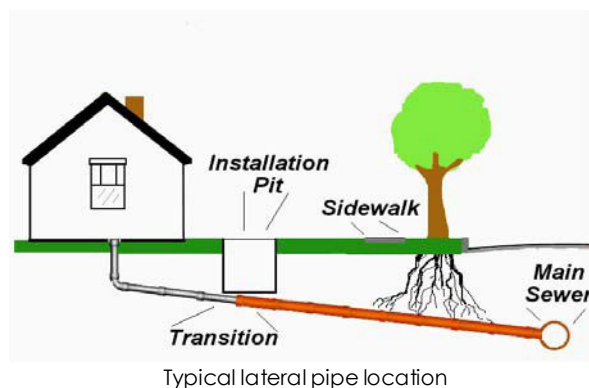
Several studies have confirmed that the lateral pipes in a typical collection system have reached their life expectancy and are either failing and/or contributing large amounts of infiltration/inflow to the main sewer pipeline. In response, technology providers have developed a number of products and technologies to line and seal lateral pipes and their connection to the mainline sewer.

Lateral pipes often have multiple bends, diameter changes, offset joints, cracks, deposits, and roots which create considerable challenges when lining or sealing. The lateral pipe connection to the sewer main also poses problems due to leaks, cracks and poor alignment often created by improper connection procedures. The technologies described in this document need to address these issues specifically, while minimizing the impact on property owners and sewer providers by requiring minimal bypass pumping and excavation.

Access to the typical lateral pipe is another issue since one end is located in the sewer main or manhole and the other in a home or building. In some cases a clean-out exists either in the building or outside of the building or at the property line.

2.0 REHABILITATION ALTERNATIVES

Rehabilitation technologies have been developed to cope with the existing lateral pipe conditions and to provide effective products with a service life and installation procedures that meet customer expectations.



There are seven (7) rehabilitation approaches to consider when evaluating how to line and seal a lateral pipe and are discussed herein.

- 2.1 Sectional Pipe Lining - Repair by lining a portion of the lateral pipe.
- 2.2 Lateral Pipe Lining - Repair by lining the entire lateral pipe.
- 2.3 Main/Lateral Connection Lining - Repair by lining the lateral/mainline connection.
- 2.4 Lateral and Main/Lateral Connection Lining - Repair by lining a portion of the lateral pipe or the entire lateral pipe and lining the lateral/main connection.
- 2.5 Main/Lateral Connection Sealing - Repair by sealing the Main/Lateral Connection by resin injection.
- 2.6 Lateral and Main/Lateral Connection Grouting - Repair by sealing the Main/Lateral Connection and the entire lateral pipe or a portion of the lateral pipe by chemical grout injection.
- 2.7 Lateral Pipe Bursting - Replacement of either part of or the entire lateral pipe by pipe bursting.

Several of the technologies provide either pipeline rehabilitation or a watertight seal solution. Some technologies provide solutions to both.

Owners must determine their expectations for a rehabilitation project in order to select the best, most applicable products and technologies. For example, if the goals of the project are to reduce infiltration entering the sewer system then the technologies that provide a long term watertight seal should be selected. If the goals are to renew the pipe structurally to as good as, or better than, original condition, then the technologies with proven and accepted design and service life concepts should be selected. The goal may be to eliminate both infiltration and rehabilitate the pipe to original standards.

All lateral rehabilitation technologies provide structural replacement or leakage control for the design and service life as determined by the manufacturer of the product and the expectations of the owner. Design life refers to the life after which a product is expected to be replaced. Service life defines the anticipated functionality of the product to perform as specified.

Field tests should be required by the owner to confirm specified technology performance. Structural designs can be specified and prepared for all cylindrical sections of a lateral liner in accordance with ASTM F 1216 Non-Mandatory Appendix X1, if applicable.

This document will detail key features and attributes for the different rehabilitation technologies for each repair approach. The information presented in this document can be used as a tool for owners and engineers to determine the best technology to meet project goals and expectations.

All lining and sealing technologies require access to the lateral pipe in one or more location. The Lateral Access Point can be one of the following;

- A clean-out located outside of the building.
- A clean-out located inside of the building.
- A manhole that connects to a lateral pipe.
- Access to lateral pipe by excavation pits.
- Accessed remotely from the sewer main.

Successful installation requires the contractor to strictly follow manufacturer's installation procedures. It is the owner's responsibility to provide experienced inspection and specific testing requirements during installation to ensure that the contract requirements are fulfilled.

2.1 SECTIONAL PIPE LINING

When a lateral pipe is evaluated it may be discovered that only one or just a few areas of the pipe are in need of repair or rehabilitation. In this case, it may be more economical to repair just the areas that are identified. There are three (3) methods of installing a cured-in-place liner that have been developed.

- 2.1.1 Pull -in-place method
- 2.1.2 Push-in-place method
- 2.1.3 Inversion method

2.1.1 Pull-In-Place Method

The pull-in-place method involves positioning a resin-saturated liner tube placed on a pneumatic expansion packer, pulling it through a lateral clean-out, and positioning it at the repair location in the lateral. The packer is inflated until the resin saturated liner is held tight against the host pipe. The liner is then cured using heat, ultra violet light or ambient curing techniques. When the liner is cured in the pipe, the packer is deflated and removed leaving behind the finished cure-in-place pipe liner.



Translucent Bladder for UV Curing of Sectional Liner



Expansion Bladder with Sectional Liner Attached

Points to Consider

- Typically no excavation is required if clean-out is existing.
- Pneumatic packer is re-usable for other sectional lining.
- Packers can be mounted on wheels and can be pulled long distances to reach a pipe repair location.
- The packer and liner can be positioned by accessing a manhole on the mainline and pulling the cable connected to the packer.
- Coordination with the sewer authority is required to access the mainline manhole.
- When inflated by the packer the overlapped liner tube material can be expanded to conform to diameter variations and be expanded to at least one pipe size larger if required.

2.1.2 Push-In-Place Method

The push-in-place method involves positioning a resin saturated liner tube placed on a pneumatic expansion packer, pushing it through a lateral clean-out and positioning it at the repair location in the lateral. The packer is inflated until the resin-saturated liner is held tight against the host pipe. The liner is then cured using heat, ultraviolet light or ambient curing techniques. When the liner is cured in the pipe, the packer is deflated and removed leaving behind the finished cure-in-place pipe liner.



Sectional liner being positioned in pipeline

Points to Consider

- No excavation required if a clean-out exists.
- Pneumatic packer is re-usable for other sectional lining.
- Packers can be mounted on wheels and pushed to reach a pipe repair location.
- Expansion packer and liner can be positioned without accessing a manhole in street.
- Coordination with the sewer authority is not needed if on private property.
- When inflated by the packer the overlapped liner tube material can be expanded to conform to diameter variations and be expanded to at least one size larger if required.

2.1.3 Inversion Method

The inversion method involves positioning a resin-saturated liner tube attached to a translucent inversion bladder by a frangible connection. Swelling compression gaskets can be attached to each end of the liner if specified. The inverting bladder carries the liner through a lateral access point and positions the liner at the exact location of repair. Then, an inspection camera is inserted into the translucent bladder while pressure is maintained to determine proper placement prior to curing.



Points to Consider

- No excavation required if clean-out exists.
- Saturated liner tube can be positioned by the translucent bladder at any distance.
- Liner can be positioned without accessing manhole in street.
- Coordination with the sewer authorities is not needed if on private property.
- Translucent bladder allows a visual inspection of proper resin saturation for repairs that are remotely located beyond the insertion point of the pipe.
- The resin-saturated liner is protected inside the bladder from contamination and resin loss.
- The resin side of the liner contacts the pipe only at the repair location.
- Video inspection of proper liner placement decreases the chances that a cured liner has to be removed.

2.2 LATERAL PIPE LINING

Lateral pipe lining involves rehabilitating the lateral from the lateral access point continuously to a specified point. The length of the liner is typically from a lateral access point (excavation or clean-out) to a point near the sewer main or from a lateral access point to a point near a building foundation. Four (4) installation methods are available to accomplish the lateral lining installation.

- | | |
|-------|----------------------------|
| 2.2.1 | Double inversion method |
| 2.2.2 | Single inversion method |
| 2.2.3 | Pull-in-place method |
| 2.2.4 | Clean-out inversion method |

2.2.1 Double Inversion Method

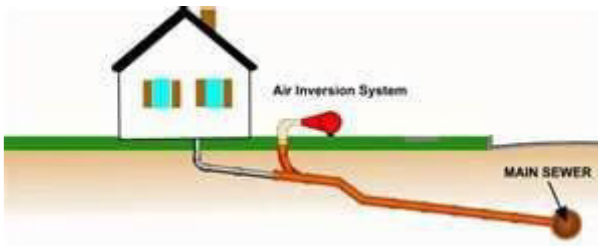
An excavation is required and a section of the lateral pipe is removed. A predetermined length of resin-saturated liner is inverted into the lateral pipe using pressure. Then, the pressure is released. Next, a bladder is inverted inside the saturated liner and the pressure is maintained, causing the saturated liner to press tightly against the host pipe until the resin is cured.

Points to Consider

- Cleaning the host pipe is more effective and measuring from direct pipe access is more accurate.
- Liner cure progress is easily monitored by direct access to liner.
- A second lateral access point is not needed to install the liner.
- Liner can be positioned without accessing manhole in street.
- Coordination with the sewer authority is not needed if on private property.

2.2.2 Single Inversion Method

An excavation is required and a section of the lateral pipe is removed. A predetermined length of resin-saturated liner and bladder are simultaneously inverted into the lateral pipe using pressure. Then, an inspection camera is inserted into the bladder while pressure is maintained to determine proper placement of the saturated liner in the lateral pipe prior to curing. The liner remains pressed tightly against the wall of the host pipe from the initial inversion until fully cured. Then the pressure is released and bladder is removed.



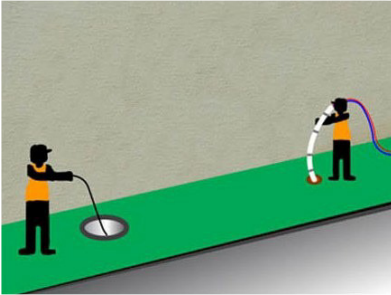
Typical Inversion from a Clean-out

Points to Consider

- A single inversion is required.
- If a translucent bladder is used, it allows a visual inspection of the proper liner placement.
- Internal pressure is maintained until the liner is cured resulting in the following:
 - Infiltration cannot re-enter existing bellies in the host pipe and contaminate the resin-saturated liner or potentially be trapped behind the cured-in-place pipe.
 - The damaged host pipe cannot further collapse while the liner is pressurized.
- A control rope is used to regulate the inversion speed, keeping pressure from building up and damaging property inside the building.
- Installation takes place entirely from the excavation.
- Coordination with the sewer authority is not needed if on private property.
- Cleaning the host pipe is effective and measuring from direct pipe access is very accurate.
- Liner cure progress is easily monitored by direct access to liner.

2.2.3 Pull-In-Place Method

The liner in the pull-in-place method can be installed from a clean-out. A pull cable is strung from the clean-out through the lateral and main sewer pipe to a mainline manhole. A resin-saturated liner with a secondary non-stick skin is positioned on a full length pneumatic inflation bladder. The liner/bladder assembly is then pulled through the clean-out with the pull cable. The liner is pulled into the lateral pipe just far enough to position the liner past the clean-out opening. A CCTV camera in the sewer mainline is used to ensure that the liner is properly positioned at the lateral pipe terminus at the mainline without protruding into the mainline sewer. The bladder is inflated thereby expanding the resin-saturated liner tightly against the host lateral pipe until cured. After the liner is fully cured, the bladder is deflated and removed along with the secondary skin from the inside of the cured liner.



Liner pulled through clean-out from mainline manhole



Liner folded for installation



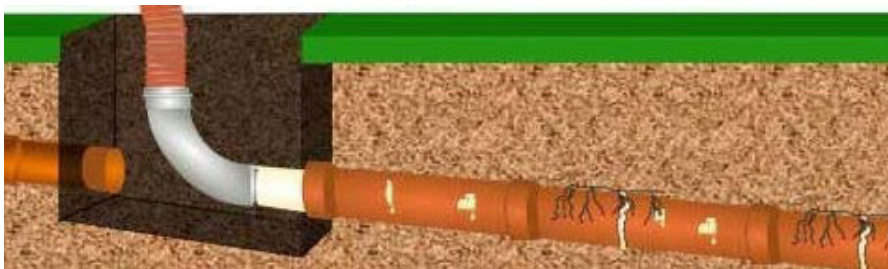
Folded liner pulled into cleanout

Points to Consider

- No excavation is required because installation takes place entirely from the clean-out.
- No positive pressure created in the building plumbing system.
- Video documentation that the liner is positioned properly at the terminus of the lateral pipe at the mainline pipe.
- Reusable pneumatic bladder reduces equipment costs.
- Overlapped weaved fiberglass conforms to diameter variations and can be expanded to at least one pipe size larger if required.

2.2.4 Clean-Out Inversion Method

The clean-out inversion method involves positioning a resin-saturated liner to a translucent bladder, with a frangible connection, by inverting them simultaneously through a clean-out. Some technologies incorporate swelling compression gaskets attached to each end of the liner. The resin-saturated liner is positioned along the bladder at a point, in the host pipe, just past the clean-out. The inversion pressure keeps the resin-saturated liner pressed tightly against the lateral pipe. An inspection camera is inserted into the bladder to ensure correct positioning of the liner prior to curing. The pressure is maintained until the liner is fully cured. Then the pressure is released and the translucent bladder removed.



Lateral liner installed from cleanout or excavation



Inverting liner



Points to Consider

- No excavation is required.
- Installation takes place entirely from the clean-out.
- Translucent bladder allows a visual inspection of proper resin saturation.
- A control rope is used to regulate the inversion speed, keeping pressure from building up and damaging property inside the building.
- Video inspection of proper liner placement decreases the chances that a cured liner has to be removed.
- Only one inversion is required.
- Pressure is maintained until liner is cured resulting in the following;
 - Infiltration cannot re-enter existing bellies in the host pipe and contaminate the resin-saturated liner or potentially be trapped behind the cured-in-place pipe.
 - The damaged host pipe cannot further collapse while the liner is pressurized.
- The resin side of the liner contacts the pipe only at the repair location.
- In some cases swelling compression gaskets are installed with the liner.

2.3 MAIN/LATERAL CONNECTION LINING

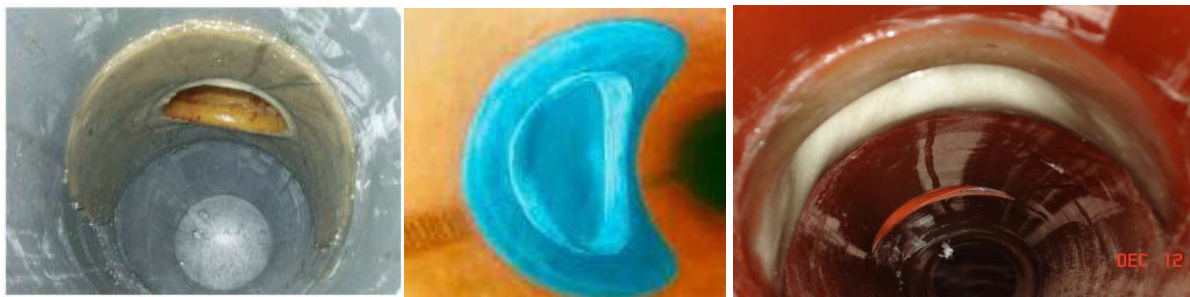
A common defect found in sanitary sewer systems is the condition of the connection between lateral pipe and the sewer main pipe. This connection is often structurally inadequate, cracked, broken or improperly installed. These defects contribute to infiltration and root intrusion. Even after mainline liner installation, this pipe connection may be lined to eliminate infiltration and root intrusion. All connection lining takes place from inside the sewer main. There are two (2) methods used to line and repair the connection.

2.3.1 Brim Style Connection Lining

2.3.2 Full Circle Style Connection Lining

2.3.1 Brim Style Connection Lining

The brim style connection liners can be installed before or after a cured-in-place pipe is installed. Without a CIPP in place the existing pipe must be thoroughly cleaned and prepared before installing the brim style liner as recommended by the manufacturer. If a cured-in-place pipe has been previously installed, the area around the lateral must have its internal coating removed and cleaned prior to installation of the liner as required by the manufacturer. A resin-saturated brim style connection liner is positioned on a pneumatic bladder. The liner is typically in the shape of a brim or top hat. The bladder is positioned within the sewer main at the lateral, allowing an extension of the lateral portion of the liner to protrude up into the lateral pipe. The bladder is inflated, pressing the liner tightly against the inside of the lateral and on the outside brim of the lateral opening inside the sewer main. On some brim style liners a sealant is applied around the brim's contact area with the mainline pipe. Once the brim style liner is cured the bladder is deflated and removed.



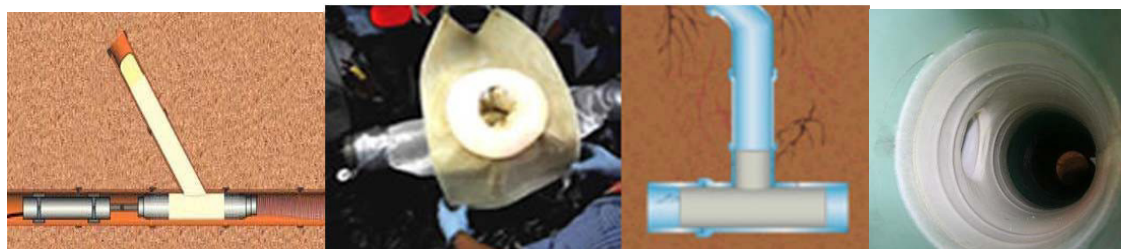
Typical brim style main/lateral connection

Points to Consider

- No excavation or clean-out required.
- A variety of curing system can be used including ambient, heat and ultraviolet.
- Hydrophilic sealants are used at the connection interface, with some technologies, to create a water-tight seal at the interface.

2.3.2 Full Circle Style Connection Lining

A resin-saturated liner is positioned on a bladder so that when expanded it will form a circular liner within the sewer main. The bladder is transported through the sewer main to the lateral pipe location, and then inflated. The liner is inserted tightly inside the lateral and into a full circle around the inside of the main sewer pipe.



Typical full circle type main/lateral connection lining

Points to Consider

- No excavation or clean-out required.
- Several curing systems can be used including ambient and heat.
- Swelling seals can be placed on each side of the lateral to create a water-tight seal at the interface with the host pipe.

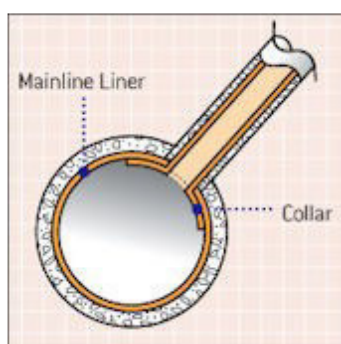
2.4 LATERAL AND MAIN/LATERAL CONNECTION LINING

The Lateral and Main/Lateral Lining is used to rehabilitate the main/lateral connection and also rehabilitate the lateral pipe. This is always done from within the main pipe. Lateral and Main/Lateral Connection Lining involves one of three installation methods.

- 2.4.1 Pull-in-place Method
- 2.4.2 Inversion Method
- 2.4.3 Two-Step Method

2.4.1 Pull-In-Place Method

The pull-in-place method consists of a saturated lateral liner tube and a saturated main liner inserted into a launching device with a pneumatic bladder. The main liner section can be either a brim style or a full circle style. The launching device with the saturated main/lateral liner assembly is inserted through an existing sewer manhole and is positioned in the main sewer at the lateral connection location. Proper positioning of the assembly will result in a portion of the lateral liner protruding into the lateral pipe. Once in position, the bladder is pressurized and inflated holding the mainline section in place and then the saturated lateral liner is pulled into the lateral via a pull-cable that has been previously strung, through the lateral pipe, from a clean-out or excavation to the insertion manhole.



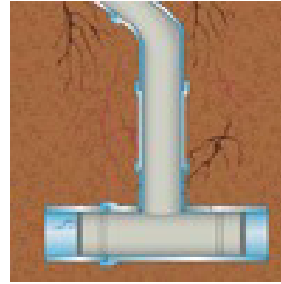
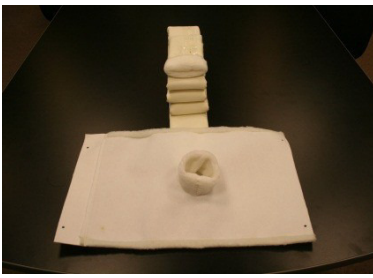
Lateral liner and brim style connection

Points to Consider

- If a clean-out exists then no excavation is required.
- Several curing systems can be used including ambient and heat.
- The joint between the mainline and the lateral liner interface is homogeneous, containing no field produced cold joints.
- Hydrophilic sealants are used at the connection interface, with some technologies, to create a water-tight seal at the main/lateral interface.

2.4.2 Inversion Method

The inversion method consists of a liner assembly comprised of a lateral liner tube and a main liner inserted into a launching device with a pneumatic bladder. The main liner section can be a brim style or a full circle style. The launching device with the saturated main/lateral liner assembly is inserted through an existing sewer manhole and is positioned in the main sewer at the lateral connection location. Proper positioning of the assembly in the mainline will result in a portion of the lateral liner protruding into the lateral pipe. The bladder is pressurized and inflated, pressing the main liner tightly against the main sewer. Then the lateral liner is inverted into the lateral pipe. The distance the liner inverts into the lateral is predetermined and can be as little as six inches or can be as long as 200 feet. This distance to be lined is typically the length of lateral pipe under the jurisdiction of the sewer authority.



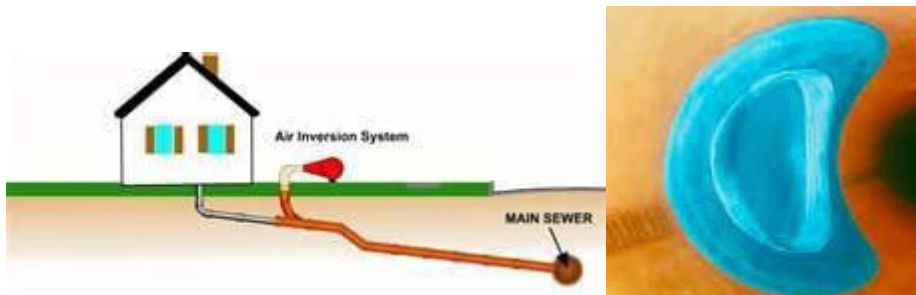
Typical lateral and main/lateral connection lining

Points to Consider

- Though desirable, a clean-out or excavation is not always required to install the liner from the mainline pipe.
- Translucent bladder can be used allowing a visual assurance of proper resin saturation.
- Swelling sealants are used at the connection interface, with some technologies, to create a water-tight seal at the interface.
- The joint between the mainline and the lateral liner interface is homogeneous, containing no field-produced cold joints.

2.4.3 Two-Step Method

The two-step method includes using any of the lateral lining methods outlined in Section 2 combined with any of the connection lining or connection sealing methods outlined in Section 3 and Section 5 of this document.



Two-step lateral lining and brim style main/lateral connection lining

Points to Consider

- The lateral liner and the connection lining or sealing can be installed at different times.
- Applicable points to consider from both the lateral liner and connection lining technologies selected would apply to the two-step method.

2.5 MAIN/LATERAL CONNECTION SEALING

The connection is prepared for injection by a cutting/milling robot operated remotely from a truck above ground. Broken or damaged pipe wall is removed by milling, opening larger pathways for injected resin and exposing new pipe free of grease and debris. After milling preparation, a mainline packer is positioned at the connection from inside the sewer main. From

the mainline packer a lateral bladder is launched up into the lateral 18-24". Both mainline packer and lateral bladder are inflated isolating the prepared connection for injection. A two-component resin or epoxy material is injected under pressure into the isolated area. Resin permeates into the soils and voids surrounding the lateral pipe connection to structurally re-establish bedding and spring-line support for the connection. Simultaneously, the resin bonds with cleaned, new pipe surfaces exposed during the milling preparation stage. Resin cures ambiently (silicate resin) in 20 minutes or with heat (epoxy) in 30 minutes. Silicate resin is appropriate for high ground water infiltration situations, because pumping pressure can be adjusted to overcome groundwater pressures. Resin is injected in stages creating a resin mass which vertically climbs upward around the connection including the first joint to ensure resin permeates an offset lateral within the first joint and other cracks or holes. Bladders are deflated and moved to the next lateral connection for repair.

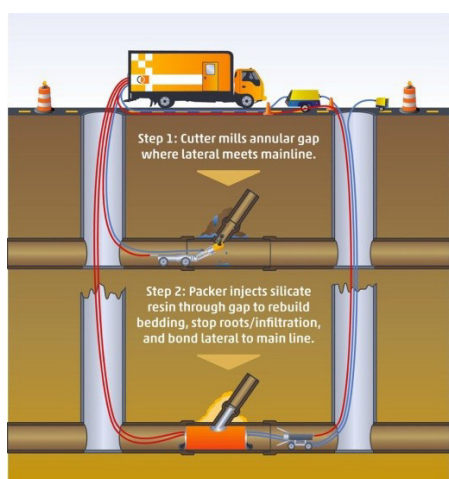
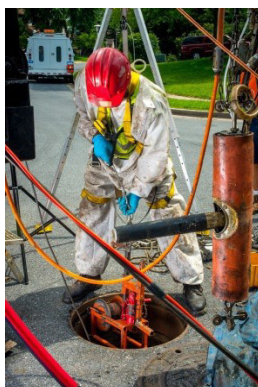


Illustration of connection sealing and bedding reconstruction



Injection bladder being lowered into existing manhole



Typical bladder used for resin injection. The heat shield is indicated in red.

Points to Consider

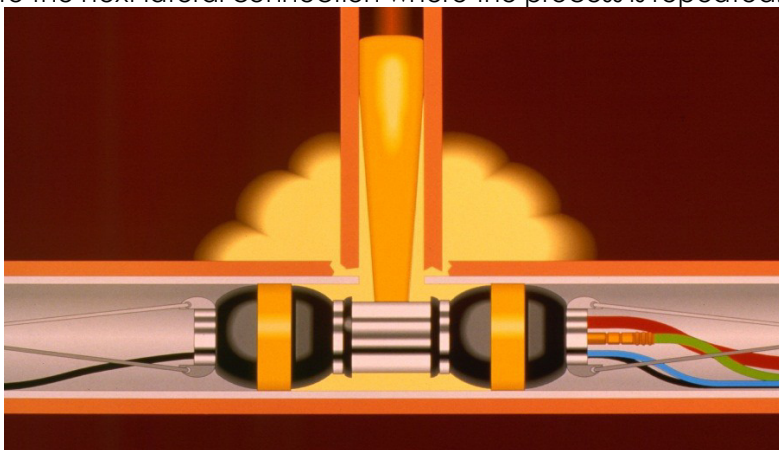
- No excavation or clean-out needed.
- Low initial viscosity of silicate resin allows for penetration through cracks and holes as well as annular space between liner and host pipe.
- Holes and cracks are filled with resin material.
- The soil area around the connection is saturated with resin and cured.
- Flexible lateral bladder permits use in bends.
- Bypass pumping usually not required.

2.6 LATERAL AND MAIN/LATERAL CONNECTION GROUTING

2.6.1 Grouting From the Mainline

The Lateral/Mainline packer is positioned inside the sewer main at the lateral location. The lateral bladder is then inflated and inverted up into the lateral for the distance to be sealed (24 inches up to 30 feet have been done successfully). The mainline bladders are then inflated and a three point seal is achieved, isolating the lateral connection and the predetermined portion of the lateral to be sealed. Finally, a two component chemical grout (acrylamide, acrylate, acrylic or urethane gel) is pumped, under pressure, from the grout pumps located in the truck above-

ground through the mainline packer. This liquid mixture is pressurized and pumped through the existing defects of the area to be sealed, saturates the pipe bedding materials, fills voids and creates a watertight grout/soil matrix preventing groundwater infiltration/exfiltration and the potential loss of fines entering the piping system through continued infiltration. The chemicals predictably react within 30 to 60 seconds to seal off infiltration and are controllable from the grout truck. Grouting pressures measured at the injection point are monitored to insure that the materials are pumped at higher pressures than the groundwater pressures. A post air test confirms that the lateral connection and that portion of the sealed lateral are watertight. The lateral bladder is deflated and retracted back into the mainline assembly and the packer assembly moved to the next lateral connection where the process is repeated.



Typical method of lateral grouting

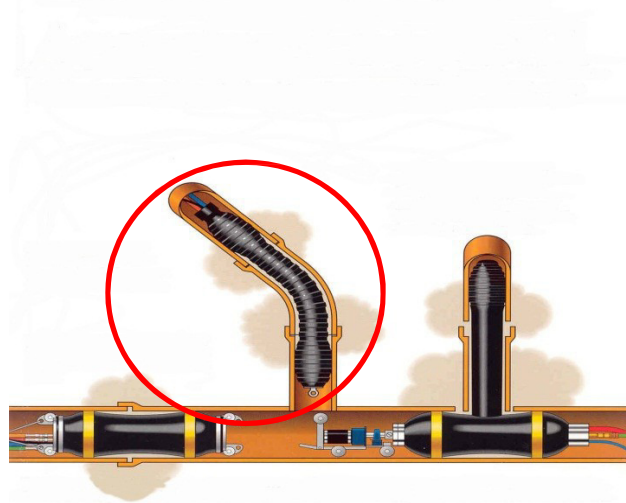
Notable Points:

- Existing holes and cracks are used to inject grout to the exterior of the pipe.
- Low initial viscosity of materials used allows for penetration through very fine cracks as well as annular spaces between host pipe and relined pipe.
- No special pipe preparation for bonding is required as the seals are achieved from outside the pipe (soil sealing process).
- Additives may be used to enhance compressive and tensile strength of the grout.
- Technology allows for test & seal procedure with the same equipment.
- Technology allows access through multiple bends.
- Technology stabilizes the pipe by filling voids and stabilizing the soil outside the lateral and mainline.

2.6.2 Grouting of Laterals from an Above Ground Access (Flexible Packer Method)

The flexible push/pull packer is inserted into the lateral pipe from a cleanout or open pit access (Depending on the lateral pipe configuration, it may be necessary to pull the packer through the lateral pipe). With either a premeasured distance or with the help of a push camera, the packer is moved to the closest joint towards the mainline/lateral connection. The flexible packer is then inflated, isolating a section of the lateral (usually three to five foot span). Finally, a two-component chemical grout (acrylamide, acrylate, acrylic or urethane gel) is pumped under pressure from the pumps located in the truck above ground. This liquid mixture is pressurized through the existing defects of the area to be sealed, saturates the pipe bedding materials, fills voids and creates a watertight grout/soil matrix preventing groundwater infiltration/exfiltration and the potential loss of fines entering the piping system through continued infiltration. The

chemicals predictably react within 30 to 60 seconds to seal off infiltration and are controllable from the grout truck. Grouting pressures measured at the injection point are monitored to ensure that the materials are pumped at higher pressures than the groundwater pressures. A post air test confirms that portion of the sealed lateral is watertight. The flexible packer is then deflated and moved towards the above-ground access by the grouting span (usually three or five feet) where the process is then repeated



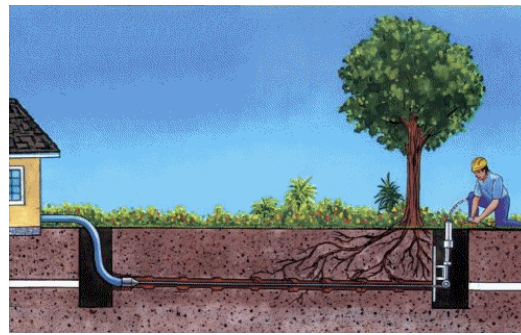
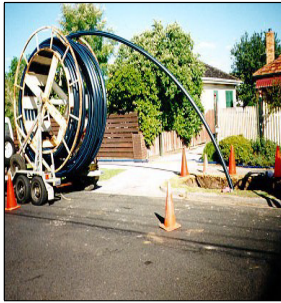
Typical grouting method for mains, laterals and lateral connections

Notable Points:

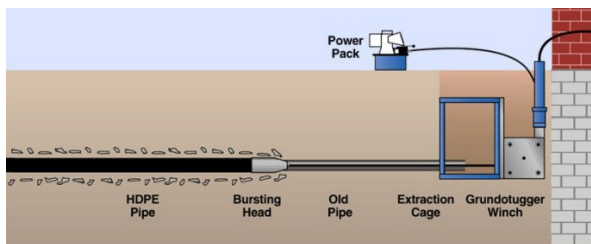
- Existing holes and cracks are used for grout injection to the exterior of the pipe.
- Low initial viscosity of materials used allows for penetration through very fine cracks as well as annular spaces between host pipe and relined pipe.
- No special pipe preparation for bonding is required as the seals are achieved from outside the pipe (soil sealing process).
- Technology allows for test & seal procedure with the same equipment.

2.7 LATERAL PIPE BURSTING

In a typical lateral pipe bursting operation, a cone-shaped tool ("bursting head") is inserted into the existing pipe and forced through it, fracturing the pipe and expanding its fragments into the surrounding soil. At the same time, a new pipe is either pulled or pushed in the annulus left by the expanding operation (depending on the type of the new pipe). In the vast majority of pipe bursting operations, the new pipe is pulled into place. The new pipe can be of the same size or larger than the replaced pipe. The rear of the bursting head is connected to the new pipe, and the front end of the bursting head to either a winching cable or a pulling rod assembly. The bursting head and the new pipe are launched from the insertion pit and the cable or rod assembly is pulled from the pulling or reception pit.



Pipe pulled with bursting tool



A typical pipe bursting setup



A typical pipe bursting head

Points to Consider

- A new pipe replaces the existing pipe.
- A larger pipe can be installed to replace the existing pipe.
- Bursting tool can go around bends.
- Hard saddle connection is made to the main sewer minimizing leakage.

3.0 MATERIALS

3.1 LINER TUBES

The liner tube's function is to:

- Fully absorb and contain the selected resin system until installed and cured in the host pipeline.
- Position the resin in the host pipe and give it dimensional thickness stability.
- Exhibit sufficient material strength to withstand the installation hydrostatic and temperature stresses during the curing process.

In order to negotiate bends, hold up to installation pressures and conform to small diameters, lining tubes are constructed out of elastic materials such as lightweight needle-punched felt or low and high pile knitted fabrics. These elastic materials stretch, increasing the difficulty to terminate a liner at an exact location near the main sewer over a long length. If a less elastic material is used then higher installation pressures are required to invert the liner.

Improved lining tube technology that incorporates glass fiber, called a scrim, with the elastic materials minimizes the stretch issues and also requires lower liner installation pressures. Fiberglass typically has higher physical properties resulting in a liner having a reduced wall thickness. The addition of the scrim allows the liner to negotiate bends in small pipe and stretch



in diameter while preventing the liner from stretching in length. It should be noted that all the liner tubes utilized in the technologies in this report will accommodate pipe diameter changes.

3.2 RESINS

Each lining method may use a different resin system including polyester, epoxy, vinyl ester, and silicate resin systems. Each resin system has unique characteristics to consider when selecting the best product and technology for a project.

3.2.1 Polyester Resin Systems

Unsaturated polyester resin (UPR) is the workhorse of the CIPP industry and represents approximately 90% of the total resin used. Polyester resin is versatile because of its capacity to be modified or tailored during the building of the resin formulations. They have been found to have almost unlimited usefulness in all segments of the composites industry. The principal advantage of these resins is a balance of properties (including mechanical and chemical) dimensional stability, cost and ease of handling or processing. Polyester resins (both filled and unfilled) are applicable in a lateral pipe carrying sanitary sewerage or wastes with an acidic or neutral pH values. This waste should not contain high levels of chlorinated solvents. The effluent temperature should be ambient or no more than 120 degrees F.

3.2.2 Epoxy Resin Systems

The structure of epoxy resin can be engineered to yield a number of different products with varying levels of performance. A major benefit of epoxy resins over unsaturated polyester resins is their lower shrinkage and they emit little odor. Generally, epoxies have short working times with long cure times. An epoxy CIPP of any significant length will require an external heat source to accelerate the cure. Epoxies provide superior mechanical properties, resistance to corrosive liquids, good performance at elevated temperatures and good adhesion to properly prepared, clean, and compatible surfaces. Epoxy resins may also be used in applications where styrene monomer or other VOCs may not be allowed.

3.2.3 Vinyl Ester (VE) Resin Systems

Vinyl esters were developed to combine the advantages of epoxy resins with the better handling/faster cure characteristics of unsaturated polyester resins. These resins are produced by reacting epoxy resin with acrylic or methacrylic acid. The resulting material is dissolved in styrene to yield a liquid that is similar to polyester resin. Vinyl esters are also cured with the conventional organic peroxides used with polyester resins. Vinyl esters offer mechanical toughness and excellent corrosion resistance. These enhanced properties provide benefits similar to an epoxy with reduced cost and increased production. Vinyl ester resins (both filled and unfilled) are applicable in a lateral pipe carrying sanitary sewerage or waste having a pH value of up to 14 at ambient conditions. VE resins can handle a variety of solvents and chlorinated compounds that polyester may not be able to handle. VE resins are also used where the effluent may be at temperatures between ambient temperatures and 160 degrees F.

3.2.4 Silicate Resin Systems

Silicate resins like water, but the cure can be accelerated or affected by water and even foam like a urethane grout. These resins provide good adhesion to properly prepared, clean and compatible surfaces. Silicate resins have similar curing issues as epoxy where the work time is



short and the cure time is long. Yet unlike an epoxy, silicate resins are typically not suitable for external heat sources as commonly used in CIPP applications. For these reasons, silicate resins are well suited for short liners, main/lateral connection liners or injection grouting. Silicate resins have applications for a wide range of corrosive environments and may also be used in applications where styrene monomer or other VOCs may not be allowed.

3.2.5 Summary of Resin Systems

Depending on the chemical makeup of the effluent, one resin may be preferred over another and the installer should contact their resin supplier to confirm that the correct resin is used to meet the specific requirements for that pipeline. However, in most all residential sewer systems, all of the resins described are suitable, for a typical cured-in-place pipe application, in municipal collection systems.

3.3 GROUTS

There is a wide range of chemical grouts on the market derived from two basic classes of grouts: those which use a chemical catalyst for curing of the gel and those activated by water. For sewer applications, grout components and catalysts are typically mixed in separate tanks on the job site. The acrylamide, acrylate, and acrylic grout classes are materials mixed with a range of potential additives

Water and the chemical grout catalyst are mixed per manufacturer. Components, from separate tanks, are then pumped through hoses to a nozzle at the point of injection. The ratio of the mixed chemical grout components and the temperature of the water determines the gel time, as the grout is activated and moves from the liquid phase to the gel or solid phase in the soil.

The second group of chemical grouts, urethane gel and urethane foam, are prepared and delivered in tubes or canisters from the manufacturer ready for injection. These chemicals are activated by water encountered in the soil or added by the contractor/applicator.

The grout properties dictate where they are used to their best advantage and to provide long term resistance to resist shrinkage of the grout and other deteriorating effects. Typically urethane foams are used within the first upper five feet of a manhole having wet/dry cycles and fluctuations. Acrylic and urethane gels are often used in the outside lower sections. Once the resin is chemically activated or contacts water, a chemical reaction occurs within the grout to form an impermeable mass with the soil matrix which blocks infiltration from coming back into the sewer system.

3.4 PIPE REPLACEMENT

The pipe bursting technology is a pipe replacement technique. Commonly the replacement pipe is polyethylene pipe, a product with characteristics such as toughness, elasticity, pressure strength and more which makes the material attractive for this technology. Other products such as PVC and ductile iron are also available to replace the existing pipe using the pipe bursting technology.



4.0 CURING METHODS

Resin systems can typically be cured using four (4) different techniques:

- 4.1 Ambient
- 4.2 Hot Water
- 4.3 Steam
- 4.4 Ultraviolet light

4.1 AMBIENT CURE

Ambient cure time typically ranges from one to six hours depending on the temperature of the host structure.

4.2 HOT WATER CURE

Hot water includes installing the product with cold water, then heating the water to a temperature that will cause the resin to polymerize and cure.

4.3 STEAM CURE

Steam curing includes installing the product with air pressure, then heating the air to steam temperature. Both the hot water and steam curing methods can have curing times of one to two hours. Also resin that is steam or hot water cured may achieve a high level of cross-linking resulting in higher physical properties.

4.4 ULTRA VIOLET LIGHT (UV) CURE

Ultraviolet light curing includes resins that are activated and cured using light instead of heat. UV light curing can be used with some technologies and offers quick curing times of under one hour.

5.0 SUMMARY

Renewing sewer laterals and main/lateral connections can be accomplished using the product types and installation methods outline herein.

Each project location should be carefully evaluated to determine the appropriate method to for a successful installation and to ensure project and customer goals are met.

Experienced installers and correct selection of product types make trenchless lateral and lateral/main sealing a good alternative for renewing sewer lateral infrastructure.

A standard set of inspections are needed for each lateral objective discussed. This would ensure consistency and provide a blueprint for successful installations of lateral and main/lateral connection rehabilitation technologies.