



North American Society for Trenchless Technology (NASTT)
NASTT's 2014 No-Dig Show



Orlando, Florida
April 13-17, 2014

TM1-T3-02

**A Technique for Renewing a Section of Mainline Pipe while
Simultaneously Renewing Multiple Service Lateral Pipes through the
Use of Continuous CIPP**

Larry Kiest, Jr.¹, and Sahar Hasan²

¹ Design Engineer, LMK Technologies, LLC. Ottawa, IL, USA

² Applications Engineer, LMK Technologies, LLC. Ottawa, IL, USA

ABSTRACT

Cured-in-Place-Pipe (CIPP) has proven to be a successful, long-term technology for rehabilitating mainline and lateral sewer pipes. The process today consists of three (3) key steps:

1. The main pipe is renewed by CIPP
2. The service connection is robotically reinstated
3. The lateral pipes and the main/lateral connections are renewed and sealed by CIPP

While the technology has proven robust, there are pipe configurations that cause CIPP to be considered an unsuitable method for pipe rehabilitation. One particular pipe configuration is where a service lateral splits into two (2) lateral pipes. Another pipe configuration is where two service connections are opposing, which is also known as “siamese laterals”. Until a recent development, the application of CIPP for these types of pipe configurations has required multiple liners—one for each service lateral pipe—which resulted in multiple layers of CIPP, increased reduction in the cross dimension of the pipe, and possible leakage at cold joints that formed at the overlapping sections. This paper will discuss the development and simultaneous application of a single-piece CIPP for the main pipe and multiple branch pipes.

INTRODUCTION

The Cured-in-Place-Pipe process is over 40-years old, and the evolution of this technology continues to develop, advancing the trenchless industry. The development of a single-piece Cured-in-Place-Pipe for renewing a main pipe section and multiple service lateral pipes allows municipalities a CIPP option that does not significantly reduce the cross section or have cold joints that may leak.

Table 1-Pipe Configurations

<p>Sewer mains typically have lateral connections at various positions along the length of pipe, and these connections are seldom opposing.</p>	<p>Siamese Laterals are opposing and have been a challenge for CIPP lining. However, the need to apply trenchless CIPP rehabilitation is desirable for all pipe configurations.</p>	<p>By far, the most difficult pipe configuration is the double-stack, where the lateral pipe is at a 12 o'clock position and connects to a bullheaded tee fitting with two service laterals extending therefrom.</p>
---	---	--



Fig 1. Typical Sewer w/ connections



Fig. 2 Siamese Opposing Laterals



Fig 3. Double Tee Stack Connections

CIPP LATERAL HISTORY

CIPP has been used for a wide variety of pipe repairs and pipe renewal projects. In the early 1990s, lateral lining techniques were developed for the insertion of a cured in-place liner into a service pipe from within the main pipe. These liners were pulled in-place and inverted in-place, and attempts to form a seal at the main/lateral connection were made by gluing a brim to the mainline CIPP (see Fig. 4). The concept of using glue to form a long-term bond in a greasy sewer where hydraulic loading is prevalent proved to not be the best option. Often these types of glued connections delaminated. Another disadvantage was the lack of engineering. Since the brim does not take the shape of a tube, the design calculations described in ASTM F1216 are not applicable.



Fig. 4 Glued Brim Style Connection

In 1995 a pull in-place liner was developed, and in 1997 an inverted liner was developed; both included of a full-hoop structural connection liner designed to bond with the mainline CIPP. Although the full-hoop construction (see Fig. 5) allowed engineers to design the lateral tube and the connection liner to withstand specific loading, specifically hydraulic loading, the repairs were prone to leak due to a lack of long-term bonding caused by lubricants applied to the coating of the mainline CIPP. The lubricant materials may include mineral oil, vegetable oil, Crisco® grease and similar materials that are slippery and slick. These materials are directly



Fig 5. Glued Full-Hoop Connection

applied to the coated surface of the liner as the liner is inverted into the main pipe. This process is described in ASTM F1216, and the purpose of the slippery material is to reduce friction as the liner tube is inverted from manhole to manhole. The problem is that the interior surface of the new mainline CIPP becomes greased up with materials well known to be release agents. Attempts were made to grind away the coating around the lateral opening and to wash the inside of the mainline CIPP with hot water and detergents. Resins having adhesive properties like epoxy or silicate were also used, yet the process was difficult, timely, and expensive if done properly. The results were inconsistent as a cold joint was formed where the full-hoop connection liner overlapped the previously installed mainline liner. The surface bond remained subject to earth movement, thermal movement, hydraulic pressures (ground water is a persistent and constant force), and shrinkage.

GASKET SEALING TECHNOLOGY

The next generation of lateral lining was engineered with a compression gasket (see Fig. 6) that forms a positive seal between the mainline CIPP and the full-hoop lateral connection liner. The gasket sealing technology is a proven method of sealing CIPP and has been successfully tested to withstand up to 70-feet of hydraulic head pressure. However, service lateral pipes come in many different shapes, sizes, and configurations. When we studied the three different pipe configurations shown above, we found that all three (3) CIPP processes for lateral pipes were unsuitable methods of renewal and sealing for pipe configurations shown in figures 2 and 3, which will be discussed in greater detail below.



Fig 6. Full-Hoop Lateral Connection Liner with Neoprene Compression Gasket

“Overlapping an uncured liner onto a cured liner forms a cold joint, just as as two slabs of concrete poured and cured at different times form a cold joint.”

SIAMESE OPPOSING LATERALS

In a pipe configuration where the opposing laterals are at 3 o'clock and 9 o'clock, a four-way tee fitting can be used. This was the case on a project in Fort Myers, Florida, where a CIPP contractor was under contract to renew the lateral pipes and form a non-leaking connection with the mainline CIPP. The contractor intended to renew the laterals using a CIPP product that is compliant with ASTM F2561-11, which consisted of a full-hoop lateral connection liner, outfitted with neoprene compression gaskets. However, upon the initial CCTV survey, the contractor was surprised to find that almost every lateral connection was made with a four-way tee fitting. The contractor brought this to the attention of the engineer, and they discussed what options were available aside from excavation. Initially, two trenchless options were discussed.

The repair methods were specified to use materials and installation methods that were compliant with the ASTM F2561-11 standard. However, in this case, the contractor would be required to install a full-hoop connection liner into one service lateral (connection at 3 o'clock) which would cover the opposing service lateral (connection at 9 o'clock) and require the covered connection to be robotically reinstated. This process would be followed by a

second full-hoop liner, outfitted with compression gaskets, for the renewal of the lateral at 9 o'clock, which would also require reinstating the opposite lateral connection.

This process is not only costly due to the time and work involved, but it also poses a couple of serious concerns for the contractor and the engineer. The first concern is cutting the lateral liner tube located in the service at 9 o'clock when reinstating the service at the 3 o'clock position. If the new CIPP is cut, the repair is defective and ineffective, especially in areas where ground water is prevalent. It is common knowledge to those skilled in the art of CIPP that holes in a liner may not only allow ground water to infiltrate the collection system, but also tree roots and—in some cases—sewage will infiltrate, promoting pollution. The other concern is the reduction of cross dimensions of the pipe with multiple layers of CIPP. This repair method was considered to be an unsuitable method for this project due to the reduction in pipe diameter and the potential for defects in the CIPP.

The other option was to install two (2) brim style lateral connection liners, but this type of repair does not meet the requirements as described in the industry standard for lateral renewal and sealing and therefore would be prone to leakage. The contractor contacted their CIPP supplier about the situation in Fort Meyers and discovered that a new technology had recently been developed for the simultaneous installation of a full-hoop lateral connection liner into two lateral pipes, outfitted with neoprene compression gaskets. The simultaneous inversion of multiple liner tubes is a technology that had been under development for several years. The first commercial installation was in 2013 in New Castle County, Delaware. The repair shown in Figure 7 is an example of how sewers have evolved. The main pipe was installed, and at a later time, service connections were made by chiseling a hole in the clay tile. This is commonly referred to as a “hammer tap”. In this case the circumferential rings of the two connections were slightly offset only by a few inches. The crew took distance measurements from the manhole to the edge of each service opening, and the clock reference positions were a visual call made by the CCTV operator.



Fig. 7 Lateral Connections New Castle County

THE REPAIR PROCESS

The process consisted of a mainline liner tube and two lateral tubes. The mainline tube in this case was 8-inches in diameter and 3-feet in length. The two lateral tubes were 6-inches in diameter and also 3-feet in length. The liner assembly was married with a corresponding invertible translucent bladder, forming a liner/bladder assembly. Next, the liner assembly was resin saturated under a controlled vacuum and loaded inside of a hose-launching device. The launcher was pulled into the pipe adjacent to the connections, air was applied, and the main liner inverted towards the connections. When the liner reached the connection, the two lateral liners inflated and inverted into the service lateral pipes. The bladders extended beyond the liner tubes so the ends of each liner (the main and the two laterals) remained open ended and pressed tight to the host pipes. Each end of the main and lateral liner tubes were also outfitted with hydrophilic O-rings that swell after 24-hours from installation (long after the liner has been cured into a structural tube) forming a compression gasket seal that ensures the liners remain leak-free for the engineered 50-year service life.



Fig. 8 Inverting Liner Outfitted with Compression Gaskets

This same process, which was first used on the New Castle County project, was also used to solve the concerns on the Fort Myers project. However, in this case, the lateral tubes needed to be 50-60 feet long each. The owner required the liner to be compliant with ASTM F2561-11, which requires that the liner be continuous with no cold joints and outfitted with compression gaskets (see Fig. 8). The pipes were surveyed, and measurements were taken. In this configuration, the laterals were Siamese factory made four-way tee fittings, so the clock positions of the connections were constantly positioned at 3 o'clock and 9 o'clock. These repairs were not easy by any means. The resin saturation process was a bit awkward, especially since the saturation process takes place in a mobile wet-out trailer. A vacuum source was attached to each lateral liner tube, and the slug of resin was pushed through both lateral liners at one time (see Fig. 9). These liners are saturated with 5-10% excess resin for the purpose of filling open joints and fractures in the old pipe as described in ASTM F2561 & ASTM F1216. The mainline connection liner, which was 3-feet long, was also vacuum saturated, and the liner/bladder assembly was loaded into a hose launcher and pulled to a location just adjacent to the lateral connections. The crew inserted lateral push cameras into each service lateral through a cleanout. In addition, a mainline camera was positioned in front of the inverting mainline tube, ensuring all three liners were fully deployed. The operators are trained to look for resin slugs at the uppermost end of the lateral liners since all of these liners are saturated with excess resin. If any resin is found, it is removed before curing the liner, ensuring a smooth transition is formed. The liners were steam cured, the bladders were reverted away from the cured liner assembly, and flows were reestablished (see a complete repair in Fig. 9).



Fig. 9 Resin Saturation Siamese Laterals

DISADVANTAGES FOUND IN THE NEW PROCESS

The process is challenging for a variety of reasons. One of the most important challenges is that the field survey measurements must be near to exact and that those measurements are matched in a liner manufacturing facility. Those in the art of CIPP renewal techniques will also understand that the correct materials must be used, and often, proprietary methods are practiced, which is common for most new technologies being introduced into a field of special products and services.

ADVANTAGES FOUND IN THE NEW PROCESS

The repair of multiple lateral pipes through the inversion of a mainline liner tube and multiple lateral tubes having a uniform wall thickness (see Fig. 10) that is assembled, sealed and tested in a controlled factory setting, gives utility owners an engineered trenchless solution for these unique pipe connections. So far, as many as three (3) service laterals have been simultaneously renewed, along with the main connection, with compression end seals on all ends of the CIPP. Current testing is underway for the rehabilitation of the entire mainline run from manhole to manhole and all service connections there between through the inversion of a mainline tube having corresponding lateral liners connected along its length.



Fig 10. Continuous CIPP Siamese Lateral Connections

“Cold joints are not comparable to a monolithic homogenous liner, which can only be produced by a single liner assembly that is resin saturated, installed, and cured at one time.”

DOUBLE- STACK LATERAL CONNECTIONS

The notorious double-stack lateral is unique to South Florida where ground conditions are a concern even at shallow depths with running sand and water. Therefore, the thought was to use a single lateral connection positioned at 12 o'clock and go straight up with the pipe to an elevation that was much less than the main pipe depth. A bullheaded tee fitting, as shown in Figure 11, is connected to the vertical lateral pipe, and two lateral pipes on a horizontal grade are connected to the left and right sides of the tee.

LINER CONSTRUCTION

As described in ASTM F2561, the tube and sheet are the framework of the main and lateral cured-in-place liner (MLCIPL) and are generally constructed of an absorbent needle punched felt or a high pile knit with a polymer film coating on its outer surface. The tube is engineered to be extremely flexible yet robust in order to negotiate bends in lateral pipes at significantly reduced inversion pressures. In the case of the double-stacked laterals, special measuring equipment is used to determine the distance from the main pipe invert to the crown of the bullheaded tee fitting. The horizontal laterals were also measured using standard measuring methods. A bigger challenge was determining the clock-position of the double laterals in relation to the main pipe. All of these measurements were necessary for the liner to be constructed to match the pipe configurations.

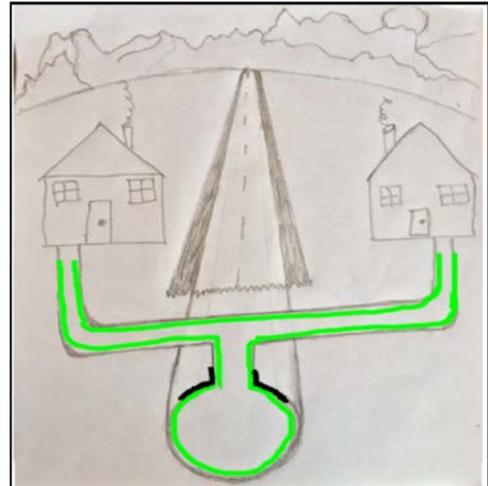


Figure 11 Monolithic Double-Stack CIPP with Gaskets

THE DOUBLE-STACK REPAIR

This style of repair utilizes the same equipment and installation methods used to renew a single lateral connection. The liner assembly consists of a flat sheet that forms a tube at the main connection and a lateral tube that is inverted into the lateral pipe. The lateral tube splits into two tubes matching the bullheaded tee fitting. This liner assembly is also married with a translucent bladder having corresponding shapes and sizes. The liner assembly is resin saturated under a controlled vacuum, loaded into a T-shaped launching device, and pulled to the lateral connection. A robot is used to align the lateral liner with the lateral pipe opening, air pressure is applied causing the liner to invert upward until the bullheaded tee is encountered, and the liner tubes begin to invert through the horizontal lateral pipes (see Fig. 12).



Fig 12. View from Cleanout of Bullheaded CIPP Tee at 6 o'clock

The first commercial double-stacked liner repairs were made in Hollywood, FL, where ground water is a serious concern. To ensure long-term, leak-free performance, a flange shaped neoprene compression gasket was inserted into the lateral connection, and each end of the liner assembly was outfitted with compression gasket seals. Just as sewers have evolved, so has CIPP technology. The good news is that owners and ratepayers benefit whenever a trenchless process can be utilized through new innovations.

