Best Value Engineered Design for a

Sealed CIPP Collection System

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by

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Attachments

Figures

Background

Miami Dade Water and Sewer Department (MDWSD) is the largest water and wastewater utility in the Southeastern United States. Beyond the normal repair and rehabilitation requirements of any such utility, MDWSD faces several additional challenges which include the need for resiliency to sea level rise and coastal flooding, high groundwater tables throughout most of its service area, and a Federal Consent Order mandating significant capital upgrades of its facilities. These upgrades include the repair, replacement or rehabilitation of MDWSD's gravity collection system.

MDWSD is meeting these challenges head on. The utility has developed a comprehensive capital plan to not only meet but to exceed the requirements of the Consent Order. MDWSD has also developed a vision for resiliency and sustainability that has earned the prestigious recognition of a *"Utility of the Future"* from a consortium of leading wastewater associations and endorsed by the Environmental Protection Agency. A major reason for this recognition is that MDWSD has embraced innovation and engagement as a leader in the full water cycle and broader social, economic, and environmental sustainability of the community.

As part of its overall vision, MDWSD has developed an Operational Resiliency Plan. One of the key elements of this plan to achieve operational sustainability is Product Quality. The requirement for quality, of course, would extend to the Cured-in-Place Pipe (CIPP) lining of gravity laterals that connect to CIPP lined gravity mainline pipes. It has been demonstrated many times over that in high groundwater conditions as much as 50-75% of the total infiltration can come from degraded sewer laterals, even after CIPP lining of the main gravity pipe.

LMK Technologies and its consultants, in recent conversations with Lester Sola, Director, and Hardeep Anand, Deputy Director for Capital Improvement and Regulatory Compliance, have presented information on the superior quality and long term service life of its ASTM F2561-compliant service lateral liner and gasket seals for CIPP sewer collection systems. A copy of the ASTM F2561 standard is enclosed as **Attachment 1.**

It is important to note that the gaskets used in creating F2561-compliant systems also comply with ASTM F4777, the Standard Specification for Elastomeric Seals (Gaskets). Miami-Dade County requires that only rubber gaskets meeting the F4777 standard are used in all its new pipe installation. It stands to reason that the County should require similar gaskets in the case of both lateral and manhole connections. Figure 1 below provides illustrations of gaskets for sealing manhole connections. Figure 2 below provides illustrations of gaskets for sealing lateral connections. Figure 3 provides illustration of sealing upper terminating end of lateral CIPP.

Figure 1 End Seal Gaskets at Manhole Connections

Figure 2 Gaskets for Sealing Lateral Connections

Figure 3 Gaskets for Sealing End of Lateral CIPP

The purpose of this report is to present further and more comprehensive technical data to support the fact that the ASTM F2561-compliant laterals and the use of molded hydrophilic seals are a higher quality, longer lasting and more sustainable solution to MDWSD's operationally resilient capital plans.

The points that are covered in this report include:

- A technical discussion as to why molded rubber pipe seals (compression gasket), as required and used by the county for all new pipe installations, are a much more consistent and long-lasting pipe seal for CIPP lining than any paste-based system.
- Test data on both the LMK neoprene hydrophilic gasket sealing system and on the Adeka paste system touted by the main installer of paste-based lateral liners which demonstrates the superiority of the hydrophilic seals and casts doubt on the potential performance and service life of paste-based sealing systems.
- Four case studies, two of which focus on successful installation of pre-engineered, neoprene hydrophilic lateral liners in South Florida. One of these studies concerns Coral Gables, FL, a community near MDWSD and with the same wastewater challenges. This study, published and peer-reviewed by the North American Society of Trenchless Technology (NASTT), demonstrates the city's sustained success in reducing infiltration and pump run times. The second case study, from the North Coral Springs Improvement District, clearly shows a significant return on investment based on the long lasting, tight sealing properties of ASTM-compliant lateral liners. A third case study, from Naperville, IL and also NASTT peer-reviewed, is the most detailed in presenting the economic benefits of using neoprene hydrophilic gaskets to seal the end connections of the mainline pipe and the service laterals: Naperville realized an estimated savings of $1.25 million per year and has been able to defer a $6 million treatment plant expansion. The final case study, from Portland, OR presents its unique approach to meeting the CMOM requirements of the City's Consent Order.
- A discussion on the point that LMK ASTM F2561 lateral lining technology can perform difficult tasks that others cannot accomplish with their non-compliant industry standard methods. These include the lining of opposing laterals (double stack and Siamese twin laterals) as well as difficult spot repairs near the old lateral.
- A discussion of the value of clean-outs which includes a cost comparison of operating with and without cleanouts based in part on data from MDWSD staff.
- A brief discussion of the procurement issues and traps which a utility can face when specifying and bidding lateral liners.
- A list of Florida and US utilities which specify and install ASTM F2561-compliant lateral liners.

Comparison of Sealing Systems

Designing long-lasting seals for CIPP for both main line linings and lateral linings starts with the recognition that all buried pipes are meant to provide a long-lasting water-tight service performance. The primary design elements are to assure the pipe's owner that the *seal made on day one will be there throughout the life of this buried structure*. These elements are: 1) a flexible, preformed gasket of a material that is durable for the service environment for the desired service life, 2) a groove or channel for holding the gasket in place as the pipes are joined together and afterward to facilitate the in-service performance requirements of the sealing function(s), and 3) the right cross-sectional geometry to stand up to the needed operational performance under a constant loading (refer to figures 4 and 5).

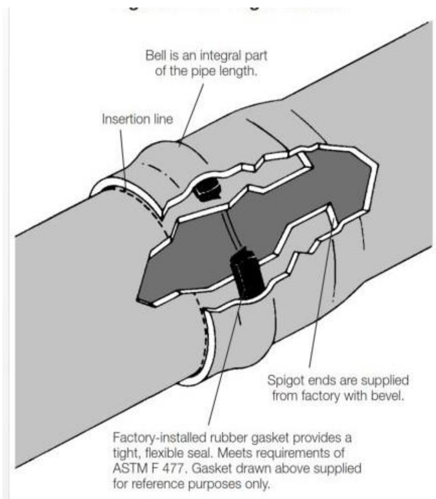


Figure 4 Comparison of Sealing Systems - Groove Contains Molded Gasket

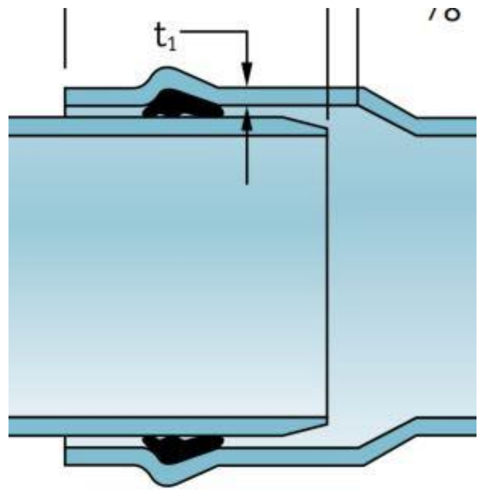


Figure 5 Comparison of Sealing Systems - Gasket Compressed in Groove

Gaskets come in many geometries owing as to whether the need is simply to stop soil and migrating groundwater (rainfall) from intruding into the pipeline, to stop external groundwater (i.e. external hydrostatic pressure) from entering the pipeline such as when the pipeline is below the water table, to hold pressurized fluid inside of the pipeline, or a combination of these functions. The effort required to join the two components of a pipe joint and the allowable misalignment both horizontally and vertically also come into play because it is a well-established fact that *pipes move with the ground surrounding them over their lifetime*. Further, the gasket must have the ability to compress while pressing tightly enough to seal out the pressure of the intruding fluid (refer to figure 6).

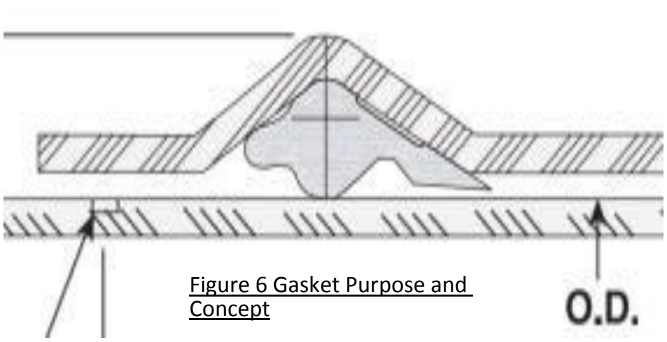
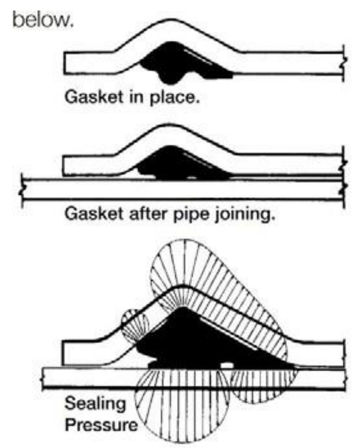


Figure 6 Gasket Purpose and Concept

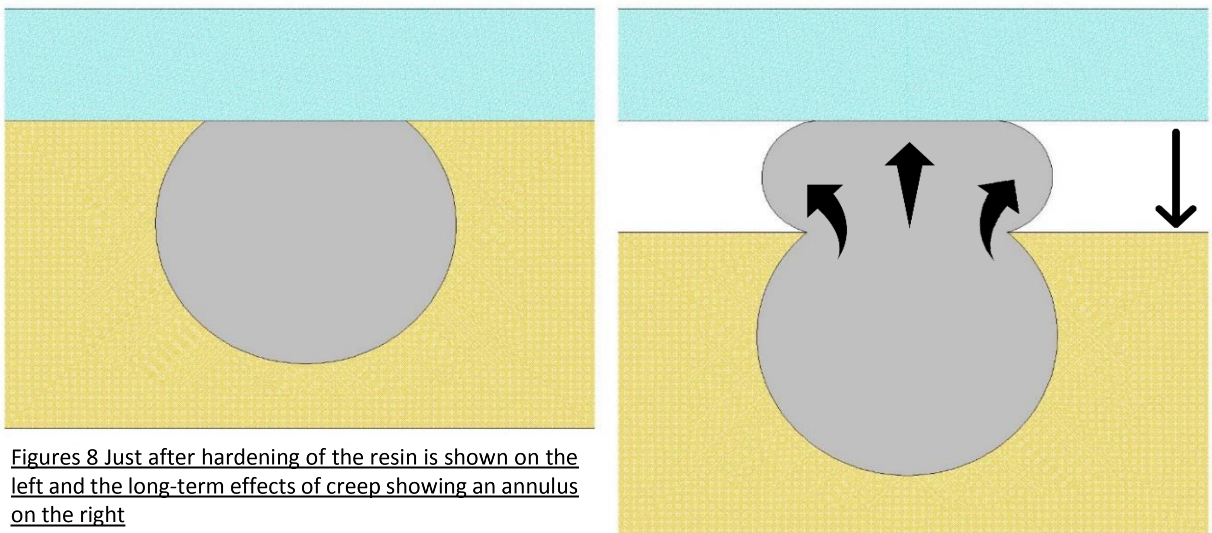


Figures 7 Gasket Design

Also, the groove or channel that holds the gasket in place must also be carefully designed to accommodate the shape of the gasket; holding it in place to properly perform its function (see figure 7).

In CIPP it is a scientific fact that with the resin hardening process comes shrinkage. Standard polyester resins used in lining typically shrink 7-10 % by volume. Recognizing this given parameter, CIPP installers must hold the liner during the hardening process tightly against the host pipe until the hardening is completed and the new CIPP is cooled down to a point that it becomes dimensionally stable. The inherent volumetric shrinkage occurs in the thickness of the finished liner which can be accounted for in the wall thickness design process. If this controlled cool down process is not properly executed during the liner's installation the liner will typically retreat (shrink) inward leaving a gap between the host pipe and the new liner. The amount of gap formed is directly related to how much the installer short-changed the installation process.

Additionally, liners under sustained external groundwater pressure creep, which is another form of shrinkage. This means that the gap the gasket needs to fill to make the seal will in fact get larger with time, which means that the gasket must be capable of "growing" to continue to fill the space tightly in order to maintain its sealing capabilities for its intended service life *(refer to figures 8 below)*. Since the name of the game in sewers is to stop groundwater intrusion, one easy way to give the gasket an ability to grow larger is to chemically modify the rubber used in the gasket's manufacture with a hydrophilic material that will prompt the seal to undergo a "controlled expansion" when in the presence of water so that any voids within the limits of the gasket's volume expansion capability (or coefficient) will be filled by the expansion of the seal. The amount of external hydrostatic head, or groundwater pressure, further requires that the expansion be significant enough to firmly press gasket against the two mating surfaces at a level that exceeds the groundwater pressure's ability to breach the seal.



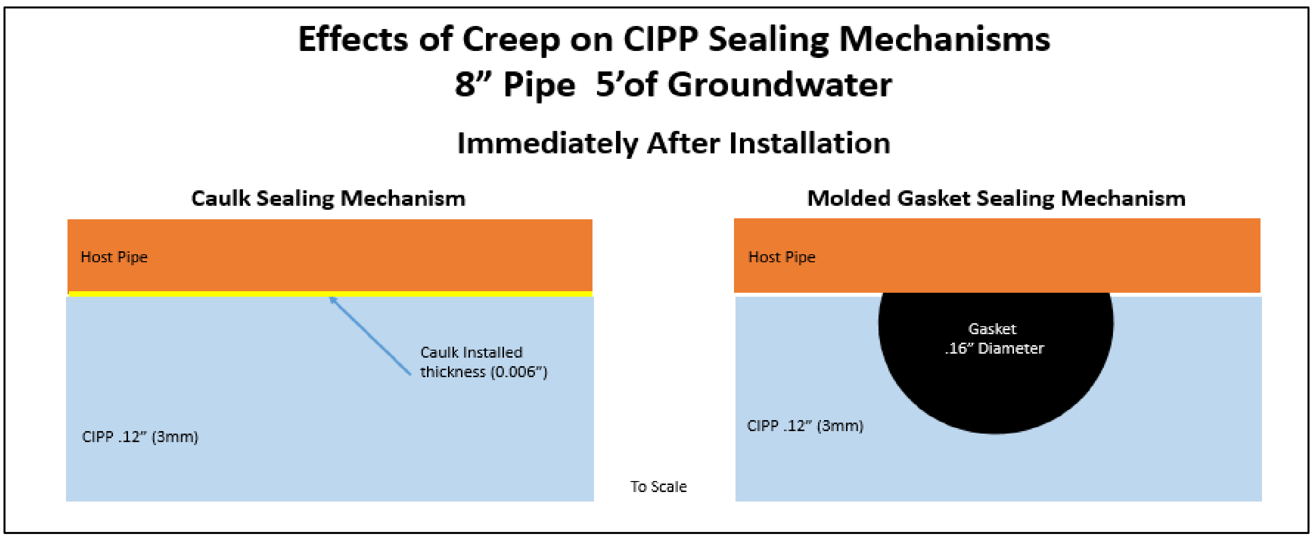
Figures 8 Just after hardening of the resin is shown on the left and the long-term effects of creep showing an annulus on the right

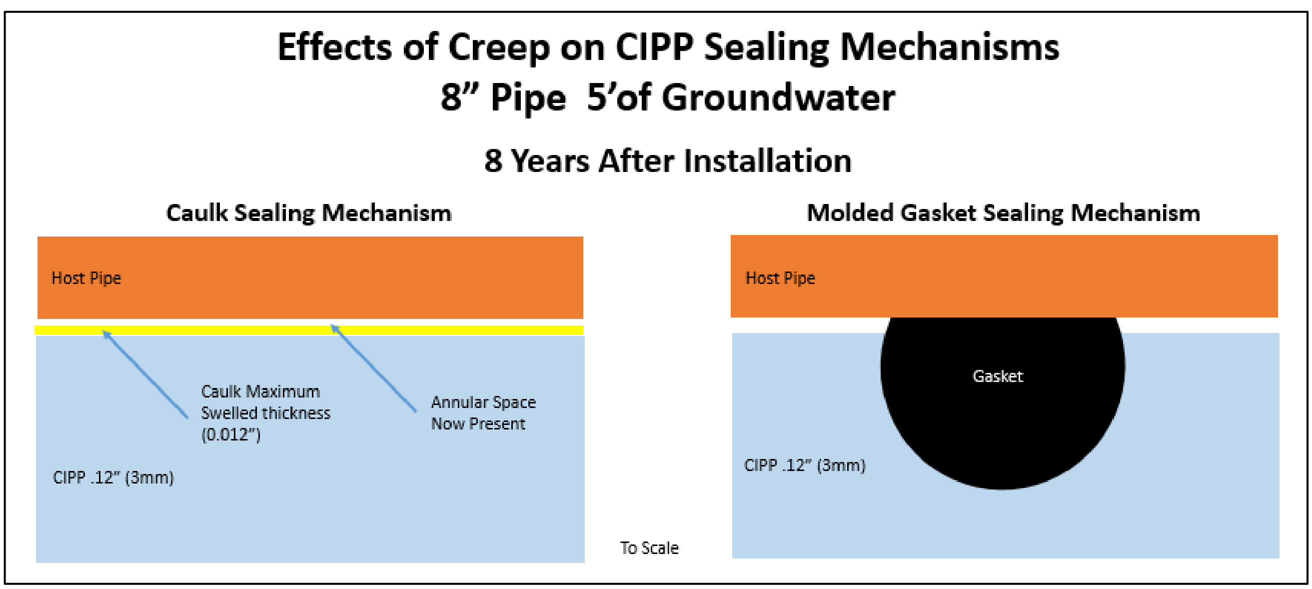
It would be very easy, and much less costly, if one could simply employ a gun-able caulking material like the ones we use in concrete construction for making a seal at a cold joint rather than having to fabricate preformed gaskets that are location specific and capable of addressing the movement of the various building materials with respect to one another over the life of the sealing requirement. Unfortunately, gun-able caulking materials (i.e. pastes), have the least amount of volumetric expansion, typically, on the order of 100%. Further, the installation pressures required during the lateral lining's installation are between 15 and 30 psi. It has been shown that under these pressures a paste material will be reduced to a thickness of 0.008 to 0.0125 inches in thickness (a standard business card has a thickness of between 0.014 and 0.016 inches). At this thickness and its corresponding area spread there is little usable expansive capacity for a "squashed paste" to provide any long-term sealing.

Even in a best case, when the installers faithfully adhere to the controlled cool-down process which keeps the full wrap liner barrel of the lateral lining system tight to the host's wall surface, there still remains to be considered the issue of dimensional shrinkage from long-term creep. The gap formed after analyzing a standard barrel wrap under just 5.0 feet of groundwater after 7.5 years is approximately .012 inches, and that is equivalent to the maximum swelling capability of the caulk. The gap over a normal design life of 50-years is approximately 0.050 inches (a U.S. quarter is 0.07 inches thick), and this distance is well beyond the capabilities of the "squashed paste" at its thickest if one makes the assumption that it still possesses the ability to grow 100% volumetrically in its paper-like form without dimensional controls.

Alternatively, using a preformed O-ring gasket material of 0.16 inches in diameter for the seal, the lateral lining installation process after the hardening of the resin (shown in yellow in figure 5) forms a tight-fitting groove for confining the hydrophilic gasket material. Such a configuration produces a controlled expansion of the gasket. A conservative increase in thickness of 190% results in maximum thickness of 0.3 inches. An analysis under the same 5.0 feet of ground water shows the O-ring gasket capable of providing a seal for approximately 95 years.

Figure 9 below shows a comparison of the caulk and the molded gasket at day 1, year 8 and year 95.





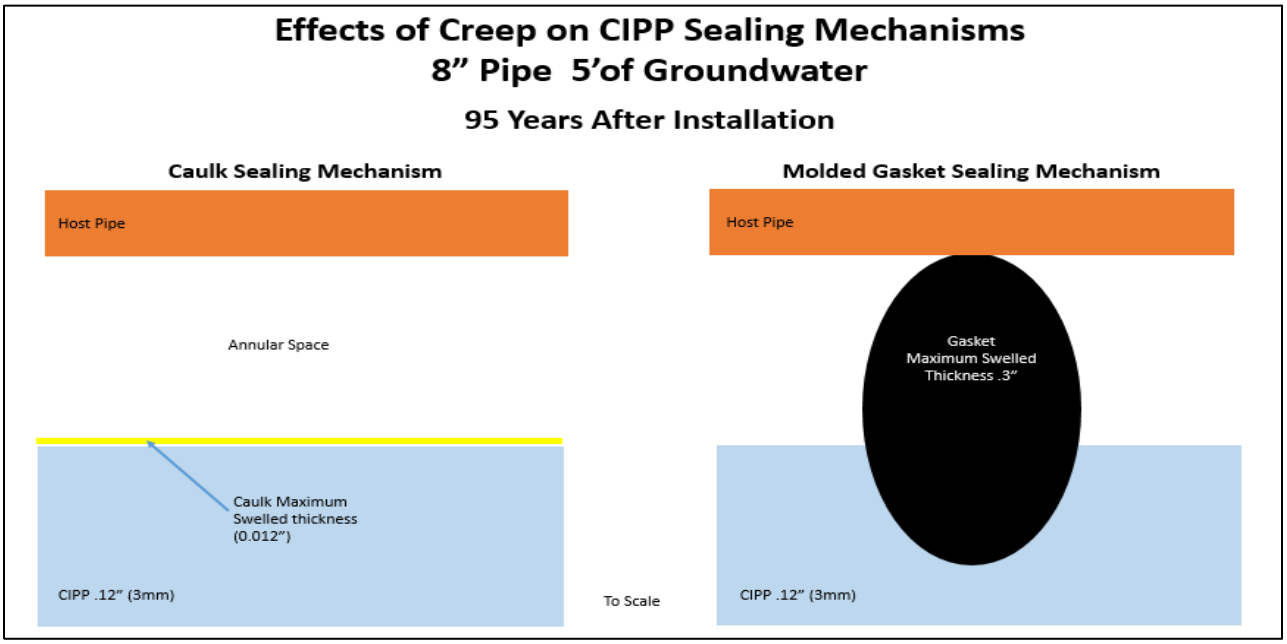


Figure 9 Comparison of Caulk and Molded Gasket through time lapse

The formulation of the preformed gasket material has an engineered minimum volumetric expansion coefficient of 190% assuring a compression seal capable of external hydrostatic head pressures far beyond what will be seen by the in service lateral connection. This makes for a water-tight performance of the system that is on a par with brand new pipe installations.

Specifically, what are the differences between the sealing mechanism used in the main installer of paste-based sealing systems in south Florida (BLD) and LMK's product and between BLD's Service Connection Seal + Lateral product and LMK's T-Liner product? BLD incorporates a product called Adeka Ultra Seal P-201A as the principle sealing mechanism in their Service Connection Seal + Lateral product. The Adeka Ultra Seal P-201A is a Hydrophilic caulk or paste substance that is manufactured in Japan. LMK incorporates a Seamless Molded Hydrophilic Gasket in the form of a flexible flange called a Hydrohat that is manufactured in the U.S. Both the paste and the Hydrohat are hydrophilic however there are significant differences in their construction and performance.

Both sealing mechanisms are positioned between the newly installed Cured-in-Place Pipe and the Host pipe. They both rely on their ability to swell to provide the sealing needed to stop water in the annular space that exists with all Cured-in-Place Pipe. As time goes by the annular space continues to get larger and larger due to movement and creep of the plastic liner. Therefore, the performance of the sealing mechanism is related to its ability to swell repeatedly and the amount that it swells.

Based on BLD installation specifications the Adeka Ultra Seal P201A is applied in a ½" bead around the circumference of a pipe and then installed within minutes. BLD specifications call for installation pressures that range from 15-30 psi depending upon the lateral diameter. Based on those installation pressures recent testing from an independent third party concluded that the finished thickness of the caulk averaged .006 inches.

According to the Adeka Ultra Seal P201A data sheet the volume expansion is 100%. To calculate the maximum swelling thickness a conservative approach assumes that all of the expansion will be in thickness. Therefore the maximum expanded thickness of the paste as applied in the field will be .012” which is less than 1/64" or roughly 1/3 the thickness of a sheet of paper.

The Hydrohat gasket that is installed with the LMK T-Liner product has been tested to expand 190% in thickness when exposed to water. The gasket is molded to be .16” thick and so will expand to .3”. Therefore the Hydrohat will expand in thickness 25 times greater than paste (*see figure 10 below*).

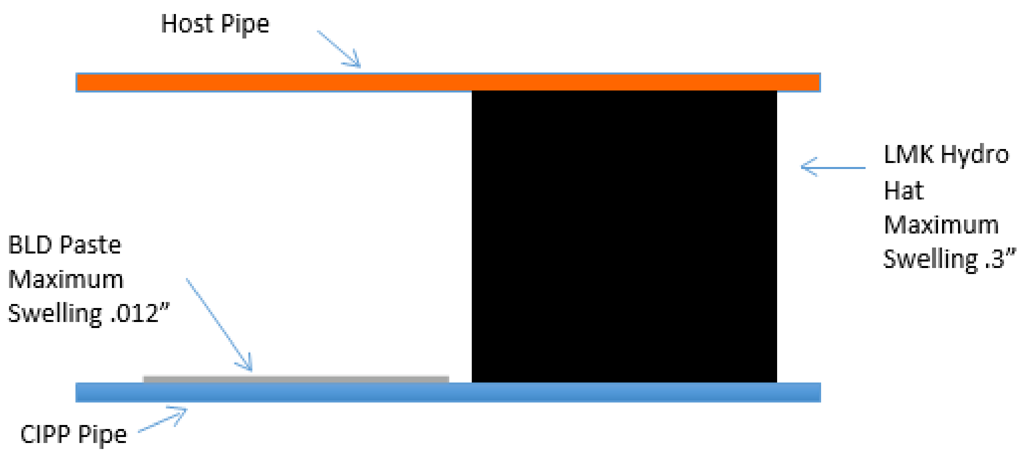


Figure 10 Expansive Properties of Paste versus Molded Neoprene Gasket

This is significant when considering the expected service life (amount of time the CIPP will not leak) of each sealing mechanism. The paste (if applied perfectly and not wiped off) may provide immediate relief but for only a short period of time, whereas the Hydrohat will provide immediate relief and continue to expand long after the capabilities of the paste have been exceeded. The amount of infiltration that the Hydrohat will keep out over its lifetime versus the paste over its lifetime is significant.

Test Data

Two laboratory tests are presented in this report. The first test report is a 10,000 hour hydration/dehydration test run conducted on LMK’s neoprene hydrophilic gasket material. The second test is a preliminary test run on the Adeka Paste hydrophilic material used as the sealant for BLD’s lateral liners. This preliminary test was performed prior to running a similar 10,000 hour hydration/dehydration on that sealant, which is currently on-going.

LMK 10,000 Hour Hydration/Dehydration Test

The CIPP gasket sealing system is an engineered solution to the problem of water tracking in the annular space that exists between a CIPP liner and the host pipe. This space exists due to the shrinkage of resins as they undergo polymerization during the process of curing. This water drains back into the sewer collection system affecting the capacity of the sewer system and consequently the capacity of any waste treatment services that the collection system utilizes.

LMK's Insignia™ Sealing System consists of three construction types of Gasket Seals: O-Rings, Lateral (flanged shape) Connection Hats, and Mainline End Seals for the purpose of eliminating infiltration from the known sources in a collection system. Neoprene, formerly known as Duprene, is the backbone of the chemical makeup of the Insignia™ Seals. Neoprene is known for its properties of chemical inertness and maintaining flexibility over a wide range of temperatures. LMK's proprietary neoprene compound further has hydrophilic properties that allow it to absorb water and expand up to190% in volume when left unconstrained. In a pipe, when the seal is constrained between the host pipe and the CIPP liner, the seal swells to close the annular gap between the liner and the pipe thus creating a compression gasket and effectively sealing the system by preventing extraneous water from infiltrating into the collection system.

Since the Insignia™ Seals are hydrophilic; a concern by the engineering society that collaborates with LMK Technologies was the performance of the seals when dehydrated or deprived of water. It was this concern that led to the development of the 10,000 hour alternating hydration/dehydration testing of the Insignia™ Seals. The test comprised of 6 samples of the Insignia™ Gasket Seals subjected to various cycles of hydration and dehydration ranging from 2 days to 6 months. The seals were tested for gain in weight and size when hydrated and the subsequent loss in weight and thickness when dehydrated.

The Insignia™ Gasket Seals expands to about 800% by weight of their original size when hydrated for prolonged periods of time. When the seals were dehydrated, they did not exhibit any degradation or loss of materials and maintained their original surface properties, which is a significant find for long-term sealing. The seals maintained their flexibility and expansion properties while continuous hydration and dehydration cycles. The seals also exhibited their expansion properties when subjected to dehydration. After a number of hydration and dehydration cycles, the gasket seals were able to retain almost up to 75% of their expansion over shorter periods of dehydration.

The results obtained by the means of this test (further detailed in the report as **Attachment 2**) establish that the Insignia™ Gasket Seals are able to maintain their water sealing properties when subjected to simulated sewer and ground water conditions of hydration and dehydration. Further, that the Gasket Seals remained smooth and malleable after multiple cycles of hydration/dehydration providing ideal surface properties for pipe sealing.

Adeka Paste Preliminary Test

This preliminary test was performed to further understand the characteristics and compressibility of the Adeka P-201A caulk material prior to designing a 10,000 hour hydration/dehydration test to compare with LMK's Insignia™ products. Testing involved utilizing a Universal Testing Machine to compress freshly extruded P-201A material to 15 and 30 psi.

Several methods were used to cure the paste and release it from two different types of release paper. After 7-10 days of curing the thickness of the compressed caulk was measured using digital microscopy. The appearance of the P-201A caulk was documented before and after compression and curing. While the product did appear to have both sealing and adhesive properties, it required significant exposure to air to cure, and in some cases did not cure at all. It is not yet clear what the mechanism for curing is for this material when it is applied in a relatively air tight environment such as a pipe section buried underground. At 15-30 psi of pressure, the thickness of P-201A was less than 0.01 inch. At this thickness level, a significant amount of shrinkage voids was observed in areas where curing was complete (see figure 11). These preliminary results do not look promising for use of this material as a long-term sealing mechanism for a lateral liner. The full preliminary report, including many more photos, are included as **Attachment 3.**

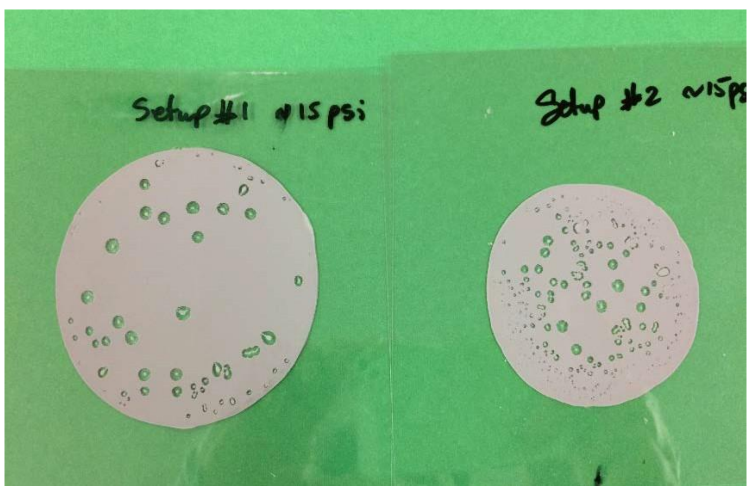


Figure 11 Laboratory samples of compressed paste

Adeka Paste Limitations

According to the sealant material manufacturer, the material is not specifically recommended for use with CIPP technology. However, in order to use the paste sealant material correctly in a CIPP as a leak prevention application, before the liner is installed, certain requirements must be fulfilled as per the product manufacturer.

The product should only be applied in a clean environment free of oil and grease. In addition the material should not be exposed to a wet environment until it has an opportunity to cure as recommended by the manufacturer. The manufacturer's literature also includes a disclaimer which states as follow:

> **NOTE: The information contained herein is based on our present state of knowledge and is intended to provide general notes on Adeka Waterstops and their uses. Any recommendations or suggestions, which may be made, are without guarantee, since the conditions of use are beyond our control. Furthermore, nothing contained in this publication shall be construed as a recommendation for any use that may infringe patent rights. Readers are cautioned to satisfy themselves as to the suitability of such goods for the purposes intended prior to use.**

This disclaimer is reinforced by the printed Application Instructions which come with the paste. A copy of these instructions are shown below (see figure 12). It is difficult to see how an old, slime coated wet sewer pipe, often under hydrostatic pressure, can meet these requirements.

Procedure in Applying

1

Clean the surface. Remove the dirt, oil and scale.

2

Cut nozzle at area for desired dimention. Puncture damp-proofing film. Remove rear cap.

3

Apply P-201 to the surface with no gap.

4

Avoid contact with water until being hardened.

Package

- Cartridge: 320cc (400g) 6 cartridges in a carton × 4

Precautions in Handling

1. Store in cool dry area. Do not expose to the direct sun exposure.
2. Do not install P-201 as a surface coating cover, open joints, with filling material.
3. Clean surface, remove dirt and oil before application. Cut nozzle of area for desired dimension. Puncture damp-proofing film, Remove rear cap.
4. Prevent water contact until it is cured.
5. If in doubt, always use a small area and check to see if P-201 will work in that application.
6. Avoid contact with skin, If contact occurs, wipe off immediately and wash with soap and water. Get medical attention if required.
7. Use within six months after date of manufacture.

NOTES

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Figure 12 Instruction for using Paste

Case Studies

Four case studies are presented in **Attachment 4**. They explore the technical challenges which Coral Gables, Florida, Coral Springs Improvement District, Florida, Naperville, Illinois and the City of Portland, Oregon each confronted and the solutions which they implemented.

The Coral Gables case study is perhaps the most relevant to MDWSD, as it is a peer-reviewed paper of a city adjacent to Miami with the same challenges of needing resiliency to sea level rise, coastal flooding and high groundwater conditions throughout its collection system. The primary goal of their collection system rehabilitation project was to mitigate the serious amount of seawater infiltrating their system during high tides, to reduce their lift station pump run times and to use trenchless technology as much as possible to reduce costs and disruption to the public. Coral Gables used a folded PVC mainline pipe liner, and used ASTM F2561-compliant lateral liner technology. They achieved dramatic results, which continue unabated four years later. In the basin that was the subject of the paper, pump run times were reduced from a high of 30.81 hours in October 2011, to an average of 4.23 hours in October 2011, post rehabilitation – an 86% reduction in pump run time. Average daily flows from the basin were correspondingly reduced from an Average Daily Flow of 65 gpm to 13 gpm.

The Naperville, Illinois case study is significant because it provides a data-driven basis to calculate the annual dollar value of its system-wide program of lining their main lines with CIPP, sealing the ends of the main line installation with neoprene hydrophilic sealing gaskets, and using ASTM 2561-compliant lateral liners. The result of its program is that, even with a 10.5% population growth in its service area, the City was able to defer a previously planned $6 million expansion of its wastewater treatment plant. Naperville's annual savings in avoided treatment costs and debt service, as well as the additional revenue of the added customer base it was able to connect to its renewed collection system due to this project, is approximately $1.25 million.

The Coral Springs Improvement District was experiencing significant infiltration even though it had previously lined much of its main line pipes with CIPP. This effort was not successful in achieving significant reduction in infiltration as they learned that most of the leakage was from the systems laterals which had not been sealed. Key lift stations often operated in surcharge conditions during rain events. As owners and operators of their own wastewater treatment plant, they had another financial interest in mitigating I&I. The amount of groundwater infiltrating made it difficult to work in the system.

The result of the District's lateral lining using ASTM F2561-compliant specifications was a conservation of groundwater resources, protection of the environment, and a good return on investment. The District invested $1 million for this rehabilitation project, which was completed over a 10-month period. The District reports reduction of infiltration into its system by 232 million gals annually, with savings of $365,000 yearly.

Even though years earlier a large part of the system had the mains lined, it wasn't until the laterals were lined that the hidden value in the previous lining project was revealed. The payback for the entire project is just 2.6 years, but going forward the District's investment will continue to save or earn CSID $365,000 each year for the life of the repairs. Another concern for the future, however, is that, since the District used a chemical grout to seal the ends of the main CIPP line rather than using molded gaskets at every manhole, continuous maintenance of that grout will be required to provide long-term results.

The Portland, Oregon case study is presented as a unique approach to repair and rehabilitation of a gravity collection system in a large city. The City's Bureau of Maintenance has been installing CIPP mainline and lateral lining since 1998 using in-house crews. The City partnered with LMK to provide the lining equipment, materials and training for these in-house crews. The City has been so successful with this approach they have increased the number of dedicated CIPP crews and trained their traditional line crews to perform lining work.

All work done by the City trained and licensed crews is done according to ASTM standards and the lateral lining is done using ASTM F2561 where they have cleanouts in place. When clean outs are not available the City uses the LMK hydrophilic neoprene gaskets and primarily installs them through the main line. While not fully ASTM F2561-compliant, this practice still provides for the superior sealing qualities of the neoprene expanding gaskets but limits the length that the lining can be applied within the lateral.

Life Cycle Cost Considerations

One of the issues previously discussed with MDWSD is the requirement for a Life Cycle Cost Analysis (LCC) for future projects to be funded with State Revolving Loan Funds (SRF). This requirement is imposed by the 2014 Water Resources Reform and Development Act (WRRDA). Even if the MDWSD's rehabilitation projects are not funded by SRF loans, common sense dictates that any utility spending large amounts of money for rehabilitation should perform an LCC prior to finalizing design and specifications.

All projected future costs must be included in the LCC, including expected service life, replacement costs, costs of transporting and treating I/I, and routine maintenance costs. The WRRDA standard sanctions a broad range of evidence in the analysis, including job site tests, published reports, manufacturer product data, anecdotal local experience, as well as projected future operating and maintenance, rehabilitation and replacement costs. This WRRDA standard closely tracks ASTM F1675, "Standard Practice for Life-Cycle Cost Analysis of Plastic Pipe Used for Culverts, Storm Sewers, and Other Buried Conduits."

An LCC analysis is highly site specific and cannot be performed based only on the technical data discussed in this report or that contained in the above case studies. But important lessons flow from the case studies: for example, Coral Springs Improvement District reported a return on investment based on their three-year operating experience using ASTM F2561-compliant lateral liners.

Additionally, the data presented in this report clearly demonstrates a strong technical case for longer-term service by using the ASTM F2561 standard versus non-compliant paste-based lateral lining systems. The case studies presented add an additional level of credence to a strong inference that adoption of ASTM F2561-compliant lateral liners would lead to a lower Life Cycle

Cost to MDWSD's collection system's rehabilitation program.

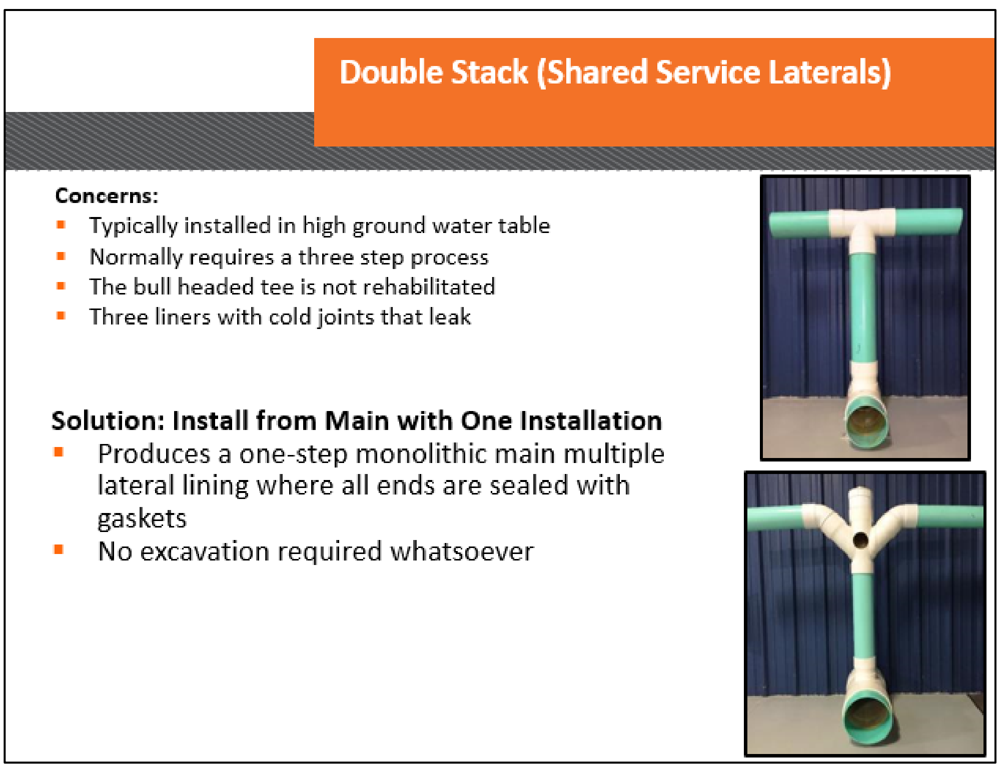
Lastly, a utility should recognize that it only increases the GASB34 valuation of its capital assets by including the clean-out and gasket features that come with ASTM F2561 compliant lining as substantiated by these LCC indicators. These are not merely added costs; they represent investments.

Difficult-to-Perform Lateral Lining Tasks

LMK's pre-engineered design capability allows the rehabilitation of difficult to perform lining tasks, including;

- The lining of shared service lines such as double stack laterals
- Siamese (opposing) laterals
- Spot repairs near the lateral to be lined

Figures 13a, 13b and 13c demonstrating these capabilities are shown below. **Attachment 5** provides further insight into the intricacies to these type of repairs which frequently occur in Miami Dade's sewer system.



13a The lining of shared service lines such as double stack laterals

Siamese (Opposing Laterals)

Concerns:

- Normally requires a three step process
- Line the first connection
- Cutting the first connection, causing a leak
- Line the second connection
- Three liners with cold joints that leak

Solution: Multi-Lateral Lining System

- Section of main is rehabilitated
- Both opposing laterals are rehabilitated
- Produces a one-step monolithic main multiple lateral lining where all ends are sealed with gaskets
- No excavation required whatsoever

13b Siamese (opposing) laterals

Mainline Spot Repair and Lateral Lining

Concerns:

- 2 step lining process
  - Mainline spot repair
  - Lateral lining
- Reinstatement of service lateral required
- Leaky connection

Solution: Spot Repair and Lateral are Renewed with One Installation

- Mainline spot repair up to 30 feet in length
- No service reinstatement necessary
- Produces a one-step monolithic main multiple lateral lining where all ends are sealed with gaskets
- No excavation required whatsoever

13c Spot repairs near the lateral to be lined

Clean-Outs

Clean-outs are required for a fully compliant ASTM F2561 installation. One method for installation of clean-outs, as shown in Figure 14, is to use a vacuum excavation method known as Vac-A-Tee. This method, described in ASTM Standard F3097 (see **Attachment 6**) and the subject of an in-depth peer-reviewed paper which is attached as **Attachment 7**, is much less expensive and disruptive than the installation of a clean-out through regular excavation.

There are many benefits to installing a clean-out during lateral lining:

- Quality of New Pipe: CIPP is a process whereby a new pipe is formed within the existing pipe. The manufacturing of the new CIPP takes place in two specific locations.
    1. The liner tube and thermoset resins are manufactured at an offsite facility with quality control and quality assurances that are strictly enforced. However, this process produces nothing more than a liner tube and resin, at this time there is no CIPP.
    2. Specialty contractors who are trained with the skillset necessary to install the liner actually produce the new pipe (CIPP) onsite as the liner is inserted, inflated and cured.

Figure 14 Shows the Minimally Disruptive Vacuum Excavation Process

This manufacturing process needs to be conducted to achieve the full high quality potential of this new pipe and its promise of long-term performance. The CIPP industry relies on ASTM F1216 as a minimum requirement as flexural strength, flexural modulus, and chemical resistance. It is imperative that these performance based attributes of the new pipe are maintained throughout the installation process.

That is why the clean-out is important: it allows the lateral pipe to be temporarily taken out of service so the new CIPP can be installed meeting the anticipated 50-year design life. When a service lateral is renewed by the CIPP method and a clean-out is not installed and the homeowner discharges sewage, the sewage becomes part of the new pipe, which clearly undermines the integrity and diminishes the design and service life of the new pipe. Just as drivers cannot use a road while it is being repaved, homeowners cannot use the sewer as it is being lined.

Furthermore, both ASTM F2561 and ASTM F1216 require 5-10% excess resin is added to the liner tube to account for resin consumed in open joints and pipe defects. When a lateral liner is installed from the main pipe and no clean-out exists the resin saturation process requiring excess resin cannot be achieved without causing a resin slug (partial blockage) at the upper end of the liner. This results in contractors short changing the utility owner on amount of thermoset resin in the liner tube and incentivizes the contractors to installed resin shy liners that do not meet the industry standard requirements.

- Protect Public Health: A clean-out allows the service lateral to be temporarily taken out of service that not only prevents the homeowner from discharging during installation of the liner but also prevents any odors from entering homes through dry plumbing fixture traps. The county should not take the risk that it will be liable for the damages sustained by a homeowner who is needlessly exposed to potentially harmful chemical odors.

- Plumbing Codes: The International Plumbing Code as well as the Florida Plumbing Code requires cleanouts to be installed for all new drain pipes and sewer pipes. The renewal of a sewer service lateral using CIPP effectively constitutes a new stand-alone pipe within a pipe.

- Future Access for County: The line between public and private is a serious issue and too often the Utility Owner is blamed for sewer backups that occur post rehabilitation of the lateral located in the public right of way. In this case, the Utility Owner is challenged to determine if the blockage is the result of the rehabilitation or if the blockage is on private property. A clean-out allows the Utility Owner to quickly determine whether the blockage is related to the rehabilitation work in the public right of way by simply lamping a clean-out.

- Future Access for Homeowner: A clean-out not only guarantees the highest quality new pipe, protects public health, conforms to plumbing codes, provides future access to the county, but also provides future access to the homeowner should their private sewer lateral need maintained in the future. Furthermore, a clean-out located at the property line provides access for homeowner’s private lateral to be rehabilitated anytime in the future through the clean-out where no excavation is required.

Following lateral lining the clean-out becomes a major asset to the utility. Routine inspection, cleaning, clearing of blocked laterals and main lines and diagnosis of whether the blockage is on the utility’s side or the customer’s side can be performed more easily and at less cost. Maintenance staff responsible for the gravity collection system can readily attest to this value.

In a February 2017 meeting, MDWSD staff estimated that they responded to approximately 250 calls per month from customers relating to blocked service. **Attachment 8** presents a cost analysis of the yearly savings in operational costs to the utility based on this number of calls and estimates of servicing these calls based on assumptions of the cost of operational effort required for response. While precise elements of the estimate may be debated, the savings to the utility on an annual basis, which are estimated at over $1.5 million dollars per year, are clearly substantial.

Moreover, this estimated cost reduction due to having clean-outs does not address the savings that accrue to customers if they are responsible for clearing the blockage on their side of the lateral.[1]

Procurement Issues

Two procurement issues often arise when a utility specifies a lateral lining technology. The first is whether an ASTM F2561-compliant specification is sole source. <u>ASTM F2561 specifications are not sole source!</u> LMK, is a technology provider, and it has licensed another manufacturer, Perma-Liner Industries, to manufacture and sell Perma-Liner Industries products that comply with the ASTM F2561 standards. Further, the projects are bid by independent, licensed contractors. The cost of the manufactured lining materials are no more than 25% of the contractors total installed cost of a lateral lining project. Therefore, as has been seen in most South Florida bids for ASTM F2561 specifications, there are numerous bidders to keep the cost to the client competitive. The figure below clearly demonstrates this, as well as the less competitive practices of our major competitor, BLD Services LLC, which performs their own installation. But an additional point needs to be clearly stated: the only entity that can fulfill a "BLD" specification in a bid document is BLD Services LLC (which is a contractor, not a technology provider), and that is an *ipso facto* statement of a sole source procurement.

The second issue is the trap of bidding the ASTM F2561 standard directly against a paste-based sealing technology system for which there is no standard. Allowing a paste-based technology to be considered "as equal" to ASTM F2561 is also a trap to the owner. ASTM F2561-compliant systems are marginally more expensive than lower quality paste-based systems, therefore this practice allows the paste-based bidders to greatly increase their bid prices and still win an award. This practice has been seen repeatedly in South Florida and essentially robs the utility and its customers from money that could be used in other parts of their capital plan. This extra money flows into the contractor's pocket.

[1] Note that the LMK hydrophilic gasket sealing lateral lining technology can be installed from the main line without a clean-out. While not fully ASTM F2561-compliant, the customer still gets the benefits of the superior long-lasting sealing technology. But there are two strong arguments against avoiding the installation of a clean-out:

a. This avoidance would ill-serve MDWSD ratepayers by denying them the benefit of the savings which this report has documented; and
b. Given that the CIPP rehabilitation of the collection system effectively constitutes the creation of a new standalone pipe, it is for all intents and purposes a violation of the Florida Plumbing Code, which requires the installation of clean-outs when new systems are installed.

Utilities That Have Adopted the ASTM F2561 Industry Standard

Many utilities in Florida, including a large number of South Florida utilities, have adopted ASTM F2561 as their primary standard for lateral lining or have installed a large number of these laterals. **Attachment 9** includes a list of these utilities with references. Since the list is quite large, and there is always turnover in engineering and operational personnel in any utility, some references might be out of date. Any specific reference that MDWSD would like to have updated will be done immediately upon request. **Attachment 10** provides F2561 specifications from the City of Fort Lauderdale and the City of Plantation as well as industry model specifications for CIPP lateral connections and end seals.

Conclusions

The technical material presented in this report clearly supports previous assertions to MDWSD that:

- LMK's hydrophilic neoprene mainline CIPP end seal gaskets and ASTM 2561-compliant lateral sealing gaskets provide a watertight, long-lasting seal for mainline CIPP and lateral CIPP liners similar to that routinely used in new pipe installations.
- Paste-based systems have significant limitations and cannot provide the water tightness nor sustainability of the hydrophilic neoprene seals.
- Long-term hydration/dehydration studies clearly demonstrate the sustainability of LMK's sealing technology, while preliminary studies of paste-based systems have demonstrated significant potential limitations.
- Case studies in South Florida and elsewhere demonstrate the success, value and client satisfaction of ASTM F2561 installations.
- LMK's pre-engineered liners can be used to perform difficult lining tasks that others cannot perform.
- Clean-outs which are required for complete compliance to ASTM F2561, provide significant advantages to the installation and quality of the installed lateral liner, and are a significant asset to the future operation and maintenance of the gravity sewer system. Clean-outs can also provide significant long-term O&M cost savings to the utility as well as to the utility customer.
- Owners not wishing to use clean-outs can still get the benefits of LMK's superior gasket sealing system.
- Purchasing documents need to be clearly thought out when bidding ASTM F2561 systems, which are not sole source, in order that the owner not to get into the trap of ending up with lower quality lateral lining systems at high prices.

Finally, based on demonstrated product quality, long-term sustainability and water tightness, the ASTM F2561-compliant sealing system should be the preferred lateral lining system to meet the requirements of MDWSD's Operational Resiliency Plan and to support its continuing excellence as a Utility of the Future.

ATTACHMENT 1

ASTM F2561-16 Standard Practice for Rehabilitation of Sewer Service Lateral and Its Connection to the Main Using a One-Piece Main and Lateral Cured-in-Place Liner

Standard Practice for
Rehabilitation of a Sewer Service Lateral and Its Connection to the Main Using a One Piece Main and Lateral Cured-in-Place Liner[1,2]

This standard is issued under the fixed designation F2561; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice covers requirements and test methods for the reconstruction of a sewer service lateral pipe having an inner diameter of 3 to 12 in. (7.6 to 30.5 cm) and its connection to the main pipe having an inner diameter of 6 to 24 in. (15.2 to 61.0 cm) without excavation. The lateral pipe is accessed remotely from the main pipe and from a lateral cleanout. This will be accomplished by the installation of a resin impregnated one-piece main and lateral cured-in-place lining (MLCIPL) by means of air or water inflation and inversion. The MLCIPL is pressed against the host pipe by pressurizing a bladder and is held in place until the thermoset resins have cured. When cured, the MLCIPL shall be a continuous, one piece, tight fitting, corrosion resistant lining extending over a predetermined length of the lateral pipe and the adjacent section of the main pipe, providing a verifiable non-leaking structural connection and seal.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 There is no similar or equivalent ISO Standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Particular attention is drawn to those safety regulations and requirements involving entering into and working in confined spaces.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D618 Practice for Conditioning Plastics for Testing

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3681 Test Method for Chemical Resistance of "Fiberglass" (Glass–Fiber–Reinforced Thermosetting-Resin) Pipe in a Deflected Condition

D5813 Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems

F412 Terminology Relating to Plastic Piping Systems

F1216 Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

2.2 *NASSCO Guidelines:*[4]

Recommended Specifications for Sewer Collection System Rehabilitation

3. Terminology

3.1 *Definitions*—Unless otherwise indicated, definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *access point*—an existing manhole at either the upstream or downstream end of a sewer main or a cleanout located on the lateral pipe.

3.2.2 *bladder*—a transparent flexible plastic hose that when pressurized, causes the main sheet to be pressed against the

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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[2] The rehabilitation of a sewer service lateral and its connection to the main using a one-piece main and lateral cured-in-place liner is covered by patents (LMK Enterprises, Inc. 1779 Chessie Lane, Ottawa, IL 61350). Interested parties are invited to submit information regarding the identification of acceptable alternatives to this patented item to the Committee on Standards, ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. Your comments will receive careful consideration at a meeting of the responsible technical committee which may attend.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] NASSCO, Inc. 11521 Cronridge Drive, Suite J, Owings Mills, MD 21117. www.nassco.org

***A Summary of Changes section appears at the end of this standard**

main pipe walls and the lateral tube to invert up into the sewer service lateral. The bladder joined with the textile lining creates a liner/bladder assembly.

3.2.3 *inversion*—the process of turning a resin-impregnated tube inside out by the use of air or water pressure.

3.2.4 *launcher*—combination of a rigid elongated tube and lay-flat hose apparatus where the main bladder is attached and the main sheet is wrapped around the exterior of the rigid portion. The lateral bladder and lateral tube are drawn inside the hose. The launcher is positioned within the main pipe; air pressure is introduced into the hose causing inflation of the main bladder/sheet and inversion of the lateral bladder tube.

3.2.5 *lift*—a portion of the MLCIPL that has cured in a position such that it has pulled away from the host pipe wall.

3.2.6 *main and lateral cured-in-place lining (MLCIPL)*—a textile including plastic coating impregnated by a thermosetting resin. This pipe is formed within a portion of the existing main pipe and the lateral pipe. Therefore, it takes the shape of an existing TEE or WYE fitting and fits tightly to the existing pipes.

3.2.7 *resin*—polyester, vinyl ester, epoxy or silicate resin systems being ambient, steam, or hot water cured.

3.2.8 *resin slug*—excess resin at the uppermost end of a lateral lining.

3.2.9 *sewer service lateral*—a pipe servicing a building or a side service.

3.2.10 *sheet*—a flat textile sheet that is formed into a 16 in. (40.6 cm) long tube within the main pipe. The sheet is connected to the lateral tube forming a one-piece TEE or WYE shaped fitting.

3.2.11 *transition*—the change in pipe diameter commonly found in lateral pipes.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of sewer service laterals and its connection to the main through the use of a resin-impregnated tube installed within an existing sewer lateral. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Tube and Sheet:*

5.1.1 The main sheet and lateral tube shall consist of one or more layers of absorbent textile that is, needle punched felt or circular knit that meet the requirements of Practice F1216 and Specification D5813, Sections 6 and 8. The main sheet and lateral tube shall be constructed to withstand installation pressures and to have sufficient strength to bridge missing pipe segments and flexibility to fit irregular pipe sections. The volume of resin used should be sufficient to fill all voids in the tube material at nominal thickness and diameter. The wet-out main sheet and lateral tube shall have a uniform thickness and excess resin distribution that when compressed at installation pressures, the MLCIPL will meet or exceed the design thickness after cure.

5.1.2 The outside layer of the tube (before inversion) and the interior of the main sheet (before inflation) shall be coated with an impermeable, translucent flexible membrane. The main sheet before insertion shall be permanently marked with a lateral identification correlating to the address of the building that the lateral pipe services. The main sheet and lateral tube shall be surrounded by a second impermeable, flexible translucent membrane (translucent bladder) that will contain the resin and facilitate vacuum impregnation and monitoring of the resin saturation during the resin impregnation (wet-out) procedure.

5.1.3 The main sheet and lateral tube shall be a one-piece assembly formed as a TEE or WYE shaped fitting. No intermediate or encapsulated elastomeric layers shall be in the textile that may cause delamination in the cured-in-place pipe. The main sheet will be flat with one end overlapping the second end and sized accordingly to create a circular lining equal to the inner diameter of the main pipe. The lateral tube will be continuous in length and the wall thickness shall be uniform. The lateral tube shall include a hydrophilic O-ring attached to the interior surface at the tail end of the tube. The lateral tube will be capable of conforming to offset joints, bells, and disfigured pipe sections.

5.2 *Resin:*

5.2.1 The resin/liner system shall conform to Test Method D3681, 10 000-h test.

5.2.2 The resin shall be a corrosion resistant polyester, vinyl ester, epoxy or silicate resin and catalyst system that when properly cured within the composite pipe assembly, meets the requirements of Practice F1216, the physical properties herein, and those, which are to be utilized in the design of the MLCIPL for this project.

5.2.3 The resin shall produce a MLCIPL, which will comply with the structural and chemical resistance requirements of Practice F1216.

6. Design Considerations

6.1 The MLCIPL shall be designed in accordance with Practice F1216, Appendix X1, with respect to the lateral and main line tubes. If the mainline pipe has been renewed with a structural lining from manhole to manhole, then the mainline portion of the MLCIPL is designed only for hydrostatic buckling.

6.1.1 The design for the main sheet and lateral tube shall assume no bonding to the host pipe.

7. Installation Recommendations

7.1 *Access Safety*—Prior to entering access areas such as manholes or an excavation pit, performing inspection, or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen shall be undertaken in accordance with local, state, or federal safety regulations.

7.1.1 *Cleaning and Pre-Inspection and Post Inspection,* in accordance with NASSCO (National Association of Sewer Service Companies) Guidelines.

7.1.2 *Accessing the Lateral*—A clean-out must be located outside of the building and upstream at the upper end of the finished lateral lining. In order to access both the upstream and downstream sides of the lateral pipe, it is recommended that the cleanout is TEE shaped where the lateral and riser pipe join.

7.1.3 *Plugging*—The upstream side of the cleanout shall be plugged during insertion and curing of the MLCIPL assembly, ensuring no flows enter the pipe and no air, steam, or odors will enter the building. When required, the main pipe flows will be bypassed. The pumping system will be sufficiently sized for normal to peak flow conditions. The upstream manhole is monitored at all times and an emergency deflate system will be incorporated so that the plugs may be removed at any time without requiring confined space entry.

7.1.4 *Inspection of Pipelines*—The interior of the pipeline shall be carefully inspected to determine the location of any condition that shall prevent proper installation, such as roots and collapsed or crushed pipe. These conditions shall be noted so that they can be corrected before installation of the MLCIPL. Experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television shall perform inspection of pipelines.

7.1.5 *Line Obstructions*—The existing service lateral shall be clear of obstructions that prevent the proper insertion and expansion of the lining system. Changes in pipe size shall be accommodated, by sizing the lateral tube according to the pipe diameter and condition. Obstructions may include dropped or offset joints of no more than 20 % of the inside pipe diameter.

7.2 *Resin Impregnation*—The lateral tube and main sheet encapsulated within the translucent bladder (liner/bladder assembly) shall be vacuum-impregnated with resin (wet-out) under controlled conditions. The volume of resin used shall be sufficient to fill all voids in the textile lining material at nominal thickness and diameter. The volume shall be adjusted by adding 5 to 10 % excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints of the host pipe. No dry or unsaturated area in the main sheet or lateral tube shall be acceptable upon visual inspection.

7.3 *MLCIPL Insertion*—The lateral tube and inversion bladder will be inserted into the carrying device. The main bladder is connected to the launching device by an airtight clamping system. The main sheet is wrapped around the "T" launching device and held firmly by four (4) hydrophilic O-rings. A two-part 100 % solid epoxy shall be applied as a 2 in. (5.1 cm) wide band in a volume of 300 mL to the main sheet/ lateral tube interface. Both the launching and carrying device are pulled into the pipe using a cable winch. The pull is complete when the main sheet/ lateral tube interface is aligned with the service connection within the main pipe. The lateral tube is completely protected during the pull. The main sheet is supported upon the rigid "T" launcher that is elevated above the pipe invert by means of a rotating skid system. The MLCIPL assembly shall not be contaminated or diluted by exposure to dirt, debris, or water during the pull.

7.4 The bladder is inflated causing the tubular main sheet to be unfolded and the hydrophilic O-rings to be expanded as both are pressed against the main pipe. The lateral tube is inverted through the center of the tubular shaped main sheet up into the existing lateral pipe by the action of the lateral bladder until the lateral tube is fully extended to the designated termination point. The main and lateral bladders shall extend past the termination points of the main sheet and the lateral tube, respectively, causing the ends to remain open whereby no cutting for reinstatement is required.

7.5 *Curing*—After insertion is complete, pressure is maintained, pressing the MLCIPL firmly against the inner pipe wall. The MLCIPL is chemically cured at ambient temperature or by a suitable heat source. The heating equipment shall be capable of delivering and circulating a mixture of steam and air or hot water throughout the MLCIPL to uniformly raise the temperature above the temperature required to cure the resin. The curing of the MLCIPL must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of the soil). When using a heat source, temperatures shall be monitored and logged at the upstream end of the lateral lining during the cure and cool down cycles. The manufacturer's recommended cure schedule shall be submitted.

7.6 *MLCIPL Processing*—Curing shall be done with air or a mixture of air and steam without pressure interruption, for the proper duration of time in accordance with the resin manufacturer's recommendations. When the heat source is removed and the temperature on both ends of the MLCIPL reaches 100°F (37.8°C) or less, the processing shall be finished.

8. Finish

8.1 The finished MLCIPL shall be continuous over the entire length of the rehabilitated sewer service lateral and 16 in. (40.6 cm) of the main pipe (5 in. (12.7 cm) on either side of a 6 in. (15.2 cm) lateral or 6 in. (15.2 cm) on either side of a 4-in. (10.2 cm) lateral connection). The MLCIPL shall provide a smooth bore interior. The MLCIPL shall be free of dry spots, lifts, and delamination. The MLCIPL shall taper at each end so as to accept video equipment and maintain a proper flow. After the work is completed, the installer will provide the owner with video footage in accordance with NASSCO guidelines documenting the overall integrity of the MLCIPL and the visual lateral identification address markings as completed work. The finished product must provide an airtight/watertight, verifiable non-leaking connection between the main sewer and sewer service lateral.

9. Recommended Inspection Practices

9.1 *Sampling*—As designated by the purchaser in the purchase agreement, the preparation of a MLCIPL sample is required. The sample shall be prepared by securing a flat plate mold using the textile tube material and resin system as used for the rehabilitated lateral and lateral to main line connection.

9.1.1 The pressure applied on the plate sample will be equal to the highest sustained pressure exerted on the textile lining during the cure process at any location.

9.1.2 The minimum length of the sample must be able to produce at least five specimens for testing in accordance with Test Method D790.

9.2 *Conditioning*—Condition the test specimens at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Practice D618, for those tests where conditioning is required.

9.3 *Short-Term Flexural Properties*—The flexural strength and flexural modulus of the MLCIPL shall be determined in accordance with Test Method D790. The values shall meet the minimum requirements of Table 1 or the values used in design, whichever are higher.

9.4 *MLCIPL Wall Thickness*—The average wall thickness for the lateral section shall meet the thickness determined by the design or as otherwise specified. The average wall thickness for the main line section shall meet the thickness determined by the design or as otherwise specified. The average thickness shall be determined in accordance with Specification D5813. The minimum wall thickness at any one point, as determined in accordance with Specification D5813, shall not be less than 87.5 % of the thickness required by design or as otherwise specified.

TABLE 1 MLCIPL Initial Physical Properties

Property	ASTM Test	Minimum Value	
		psi	(MPa)
Flexural Strength	D790	4500	(31)
Flexural Modulus	D790	250 000	(1724)

9.5 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an air test method, where test plugs are placed adjacent to the upstream and downstream ends of the main sheet and at the uppermost end of the lateral tube. This test should take place after the MLCIPL has cooled down to ambient temperature. This test is limited to pipe lengths with no service connections. The test pressure shall be 4 psi (27.6 kPa) for a 3-min test time and during this time the pressure shall not drop below 3.5 psi (24.1 kPa).

10. Keywords

10.1 ambient cure; continuous; cured-in-place pipe; epoxy; felt; hydrophilic O-rings; inflation; inversion; knit; lateral identification; lateral pipe; lateral tube; launcher; liner/bladder assembly; main pipe; main sheet; main to lateral connection; MLCIPL; one-piece; resin; sewer lateral lines; sheet; steam cure; TEE; textile sheet; textile tube; transition; translucent bladder; tube; vacuum impregnate; WYE

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F2561–11) that may impact the use of this standard.

(1) Revised—3.2.4, 3.2.5.
(2) Revised—5.1.1, 5.1.2, 5.1.3.
(3) Revised—7.2, 7.3, 7.4.
(4) Revised—Section 10, Keywords.

ATTACHMENT 2
10,000 Hour Insignia™ Test Report

10,000 Hour Insignia Test

Report

Summary: Report of the 10,000 Hour Hydration-Dehydration Test conducted on the Insignia™ Hydrophilic Gasket Seals to establish performance of the seals in simulated sewer conditions

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Report Summary

The Insignia™ Hydrophilic Gasket Seals were developed by the Research & Development Team at LMK Technologies as a solution to the problem of water tracking in the annular space that exists between a CIPP liner and the host pipe. This space exists due to the shrinkage of resins as they undergo polymerization during the process of curing. This water drains back into the sewer collection system affecting the capacity of the sewer system and consequently the capacity of any waste treatment services that the collection system utilizes.

The Insignia™ Sealing System consists of three construction types of Gasket Seals: O-Rings, Lateral Connection Hats, and Mainline End Seals for the purpose of eliminating infiltration from the known sources in a collection system. Neoprene formerly known as Duprene is the backbone of the chemical makeup of the Insignia™ Seals. Neoprene is known for its properties of chemical inertness and maintaining flexibility over a wide range of temperatures. LMK's proprietary neoprene compound further has hydrophilic properties that allow it to absorb water and expand up to 800% when left unconstrained. In a pipe, when the seal is constrained between the host pipe and the CIPP liner, the seal swells to close the annular gap between the liner and the pipe thus creating a compression gasket and effectively sealing the system by preventing water from infiltrating into the collection system.

Since the Insignia™ Seals are hydrophilic; a concern to the engineering society that collaborates with LMK Technologies was the performance of the seals when dehydrated or deprived of water. It was this concern that led to the development of the 10,000 hour alternate hydration/dehydration testing of the Insignia™ Seals. The test comprised of 6 samples of the Insignia™ Gasket Seals subjected to various cycles of hydration and dehydration ranging from 2 days to 6 months. The seals were tested for gain in weight and size when hydrated and the subsequent loss in weight and thickness when dehydrated.

The Insignia™ Gasket Seals expands to about 800% of their original size when hydrated for prolonged periods of time. When the seals were dehydrated, they did not exhibit any degradation or loss of materials and maintained their original surface properties, which is a significant find for long term sealing. The seals maintained their flexibility and expansion properties while undergoing continuous hydration and dehydration cycles. The seals also exhibited their expansion properties when subjected to dehydration. After a number of hydration and dehydration cycles, the gasket seals were able to retain almost up to 75% of their expansion over shorter periods of dehydration.

The results obtained by the means of this test (further detailed in the report) establish that the Insignia™ Gasket Seals are able to maintain their water sealing properties when subjected to simulated sewer and ground water conditions of hydration and dehydration.

Test Procedure

Focus: To determine the change in physical properties of an Insignia™ Hydrophilic Seals after they have been subjected to varying durations of hydration and dehydration cycles.

Apparatus: The following equipment and materials are to be used for conducting the test

1. Insignia™ O-Rings
2. Scale
3. Vernier Calipers

Methodology: The following procedure is to be followed for conducting the test

1. 5 specimens of Insignia™ O-rings will be weighed to determine the initial weight and thickness and then will be labeled beginning with Sample A up to Sample F
2. Sample A will remain submerged for 48 hours and then will be allowed to dry for 48 hours and will be measured for weight and thickness upon removal and after drying
3. Step 2 of the test procedure is to be repeated on Samples B to E; at 1 week, 1 month, and 6 months respectively
4. Sample F will be the control sample and will remain submerged for the entire duration of the test

Documentation: The test will be documented using the following techniques

1. Photographs of the Hydrophilic Seals during various stages of the tests including the seal formed in the pipe after dehydration
2. Observations of the weight changes of the O-rings
3. Observation of sealing properties of the O-rings after being subjected to the Hydration/Dehydration/Hydration Cycle
4. Observation of surface properties of the O-rings to check for loss of material, loss of flexibility, etc.

Observations: Please refer to the appendix for the observations

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Observations for Sample A – 2 Day Cycle

Sample A of the Insignia™ Gasket Seals was subjected to a 2 day cycle of alternate hydration or dehydration. A total of 208 observations were recorded of which half were in the dry state while the other half were in the wet state. The observations were further studied for the gain/loss in thickness and weight as the samples underwent multiple hydration and dehydration cycle.

Calculations for Sample A – 2 Day Cycle

Maximum increase in thickness (Dry to Wet):
= [(5.66 – 4.56)/4.56]*100
= 24.12%

Maximum increase in weight (Dry to Wet):
= [(8.6 – 4.7)/4.7]*100
= 82.97%

Thickness increase over a period of 10,000 Hours (Dry to Dry):
= [(5.66 – 3.94)/3.94]*100
= 43.65%

Thickness increase over a period of 10,000 Hours (Wet to Wet):
= [(5.97 – 4.56)/4.56]*100
= 30.92%

Weight increase over a period of 10,000 Hours (Dry to Dry):
= [(7.6 – 4.7)/4.7]*100
= 61.70%

Weight increase over a period of 10,000 Hours (Wet to Wet):
= [(9.5 – 8.6)/8.6]*100
= 10.46%

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Observation Charts for Sample A – 2 Day Cycle

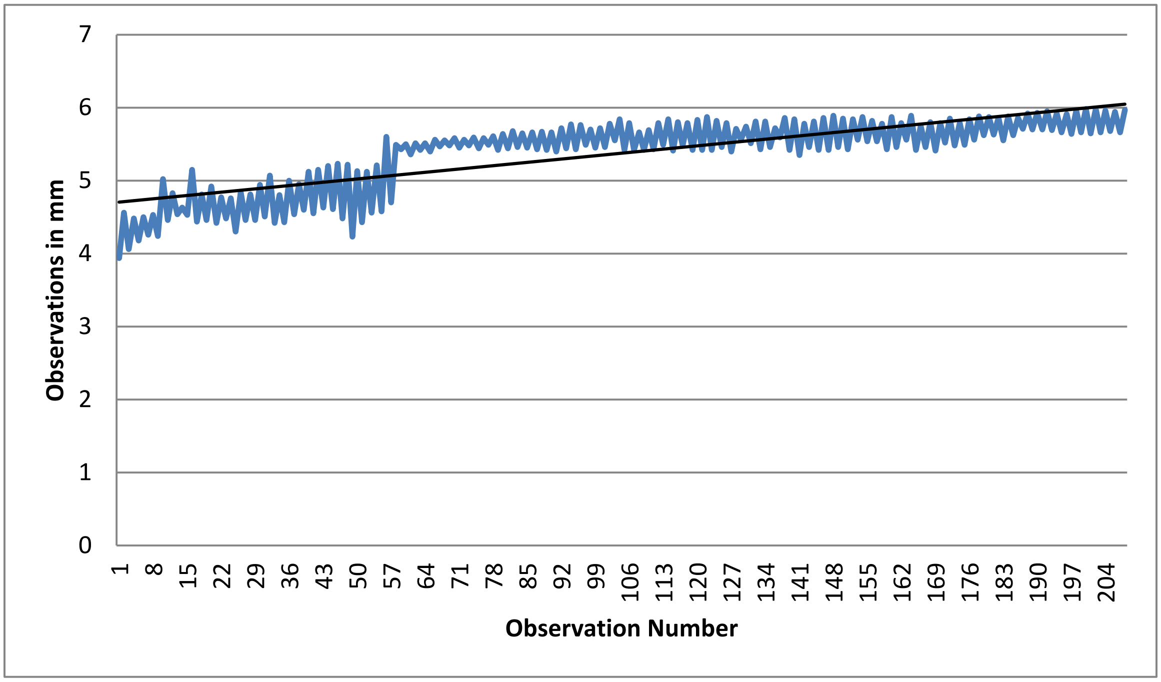

Figure 1: Thickness Observation Chart for Sample A

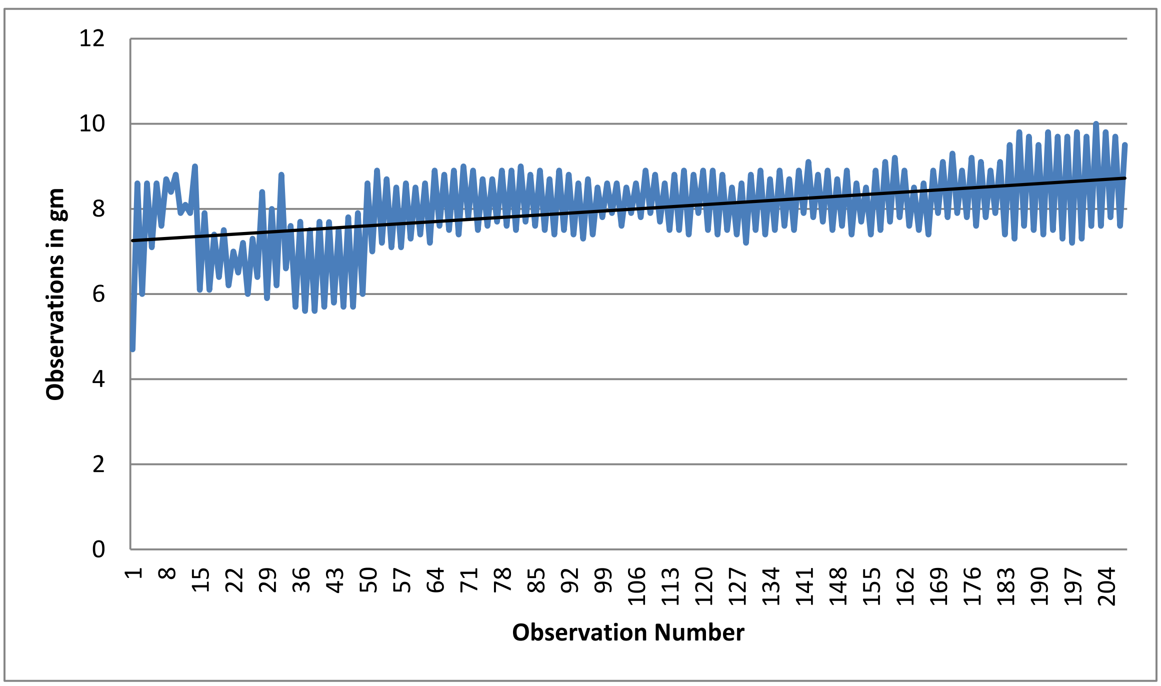

Figure 2: Weight Observations Chart for Sample A

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Observations for Sample B – 7 Day Cycle

Sample B of the Insignia™ Gasket Seals was subjected to a 7 day cycle of alternate hydration or dehydration. A total of 58 observations were recorded of which half were in the dry state while the other half were in the wet state. The observations were further studied for the gain/loss in thickness and weight as the samples underwent multiple hydration and dehydration cycle.

Calculations for Sample B – 7 Day Cycle

Maximum increase in thickness (Dry to Wet):
= [(6.58 – 4.49)/4.49]*100
= 46.54%

Maximum increase in weight (Dry to Wet):
= [(11.8 – 5.2)/5.2]*100
= 126.92%

Thickness increase over a period of 10,000 Hours (Dry to Dry):
= [(4.53 – 4.23)/4.23]*100
= 7.09%

Thickness increase over a period of 10,000 Hours (Wet to Wet):
= [(6.58 – 4.69)/4.69]*100
= 40.29%

Weight increase over a period of 10,000 Hours (Dry to Dry):
= [(6.4 – 4.5)/4.5]*100
= 42.22%

Weight increase over a period of 10,000 Hours (Wet to Wet):
= [(10.4 – 7.2)/7.2]*100
= 44.44%

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Observation Charts for Sample B – 7 Day Cycle

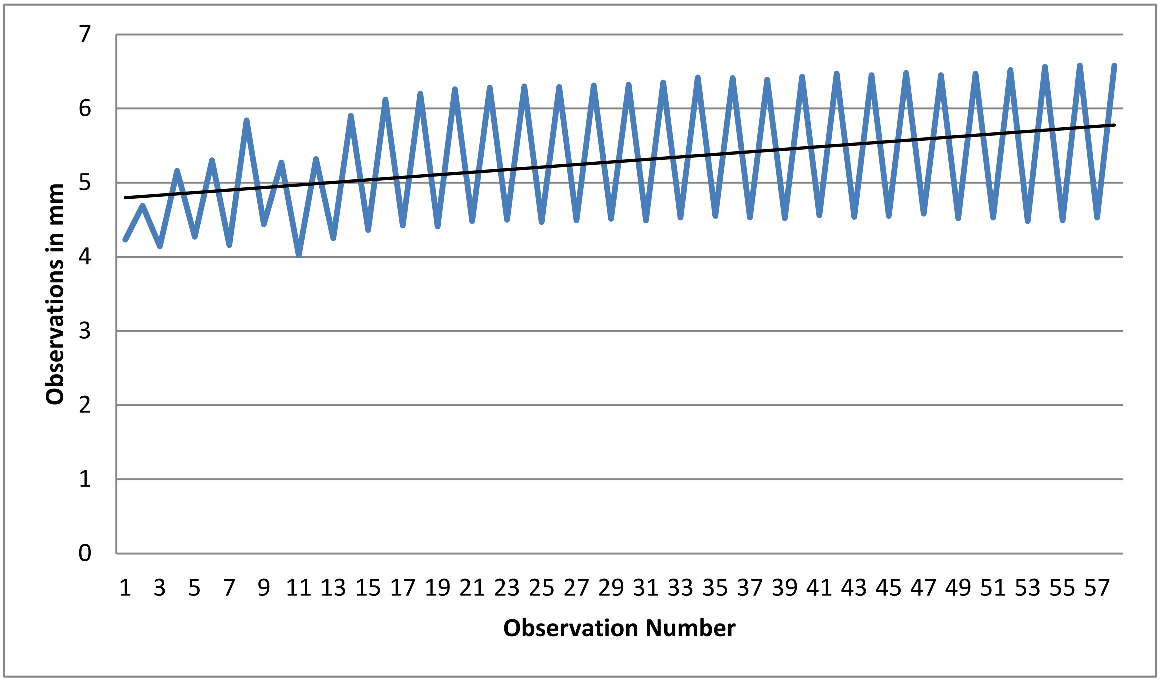

Figure 3: Thickness Observation Chart for Sample B

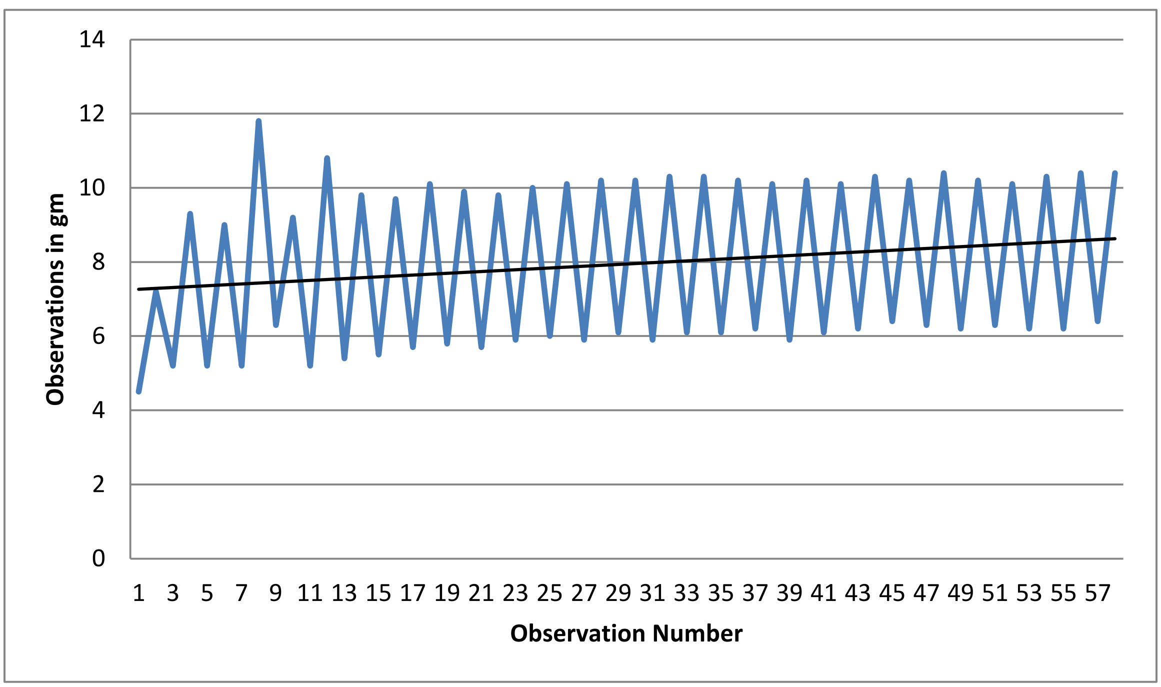

Figure 4: Weight Observations Chart for Sample B

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Observations for Sample C – 30 Day Cycle

Sample B of the Insignia™ Gasket Seals was subjected to a 30 day cycle of alternate hydration or dehydration. A total of 14 observations were recorded of which half were in the dry state while the other half were in the wet state. The observations were further studied for the gain/loss in thickness and weight as the samples underwent multiple hydration and dehydration cycle.

Calculations for Sample C – 30 Day Cycle

Maximum increase in thickness (Dry to Wet):
= [(6.56 – 4.23)/4.23]*100
= 55.08%

Maximum increase in weight (Dry to Wet):
= [(17.3 – 5.1)/5.1]*100
= 239.21%

Thickness increase over a period of 10,000 Hours (Dry to Dry):
= [(4.28 – 3.98)/3.98]*100
= 7.53%

Thickness increase over a period of 10,000 Hours (Wet to Wet):
= [(4.28 – 3.98)/3.98]*100
= 7.70%

Weight increase over a period of 10,000 Hours (Dry to Dry):
= [(5.1 – 4.5)/4.5]*100
= 13.33%

Weight increase over a period of 10,000 Hours (Wet to Wet):
= [(17.3 – 16.3)/16.3]*100
= 6.13%

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Observation Charts for Sample C – 30 Day Cycle

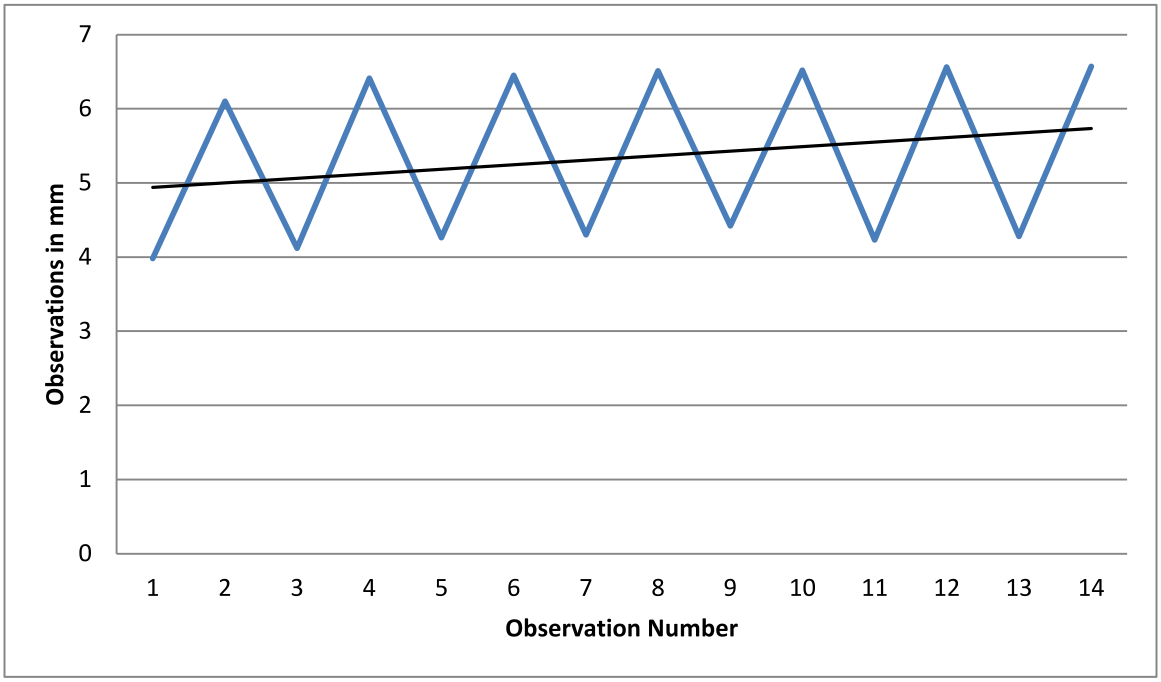

Figure 5: Thickness Observation Chart for Sample C

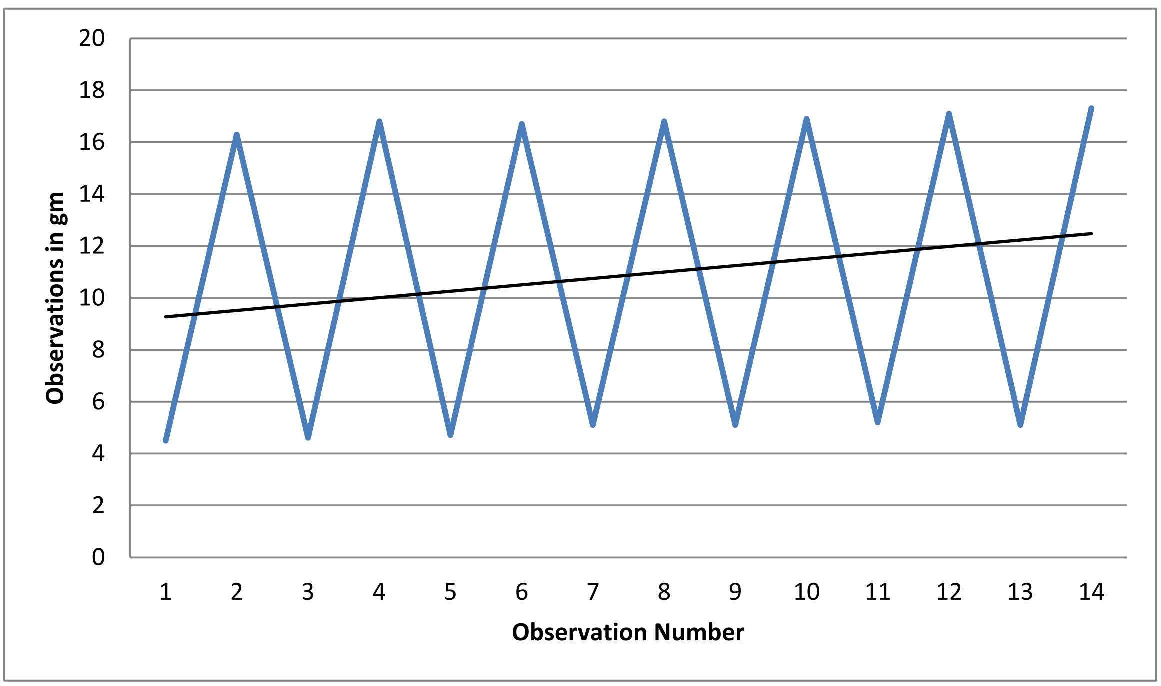

Figure 6: Weight Observations Chart for Sample C

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Observations for Sample D – 90 Day Cycle

Sample D of the Insignia™ Gasket Seals was subjected to a 90 day cycle of alternate hydration or dehydration. A total of 6 observations were recorded of which half were in the dry state while the other half were in the wet state. The observations were further studied for the gain/loss in thickness and weight as the samples underwent multiple hydration and dehydration cycle.

Calculations for Sample D – 90 Day Cycle

Maximum increase in thickness (Dry to Wet):
= [(9.11 – 4.1)/4.1]*100
= 122.19%

Maximum increase in weight (Dry to Wet):
= [(32.3 – 8.3)/8.3]*100
= 289.15%

Thickness increase over a period of 10,000 Hours (Dry to Dry):
= [(4.11 – 3.96)/3.96]*100
= 3.78%

Thickness increase over a period of 10,000 Hours (Wet to Wet):
= [(9.10 – 7.67)/7.67]*100
= 18.64%

Weight increase over a period of 10,000 Hours (Dry to Dry):
= [(8.3 – 4.5)/4.5]*100
= 84.44%

Weight increase over a period of 10,000 Hours (Wet to Wet):
= [(32.3 – 28.7)/28.7]*100
= 12.54%

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Observation Charts for Sample D – 30 Day Cycle

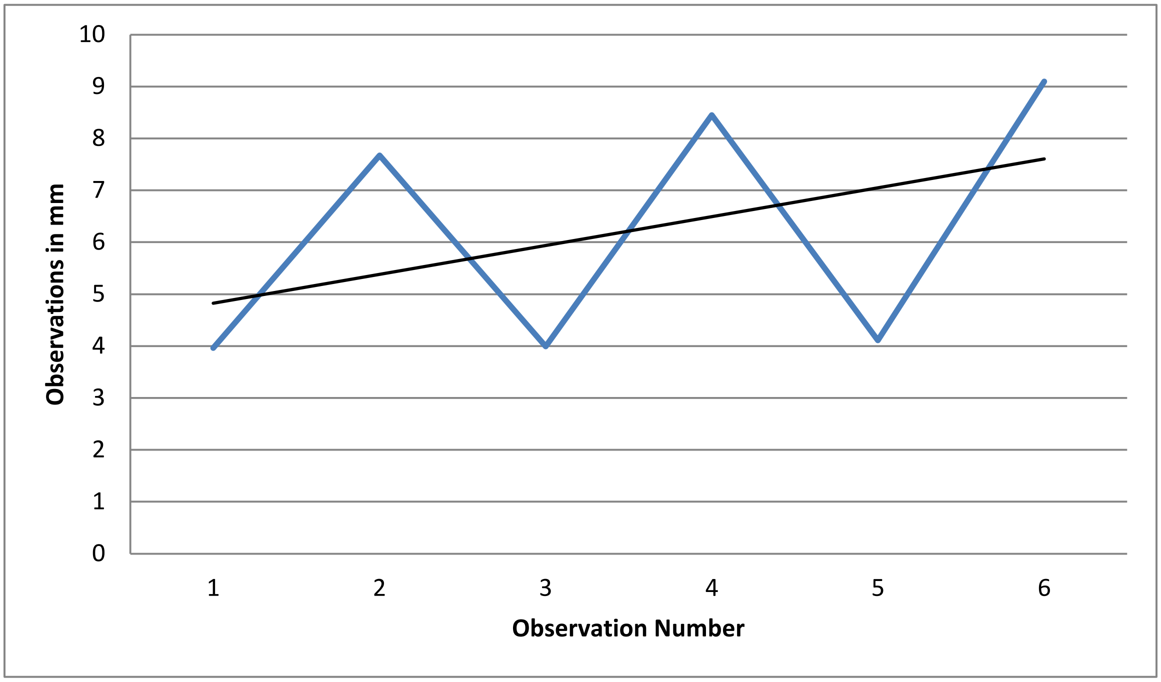

Figure 7: Thickness Observation Chart for Sample D

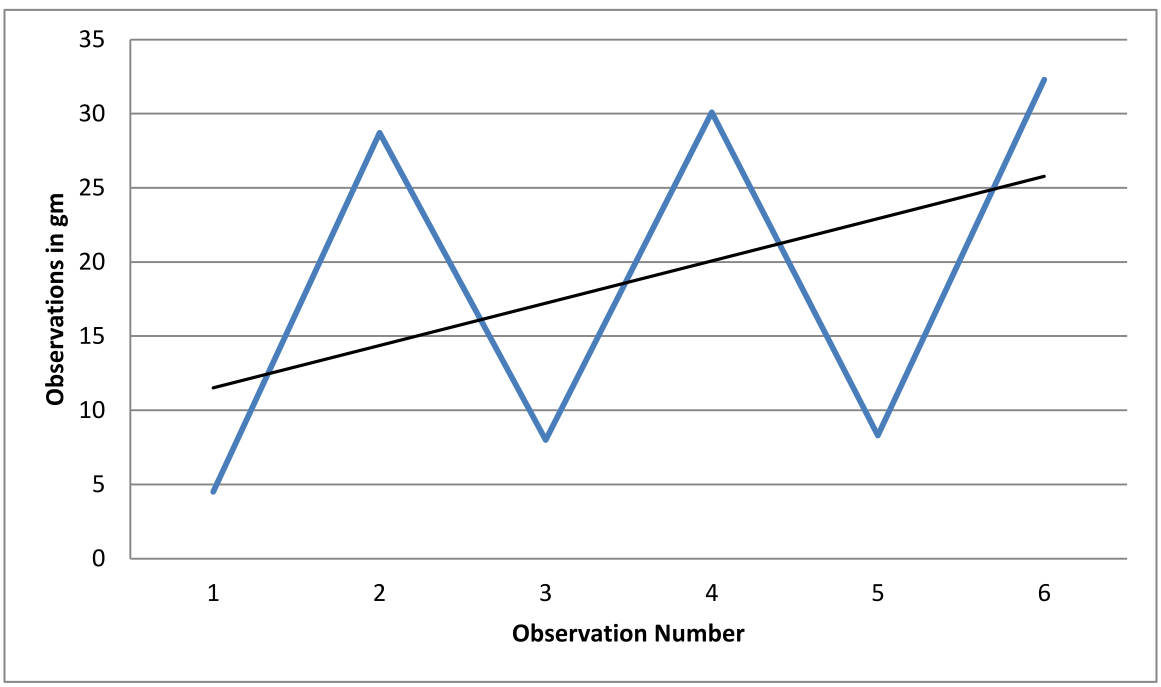

Figure 8: Weight Observations Chart for Sample D

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Observations for Sample E – 180 Day Cycle

Sample D of the Insignia™ Gasket Seals was subjected to a 180 day cycle of alternate hydration or dehydration. A total of 4 observations were recorded of which half were in the dry state while the other half were in the wet state. The observations were further studied for the gain/loss in thickness and weight as the samples underwent multiple hydration and dehydration cycle.

Calculations for Sample E – 180 Day Cycle

Maximum increase in thickness (Dry to Wet):
= [(11.96 – 4.36)/4.36]*100
= 174.31%

Maximum increase in weight (Dry to Wet):
= [(53.2 – 8.4)/8.4]*100
= 533.33%

Thickness increase over a period of 10,000 Hours (Dry to Dry):
= [(4.36 – 3.94)/3.94]*100
= 10.65%

Thickness increase over a period of 10,000 Hours (Wet to Wet):
= [(11.96 – 9.42)/9.42]*100
= 26.32%

Weight increase over a period of 10,000 Hours (Dry to Dry):
= [(8.4 – 4.7)/4.7]*100
= 78.72%

Weight increase over a period of 10,000 Hours (Wet to Wet):
= [(53.2 – 41.7)/41.7]*100
= 27.57%

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Observation Charts for Sample E – 180 Day Cycle

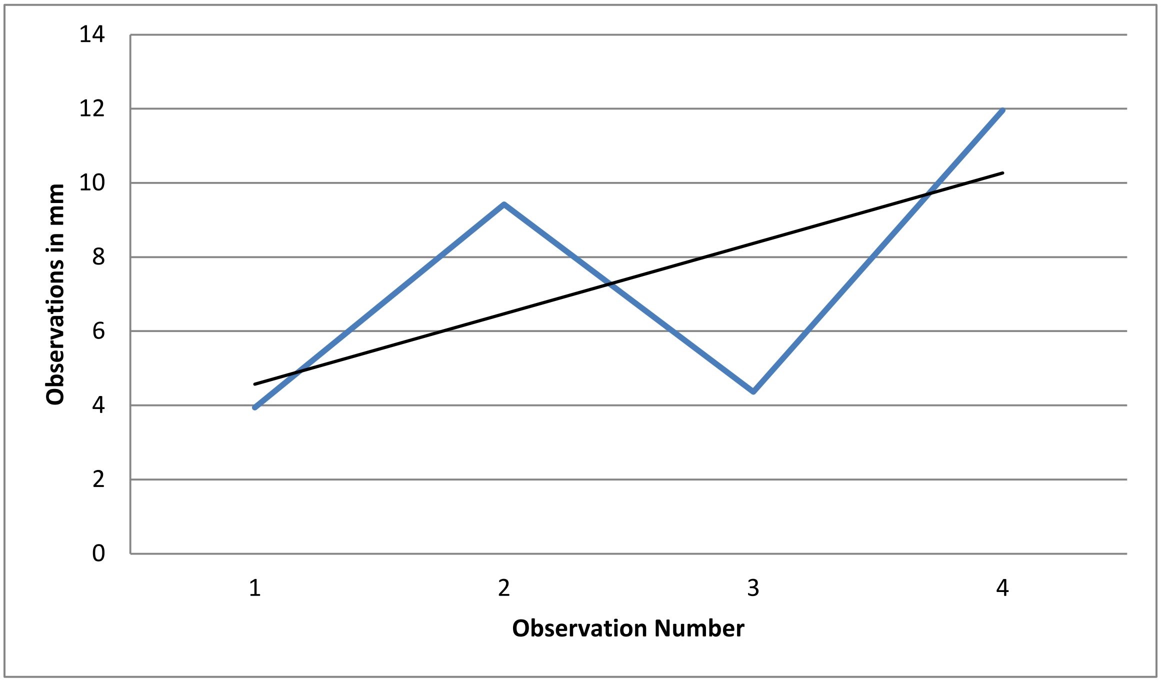

Figure 9: Thickness Observation Chart for Sample E

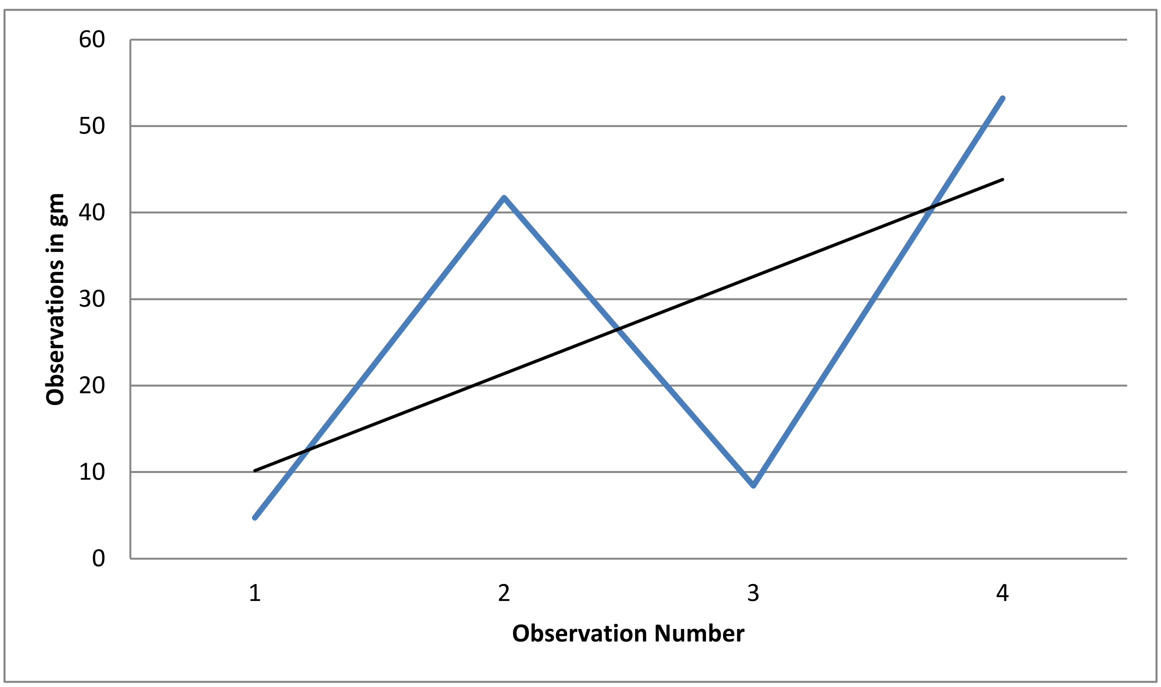

Figure 10: Weight Observations Chart for Sample E

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Observations for Sample F – 416 Day Cycle

Sample F of the Insignia™ Gasket Seals was subjected to a 416 day hydration. A total of 2 observations were recorded of which half were in the dry state while the other half were in the wet state. The observations were further studied for the gain/loss in thickness and weight as the samples underwent multiple hydration and dehydration cycle.

Calculations for Sample F – 416 Day Cycle

Increase in thickness (Dry to Wet):
= [(11.46 – 3.94)/3.94]*100
= 190.86%

Maximum increase in weight (Dry to Wet):
= [(52.3 – 4.7)/4.7]*100
= 1012.16%

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Summary & Conclusions

The data can be summarized as below

Sample	Increase in Thickness (mm)	Increase in Weight (gm)
A – 2 days	24.12%	82.97%
B – 7 days	46.54%	126.92%
C – 30 days	55.08%	239.21%
D – 90 days	122.19%	289.15%
E – 180 days	174.31%	533.33%
F – 416 days	190.86%	1012.16%

The following conclusions can be drawn from the data reported above:

- The trend line of each observation chart indicates that not only do the seals maintain their expansion properties when subjected to alternate hydration and dehydration data but also progressively increase the amount of water they take on and consequently their expansion.
- The gasket seals are able to retain an expansion of at least 4% or higher even when subjected thus ensuring that a seal will be maintained between the liner and the host pipe even when the seals face dehydration in the sewer.
- The seals retain moisture even when dehydrated over periods as long as 3 months.

Visual observations further confirm the following facts:

- The seals do not show any degradation or loss of material when dehydrated
- The seals maintain their flexibility even after being subjected to multiple hydration and dehydration cycles

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Appendix

Table 1: 2 Day Cycle Observations for Sample A

Obs. No.	Thickness Observations		Weight Observations	
	Test Sample B (mm)	State	Test Sample B (mm)	State
1	3.94	Dry	4.7	Dry
2	4.56	Wet	8.6	Wet
3	4.06	Dry	6.0	Dry
4	4.48	Wet	8.6	Wet
5	4.18	Dry	7.1	Dry
6	4.5	Wet	8.6	Wet
7	4.26	Dry	7.6	Dry
8	4.53	Wet	8.7	Wet
9	4.24	Dry	8.4	Dry
10	5.02	Wet	8.8	Wet
11	4.46	Dry	7.9	Dry
12	4.83	Wet	8.1	Wet
13	4.54	Dry	7.9	Dry
14	4.63	Wet	9	Wet
15	4.53	Dry	6.1	Dry
16	5.15	Wet	7.9	Wet
17	4.44	Dry	6.1	Dry
18	4.81	Wet	7.4	Wet
19	4.46	Dry	6.4	Dry
20	4.92	Wet	7.5	Wet
21	4.42	Dry	6.2	Dry
22	4.77	Wet	7	Wet
23	4.48	Dry	6.5	Dry
24	4.76	Wet	7.2	Wet
25	4.3	Dry	6	Dry
26	4.84	Wet	7.3	Wet
27	4.46	Dry	6.4	Dry
28	4.81	Wet	8.4	Wet
29	4.46	Dry	5.9	Dry
30	4.94	Wet	8	Wet
31	4.51	Dry	6.2	Dry
32	5.07	Wet	8.8	Wet
33	4.42	Dry	6.6	Dry
34	4.8	Wet	7.6	Wet
35	4.43	Dry	5.7	Dry

36	5	Wet	7.7	Wet
37	4.54	Dry	5.6	Dry
38	4.95	Wet	7.5	Wet
39	4.6	Dry	5.6	Dry
40	5.12	Wet	7.7	Wet
41	4.55	Dry	5.7	Dry
42	5.15	Wet	7.69	Wet
43	4.63	Dry	5.8	Dry
44	5.2	Wet	7.5	Wet
45	4.61	Dry	5.7	Dry
46	5.23	Wet	7.8	Wet
47	4.48	Dry	5.7	Dry
48	5.22	Wet	7.9	Wet
49	4.23	Dry	6	Dry
50	5.13	Wet	8.6	Wet
51	4.43	Dry	7	Dry
52	5.12	Wet	8.9	Wet
53	4.56	Dry	7.2	Dry
54	5.21	Wet	8.7	Wet
55	4.58	Dry	7.1	Dry
56	5.6	Wet	8.5	Wet
57	4.7	Dry	7.1	Dry
58	5.49	Wet	8.6	Wet
59	5.43	Dry	7.3	Dry
60	5.5	Wet	8.5	Wet
61	5.36	Dry	7.4	Dry
62	5.51	Wet	8.6	Wet
63	5.42	Dry	7.2	Dry
64	5.51	Wet	8.9	Wet
65	5.4	Dry	7.6	Dry
66	5.56	Wet	8.8	Wet
67	5.47	Dry	7.5	Dry
68	5.55	Wet	8.9	Wet
69	5.48	Dry	7.4	Dry
70	5.58	Wet	9	Wet
71	5.45	Dry	7.8	Dry
72	5.56	Wet	8.9	Wet
73	5.48	Dry	7.5	Dry
74	5.59	Wet	8.7	Wet
75	5.44	Dry	7.6	Dry

76	5.58	Wet	8.7	Wet
77	5.49	Dry	7.7	Dry
78	5.61	Wet	8.9	Wet
79	5.42	Dry	7.6	Dry
80	5.64	Wet	8.9	Wet
81	5.44	Dry	7.5	Dry
82	5.68	Wet	9	Wet
83	5.46	Dry	7.7	Dry
84	5.65	Wet	8.8	Wet
85	5.45	Dry	7.6	Dry
86	5.66	Wet	8.9	Wet
87	5.43	Dry	7.5	Dry
88	5.67	Wet	8.7	Wet
89	5.42	Dry	7.4	Dry
90	5.66	Wet	8.9	Wet
91	5.4	Dry	7.5	Dry
92	5.72	Wet	8.8	Wet
93	5.44	Dry	7.4	Dry
94	5.77	Wet	8.6	Wet
95	5.43	Dry	7.3	Dry
96	5.76	Wet	8.7	Wet
97	5.49	Dry	7.4	Dry
98	5.7	Wet	8.5	Wet
99	5.45	Dry	7.8	Dry
100	5.72	Wet	8.6	Wet
101	5.46	Dry	7.9	Dry
102	5.78	Wet	8.6	Wet
103	5.55	Dry	7.6	Dry
104	5.84	Wet	8.5	Wet
105	5.42	Dry	7.9	Dry
106	5.79	Wet	8.6	Wet
107	5.42	Dry	7.8	Dry
108	5.66	Wet	8.9	Wet
109	5.42	Dry	7.9	Dry
110	5.69	Wet	8.8	Wet
111	5.43	Dry	7.7	Dry
112	5.79	Wet	8.6	Wet
113	5.49	Dry	7.5	Dry
114	5.84	Wet	8.8	Wet
115	5.41	Dry	7.5	Dry

116	5.8	Wet	8.9	Wet
117	5.48	Dry	7.4	Dry
118	5.79	Wet	8.8	Wet
119	5.42	Dry	7.9	Dry
120	5.83	Wet	8.9	Wet
121	5.42	Dry	7.5	Dry
122	5.87	Wet	8.9	Wet
123	5.42	Dry	7.4	Dry
124	5.82	Wet	8.8	Wet
125	5.46	Dry	7.5	Dry
126	5.79	Wet	8.5	Wet
127	5.4	Dry	7.4	Dry
128	5.71	Wet	8.6	Wet
129	5.56	Dry	7.2	Dry
130	5.74	Wet	8.8	Wet
131	5.51	Dry	7.5	Dry
132	5.81	Wet	8.9	Wet
133	5.43	Dry	7.4	Dry
134	5.81	Wet	8.7	Wet
135	5.46	Dry	7.5	Dry
136	5.72	Wet	8.9	Wet
137	5.59	Dry	7.6	Dry
138	5.86	Wet	8.7	Wet
139	5.42	Dry	7.5	Dry
140	5.84	Wet	8.9	Wet
141	5.35	Dry	7.9	Dry
142	5.78	Wet	9.1	Wet
143	5.46	Dry	7.8	Dry
144	5.81	Wet	8.8	Wet
145	5.42	Dry	7.7	Dry
146	5.86	Wet	8.9	Wet
147	5.42	Dry	7.5	Dry
148	5.89	Wet	8.7	Wet
149	5.46	Dry	7.6	Dry
150	5.85	Wet	8.9	Wet
151	5.43	Dry	7.4	Dry
152	5.84	Wet	8.6	Wet
153	5.56	Dry	7.7	Dry
154	5.87	Wet	8.5	Wet
155	5.54	Dry	7.4	Dry

156	5.82	Wet	8.9	Wet
157	5.54	Dry	7.5	Dry
158	5.78	Wet	9.1	Wet
159	5.43	Dry	7.7	Dry
160	5.87	Wet	9.2	Wet
161	5.46	Dry	7.8	Dry
162	5.79	Wet	8.9	Wet
163	5.56	Dry	7.6	Dry
164	5.89	Wet	8.5	Wet
165	5.42	Dry	7.5	Dry
166	5.75	Wet	8.6	Wet
167	5.46	Dry	7.4	Dry
168	5.8	Wet	8.9	Wet
169	5.41	Dry	7.9	Dry
170	5.79	Wet	9.1	Wet
171	5.52	Dry	7.8	Dry
172	5.85	Wet	9.3	Wet
173	5.48	Dry	7.9	Dry
174	5.79	Wet	8.9	Wet
175	5.49	Dry	7.8	Dry
176	5.84	Wet	9.2	Wet
177	5.56	Dry	7.6	Dry
178	5.88	Wet	9.1	Wet
179	5.62	Dry	7.8	Dry
180	5.87	Wet	8.9	Wet
181	5.63	Dry	7.9	Dry
182	5.86	Wet	9.1	Wet
183	5.55	Dry	7.4	Dry
184	5.88	Wet	9.5	Wet
185	5.62	Dry	7.3	Dry
186	5.86	Wet	9.8	Wet
187	5.71	Dry	7.6	Dry
188	5.92	Wet	9.7	Wet
189	5.70	Dry	7.5	Dry
190	5.93	Wet	9.5	Wet
191	5.70	Dry	7.4	Dry
192	5.95	Wet	9.8	Wet
193	5.69	Dry	7.5	Dry
194	5.92	Wet	9.7	Wet
195	5.66	Dry	7.3	Dry

196	5.91	Wet	9.7	Wet
197	5.64	Dry	7.2	Dry
198	5.96	Wet	9.8	Wet
199	5.66	Dry	7.3	Dry
200	5.98	Wet	9.7	Wet
201	5.65	Dry	7.6	Dry
202	5.98	Wet	10.0	Wet
203	5.66	Dry	7.6	Dry
204	5.96	Wet	9.8	Wet
205	5.68	Dry	7.8	Dry
206	5.94	Wet	9.7	Wet
207	5.66	Dry	7.6	Dry
208	5.97	Wet	9.5	Wet

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TABLE 2: 7 DAY CYCLE OBSERVATIONS FOR SAMPLE B

Obs. No.	Thickness Observations		Weight Observations	
	Test Sample C (mm)	State	Test Sample C (gm)	State
1	4.23	Dry	4.5	Dry
2	4.69	Wet	7.2	Wet
3	4.14	Dry	5.2	Dry
4	5.16	Wet	9.3	Wet
5	4.27	Dry	5.2	Dry
6	5.3	Wet	9	Wet
7	4.16	Dry	5.2	Dry
8	5.84	Wet	11.8	Wet
9	4.44	Dry	6.3	Dry
10	5.27	Wet	9.2	Wet
11	4.02	Dry	5.2	Dry
12	5.32	Wet	10.8	Wet
13	4.25	Dry	5.4	Dry
14	5.9	Wet	9.8	Wet
15	4.36	Dry	5.5	Dry
16	6.12	Wet	9.7	Wet
17	4.42	Dry	5.7	Dry
18	6.2	Wet	10.1	Wet
19	4.41	Dry	5.8	Dry
20	6.26	Wet	9.9	Wet
21	4.48	Dry	5.7	Dry
22	6.28	Wet	9.8	Wet
23	4.5	Dry	5.9	Dry
24	6.3	Wet	10	Wet
25	4.47	Dry	6	Dry
26	6.29	Wet	10.1	Wet
27	4.49	Dry	5.9	Dry
28	6.31	Wet	10.2	Wet
29	4.51	Dry	6.1	Dry
30	6.32	Wet	10.2	Wet
31	4.49	Dry	5.9	Dry
32	6.35	Wet	10.3	Wet
33	4.53	Dry	6.1	Dry
34	6.42	Wet	10.3	Wet
35	4.55	Dry	6.1	Dry
36	6.41	Wet	10.2	Wet
37	4.53	Dry	6.2	Dry

38	6.39	Wet	10.1	Wet
39	4.52	Dry	5.9	Dry
40	6.43	Wet	10.2	Wet
41	4.56	Dry	6.1	Dry
42	6.47	Wet	10.1	Wet
43	4.54	Dry	6.2	Dry
44	6.45	Wet	10.3	Wet
45	4.55	Dry	6.4	Dry
46	6.48	Wet	10.2	Wet
47	4.58	Dry	6.3	Dry
48	6.45	Wet	10.4	Wet
49	4.52	Dry	6.2	Dry
50	6.47	Wet	10.2	Wet
51	4.53	Dry	6.3	Dry
52	6.52	Wet	10.1	Wet
53	4.48	Dry	6.2	Dry
54	6.56	Wet	10.3	Wet
55	4.49	Dry	6.2	Dry
56	6.58	Wet	10.4	Wet
57	4.53	Dry	6.4	Dry
58	6.58	Wet	10.4	Wet

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TABLE 3: 30 DAY CYCLE OBSERVATIONS FOR SAMPLE C

Obs. No.	Thickness Observations		Weight Observations	
	Test Sample D (mm)	State	Test Sample D (gm)	State
1	3.98	Dry	4.5	Dry
2	6.1	Wet	16.3	Wet
3	4.12	Dry	4.6	Dry
4	6.41	Wet	16.8	Wet
5	4.26	Dry	4.7	Dry
6	6.45	Wet	16.7	Wet
7	4.3	Dry	5.1	Dry
8	6.51	Wet	16.8	Wet
9	4.42	Dry	5.1	Dry
10	6.52	Wet	16.9	Wet
11	4.23	Dry	5.2	Dry
12	6.56	Wet	17.1	Wet
13	4.28	Dry	5.1	Dry
14	6.57	Wet	17.3	Wet

TABLE 4: 90 DAY CYCLE OBSERVATIONS FOR SAMPLE D

Obs. No.	Thickness Observations		Weight Observations	
	Test Sample E (mm)	State	Test Sample E (gm)	State
1	3.96	Dry	4.5	Dry
2	7.67	Wet	28.7	Wet
3	3.99	Dry	8	Dry
4	8.45	Wet	30.1	Wet
5	4.11	Dry	8.3	Dry
6	9.10	Wet	32.3	Wet

TABLE 5: 180 DAY CYCLE OBSERVATIONS FOR SAMPLE E

Obs. No.	Thickness Observations		Weight Observations	
	Test Sample F (mm)	State	Test Sample F (gm)	State
1	3.94	Dry	4.7	Dry
2	9.42	Wet	41.7	Wet
3	4.36	Dry	8.4	Dry
4	11.96	Wet	53.2	Wet

TABLE 6: 416 DAY CYCLE OBSERVATIONS FOR SAMPLE F

Obs. No.	Thickness Observations		Weight Observations	
	Test Sample F (mm)	State	Test Sample F (gm)	State
1	3.94	Dry	4.7	Dry
2	11.46	Wet	52.3	Wet

Return to the Top

ATTACHMENT 3
Adeka P-201A Caulk Material Test Report

PSILab
Testing • Forensics • Consulting

117 South Sunset St., Suite I
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(720) 204-1529
info@psilab.net
www.psilab.net

PROJECT REPORT

REPORT NUMBER: LMK-032117-1

DATE: 4/17/2017

CLIENT INFORMATION

LMK Technologies
1779 Chessie Lane
Ottawa, IL 61350

SAMPLE DISCRIPTION

At the direction of Tim Back, PSILab purchased 3 tubes of caulk from Coastal Construction Products (www.coastalone.com) for compression properties testing and thickness measurement. A picture of the caulk is shown in Figure 1 below.

Figure 1. Adeka P-201A caulk from Coastal Construction Products.

TEST PERFORMED

Tim Back has authorized PSILab to perform preliminary testing to further understand the characteristics and compressibility of the Adeaka P-201A caulk material. This information will also be useful for determining the optimal method for creating a sheet of caulking material that is suitable for a future 10,000-hour hydration-dehydration test (comparing with LMK's Insignia™ products).

Testing involved utilizing the Universal Testing Machine to compress the freshly extruded P-201A material to 15psi and 30psi. Because of the unknown curing and "releasability" of this caulk, PSILab experimented with using a polyester release paper (Melinix 516) and Teflon sheet. After 7-10 days of curing, the thickness of the compressed caulk is measured using digital microscopy measurement technique. The appearance of the P-201A caulk was documented before and afterwards compression and curing.

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RESULT

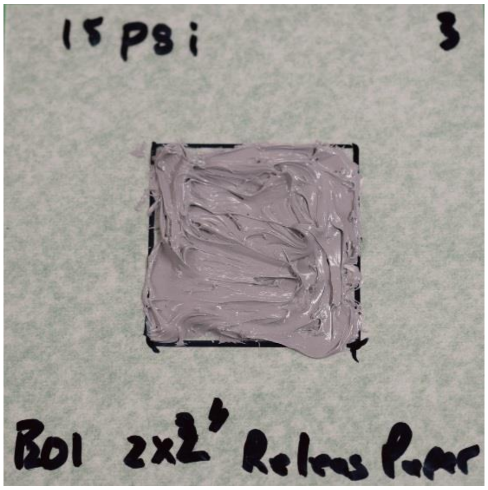

Figure 2: Adeka P-201A caulk spread over 2 square in prior to compression.

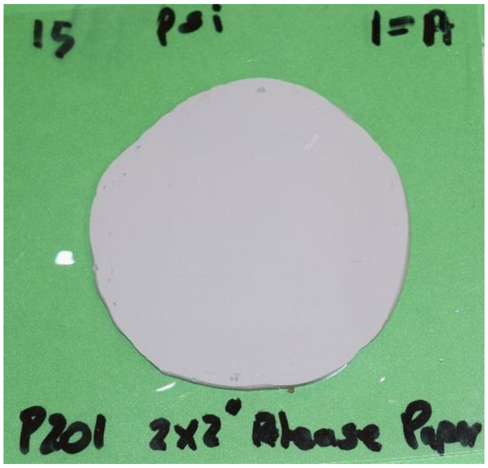

Figure 3: Adeka P-201A caulk after compression up to 60 lbs. force (~15psi).

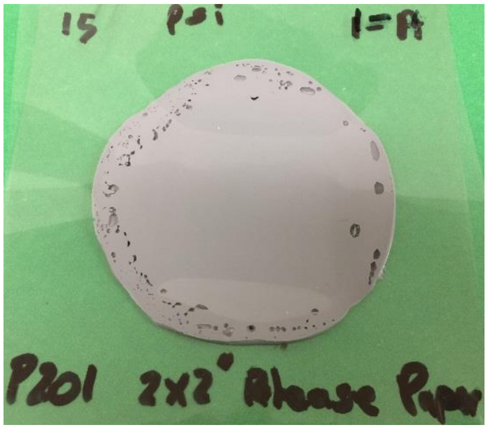

Figure 4: Adeka P-201A caulk after 10 days of drying in a 23C/50RH environment. Note the shrinkage voids which developed upon curing.

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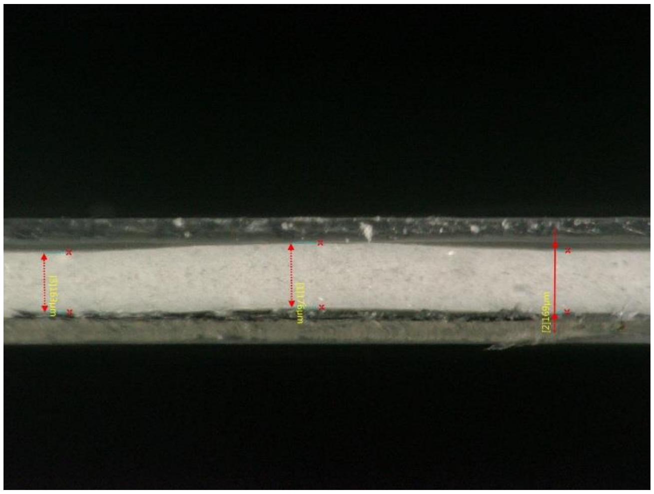

Figure 5: Average thick of the P-201A measured 10 days after compression @15psi. The average thickness was 160µm (0.0067 in). The clear outside layers are the Melinix release sheets.

Figure 6: Adeka P-201A caulk after compression up to 120 lbs. force (~30psi).

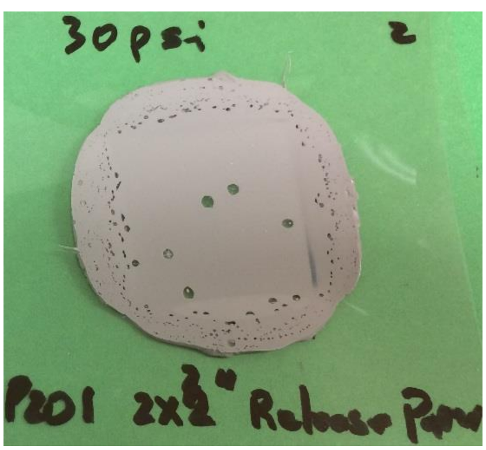

Figure 7: Adeka P-201A caulk after 10 days of drying in a 23C/50RH environment. Note the shrinkage voids which developed upon curing.

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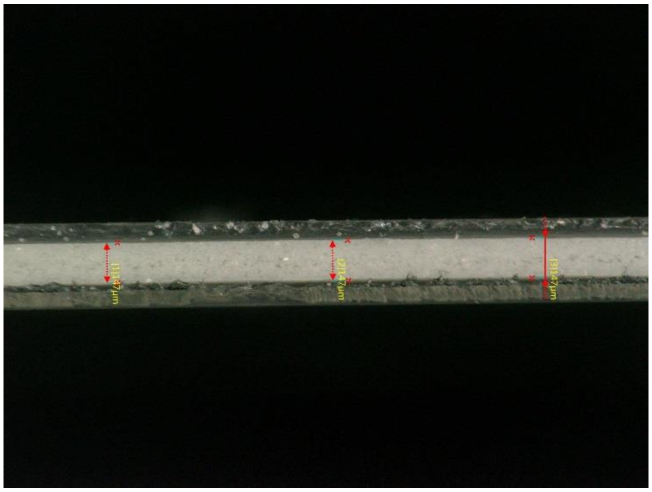

Figure 8: Average thickness of the P-201A measured 10 days after compression @30psi. The average thickness was 147µm (0.0058 in). The clear outside layers are the Melinix release sheets.

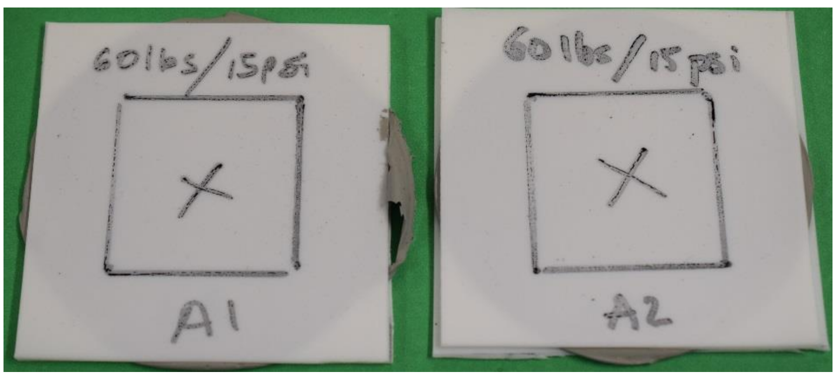

Figure 9: Compression of P-201A @ 15psi using Teflon sheets.

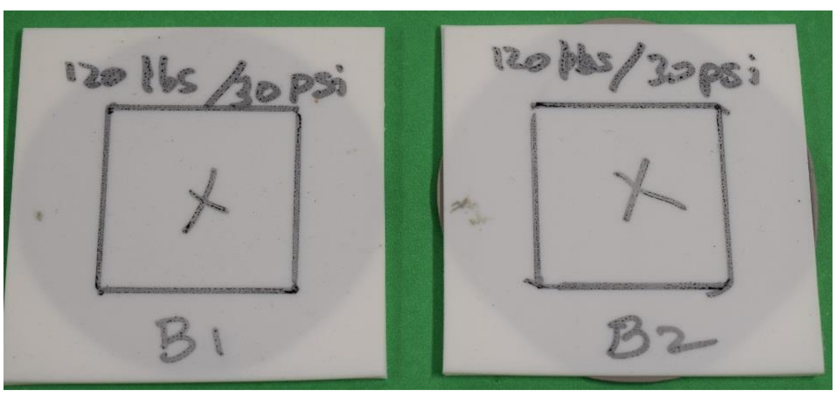

Figure 10: Compression of P-201A @ 30psi using Teflon sheets.

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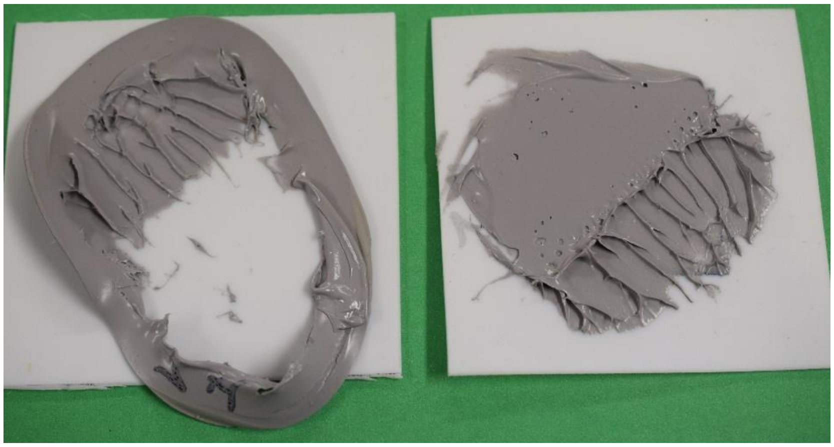

Figure 11: P-201A after compression in Teflon and curing for 7 days. When the Teflon sheets were pulled apart, the center of the sample remained uncured. Note the samples were moved to an outdoor environment with exposure to direct sunlight for 1 day in an unsuccessful attempt to assist with curing.

Adeka-P201A is a thick, grayish material that has similar consistency, viscosity, and "spreadability" as many standard caulking products. Furthermore, the product appears to have both sealing and adhesive properties – not being able to come off both polyester and Teflon releasing materials. The caulk appears to require significant exposure to air to cure. When sandwiched between Teflon sheets, P-201A did not appear to cure at all. It is not yet clear what the mechanism for curing is for this material when it is applied in a relatively air tight environment such as a pipe section buried underground. At 15-30 psi of pressure, the thickness of P-201A was less than 0.01 inch (ranging from0.0058 to 0.0067 inch). At this thickness level, a significant amount of shrinkage voids was observed in areas where curing was complete, such as in the thinner samples and in the surrounding areas of the compressed samples (Figure 12). Videos of the compression tests are available via the digital addendum.

Figure 12: Shrinkage voids in a P-201A sample after 20psi compression in Melinix releasing paper after 10 days of curing.

Report Written by:

Steve Lam
Project Manager

Report Reviewed by:

Steve Ferry
Laboratory Director

ATTACHMENT 4
Case Studies

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

Orlando, Florida
April 13-17, 2014

MA-T3-02

Rehabilitation of the Coral Gables Wastewater Collection System

Sahar Hasan, LMK Technologies, Ottawa, IL
Mark Gulyas, LMK Pipe Renewal, Ft. Lauderdale, FL
Jorge Acevedo, City of Coral Gables, Coral Gables, FL

ABSTRACT

The City of Coral Gables located in the Miami-Dade County has a population of approximately 50,000 and is home to the University of Miami. The City of Coral Gables recently completed a sewer rehabilitation project to comply with a consent decree caused from excessive flows in the collection system. The project was based in an area known as "Gables by the Sea", located on the Biscayne Bay. This area is known to have low elevations (See Figure 1). Like most sewer rehabilitation projects in coastal areas, the greatest challenge was controlling the water flooding the collection system located by the sea. The primary goal of this project was to mitigate the serious amount of sea water infiltrating the system during high tides; and to extend the service life of the piping system using trenchless technologies for at least another fifty years. This project was a successful collaboration between the city of Coral Gables, the consulting engineer, and the contractors. Proven trenchless products were used to obtain the highest quality of rehabilitation results for "sealing" this portion of the city's collection system. The mainline pipe lining was accomplished with a folded PVC pipe-liner. The upstream and downstream ends of the mainline PVC liner were sealed using a seamless molded "end seal" gasket that prevents water from tracking behind the liner and leaking at the liner ends (at the manhole). The lateral pipes were renewed using CIPP including a full-hoop main-connection liner outfitted with a main/lateral compressible gasket. Two methods for installing cleanouts were utilized, the traditional open cut method and using a vacuum truck to form a small bore hole down to the lateral pipe, then remotely attaching a pipe saddle from above ground. The project posed significant challenges with respect to the tidal induced infiltration and ground settlement which had caused the main and lateral pipes to crack and offset.

Despite the challenges faced on the project, the results outlined in the paper below, prove how the combination of professional engineering design, experienced contractors, and high quality products yielded success as the city boasts a reported decrease in pump run times from approximately 20-hours a day to 4-hours. This reduction is approximately an 80% decrease in pump station run times. This paper further elaborates on the project details, including method of application of the trenchless technologies and the challenges faced. Furthermore, the benefits

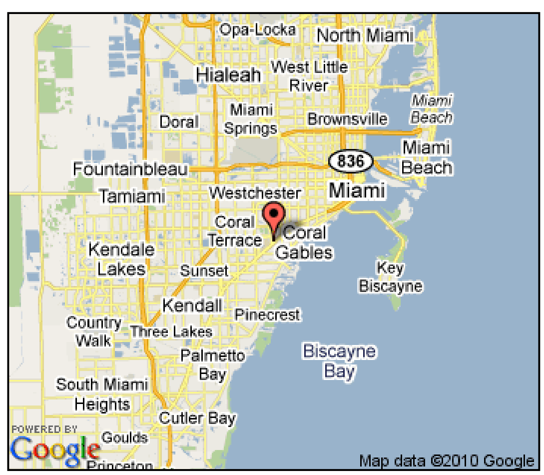

Figure 1: Location of Coral Gables
(Source: Google Maps)

of the rehabilitation project are illustrated using post inspection videos as well as historical and current flow data supplied by the engineering firm of Hazen & Sawyer.

INTRODUCTION

Clean water infiltrating a sewer collection system (See Figure 2) and consequently excessive pump run times is a real problem for many municipalities. This problem is compounded even further if the sewer system is tidally influenced. The City of Coral Gables, known as the City Beautiful is bordered by the Biscayne Bay on its east coast which leads out to the Atlantic Ocean. During the high tide events the collection system would be surcharged, overwhelming the pumping capacity of the stations. Even though the pumps were running at full capacity, the manholes would not pump down and remained surcharged so much so that the pipe invert could be seen through 8 feet of clear water in a manhole.

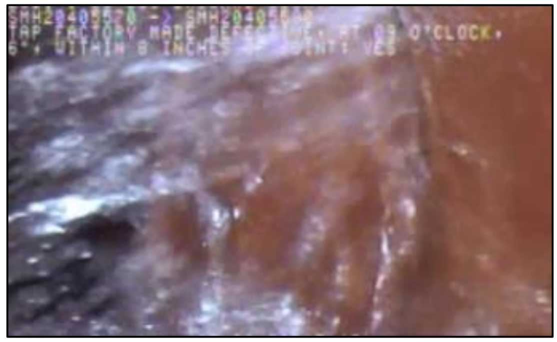

Figure 2: Infiltration at a Lateral Joint

THE PROJECT IMPETUS

The lift station addressed during this project (Lift Station A: Lugo/San Pedro) consists primarily of Vitrified Clay Pipe (VCP), in a system that was constructed approximately 40 years ago. This station was experiencing an average pump run times of 20-hours per day, most of which was around high tide events. The system was further burdened by rain events. The City of Coral Gables is under a state consent order which mandates that all pump stations running in excess of 10 hours a day must be rehabilitated to bring the pump run times into compliance. In this case, sea water was infiltrating the system which also lead to corrosion issues with pumps and negatively affected the biological process at the treatment facility.

THE PROJECT SCOPE

Table 1: Project Stakeholders

Entity	Location and Contact	Services Provided
Utility Owner	City of Coral Gables Mr. Jorge Acevedo, P.E.	
Engineering Firm	Hazen & Sawyer, P.C. Mr. Ethan Heijn, P.E.	I&I Studies and Flow Data
Mainline Contractor	Miller Pipeline Corp	Mainline Rehabilitation with EX Pipe-PVC Folded Mainline Liner/Insignia End Seals
Lateral Lining/ Sectional Contractor	LMK Pipe Renewal, LLC	Lateral and Sectional Rehabilitation with T-Liner®/ Insignia Connection Seals Sectional CIPP/Insignia Connection Seals
Cleanout Installation Contractor	TeleVac South, Inc.	VAC-A-TEE® Minimally Invasive Cleanout

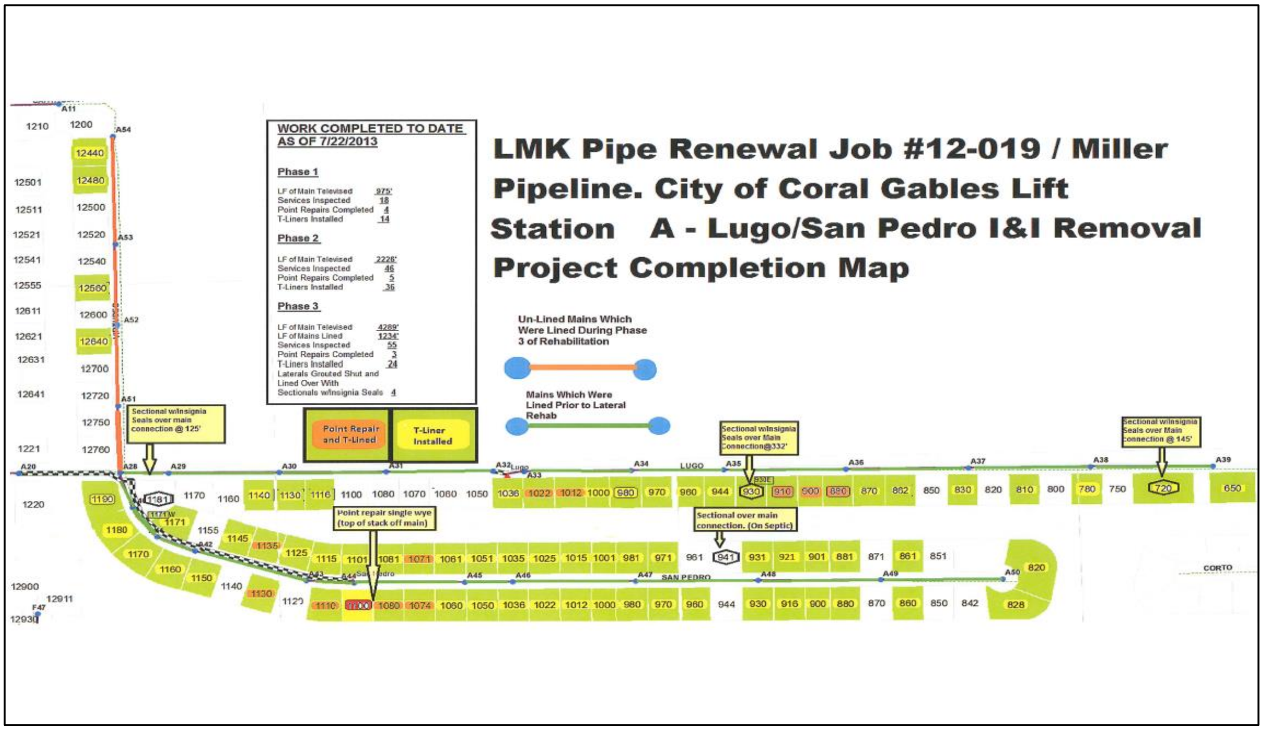

Figure 3: San Lugo/Pedro Basin

The City of Coral Gables kicked off the project by conducting flow studies during peak flows as well as non-peak flow times to obtain pre-rehabilitation flow data. In August 2012, the city began the rehabilitation work to renew and seal the Lugo/San Pedro Basin (See Figure 3). Lift Station A consists of 8-inch mainlines; with the deepest main located at a depth of 11-feet and the shallowest at a depth of 4-feet depth. The city televised a total of 7,490 linear feet of mainlines of which 6,256 linear feet had been lined on a previous rehabilitation project. However, the laterals being the source of most of the water was infiltrating in to the system were not renewed. The water infiltrating into the system through lateral pipe defects then tracked behind the main liner, reentering the system at the service connections and manhole connections as shown below in Figure 4. It was recognized early on in the project that the ability to control the water would be key to the success of the pipe renewal processes. Good communication practices between the owner, the engineer, and the contractors also played a vital role in the overall success of this I&I removal project.

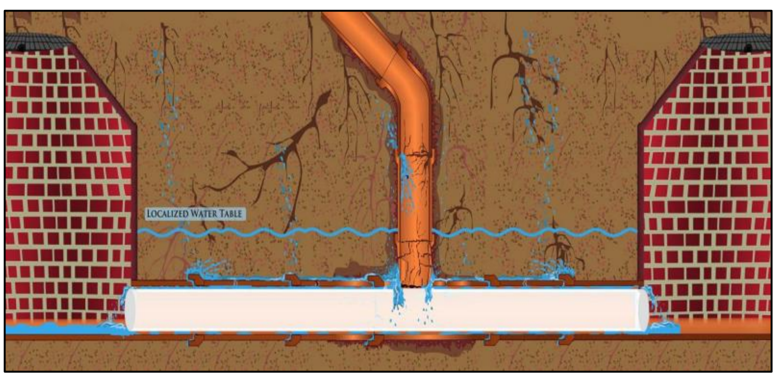

Figure 4: Water Reentering the System Post Mainline Rehabilitation

The work commenced with the crews setting up the required by-pass pumping system. The work had to be a carefully coordinated effort since it could only be scheduled around a falling tide otherwise the surcharged system would cause overflows in the lift station. A tremendous effort and timing was necessary to manage the water. The sea water was however vividly clear thus enabling the survey crew to collect the data using their CCTV equipment under water.

The first objective was to reduce the amount of water infiltrating into the system by installing liners during low tides. Chemical grout (Avanti AV-100) was pumped using a Logiball® Lateral Packer to control the seawater infiltrating the system. The grout was injected into lateral connections and manholes. Chemical grout was also injected between the host pipe and the existing folded mainline liner (6,256-feet from a previous lining project) that did not include end seals.

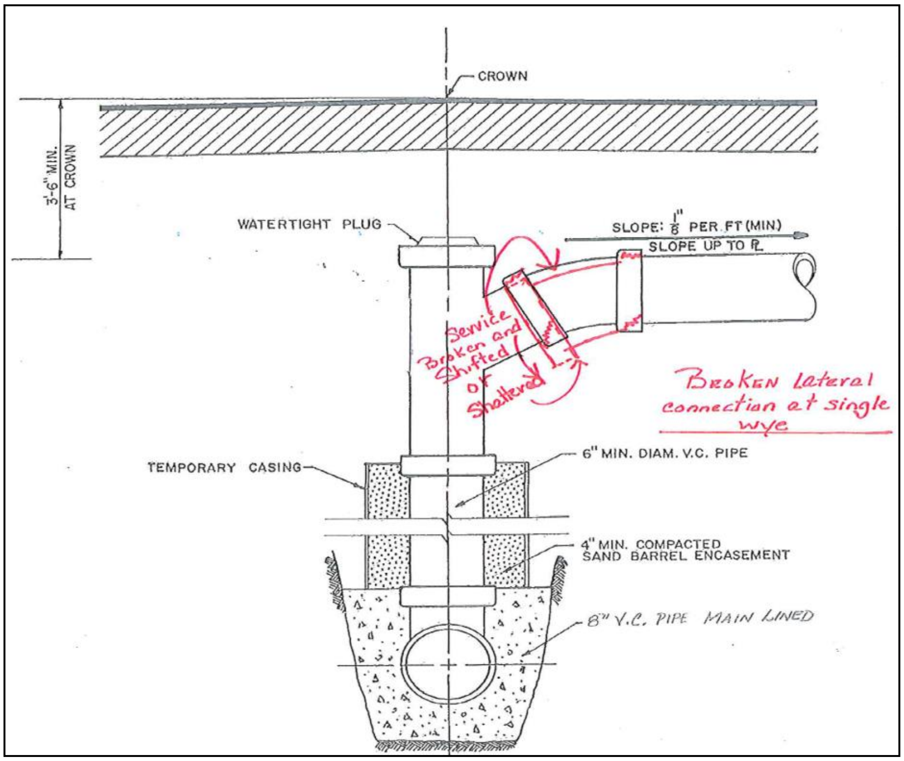

Figure 5: Cracked and Offset Joints Due to Ground Settlement

A few sections of mainline pipe in this system, approximately 1,234-feet, had not been lined. The mainline contractor renewed the remaining 1,234 linear feet of main pipe using the folded PVC liner. The Insignia™ End Seal, a tubular sleeve shaped gasket measuring 3.5-inches in length and having a gasket wall thickness of 2.5mm was inserted into each end of the mainline pipes. The gasket is made from neoprene rubber engineered to have hydrophilic properties that cause the gasket to swell when in contact with water which places the liner under compression and forms a positive flexible seal. The use of compression gasket seals at each manhole connection insured a water-tight connection to prevent water from tracking behind the liner and reentering the collection system. A number of inverted sectional CIPP liners were used to seal off abandoned service connections. The sectional repair methods and materials were compliant with ASTM F2599-11 and outfitted with compression gasket end seals ensuring a water-tight seal.

The service lateral pipes typically connected to the main pipe at 12:00 o'clock (a lateral stack) to bring the pipe up to a much shallower elevation where the pipe transitioned to a horizontal grade as shown in Figure 5. The crew used a special installation technique called "pull tape" to guide the liners from the main pipe up and around fittings as shown in Figure 5. A total of 74 service lateral pipes were rehabilitated using an ASTM F2561-11 compliant CIPP liner which includes compression gasket seals at the connection to eliminate infiltration into the collection system as shown in Figure 6. The average length of the rehabilitated lateral was 24-

Figure 6: Main to Lateral Connection Gasket

feet and every lateral liner was also outfitted with compression end seals at the upper end near the cleanout. Several of the lateral pipes required excavated point repairs due to settling and offset pipe sections.

THE RESULTS

This project was a small yet challenging job with big results that had major impacts on the entire collection system. The average daily flows and pump run times of the San Pedro/Lugo Station are demonstrated below in Tables 2, 3 and Figure 7. The pump run times went from a high of 30.81 hours in October of 2011 to a run time of just 4.23 hours per day post rehabilitation in August of 2013– essentially resulting in 86% decrease in pump run time.

Table 2: Pump Run Times Pre and Post Rehabilitation: Station A: San Pedro/Lugo

Month	Pump Run Times	Month	Pump Run Times
Aug-11	0.69	Aug-12	
Sep-11	21.26	Sep-12	20.39
Oct-11	30.81	Oct-12	22.80
Nov-11	28.66	Nov-12	
Dec-11	18.66	Dec-12	18.83
Jan-12	7.39	Jan-13	5.18
Feb-12	15.12	Feb-13	4.09
Mar-12	12.65	Mar-13	5.52
Apr-12		Apr-13	1.58
May-12	8.90	May-13	6.94
Jun-12	20.68	Jun-13	5.13
Jul-12	17.01	Jul-13	4.98
		Aug-13	4.23

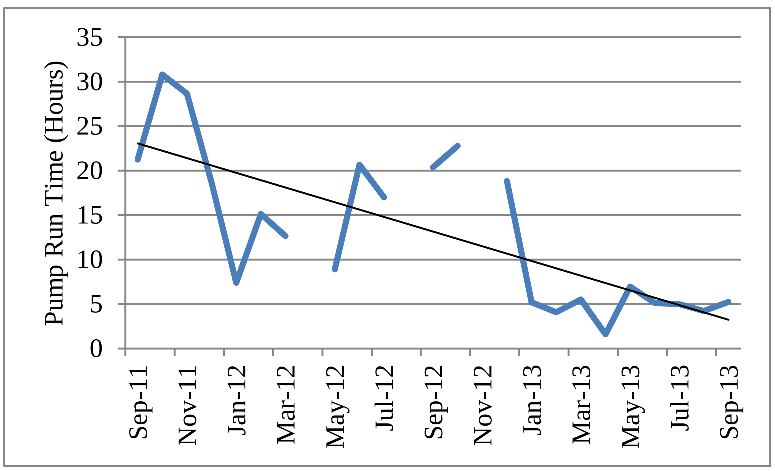

Figure 7: Decrease in Pump Run Times of Station A

Table 3: Average Daily Flow for Station A

Lugo Average Daily Flow (gpm)	
2012	**2013**
65	13
Lugo Cumulative Flow (Jun 15 to Sep 15) (gal)	
8.725 million	1.785 million

REFERENCES

ASTM Standard F1216, 2009, "Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube," ASTM International, West Conshohocken, PA, 2009, DOI: 10.1520/F1216-09, www.astm.org.

ASTM Standard F2599, 2011, "Standard Practice for The Sectional Repair of Damaged Pipe By Means of An Inverted Cured-In-Place Liner," ASTM International, West Conshohocken, PA, 2011, DOI: 10.1520/F2599-11, www.astm.org.

ASTM Standard F2561, 2011, " Standard Practice for Rehabilitation of a Sewer Service Lateral and Its Connection to the Main Using a One Piece Main and Lateral Cured-in-Place Liner," ASTM International, West Conshohocken, PA, 2011, DOI: 10.1520/F2561-11, www.astm.org.

North American Society for Trenchless Technology (NASTT)
No-Dig Show 2012

Nashville, TN
March 11-15, 2012

Paper B-3-02

Hydrophilic Gasket Sealing Technology: A Solution to Sealing Deficiencies in Cured in-Place Pipe Lining

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[1] Director of Marketing, LMK Technologies, Ottawa, IL
[2] Repair & Excavation Supervisor, City of Naperville Public Works, Naperville, IL

ABSTRACT: Current Cured in-Place Pipe (CIPP) technologies used to rehabilitate the collection system will not eliminate wastewater treatment plant costs associated with Inflow and Infiltration (I&I) without the inclusion of pipe end seals. There are many misconceptions about CIPP linings and water migration. Although the myth that CIPP linings bond to the host pipe has largely been discredited, it is still not commonly known that due to the physical properties of thermo-set resins, CIPP liners shrink due to polymerization as the liner cures resulting in an annular space between the liner and the host pipe. This annular space allows groundwater to track behind the liner and migrate back into the collection system causing not only a significant amount of avoidable wastewater treatment, but also sanitary sewer overflows (SSOs) and possible groundwater contamination should the affluent exfiltrate from the collection system. The awareness of this issue in the CIPP rehabilitation process has initiated research, which has led to the development of compression gasket end seals engineered to address the annular space at manhole connections and lateral connections using seamlessly molded hydrophilic gaskets during CIPP installation. Although a full-circle CIPP lining is a structural solution to sub-par piping infrastructure, it is not a water-tight repair as discussed above. As such, end users who rely on CIPP linings to attain a watertight seal, run the risk of allocating funds and resources to solve these issues without achieving their objectives.

1. INTRODUCTION

Today, our industry is more knowledgeable on CIPP linings; many owners and specifying engineers recognize that CIPP linings will restore the structural integrity of a sewer pipe but that they do not actually bond to the host pipe due to Fats, Oils, and Grease (F.O.G) that exist in the sewer line. All thermo-set resins shrink, some more than others, but since bonding does not occur, even the slightest amount of shrinkage provides an annular space allowing water to track behind the CIPP and re-enter the collection system at service lateral connections and manhole connections. CIPP linings have been known to reduce infiltration and exfiltration, but to properly rehabilitate a sewer system to be comparable to a new piping system; compression gasket sealing technology must be utilized. Compression gasket sealing technology has been used for many years in pipe joining applications, such as bell and spigot piping. The standard protocol of use for hydrophilic gaskets is to ensure a gasket is placed at each manhole penetration and lateral connection in a collection system to achieve a leak free connection. This results in a total system seal. A lateral connection liner that is sealed by using a hydrophilic connection seal will eliminate the infiltration at the main to lateral connection, but without the inclusion of end seals water will migrate behind the mainline liner and enter the collection system at manhole penetrations. Therefore, a total sealed system is comprised of an industry approved mainline liner, an industry approved lateral connection liner at each service, and an industry accepted manhole rehabilitation product, each with the corresponding compression gasket seal for their connections.

2. PREVIOUS METHODS OF HYDROPHILIC SEALING IN THE COLLECTION SYSTEM

Until now, many thought you could seal a lateral connection by gluing a collar to the inner side of the mainline liner. This doesn't work because the liner is not a structural repair and resins do not bond to the host pipe or the installed CIPP liner. There are no industry standards, ASTM standards, or test protocols for verifying that a resin saturated lateral connection liner will actually bond to a mainline liner. In cases where a liner did bond there are no industry standards or test protocol to determine how much hydrostatic pressure the bond can withstand. In addition, there are conditions in the pipeline that actually prevent any bonding from occurring.

Mainline CIPP liners do not bond to the host pipe for several reasons and similar issues apply when attempting to bond a *brim style* CIP-Lateral/Connection liner to a full-length liner, regardless of the thermo-set resin selected. The issues and concerns begin with the full-length CIPP liner tube, as it is prepared for pipe insertion by applying a lubricant such as mineral oil, vegetable oil, or the like to the external plastic film on the liner for the purpose of reducing friction as the liner tube inverts into the main pipe. These lubricants are release agents, materials that actually prevent adhesion. Even if the surface was prepared with high pressure hot water and scrubbing, the engineer has no reliable way of verifying that the installed mainline liner is prepared for adhesion. This is a major concern, and there are no proven methods, practices, ASTM standards or studies to describe or substantiate the success of removing lubricants applied to the mainline liner coating, and F.O.G. which are inherit in a sewer collection system. Even if a surface bond was created, one cannot scientifically quantify or engineer the bond strength, nor the service life of a CIP-Lateral/Connection liner (*brim* or *full-circle* construction) based solely on bonding to a cured-in-place-pipe, and it must be considered that ground water if present, is a persistent constant force which can exaggerate long-term creep. This is further supported by the absence of ASTM standards and engineering calculations to design the life cycle of a CIPP bonded to a CIPP. The solution to these concerns is ***compression gasket*** seals, a proven long-term pipe sealing method specified by engineers globally for joining bell/spigot pipe. Gasket sealing is compatible for use with all types of piping i.e. concrete, VCP, PVC, DI, CI, and etc. ASTM F2561 provides an engineered structural liner that includes compression gasket seals that are compatible with all full-length main lining materials. The gaskets are flexible and create the seal which is not compromised by thermal expansion/contraction, F.O.G., and has been tested to be leak-free when subjected to external hydrostatic pressure of 30-PSI. Upon installing an industry approved CIPP liner with the inclusion of compression gasket sealing technology, a structural, water-tight repair which is comparable to that of a new infrastructure system is made and unnecessary wastewater treatment plant costs associated with the deficiencies are eliminated.

Also, end seals are needed at the manhole connections; until now there have been attempts made to make that seal using a flat rope in the pipe prior to lining, but these seals possess design deficiencies.

Previously, the sealing of the annular space between host pipe and CIPP liner to prevent water migration behind the mainline liner from re-entering the collection system at the manhole has been attempted using a hydrophilic grout in the pipe prior to lining. Design deficiencies in application have rendered the hydrophilic grouting process an inadequate solution for a true sealed system. The grout itself is not a molded gasket set in a controlled environment which possesses uniform wall thickness and expansion properties. Typically, application of hydrophilic grout is performed by a packer with the grout in a liquid form which inflates using air pressure to adhere it to the crown of the pipe. Once the packer deflates the grout cannot work against gravity pulling it away from the crown of the pipe, and so the grout is not secured. In addition, air pressure used to apply the hydrophilic grout to the crown of the pipe forces the grout to spread from the point of repair, thinning it to an insufficient volume and un-even thickness. Even after expansion on contact with water, this application can continue to leak since there is not enough grout in the right places to sufficiently seal the connection after the installed CIPP has undergone polymerization.

Another method has been attempted to seal this annular space before CIPP rehabilitation using a hydrophilic rope. The rope is positioned covering the inside circumference of the pipe with one end overlapping the other. The design error with this method is the weak point where the rope is overlapped, which allows separation after the liner has been installed defeating the purpose of a full circle watertight seal. There have been methods which bond the two ends with glue, but since these two sealing applications contain no structural element to secure the rope or ring in place, these installations can result in this rope failing in the pipe by being pushed over or bent during lining leaving an even larger annular space between the liner and host pipe. These seals are also bulky and leave a bump in the newly rehabilitated pipe.

.

3. The Research and Development of a Solution

In the interest of creating a true sealed system that is safe, efficient, and provides a high quality and uniform seal, a product has been developed, that when installed in the CIPP liner creates a watertight seal in the rehabilitated area preventing I&I from tracking behind the cured liner and migrating back into the collection system.

Issues to be resolved in this research venture are as discussed above. Again, previous applications did not address a hydrophilic sealing product's uniform wall thickness, the security of hydrophilic material in the pipe at each point of installation including CIPP rehabilitation, and proper expansion and volume of the hydrophilic material for a watertight seal.

This project was initiated by researching a hydrophilic neoprene (not unlike those in bell and spigot piping) that expands upon contact with water. This expansion typically occurs within 48 hours and completes with a swell that, when left unconstrained, will grow three-dimensionally. Since these gaskets are constrained in the collection system between host pipe and liner, the swelling fills the annular space created by the shrinking of resin and creates a watertight seal. These gaskets will continually swell when water is present so that water can no longer track behind the liner and re-enter the collection system.

Recognizing the need for a solution, seals for manhole and mainline connections, lateral and mainline connections and overlapping CIPP liners have been produced. These seals offer a watertight solution and eliminate I&I due to the improved technology that has been applied from knowledge of the design flaws discovered with previously used sealing applications.

New hydrophilic end seal systems differ from the old technology in three ways. Firstly, the end seal is a seamlessly molded low-profile gasket; no glue or rope-like material is used. This negates weak points in the seal and guarantees a 360 degree watertight seal around the whole circumference of the pipe. Secondly, the end seal is held in place with a retaining ring which ensures a structural element during lining to aid in correct placement and installation. This means there is no movement of the seal during placement or lining, but the ring will hold the seal open to ensure no failed seals which have fallen down in the pipe will be lined over during installation of CIPP liners.

The technology for manhole and mainline connections has been adapted to serve main/ lateral connections in the shape of a swelling hat gasket. This hat is placed at the source of the infiltration where the water is tracking behind the liner. Therefore, by using these sleeves the end user gains the positives of hydrophilic sealing without the drawbacks of previous applications. With the additions of these seals during the installation process the installer is able to create a CIPP rehabilitation that is both a structural and watertight repair meaning after the installation of both the end user is confident that I&I has been not only reduced, but eliminated.

4. The Benefits of a Sealed System

The benefits to utilizing these new hydrophilic sealing gaskets are as follows: the repair is low profile, larger surface area allows for a thorough seal, retaining rings offer stability, uniform thickness and expansion ensure a high quality repair, and long lasting results eliminate maintenance and treatment fees associated with a faulty system. To prove that these swelling gasket seals work, we will refer to the city of Naperville, IL. The City of Naperville has been using this structural lateral connection liner in combination with these swelling compression gaskets. The benefits of a truly sealed sewer system take many forms. For example, until recently the city had experienced heavy growth. However, as the population rose the wastewater treated on a daily basis actually went down. This in turn saved treatment cost such as power, chemicals, labor and other related expenditures tied to daily wastewater treatment. In the City's case, a planned multi-million dollar plant expansion has also been deferred as a result of creating more system capacity by sealing the sanitary sewer system.

Another benefit is the greatly reduced maintenance costs associated with sewer systems. Areas that were root sawed yearly no longer need such. Lined mains also require far less cleaning. The basins that have been lined and sealed require cleaning every four years instead of yearly. These savings are significant and shouldn't be overlooked.

One benefit that isn't often discussed is the increased capacity the sewer main will have once the system is sealed. Recovered capacity in many cases will allow for more service connections which represent a revenue enhancement that does not involve an increase in fees and or taxes.

The City of Naperville spends about 2.8 million dollars per year on sealing the sanitary sewer system. This money is spent on the lining of mains and laterals and on the sealing of manholes. Concentrating system sealing in troubled basins has provided the most effective method of reducing I&I. By doing so, all of the benefits above have been achieved.

ILLUSTRATIONS

Number illustrations (whether drawings or photographs) consecutively in the order of appearance and refer to them as Figure 1, Figure 2 to 4, etc. Avoid placing illustrations sideways on a page; however, if this is not possible, no other text should appear on that page (Najafi, 2003). Photographs should be of good quality contrast. Figure lettering should be approximately the same size as the text with a minimum of 10 point font. Make sure that illustrations borrowed or adapted from another source are properly acknowledged.

Captions should be placed immediately below the illustration.

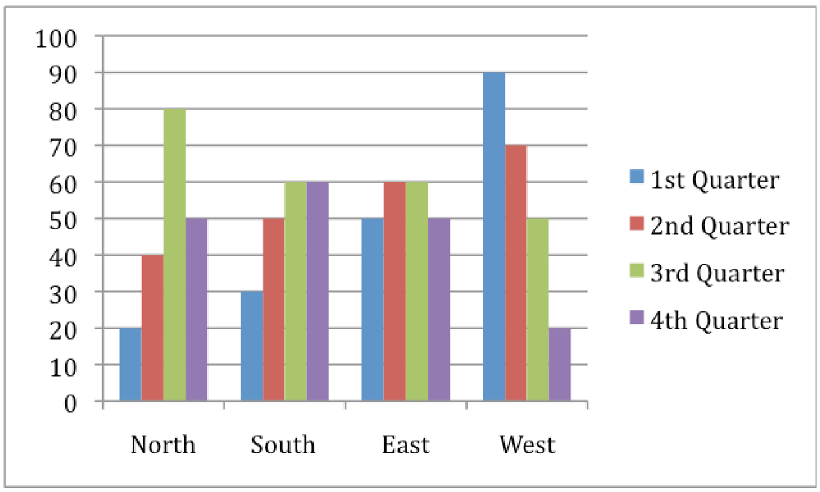


Figure 1. Guidelines for No-Dig Show 2010: sample figure and positioning of the legend.

5. TABLES

Number tables consecutively in order of appearance and place them as close as possible to where they are first referenced in the text. Refer to tables as Table 1, or Tables 1 and 2, in the body of text. Avoid abbreviations in column headings (other than units). Indicate units in the line immediately below the heading. Type the caption above the table to the same width as the table, and do not leave a line space between the table caption and the table.

Table 1. Sample table for the as explained in the requirements for papers.

Title	**Sub-title (units)**	**Sub-title (units)**
Line 1	1234	4321
Line 2	1321	8765

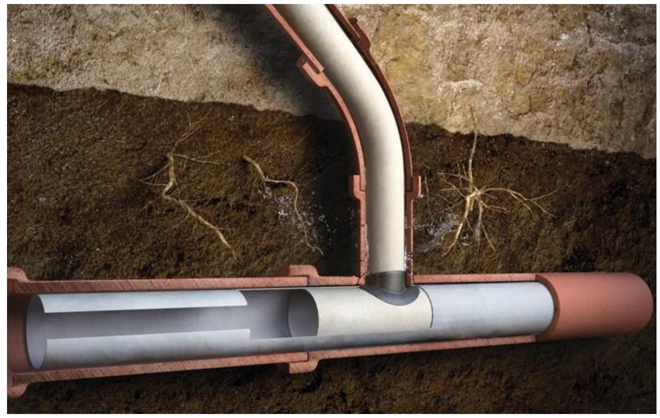
6. REFERENCES

Gokhale, S., and Ariaratnam, S. (2002). Life Cycle Modeling of Sewer Infrastructure, Journal of NoDig Engineering, Volume 3, No. 2, pp. 33-42.

Najafi, M. (2003). Educational needs in Trenchless Technology. Proceedings of No-Dig Show 2003, Las Vegas, Nevada, March 31-April 2, 2003.

Lateral Lining in Florida

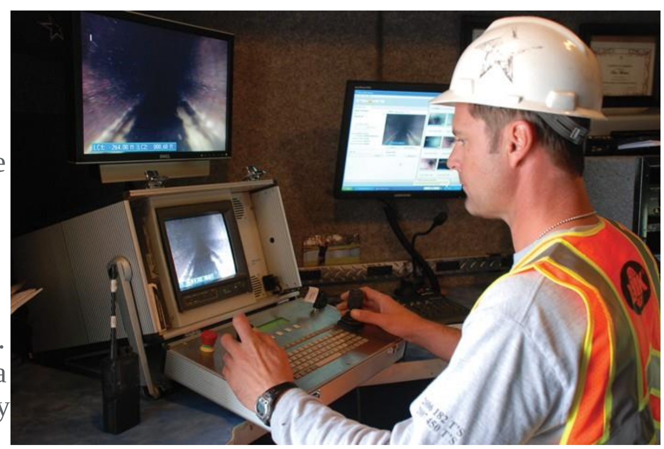
April 2, 2014 Archives



Today's municipal infrastructure projects are often awarded to the lowest bidder. Too often that is also coupled with a utility's use of bid specifications driving work to a lowest common denominator approach that saves money in the short-run, but leads to a low quality solution and increased costs for the long term.
Here is how one Florida community reduced inflow-and-infiltration (I/I) by 232 million gals and stands to save $368,000 per year, with an investment of $1 million.

What makes this project different from other lining projects?

The Coral Springs Improvement District, located in Broward County, Fla., is contained within the City of Coral Springs. The District manages its own collection and water systems and is home to around 45,000 residents.
Lift Station Basin No. 1 was placed in service in 1974; the collection basin serves more than 400 single family homes. There are approximately 20,600 ft of 8-in. VCP mainline pipe and 6,000 ft of 6-in. VCP lateral pipes. In 1999, the District lined 17,000 ft of mains to reduce pump run times which produced positive results, but not the long-term results they needed. The District had continued to experience unacceptably high levels of I/I. The laterals were suspected as the major cause of the problem, so the District took an aggressive approach to investigating the root cause of the problem and finding a long-term solution.



Twenty-year-veteran, director Dan Daly of the Coral Springs Improvement District, was the driving force behind the project. Day-to-day management of construction was overseen by foreman Curt Dwiggins and field supervisor Steve Seigfried.

The first phase of the project consisted of inspecting all laterals in the entire basin area, and mainline pipe that was not lined in previous years. The laterals were inspected by launching a camera up the lateral from the main to the private property line. Inspecting the laterals was challenging because the infiltrating groundwater kept the system surcharged. LMK Pipe Renewal of Fort Lauderdale provided organized spreadsheets and PACP video inspection reports identifying the condition of the pipe and what repairs would be required to seal the system.

It was determined there were three major sources of infiltration occurring:

1. Groundwater was tracking behind the mainline liners and entering the system where the mainline liner was cut open to reinstate the service connections. Additionally, the terminating ends of the old mainline liners were leaking allowing ground water to enter the system.

2. The lateral survey revealed leaking lateral pipe defects such as cracks, calcium deposits, offsets, holes, roots and staining.

3. There were also defective mainline segments that were not lined during the 1999 project.

The District was quite clear about new repairs to the system: The goal was to “seal the system, not just line it.” The hidden value rested in sealing the mainline water tracking issues and renewing the laterals with a positive seal to the mainline liners. All materials installed on this project were required to comply with industry recognized ASTM standards. The lateral pipes were renewed and sealed in accordance with ASTM F2561-11, which was comprised of a one-piece full-hoop main and lateral CIPP outfitted with compression gaskets. The mains that were renewed with CIPP were installed in accordance with ASTM F1216 and the terminating ends were also sealed by use of Insignia Seals, which are tubular molded swelling compression gaskets.

The District’s concerns were solved by the incorporation of compression gaskets at the service connections and the terminating ends of the CIPP lateral lining. These gaskets provide the same type of seal that is used on PVC pipe, DIP, concrete pipe, etc., but these gaskets are designed specifically for use with CIPP and folded plastic liners. When the gaskets are positioned between the pipe-liner and the host pipe, they create a compression gasket as they swell in the presence of moisture or water. These gasket seals make CIPP similar to that of new direct bury pipe. An added benefit that the District liked is the gaskets; they’re visible through the liner allowing inspectors to be certain that a seal is properly placed and verifiable.

There is a common misunderstanding about CIPP pipe lining. Assumptions that the resin sticks or bonds to the host pipe are not valid; little or no bonding occurs and the explanation is practical from an engineering design point of view. The host pipe actually acts like a mold, yet shrinkage commonly occurs through polymerization of the resin, and thermal expansion/contraction occurs along with earth movement. Likewise, FOG (fats, oil and grease) prevents bonding. These conditions create an annular space where the constant groundwater pressure migrates between the pipe and the liner only to leak back into the system at lateral reinstatements and into the manholes. The Insignia Seals situated in the annular space, expand and form a compression seal between the host pipe and the new liner.

“For the past five years, CSID has been upgrading and updating much of our infrastructure. We had many projects that went smoothly and a few projects that seemed to have a life of their own. Fortunately the LMK relining and system sealing was the smoothest project to date. Between our CSID personnel and LMK’s project manager and crew, we were happy to be able to report our progress to the Board of Supervisors each month. There were not any change orders needed for this project and LMK finished on time,” said Daly. “Since we operate our own wastewater treatment plants here on our CSID campus, we are able to appreciate the reduction of inflow on a daily basis when our area receives a large amount of rain. No longer are we processing rain water inflow that used to manifest itself in Lift Station 1 due to leaking laterals and tree root laden sewer pipes. It was very important to CSID to have documentation and video of the entire project, start to finish. We are currently evaluating another Lift Station basin and anticipate beginning the camera documentation soon, and you can bet that we will opt for LMK.”

“The significant amount of I/I reduction impacted other stations in the system and brought our utility management issues under control. Lift Station Number 1 pumps into a manifold force main, we have seen a reduction in adjacent stations run times as well. This further reduces stress on the pumps beyond this station. These reductions weren’t even part of the savings calculated. It’s just another benefit to the system for correcting excess infiltration,” said Seigfried.

“This is our largest lift station in the system and it was experiencing large amounts of infiltration; I didn’t think we would ever see the bottom of the station again. With the repairs performed, the pressures are down in the overall system and we haven’t had a call out on this station since we did the project,” said Dwiggins.

“The amount of groundwater infiltrating made it difficult to work in the system. For the most part, the mains were already lined; the water was tracking and also coming down the laterals ending up in the sewer. We had to isolate and pump down the section in which we were working. We could tell that we were having a big impact on the system because the more work we performed, the less bypass pumping we had to do. The system was drying up! In this station we reduced the flow by approximately 636,000 GPD. To put this into perspective, that’s about 32 swimming pools per day. All that water now remains in the aquifer instead of being pumped down the sewer,” explained LMK Pipe Renewal project manager Mark Gulyas.

The result is a conservation of our groundwater resources, protection of the environment, and a good return on investment. The District invested $1 million for this rehabilitation project, which was completed over a 10-month period. The District reports reduction of infiltration into its system by 232 million gals annually, with savings of $365,000 yearly. Even though years earlier a large part of the system had the mains lined, it wasn’t until the laterals were lined that the hidden value in the previous lining project was revealed. The payback for the entire project is just 2.6 years, and going forward the District’s investment will actually continue to save or earn CSID $365,000 each year for the life of the repairs.

Quality wins out every time when you consider the cost of resolving defects left behind by inadequate designs. Savings are waiting to be realized, this project is a win-win for many years to come.

North American Society for Trenchless Technology
2007 No-Dig Conference & Exhibition

San Diego, California
April 15-20, 2007

Paper #

PORTLAND BES ADVANCES IN SEWER MAINTENANCE AND REPAIRS BY OPERATING MULTIPLE CIPP CREWS.

Joe Dvorak[1] and Larry Kiest, Jr. [2]

[1] Bureau of Environmental Services, City of Portland, Portland, OR
[2] Department of Engineering and Design, LMK Enterprises, Inc., Ottawa, IL

ABSTRACT: This paper will discuss how the City of Portland has successfully attained a wealth of experience and knowledge through years of training and technology transfer which allows the city's crews to perform sewer repairs in a matter of hours that in some cases would normally consume weeks of heavy construction with serious disruption to the public at extreme cost.

The City of Portland, Bureau of Maintenance (BOM) has been installing cured in-place pipe (CIPP) with in-house crews since 1998 and today, operates one-full time lining crew. This crew has made repairs 50' deep and 50' long, in as little as one work day. In addition, six repair crews, who typically specialize in open-trench repairs, also install CIPP in laterals. Funding is currently underway to add an additional full-time lining crew specializing in mainline rehabilitation and T-Liners.

The city's lining operations consists of mobile units. The largest unit is housed in a 38-foot 3-axle 5th wheel trailer which is temperature controlled; outfitted with three phase AC generator, screw air compressors, vacuum pumps, lighting, safety equipment, wet-out table and storage

The city's crews are stocked with bulk lining tubes, bulk inversion bladder tubes and thermo-set resin. This "bulk lining" system allows the city crews to make repairs immediately when pipe conditions are critical. The City of Portland partnered with LMK Enterprises, Inc. in 1998 for lining materials, equipment and technology transfer. The lining trailers and installation units are custom built by LMK Fabrication, Inc. and Portland BES is supplied with Sectional and Lateral CIPP pipelining systems by LMK Enterprises. The main objective is to fix defective sanitary and storm piping as quickly as possible while minimizing disruption to the public, reducing environmental impact and maximizing cost saving to the department of BES.

I. INTRODUCTION:

A. The City of Portland is known as the city of bridges and Portland prides itself on keeping things moving not only above ground, but also below ground. The Bureau of Environmental Services (BES) is responsible for maintaining some 2,200 miles of the city's sanitary and stormwater collection system. Maintaining this vast network of sewer pipes involves identifying and repairing structural defects. Historically, the Bureau of Environmental Services has relied upon conventional excavation for making repairs to its sewer mains and sewer laterals.

II. HISTORY

A. In 1995, the city was faced with a failing 15 inch storm sewer. This particular storm line was laid on an extreme grade and in front of the KOIN Tower located downtown Portland. During heavy rainfall, the failing pipe contributed to flooding of the adjacent buildings underground parking garage. The city's Maintenance Engineer Tom Caufield contacted LMK to make repairs to the pipe using their cured-in place sectional process. LMK's crews installed two 15" x 30' CIPP sectional liners in one day and the problem was solved.

III. MUNICIPAL CIPP CREW

A. The success of the repairs made at the KOIN Tower promoted to the city's inquiry to adopt LMK's technology as a method for pipe repair for the Bureau of Environmental Services. In 1998, the city of Portland took possession of their first CIPP lining trailer. The trailer was a 30 foot self contained unit complete with temperature control, vacuum impregnation equipment, remote positioning and air inversion launching tools.

B. The Bureau of Environmental Services appointed specific city employees to the city's new CIPP lining crew. The crew was trained by LMK's certified trainer. Training consisted of class room training and on-site training during actual liner installations within the city of Portland. The crew was trained how to effectively repair sections of sewer mains by using a unique air inversion process that is chemically cured and therefore does not require hot water or steam which is typical with most CIPP lining systems. Educating the crew with proper handling of resins, mixing of resin and catalyst and vacuum impregnation was essential to ensuring a proper finished CIPP.

IV. TECHNOLOGY

A. The city is pleased with the containment aspect of the inversion system as compared to traditional pull-in place sectional liners. This unique inverted sectional system complies with ASTM Standard F2599-06. The city crews deploy vacuum impregnation technology to apply the thermo-set resin to the liner tube as it is positioned within a translucent bladder. When the liner tube is positioned within the bladder tube, they are then referred to as a liner/bladder assembly. Since the bladder is translucent, the workers can visually verify the liner is thoroughly saturated ensuring no dry spots remain before liner insertion. Once the liner is resin impregnated, the liner/bladder assembly is loaded into a flexible tubular launching device. As the launching device is pulled to the point of repair, no resin is lost or contaminated since the wet-out liner tube is contained within the launching device.

B. The city is also concerned about workers safety and the fact that the LMK system contains resin during resin impregnation is huge benefit to workers safety and environmental concerns.

V. INVESTMENT AND SAVINGS:

A. The city's crew began installing liners in diameters of 8 – 12 inches and lengths up to 10 feet. One of the repairs the city's crew completed was on a very deep sewer, nearly 50 feet deep. The crew completed this repair in one day and the savings the city's crew achieved with this one repair more that covered the city's entire investment including training and equipment.

B. Since 1998, the city's crew has become one of the most skilled crews for CIPP linings utilizing vacuum impregnation of ambient cure resins, air inversion techniques and ambient curing methods. The city's crews have expanded their capabilities by installing several linings in multiple line segments including cleaning, pre and post video documentation within one days work. Their experience and capabilities have expanded to liner diameters up to 24 inches and liner lengths up to 50 feet.

Crew Lining Sewer in Sensitive Area

C. The city's lining crews have produced savings that are significant. The Sectional Inversion Lining System has allowed the cities maintenance crews to make more repairs in less time than compared to traditional excavation. City crews make repairs faster and more efficient and save costly restoration to streets, curbs, sidewalks and avoid damage to trees.

VI. CIPP LATERAL LINING:

A. With continued results from practicing the sectional inversion system, the city expanded their capabilities to include lateral lining. In 2000 the city purchased LMK's T-Liner system, a one piece main and lateral CIPP lining system that complies with ASTM F2561-06. This lateral lining system renews 16 inches of the main pipe (5 inches on each side of a 6 inch service connection) and the lateral pipe so both the lateral pipe and main connection is renewed. The entire installation is made remotely from the main pipe with absolutely no digging.

VII. EXPANDING CREWS CAPABILITIES:

A. Portland's crews have become so knowledgeable in the use of LMK's CIPP inversion system, that they have set-up a small version of LMK's manufacturing facility. Today, Portland's crews order liner tube and bladder tube in bulk, cut lining tubes and bladder tubes to the appropriate lengths and assemble the liner/bladder assemblies at Portland's Bureau of Environmental Services facility.

B. Portland's crews not only assemble the liner/bladder assemblies, but they also calculate resin quantities and promote and mix bulk resin in-house. This in-house knowledge has earned Portland the opportunities to adjust the cure time based on site specific conditions for each repair. The bulk liner, bladder and resin system has taken Portland's crews to one of the highest level within LMK's group of installers. This advanced technology for Portland has also proven to be not only economical for the city's material purchases and adjustable for site conditions, but also has proven to be extremely beneficial in cases of emergency sewer repair situations.

VIII. MUNICIPAL HEROS:

A. Portland's success has not gone unnoticed by other municipalities. Many neighboring cities have visited Portland to see for themselves the success of the city's CIPP lining crew. Several municipalities have followed suit appropriating funds for their own municipal CIPP lining crew.

B. Surrounding municipalities have also hired Portland's CIPP lining crew to make sewer repairs in areas where excavation would have been detrimental to their communities.

C. Currently, Portland operates one full-time lining crew, with six other repair crews with lateral lining capabilities. Portland is budgeting funds to expand to another complete lining crew. The results with the city's CIPP lining crew speak for itself, yet most residents don't even know the Bureau of Environmental Services repaired a failing sewer under their streets, walkways and landscaped areas. Many repairs are made at night extending a greater service to Portland's residents and businesses by minimizing traffic impacts and not requiring a reduction in sewer service.

IX. CONCLUSION:

A. The city has completed more than 900 CIPP liner work-orders since 1998 making cost effective repairs to sewer mains and lateral pipes saving time and money. Not only does Portland work hard to keep their sewer collection system maintained, they accomplish their task by trenchless methods which keep residents and business moving.. The City of Portland has made an investment in their infrastructure and is leading the way for other municipalities to understand how city crews can make a huge impact on maintaining municipal infrastructure by utilizing modern technologies that are typically practiced by private contractors.

B. LMK holds 43 issued patents on methods for renewing lateral and main pipes. LMK has licensed their patent rights and Know How rights to 43 licensed installers and has licensee coverage in Argentina, Brazil, Canada, Denmark, Germany, Holland, Mexico, Singapore and the Far East, Sweden, and the United States. LMK recognizes the City of Portland as one of the most aggressive installers of LMK'S technology. Other municipal installers include Tulsa OK, Wichita KS, Charleston SC, Naperville IL, Rock River Sanitary District, Zanesville OH, Porter Tower City Authority PA, Village of Addison IL and the Village of Lombard.

ATTACHMENT 5
"Double Stack-Sewer Service Connections in South Florida"
Trenchless Technology Magazine

DOUBLE STACK

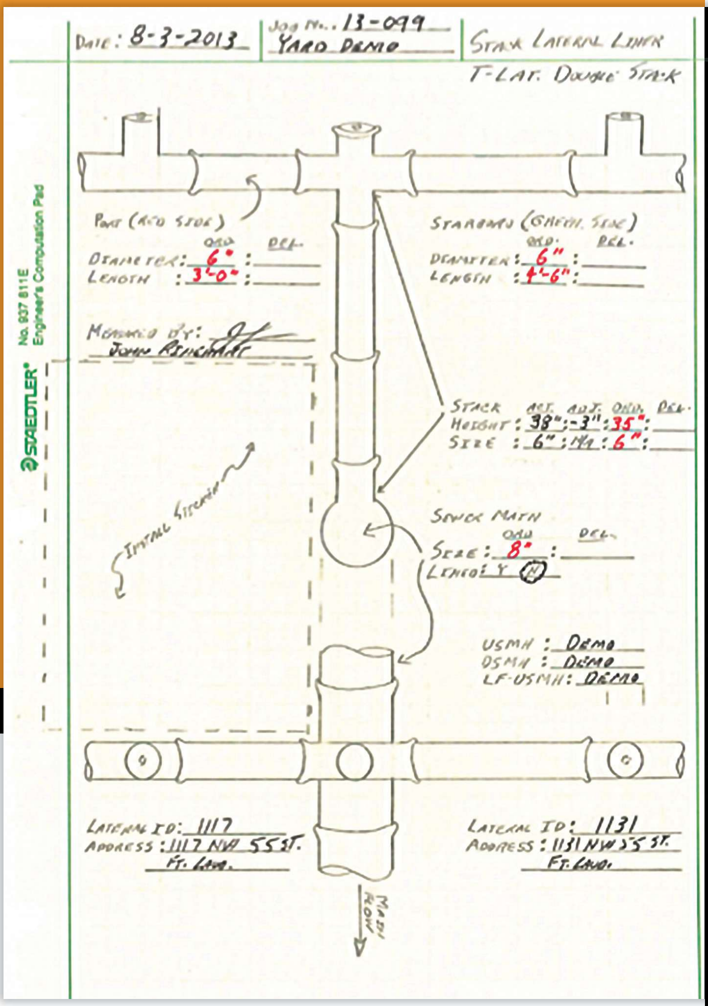
SEWER SERVICE CONNECTIONS IN SOUTH FLORIDA

By Larry Kiest Jr.

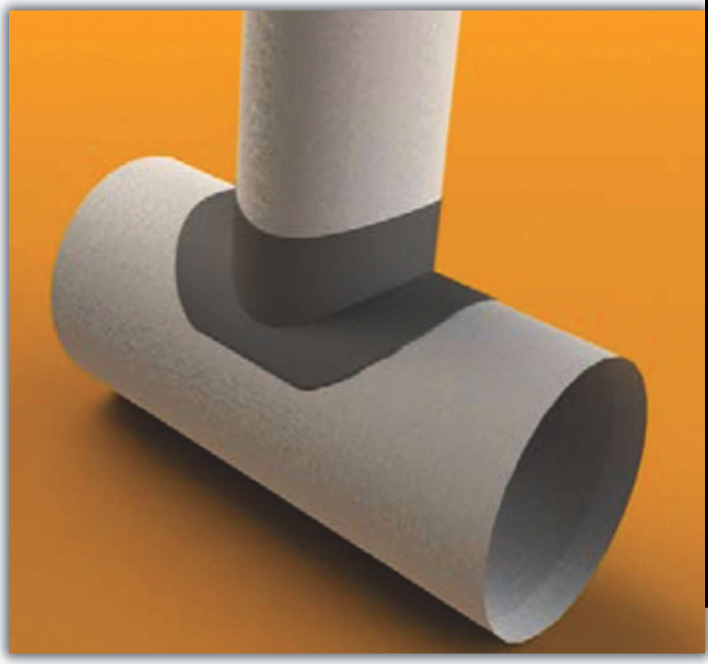
After 45 Years, the cured-in-place pipe (CIPP) process has become the "anchor" of trenchless pipeline rehabilitation. Since the initial installation in 1971, the evolution of materials and processes has brought about new applications for CIPP rehabilitation. It is the continued research and development over the past 45 years that has advanced the capabilities of CIPP, and, today, the resin-saturated liner, inverted in a pipe, is used to make repairs that were yesterday considered impossible.

All over South Florida, municipalities are investing significant resources in renewing their sewer infrastructure — and for good reason. The groundwater conditions in certain areas of South Florida are atrocious, and the amount of water that can enter a sewer collection system through pipe defects brings a staggering cost to municipalities and their rate payers. Municipalities and their contractors are working diligently to renew and seal their collection system, but not without a unique set of challenges due to the groundwater conditions, infrastructure configuration, and double-stack service connections.

South Florida's groundwater conditions are mostly running sand/water. When the system was installed, it was advantageous to bring the lateral pipes straight up as to be out of the groundwater table as much as possible. Since hardly anyone has a basement in South Florida, this was easy to do. Normally, you see lateral connections at 3:00 or 9:00, but in this case, the lateral connection is at 12:00 and runs straight up to a bull-headed TEE or double WYE fitting. From there, one pipe runs laterally to the left and another pipe runs laterally to the right. The lateral pipes were then split again by use of a double WYE fitting located near the property line servicing two properties in each side of the street. This unique pipe configuration can be found in



Notorious Double Stack Laterals



Double Stack Liner Assembly

municipalities all over Florida. At the time sewer systems were installed, it made good sense, since one lateral connection coming off the main provides service to four properties. This would drastically reduce the number of lateral connections, and the vertical rise to an elevation above the main pipe meant a much shallower lateral trench was needed to install the system.

Numerous utility agencies have the same challenge, how to repair the notorious "Double Stack" Lateral pipes without the cost and disruption of conventional excavation. LMK Pipe Renewal (a Florida contractor) set out to find a solution to the unique double stacked piping system. The challenge for CIPP would be the ability to measure in detail the length of the riser pipe, as well as determine the orientation of the double WYE or TEE fitting. This information is crucial for manufacturing the custom made liner. Another challenge is presented when selecting the best material for the liner. Any stretch in the material would mean the liner would be too long causing wrinkling. Lastly, end seals by way of fitted CIPP gasket is always considered best practice for a leak-free liner… So, there were plenty of challenges in designing a CIPP solution for the notorious the CIPP Double Stack liners.

The Double Stack CIPP Liner

The solution was to use a single piece CIPP that rebuilt the main/lateral connection (including compression gaskets) in accordance with ASTM F2561-16. A main liner tube measuring 20 in. in length was installed in the main pipe and includes a vertical lateral portion (5 to 6 ft long) that forms a T-shape. This T-shaped liner is outfitted with a flange shaped compression gasket that is seated into the lateral connection. The vertical lateral liner portion extends to another upside down TEE (hence the term double stack). From this point, two lateral liner tubes would extend laterally toward properties on opposite sides of the road. Additionally, it is not uncommon for the liner to transition from a 6- to a 4-in. diameter, so the accuracy of these measurements is also crucial. To ensure water tightness, hydrophilic O-rings were attached to the terminating ends of the lateral liner tubes as described in the F2561 industry standard.

The Installation Process

Pipe Renewal has had numerous contracts where the notorious Double Stack laterals were found, but were historically not included in the CIPP work. The contractor worked closely with LMK Technologies (a supplier of CIPP products) on the equipment/methods used for obtaining the pipe detail and on how that information would be used to manufacture the custom tailored Double Stack liners. The contractor initially performed a pipe survey from the main pipe to the invert of the upper TEE fitting. Additionally, each lateral was surveyed from a clean-out to the center of the vertical riser, or center of the TEE fitting. The necessary information was obtained, a pipe detail was prepared, and the first liner order was placed. The crew then assembled a pipe mockup matching the pipe configuration they surveyed in the ground.

The testing in the piping mockup was the same as an actual in-ground installation. The liner assembly is saturated with a thermoset resin under a controlled vacuum. The technicians first saturate the two lateral tubes using a calibration roller, then the main tube is saturated. The saturated liner assembly is then loaded into a launching device, towed through the main pipe so the opening in the launcher is aligned with the lateral opening, and for Double Stacks that opening is always at 12:00.

Full-Hoop Lateral Connection Liner outfitted with Compression Gasket

A technician is then outfitted with a lateral sewer camera at each sewer cleanout located at the property line on opposite sides of the street. The image captured by the sewer camera allows the technicians to robotically position the liner and apply air pressure causing the main tube to inflate and the lateral riser tube to invert straight up to the TEE. As the liner inverts, the camera operators pull the lateral camera back, keeping a visual on the inverting liner. As soon as the liner hits the crown of the inverted TEE, the two lateral liners begin to simultaneously invert. The lateral tubes can be 30 ft in length meaning the cleanouts can be 60 ft apart.

The liners are inverted and cured with steam, which ensures a thorough cure. The liner is then cooled down and the inflatable bladders that press the liner tight against the pipe wall are removed. The result is a single piece homogenous CIPP including compression gaskets that renews the main connection, the riser pipe, and two laterals through one completely trenchless installation. This process was performed time and time again and as one might suspect, there was a lot of fine tuning. Good communication with the liner manufacturer and the ability to work with numerous municipalities in South Florida allowed the contractor the ability to prove a viable solution to the notorious Double Stack laterals.

Since that first installation in 1971, CIPP continues to be the ever changing advancing technology that provides sound engineering solutions for municipalities everywhere. Its versatility and proven longevity make it appropriate for a variety of applications.

Larry Kiest Jr. is CEO and CTO of LMK Enterprises.

ATTACHMENT 6

ASTM F3097-15 Standard Practice for Installation of an Outside Cleanout through a Minimally Invasive Small Bore Vacuum Excavation

Designation: F3097 − 15

Standard Practice for Installation of an Outside Sewer Service Cleanout through a Minimally Invasive Small Bore Vacuum Excavation[1]

This standard is issued under the fixed designation F3097; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers installation methods, test methods and required materials for the installation of an outside sewer service clean out, by means of a small vacuum excavated borehole. The utilization of this practice greatly reduces disruption to the general public and requires minimal restoration.

1.2 *Units*—The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C920 Specification for Elastomeric Joint Sealants

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2855 Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings

D3034 Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings

F412 Terminology Relating to Plastic Piping Systems

3. Terminology

3.1 Unless otherwise indicated, definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *adhesive/sealant*—an elastomeric bonding agent designed to provide a water activated, leak resistant flexible bond between a PVC pipe saddle and a lateral sewer service pipe.

3.2.2 *borehole* —a small diameter vacuum excavated hole.

3.2.3 *cleanout*—a fitting located on a lateral sewer service pipe having a vertical riser pipe extending therefrom to the surface providing access to the lateral sewer service pipe.

3.2.4 *cleanout riser pipe*—a section of pipe that is connected to the boss of a saddle and extends from the saddle to the surface.

3.2.5 *coring*—the process of remotely cutting a hole through the crown of a sewer service pipe such that the coupon is retrieved to establish communication from a cleanout riser pipe and a lateral sewer service pipe.

3.2.6 *coupon*—a disc shaped piece of the lateral sewer service pipe produced by coring.

3.2.7 *lateral sewer service pipe*—a sewer pipe that connects a building to a municipal, main sewer pipe in a lateral direction and collects sanitary waste or storm water.

3.2.8 *saddle*—a PVC saddle that encompasses more than 50% of a lateral sewer service pipe where the side walls of the saddle extend beyond the spring line of the host pipe. The saddle includes setoff tabs that allow for uniform distribution of the adhesive/sealant.

3.2.9 *setoff tabs*—Protruding tabs located on the underside of the saddle one located on each side of the saddle boss for the purpose of insuring a specific annulus between the host pipe and the saddle and a specific layer thickness of adhesive/sealant.

3.2.10 *sonde*—a device outfitted in a closed circuit video inspection camera that emits a signal in subterranean pipelines that is traceable by use of a locating receiver at surface.

4. Summary of Practice

4.1 The process of installing a cleanout through a minimally invasive excavation begins with locating the 4 in. or 6 in. sewer service lateral. This is accomplished by use of a CCTV outfitted with a locatable sonde and vacuum excavating a small borehole, providing access to the exterior surface of a lateral

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[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

sewer service pipe. Once the lateral sewer service pipe has been exposed, a self-clamping saddle is prepared by applying a specified amount of adhesive/sealant to the underside of the saddle and a riser pipe is attached to the boss of the saddle. The prepared saddle is lowered into the small diameter bore hole until it contacts the lateral sewer service pipe; a downward force is applied to the riser pipe causing the side walls of the saddle to spread and encompass more than 50-percent of the host pipe. Surface restoration is minimal and in most cases is accomplished the same day the cleanout is installed.

5. Significance and Use

5.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the installation of a sewer service cleanout

6. Components

6.1 The saddle shall be formed as a semi-circle and shall encompass more than 180-degrees of the pipe circumference. The saddle shall have an inner diameter equal to the outer diameter of the host pipe (see Fig. 1).

6.2 The riser pipe shall be PVC pipe in accordance with Specification D3034.

6.3 Adhesive/Sealant shall be in accordance with Specification C920.

6.4 The solvent cement shall be in accordance with Practice D2855.

7. Tools Required for Installation

7.1 *Vacuum excavation unit*—mobile piece of equipment that supplies sufficient volume of vacuum necessary to excavate a vertical bore hole.

7.2 *Coring equipment*—A suitable coring saw with an outer diameter ⅛ in. less than the inner diameter if the riser pipe with a cutting blade suitable for the specific pipe material on which the cleanout has been installed.

7.3 *Power head*—power device that rotates the coring saw.

7.4 *Extension rods*—extension shafts that connect the power head to the coring saw. Available in various lengths according to the depth of the service lateral pipe that the cleanout is being attached to.

7.5 *Video camera*—CCTV camera that's outfitted with a sonde locating device and a compatible receiver. The camera is suitable sewer pipe conditions.

7.6 *Water*—The amount of water required to perform the exfiltration test is outlined in Table 1.

8. Procedure

8.1 The first step in installing a trenchless sewer service cleanout begins with locating the non-lined lateral sewer service pipe. A method utilized and associated with this installation process consists of inserting a video camera with an internal sonde into the lateral service line remotely from the mainline pipe, or from the interior building cleanout. A technician at the surface uses a compatible receiver to locate the signal from the camera/sonde to mark the specific location for the new cleanout as dictated by the utility owner (Refer to Fig. 2). The identified location shall be marked by driving a steel pin in the soil when possible, or marking the surface with marking paint. The video camera operator shall determine the condition of the lateral pipe is suitable for the saddle placement prior to vacuum excavation to form the borehole.

8.2 A borehole approximately 20-in. in diameter is created by vacuum excavation. This is accomplished by cutting the soil by use of compressed air or by water jetting. The loosened soil is simultaneously drawn under a controlled vacuum through suction tubing and discharged into a mobile debris tank (Refer to Fig. 3). This process continues until the lateral pipe is exposed. The sewer service pipe is cleaned to remove debris. The cleaning process is accomplished by using an extendable water pressure cleaning nozzle. A saddle is affixed to one end of a PVC riser pipe using solvent cement in accordance with Practice D2855. The elastomeric adhesive/sealant is applied to the underside of the saddle. The pipe and saddle are lowered down into the hole until the saddle contacts the pipe, a manual downward force is applied to the riser pipe causing the side walls of the saddle to spread until the lower most portion of the saddle extends a short distance beyond the spring line of the pipe causing the saddle to draw down onto the pipe producing a clamping affect.

8.3 Once the saddle has been installed, (Refer to Fig. 4) approximately 4 oz. of water is introduced into the riser pipe in order to activate the adhesive/sealant. Once the recommended

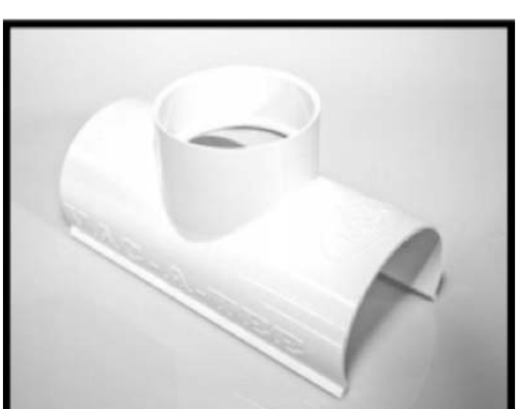

FIG. 1 Saddle greater than 180°

TABLE 1 Water Volume Required to Perform Leak Test

Depth of Lateral (ft)	Amount of Water Required (Gal)
6	15.68
7	18.29
8	20.90
9	23.51
10	26.15
11	28.73
12	31.36
13	33.96
14	36.58
15	39.18
16	41.80
17	44.40
18	47.02
19	49.63
20	52.25

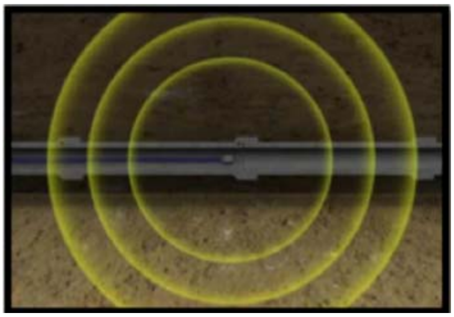

FIG. 2 Locating the Lateral Pipe

FIG. 3 Vacuum Excavation Equipment

time has passed after the saddle has been attached to the pipe and the vacuum excavated borehole is filled and compacted with approved backfill material such as sand, the water test is performed. Once the water test has passed, the crown of the lateral pipe is cored by means of a powered core saw that is inserted down the riser pipe into contact with the crown of the pipe removing the coupon within the core saw.

8.3.1 Next, the annular space between the borehole and the riser pipe is filled with a minimum of 2 ft. of sand or pea-gravel. The remaining is backfilled as specified by the engineer to within 6-in. of the surface grade and an approved cleanout cap is installed. The surface is restored to match the existing condition such as adding black soil with seed or sod, or concrete or asphalt. The adhesive/sealant is typically cured within 12 h of application and can be water tested any time thereafter. Once the saddle connection has been tested and confirmed to be verifiably non-leaking, the crown of the lateral

FIG. 4 Vacuum Excavated Borehole

pipe is cored and the cored coupon is retrieved through the core bit. The surface is then restored to its original condition

8.4 *Exfiltration Water Test*—Prior to coring for accessing the lateral pipe, an exfiltration water test shall be performed. This is accomplished by filling the riser pipe with a minimum six-foot column of water. The test shall be performed no less than 12-h from the time of affixing the saddle to the pipe. The column of water shall be left for a minimum of five (5)-min before commencing the exfiltration test. Next the water level shall be measured from the top of the riser pipe for a five (5)-min period. No drop in water elevation will be allowed. The coupon shall not be cored until a verifiable non-leaking connection has been confirmed. Should the leak test fail or not pass a repair is made by pouring a low viscosity epoxy resin down the riser pipe to a depth of 1 in. above the crown of the pipe. The epoxy resin leaches out through any breach in the seal sealing the breach. The epoxy resin cures and the leak test is performed again once the test passes then the coring process as described above is repeated. The crown of the pipe is never cored opening until the leak test has been satisfied proving a verifiable non-leaking connection between the saddle and the lateral pipe has been made.

9. Keywords

9.1 adhesive; borehole; coring; coupon; minimally invasive; riser pipe; saddle; vacuum excavation

ATTACHMENT 7

A Comprehensive Understanding of ASTM F3097-15 “Standard Practice for Installation of an Outside Cleanout through a Minimally Invasive Small Bore Vacuum Excavation”

North American Society for Trenchless Technology (NASTT)
NASTT's 2016 No-Dig Show

Dallas, Texas
March 20-24, 2016

WM-T3-01

A Comprehensive Understanding of ASTM F3097-15 "Standard Practice for Installation of an Outside Sewer Service Cleanout through a Minimally Invasive Small Bore Vacuum Excavation"

Rick Gage, Vice President, Sales, LMK Technologies, Ottawa, IL
Amana Arayan, Marketing Manager, LMK Technologies, Ottawa, IL

1. ABSTRACT

ASTM Standards are a very important tool widely used by specifying engineers through North America. The ASTM standard provides guidelines to ensure the optimum results for a given product or procedure.

ASTM F3097-15 is a standard practice for installation of an outside sewer service cleanout through a minimally invasive small bore vacuum excavation. The process begins with locating the sewer service lateral. This is accomplished by use of a CCTV outfitted with a locatable sonde and vacuum excavating a small borehole. Once the lateral sewer service pipe has been exposed, a self-clamping saddle is prepared. The saddle is lowered into the small diameter bore hole until it contacts the lateral sewer service pipe; a downward force is applied to the riser pipe causing the side walls of the saddle to spread and encompass more than 50-percent of the host pipe. The utilization of this practice greatly reduces disruption to the general public and requires minimal restoration.

2. INTRODUCTION

ASTM F3097-15 is an American Standard issued and printed by ASTM International. It is a standard practice for installation of an outside sewer service cleanout through a minimally invasive small bore vacuum excavation. This paper will discuss technical installation methods, test methods and required materials for the installation of an outside sewer service clean out, by means of a small vacuum excavated borehole. This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the installation of a sewer service cleanout.

3. TERMINOLOGY

The terminology section includes definitions and terms that are specific to ASTM F3097. The terms listed are utilized throughout the standard, more specifically in the materials, design considerations and installation sections. Definitions to terms specific to this standard:

- Adhesive/sealant—an elastomeric bonding agent designed to provide a water activated, leak resistant flexible bond between a PVC pipe saddle and a lateral sewer service pipe.

- Borehole —a small diameter vacuum excavated hole.

- Cleanout—a fitting located on a lateral sewer service pipe having a vertical riser pipe extending therefrom to the surface providing access to the lateral sewer service pipe.

- Cleanout riser pipe—a section of pipe that is connected to the boss of a saddle and extends from the saddle to the surface.

- Coring—the process of remotely cutting a hole through the crown of a sewer service pipe such that the coupon is retrieved to establish communication from a cleanout riser pipe and a lateral sewer service pipe.

- Coupon—a disc shaped piece of the lateral sewer service pipe produced by coring.

- Lateral sewer service pipe—a sewer pipe that connects a building to a municipal, main sewer pipe in a lateral direction and collects sanitary waste or storm water.

- Saddle—a PVC saddle that encompasses more than 50% of a lateral sewer service pipe where the side walls of the saddle extend beyond the spring line of the host pipe. The saddle includes setoff tabs that allow for uniform distribution of the adhesive/sealant.

- Setoff tabs—Protruding tabs located on the underside of the saddle one located on each side of the saddle boss for the purpose of insuring a specific annulus between the host pipe and the saddle and a specific layer thickness of adhesive/sealant.

- Sonde—a device outfitted in a closed circuit video inspection camera that emits a signal in subterranean pipelines that is traceable by use of a locating receiver at surface.

4. SIGNIFIGANCE AND USE

This standard practice allows construction crews to create an outside cleanout without conventional means of excavation which allows access to the lateral pipe for cleaning, inspection and cured-in-place lateral lining.

5. COMPONENTS

The components consist of a specifically sized PVC saddle, adhesive and PVC riser pipe. The PVC saddle is engineered to snap over the host lateral pipe and by use of water activated adhesive create a water-tight seal to the pipe's exterior. The saddle has an inner diameter that is equal to the outer diameter of the host pipe. The host lateral pipes may differ from clay, cast iron, ductile iron, PVC and concrete. Lateral pipe diameters may also differ but are mostly four and six inch. Therefore, it is very important that the technicians know the ID of the pipe and know pipe type. The inner diameter of these different pipes may be exactly the same but due to the varying thicknesses of the pipe wall; the outside dimensions will be very different. The one-part adhesive/sealant is dispensed out of a tube with a caulk gun is applied to the underside of the saddle. It has been specially formulated for applications where water is present. Therefore, the adhesive begins to activate in the presence of water. The riser pipe is standard SDR 26 or Schedule 35 PVC pipe which is solvent welded to the boss of the saddle and cured prior to below surface installation.

Figure 1: Outside Sewer Service Cleanout through a Minimally Invasive Small Bore Vacuum Excavation

6. TOOLS REQUIRED FOR INSTALLATION

The following tools are essential for a proper installation;

- Lateral sewer camera with sonde and locator – The camera and sonde are introduced from the main sewer and travel up the lateral pipe to the optimum location for installation. Or the camera and sonde are pushed down the pipe from an access located inside the dwelling. A locator is used to accurately identify the installation location through frequency waves.

- Potholing unit – This is a mobile truck or trailer that can create a vertical bore hole by either vacuum or hydro excavation.

- Coring equipment – this consists of varying coring bits specific to pipe diameter and pipe type and various sized extension rods that can be interchanged depending on depth to installation.

- Auger power head – This is a one-person operated power device that connects to the rods and coring bits. It provides the rotating cutting power.

Figure 2: Coring equipment and power head

7. PROCEDURE

The first step in installing a trenchless sewer service cleanout begins with accessing the lateral pipe and locating the point of installation above ground. A method utilized and associated with this installation process consists of inserting a video camera with an internal sonde into the lateral service line remotely from the mainline pipe, or from the interior building cleanout. A technician at the surface uses a compatible receiver to locate the signal from the camera/sonde to mark the specific location for the new cleanout as dictated by the utility owner. However, this is not always possible due to right of way regulations and what might be sitting at that particular location, such as a sidewalk, curb or a tree as example. Therefore, there needs to be some plan in place or flexibility should the predetermined location not be suitable.

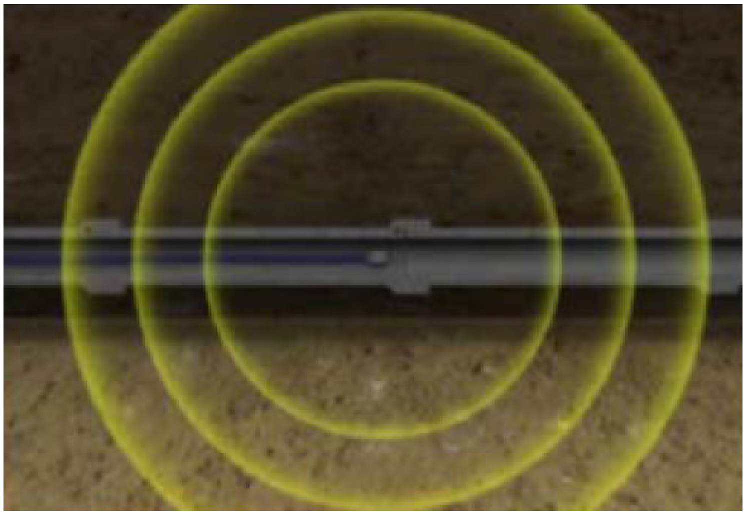

Figure 3: The sonde is transmitting a frequency to be picked up by the locating device.

The identified location shall be marked by driving a steel pin in the soil when possible, or identifying the surface with marking paint. The video camera operator shall determine if the condition of the lateral pipe is suitable for the saddle placement.

A borehole approximately 16 to 24 inches in diameter is created by vacuum or hydro excavation. This is accomplished by cutting the soil, by use of compressed air or by water jetting. The loosened soil is simultaneously drawn under a controlled vacuum through suction tubing and discharged into a mobile debris tank.

Figure 4: Vacuum excavation equipment

This process continues until the lateral pipe is exposed. Be aware this can be a difficult task. In previous history the drain layer has buried a large rock over the pipe before closing up the trench. Depending on the size a jackhammer a new location may have to be utilized. Sometimes the locate may be wrong by 6 to 18 inches in any direction but easily resolvable. Once the lateral pipe is exposed, the pipe is cleaned off and any debris on the pipe is removed. The cleaning process is typically accomplished by using a garden hose and spraying water over the exposed lateral pipe. A depth measurement is taken and PVC riser pipe is cut that length. Then the saddle is affixed to one end of the PVC riser pipe using solvent cement. Once cured, the specifically formulated adhesive/sealant is applied to the underside of the cleanout saddle. The adhesive is sufficiently supplied based on size of saddle and is spread evenly throughout. The pipe and saddle are lowered down into the hole and the saddle is snapped over the pipe by manual downward force. The side walls of the saddle spread and the lower most portion of the saddle extends a short distance beyond the spring line of the pipe causing the saddle to be drawn down onto the pipe producing a clamping affect.

Once the saddle has been installed and held in position for 30 seconds, approximately 4 oz. of water is introduced into the riser pipe. The water helps to activate the curing process of the adhesive.

Figure 5: Hydro excavated borehole

Now the borehole is backfilled with two feet of sand and then approved backfill material. After the adhesive cures, minimum twelve hours, a hydrostatic pressure test is performed. Water is introduced into riser pipe and the water level shall be measured from the top of the riser pipe for a five minute period. No drop in water elevation is allowed. The coupon is not cored until a verifiable non-leaking connection has been confirmed. Should the leak test fail or not pass, a repair is made by pouring a low viscosity, fast cure epoxy resin system down the riser pipe to the crown of the pipe. The epoxy resin leaches out through any breach in the seal, sealing the breach. Once the epoxy resin has cured the leak test is performed again. Once the connection to the saddle has passed the pressure test, the crown of the lateral pipe is cored. The water that was left in the riser pipe offers the technician two key benefits; the first benefit is that the water will cool the coring bit and the second, the drop in water level becomes the technician's indicator that they have begun to cut through the crown the lateral pipe. At this point the technician will back off the downward pressure that is being applied to the auger to ensure that they don't drop down and cut through the bottom of the lateral pipe. Once the coring bit penetrates through the crown of the pipe the water flushes down lateral pipe and the coupon is stuck inside of the bit. The equipment is removed and now the technician has access into the lateral pipe and can go downstream towards the main or upstream towards the house.

8. PURPOSE OF STANDARD

The ASTM F3097-15 covers the all necessary aspects, including design and materials, to successfully install an outside sewer service cleanout that is equal to a traditional dig and replace but without the need for large, very disruptive excavation. This minimally invasive process keeps surrounding areas of landscaping, green space and buried utilities to its original form. This standard practice when followed will produce an effective sewer service cleanout that benefits the municipality and the owner of the dwelling.

7. REFERENCES

ASTM F3097-15, Standard Practice for Installation of an Outside Sewer Service Cleanout through a Minimally Invasive Small Bore Vacuum Excavation, ASTM International, West Conshohocken, PA, 2015, www.astm.org.

ASTM C920-14, Standard Specification for Elastomeric Joint Sealants, ASTM International, West Conshohocken, PA, 2014, www.astm.org.

ASTM D1600-14, Standard Terminology for Abbreviated Terms Relating to Plastics, ASTM International, West Conshohocken, PA, 2014, www.astm.org.

ASTM D2855-96(2010), Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings, ASTM International, West Conshohocken, PA, 2010, www.astm.org.

ASTM D3034-15, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings, ASTM International, West Conshohocken, PA, 2015, www.astm.org.

ASTM F412-15, Standard Terminology Relating to Plastic Piping Systems, ASTM International, West Conshohocken, PA, 2015, www.astm.org.

ATTACHMENT 8
MDWSD Annual Operations Cost Difference with and without Cleanouts

Cost Calculations

Miami-Dade WSD Operational Costs for Responding to Back-Up Calls With and Without Cleanouts

Assumptions

- 200-250 Calls per month (say 225); (Reference MDWSD Operations Staff)
- 50% after hours (estimate based on Palm Beach County experience)
- Labor Costs: crew technician regular time inc. benefits: $30.00/hr.
- overtime: $50.00/hr. (2 hr. minimum)

- Equipment Costs: Service Truck - $100.00/hr.
  Jet (Vac) Truck - $175.00/hr.
  TV Truck - $175.00/hr.

- 80% calls are on customer side (estimate based on PBC experience)

Costs of Call With Clean Out

Customer Problem (crew can use cleanout for visual inspection)

Regular Time: 1 hr., 1 crew tech w/Service truck=		$130.00
Overtime: 2 hr., 1 crew tech w/Service truck=		$200.00
	Total	$330.00

[.5 (130 + 200)] X (225)(.8) = $29,700.00

Utility Problem

Regular Time: 2 hr., 1 crew tech w/Service truck =		$260.00
2 hr., 2 crew tech, 2 hr. w/Jet truck =		$470.00
	Total	$730.00
Overtime: 2 hr., 1 crew tech w/Service truck =		$300.00
2 hr., 2 crew tech w/Jet truck =		$550.00
	Total	$850.00

[.5 (730 + 850)] X (225) (.2) = $35,550.00

Total Costs with Cleanouts/Mo = $62,250.00

<u>Costs of Call Without Cleanout</u>

<u>(Crew Must Launch CCTV Through Manhole to Lateral, Jet Truck to Clear Obstructions)</u>

<u>Customer Problem</u>

Regular Time: 2 hr., 2 crew tech w/Jet truck & TV truck =		$ 820.00
Overtime: 2 hr., 2 crew tech w/Jet truck & TV truck =		$ 900.00
	Total	$1720.00

[.5 (820 + 900)] X (225) (.8) = $117,900.00

<u>Utility Problem</u>

Regular Time: 4 hr., 2 crew tech w/Jet truck & TV truck		$1640.00
Overtime: 4 hr., 2 crew tech w/Jet truck & TV truck =		$1800.00
	Total	$3440.00

[.5 (1640 + 1800)] (225) (.2) = $77,400.00

Total Costs Without Cleanouts/Mo. = $195,300.00

Annual Operating Costs for 225 Monthly Back-Up Calls with and without Cleanouts

With: 12 (62,250.00) = $747,000.00

Without: 12 (195,300.00) = $2,343,600.00

Difference $1,596,600.00/Yr.

Equals Vac- A- Tee Installation (@$800.00) of 1995 Cleanouts

ATTACHMENT 9
Municipalities That Require ASTM F2561 Standard Using Compression Gaskets

ASTM F2561-11 "Standard Practice for Rehabilitation of a Sewer Service Lateral and Its Connection to the Main Using a One Piece Main and Lateral Cured-in-Place Liner".

Below is a list of municipalities located in the State of Florida who specify and/or are using CIPP products that comply with the ASTM F2561 standard as a minimum requirement in their specifications for sewer rehabilitation projects, specifically those which include renovating service lateral pipes. The standard is a materials and installation practice that sets a minimum level of quality by applying sound science and keeping with accepted engineering practices. The ASTM standard represents years of engineering design work and addresses the concerns for engineering design calculations and long-term bonding of CIPP products in a sewer environment, particularly where a CIP-lateral liner connects to a CIP-main liner. The ASTM F2561 standard requires the use of an inverted CIP-lateral liner that includes a full-hoop CIP- main connection liner producing minimum physical properties based on a 50-year design life. The ASTM standard also requires the use of compression gasket Seals to seal the juncture where the CIP-lateral liner connects to the CIP-main liner. The compression gaskets address the annular spaces that exist with CIPP materials, specifically at the main/lateral interface, and at the ends of CIP-main liners (manhole connections). These seals replace the need to regularly grout the annular space at the ends of main and lateral CIPP.

- **City of Plantation, Broward County, Florida**
  Contact: Jeff Jones (954) 797-2159
  Utilities Maintenance Supervisor
  400 Northwest 73rd Avenue, Plantation, FL 33317

- **City of Coral Gables**, **Miami Dade County, Florida**
  Contact: Jorge E. Acevedo, PE (305)-460.5006
  Public Works Department 2800 SW 72 Avenue
  Miami, FL 33155

- **City of North Miami Beach**, **Miami Dade County, Florida**
  Contact: Pedro Melo (305)-624.1177
  17820 NW 29 Ct
  Miami, FL 33056

- **Town of Bay Harbor Islands, Florida**
  Contact: Randy Daniel, P.E. (305)-866.6241
  9665 Bay Harbor Terrace
  Bay Harbor Islands, FL 33154

- **City of Fort Lauderdale, Florida**
  Contact: Ms. Katherine Griffith (954)-828.6126
  100 North Andrews Avenue
  Fort Lauderdale, FL 33309

- **City of Coral Springs, Florida** (954)-345.2189
  Contact: Mr. Mike Medley
  3800 N.W. 85th Avenue
  Coral Springs, FL 33065

- **City of Cooper City, Florida**
  Contact: Mr. Chad Bergeron (954)-434.5519
  11791 SW 49 Street
  Cooper City, FL 33211

- **City of Brooksville, Florida**
  Contact: Lauren Busacca (352)-544.5465
  Alan Schaffer, PE (352)-754.4551
  600 S Brooksville Avenue
  Brooksville, FL 34601

- **City of Hollywood, Florida**
  Contact: Mr. Jose Polanco, P.E. (954)-921.3930
  1621 N. 14th Avenue
  Hollywood, FL 33022-9045

- **City of Dania Beach, Florida**
  Contact: Mr. Fred Bloetscher, PhD. P.E. (954)-925.3492
  P.O. Box 221890
  Hollywood, FL 33022-1890

- **Broward County, Florida**
  Contact: Mr. Clive Haynes (954)-831.0851
  2555 W. Copans Road
  Pompano Beach, FL 33069-1233

- **City of Venice, Florida**
  Contact: Tim Hochuli, P.E. (941)-486.2626
  401 W. Venice Avenue
  Venice, FL 34285

- **Lee County**, **Florida**
  Contact: Mr. Rich Simms (239)-693.2992
  5180 Tice Street
  Fort Myers, FL 33905

- **Pinellas County, Florida**
  Contact: Mr. Jim Schafer, P.E. (727)-453.3343
  14 South Ft. Harrison Avenue
  Clearwater, FL 33756

- **Collier County, Florida**
  Contact: Jesse Komorny, P.E. (239) -591-0186
  6027 Shirley Street
  Naples, FL 34109

- **Charlotte County, Florida**
  Contact: Charlie Rine (941) 883-3561
  25550 Harbor View Road
  Port Charlotte, FL 33980

- **City of Sarasota, Florida**
  Contact: Alex Hernandez, P.E. (941)-365.2325
  1750 12 Street
  Sarasota, FL 34236

- **City of Indian Rocks Beach, Florida**
  Contact: Dean Scharmen (727)-595.6889
  1507 Bay Palm Boulevard
  Indian Rocks Beach, FL 33785

- **Lauderdale by the Sea, Florida**
  Contact: Don Prince (954)-640.4232

- **Palm Beach County, Florida**
  Contact: Adam Galicki, P.E. (561)-493.6122

- **City of Homestead, Florida**
  Contact: Ethan Heijn, P.E. (954)-987.2949

- **Deerfield Beach, Florida**
  Contact: Fred Scott (954)-480.4403

- **City of Monticello, Florida**
  Contact: Joe Miller George & Assoc. (850)-521.2269

- **Hallandale Beach, Florida**
  Contact: Louis Granda (954)-457.1629

- **City of Wilton Manors, Florida**
  Contact: David Archacki (954)-390.2190

- **City of Starke, Florida**
  Contact: Joe Miller George & Assoc. (850)-521.0344
  Below is a list of municipalities that are not located in the state of Florida that specify and/or are using CIPP products that comply with the ASTM F2561 standard as a minimum requirement in their specifications for sewer rehabilitation projects, specifically those which include renovating service lateral pipes:

  - **New Castle County, DE**
  - **City of Dallas, TX**
  - **City and County of Honolulu**
  - **City of Victoria, BC**
  - **City of Edmonton, AB**
  - **City of Calgary, AB**
  - **City of Portland, OR**
  - **City of Belgrade, MN**
  - **City of Duluth, MN**
  - **City of Milwaukee, WI**
  - **Village of White Fish Bay, WI**
  - **Village Mount Pleasant, WI**
  - **City of Racine, WI**
  - **City of Bayside, WI**
  - **City of Mequon, WI**
  - **City of Wheaton, IL**
  - **City of Naperville, IL**
  - **DuPage County, IL**
  - **City of Highland Park, IL**
  - **City of Mexico, MO**
  - **City of Imperial, MO**
  - **City of Kansas City, MO**
  - **City of Clermont County, OH**
  - **City of Toronto, ON**
  - **Sanitary District 1, KY**
  - **City of St. Louis, MO MSD**
  - **City of Cobb County, GA**
  - **City of Fayetteville, NC**
  - **City of Richmond, VA**
  - **City of Richmond, CA**
  - **City of Franklin, VA**
  - **City of Baton Rouge, LA**
  - **City of Pensacola, Emerald Coast Utilities Authority**
  - **City of Pinehurst, NC**
  - **Washington Suburban Sanitary Commission, MD**
  - **Prince William County, VA**
  - **Allegheny County, PA**
  - **City of Hagerstown, MD**
  - **City of Fort Saskatchewan, Alberta**

- **Town of Leesburg, VA**
- **City of Riverlea, OH**
- **North West Ohio Regional Sewer District**

ATTACHMENT 10

City of Fort Lauderdale, FL-Request for Qualifications (excerpt), City of Plantation, FL-IFB (excerpt), and Model CIPP and End Seal Lateral Specifications

Request for Qualifications

RFQ # 466-11799

Wastewater Conveyance System Long-Term Rehabilitation Program

Venice of America

City of Fort Lauderdale

Issued on behalf of: THE PUBLIC WORKS DEPARTMENT

Procurement Services Division
Althea Pemsel, Senior Procurement Specialist
Fort Lauderdale City Hall
100 N. Andrews Avenue, 6th Floor
Fort Lauderdale, Florida 33301
www.fortlauderdale.gov

Submission Deadline

Day/Date:	**September 13th, 2016**
Time:	**2:00 PM EST**
Location:	**Fort Lauderdale City Hall** **Procurement Services Division** **100 N. Andrews Avenue, #619** **Fort Lauderdale, FL 33301**

Contractors shall satisfy each of the following requirements cited below. Failure to do so may result in the RFQ being deemed non-responsive.

Licenses/Certifications and Specific Experience Required:

1) Contractor must possess an underground utility and excavation license, or a Broward County primary pipeline license, and/or a Certified General Contractor's license;

2) The CCTV Operator must possesses NASSCO (National Association of Sewer Service Companies) PACP (Pipeline Assessment & Certification Program)/LACP (Lateral Assessment & Certification Program)/MACP (Manhole Assessment & Certification Program) certifications;

3) The material and installation practices for sewer service lateral shall, at a minimum, adhere to the requirements of ASTM F2561-11 – Standard Practice for Rehabilitation of a Sewer Service Lateral and its Connection to the Main Using a One-Piece Main and Lateral Cured-in Place Liner; the liner assembly shall meet the ASTM F1216 and ASTM D5813 requirements;

4) Contractor and/or approved subcontractor must have experience installing full wrap, one piece lateral connection utilizing a compression O-ring gasket;

5) The City requires experience in installing the following products or approved equal: Insignia End Seals by LMK Enterprises, AV-202 multigrout, and Inliner Technologies, Insituform, or National liner. An equal product must be submitted for approval and must have a minimum of 500,000 linear feet or 2,000 manhole-to-manhole line sections of documented successful wastewater collection system installation in the U.S. and 250,000 linear feet of product shall have been in successful service within the State of Florida for a minimum of five (5) years. Third party test results with data supporting the long term performance and structural strength of the product(s) proposed shall be reviewed by the City. Test samples shall be prepared so as to simulate installation methods and trauma of the product. No product will be approved without independent third party testing verification;

6) The installer(s) of the contractor and/or subcontractor must document 100,000 linear feet of lateral liner installation with 10,000 linear feet occurring in the State of Florida, 40,000 mainline/lateral connections with 4,000 of them occurring in the State of Florida, 25 stack single or double wye lateral installations, and 500 lateral transitions with 100 installations occurring within the State of Florida. Additionally, the installer must have successfully installed at least 500,000 feet of the mainline product(s) preferred by the City in wastewater collection systems with 250,000 feet installed in Florida.

1.13 RESPONSES

Sealed responses will be accepted in accordance with the schedule detailed on the cover of this RFQ. After that date and time, the City reserves the right to increase or decrease the pool of contractors by permitting additional SOQs. The contractor shall file all documents necessary to support its SOQs and shall include them with its RFQ. Contractors shall be responsible for the actual delivery of responses during business hours to the exact address indicated on the cover and in the RFQ.

1.14 INSURANCE

Contractor will be required and shall require all of its sub-contractors to provide, pay for, and maintain in force at all times during the term of an agreement, such insurance, including, Workers' Compensation Insurance, Comprehensive General or Commercial Liability Insurance, Business Automobile Liability Insurance, and Employer's Liability Insurance as stated below.

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Published: 10/29/2014 3:07:40 PM

SECTION 02765 - CURED-IN-PLACE PIPE LINING

PART 1 -- GENERAL

1.01 SCOPE

A. It is the intent of this specification to provide for the reconstruction of pipelines and conduits by the installation of a resin-impregnated flexible tube which is formed to the original conduit and cured to produce a continuous and tight fitting Cured-In-Place Pipe (CIPP).

B. The work specified in this Section includes all labor, materials, accessories, equipment and tools necessary to install and test cured-in-place pipe lining in main lines and in service laterals.

1.02 GENERAL

A. This specification references ASTM F1216 (Rehabilitation of pipelines by the inversion and curing of a resin-impregnated tube), ASTM F1743 (Rehabilitation of pipelines by pulled-in-place installation of a cured-in-place thermosetting resin pipe), and ASTM D790 (Test methods for flexural properties of unreinforced plastics) which are made a part hereof by such reference and shall be the latest edition and revision thereof. In case of conflicting requirements between this specification and these referenced documents, this specification will govern. ASTM F1216 is applicable to CIP mainline pipe lining, ASTM F2561 is the governing standard for CIP main/lateral pipe connection lining.

1.03 SUBMITTALS

A. The CONTRACTOR shall submit shop drawings and other information to the OWNER for review in accordance with Section 01300, "Submittals".

B. With the bid, the following submittals are required.

1. Documentation as outlined herein under the section titled, PRODUCT AND INSTALLER ACCEPTABILITY, including installation references of projects that are similar in size and scope to this project. The submittal shall include, at a minimum, the client contact name, phone number, and the diameter and footage of pipe rehabilitated. Documentation for product and installation experience must be satisfactory to the OWNER.

C. After contract award, the following submittals are required.

1. Detailed design calculations as specified herein under the section titled, MATERIALS FOR MAIN LINES.

2. Various test results as specified herein under the section titled, TESTING REQUIREMENTS.

3. Documentation as specified herein under the sections titled WET-OUT AND CURE REPORT and TELEVISION SURVEY.

E. The outside layer of the tube (before wetout) shall be coated with an impermeable, flexible membrane that will contain the resin and facilitate monitoring of resin saturation during the resin impregnation (wetout) procedure.

F. The tube shall be homogeneous across the entire wall thickness containing no intermediate or encapsulated elastomeric layers. No material shall be included in the tube that may cause delamination in the cured CIPP. No dry or unsaturated layers shall be evident.

G. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color so that a clear detailed examination with closed circuit television inspection equipment may be made.

H. Seams in the tube shall be stronger than the unseamed felt.

I. The outside of the tube shall be marked for distance at regular intervals along its entire length, not to exceed 5 ft. Such markings shall include the Manufacturers name or identifying symbol. The tubes must be manufactured in the USA.

J. Contractor is to install Hydrophilic End Seals at all manhole penetrations. The End Seals must be in a tubular form which when installed will form a 360 degree seal between the host pipe and the newly installed liner and must be a minimum of three inches wide. The use of caulking, rope or band type of an end seal will not be allowed. Acceptable End Seals are Insignia™ End Seals by LMK Enterprises, 1779 Chessie Lane, Ottawa, IL 61350 (815) 433-1275, or pre-approved equal.

K. The resin system shall be a corrosion resistant polyester, vinyl ester, or epoxy and catalyst system that when properly cured within the tube composite meets the requirements of ASTM F1216 and ASTM F1743, the physical properties herein, and those which are to be utilized in the Design of the CIPP for this project. The resin shall produce CIPP which will comply with the structural and chemical resistance requirements of this specification.

L. The finished pipe in place shall be fabricated from materials which when cured will be chemically resistant to withstand internal exposure to domestic sewage. All constituent materials will be suitable for service in the environment intended. The final product will not deteriorate, corrode or lose structural strength that will reduce the projected product life. In industrial areas a liner system using epoxy vinyl ester resin shall be utilized and a polyester resin shall be used in non-industrial areas. The OWNER shall determine the type of appropriate resin to be utilized for each line segment.

M. The CIPP shall be designed as per ASTM F1216, Appendix X1. The CIPP design shall assume no bonding to the original pipe wall. The structural performance of the finished pipe must be adequate to accommodate all anticipated loads throughout its design life.

N. The CIPP must have a minimum design life of fifty (50) years. The minimum design life may be documented by submitting life estimates by national and/or international authorities or specifying agencies. Otherwise, long-term testing and long-term in-service results (minimum ten (10) years) may be used, with the results extrapolated to fifty (50) years.

O. The CONTRACTOR must have performed long-term testing for flexural creep of the CIPP pipe material installed by his company. Such testing results are to be used to determine the long-term, time dependent flexural modulus to be utilized in the product design. This is a performance test of the materials (tube and resin) and general workmanship of the installation and curing. A percentage of the instantaneous flexural modulus value (as measured by ASTM D-790 testing) will be used in design calculations for external buckling.

Section 02770

CURED-IN-PLACE PIPE LINING - Laterals

1.0 INTENT

This specification covers material requirements, installation practices, and test methods for the reconstruction of a sewer service lateral pipe and the main connection without excavation. The pipe renovation shall be accomplished by the inversion and inflation of a resin impregnated, single-piece lateral and main connection liner. When cured, the liner extends over a predetermined length of the service lateral and the full circumference of the main pipe at the connection (CIPP) outfitted with gasket seals. The Materials and Installation practices shall, at a minimum, adhere to the requirements of ASTM F2561-11 "Standard Practice for Rehabilitation of a Sewer Service Lateral and its Connection to the Main Using a One-Piece Main and Lateral Cured-in Place Liner"

This specification takes precedence over any other similar specification that may be found in other sections of the bid documents.

2.0 GENERAL

The reconstruction shall be accomplished using a resin absorbent textile tube of particular length and a thermo-set resin with physical and chemical properties appropriate for the application. The launching device and launching hose is winched through the mainline and positioned at the appropriate service lateral connection. The mainline bladder is inflated seating the hydrophilic seals and presses the connection liner against the main pipe at the connection while the lateral tube inverts up into the lateral pipe by the action of the inversion bladder. The resin-saturated liner is cured, the hydrophilic gaskets are in place then the inversion bladder and launching device are removed.

3.0 PRODUCT AND INSTALLER ACCEPTABILITY

A. All sewer products are intended to have a minimum 50 year design life, in order to minimize the owner's long term risk of failure, only proven products and installers with substantial successful long term track records will be considered.

B. Products and installers must document the following minimum criteria to be deemed commercially acceptable:

Product	Unit	Florida Minimum Requirement	U.S. Minimum Requirement
Lateral Liner	LF	50,000	500,000

Main / Lateral Connections	EA	4,000	40,000
Stack Single or Double Wye	EA	25	25
Lateral Transitions	EA	100	500
Siamese Lateral Connections	EA	25	25

3.1 For materials and product to be considered commercially proven, the above referenced minimum units of successful wastewater collection system installations must be documented to the satisfaction of the owner to assure commercial viability of the proposed liner system. If changes in the product (installation, resin, materials, configuration, assembly, seals) did occur the date and scope of changes must be part of the product history documentation for the owner to review and tabulated to show the quantity of each specific product type or version. Any modifications to the finished product bid must show the date and reason the change was made.

3.2 All sewer rehabilitation materials and products submitted for approval must provide third party test results supporting the long term performance and structural strength of the product and such data shall be satisfactory to the owner. Tests are to include the main, laterals, and main/lateral connection materials and hydrophilic gasket seals. Test samples shall be prepared so as to simulate installation methods and trauma of the product. No product will be approved without independent third party testing verification for all components proposed.

3.3 The Contractor (the licensed company or subcontractor bidding) must meet the minimum requirements above. This is a company requirement; personal history is valuable, however will not be considered in evaluating the company's ability to meet the minimum requirements of this specification. The Contractor must have installed the same product (in the same constructed configuration) proposed for a minimum of five years.

4.0 MATERIAL

4.1 *Liner Assembly-* The liner assembly shall be continuous in length and consist of one or more layers of absorbent needle punched felt, circular knit or circular braid that meet the requirements of ASTM F1216 and ASTM D5813 Sections 6 and 8. No intermediate or encapsulated elastomeric layers shall be in the textile that may cause de-lamination in the CIPP. The textile tube and sheet shall be constructed to withstand installation pressures, have sufficient strength to bridge missing pipe segments, and flexibility to fit irregular pipe sections. The resin saturated textile tube and sheet shall meet ASTM F 1216, 7.2 as applicable, and the tube shall have 5% to 10% excess resin distribution (full resin contact with the host pipe) that when compressed and cured will meet or exceed the design thickness.

4.2 *Mainline Liner Tube-* The main liner tube shall be formed from a flat sheet of resin absorbent material suitable for CIPP. The forming of the tube is accomplished by one end of the textile sheet overlapping the second end and sized accordingly to create a circular lining equal to the inner diameter of the lined main pipe. The interior of the textile sheet shall be laminated with an impermeable, translucent flexible membrane. The textile sheet before insertion shall be permanently marked on the membrane as a "Lateral Identification" correlating to the address of the building the lateral pipe provides service.

4.3 *Lateral Liner Tube-* The exterior of the lateral liner tube shall be laminated with an impermeable, translucent flexible membrane. Longitudinal seams in the tube shall be stitched and thermally sealed. The lateral tube will be continuous in length. The lateral tube will be capable of conforming to offset joints, bends, bells, disfigured pipe sections and pipe diameter transitions.

4.4 *Mainline Connection-* The main tube and lateral tube shall form a one-piece assembly by stitching the lateral tube to the mainsheet aperture. The connecting end of the lateral tube shall be shaped to match the aperture and curvature of the main tube. The lateral tube and main tube shall be sealed by use of a flexible UV cured adhesive/sealant. The main/lateral tube assembly shall take the shape of a "TEE" or "WYE" with corresponding dimensions such as a curved circle or a curved elliptical opening in the pipefitting. Submittals for the liner assembly must include the manufacturer's assembly methods and test protocol for the main/lateral liner assembly to be certified as airtight prior to resin saturation. Each liner assembly must include this test data and be certified by the manufacturer to be airtight prior to resin saturation.

4.5 *Gasket Seals-* The mainline connection shall include a seamless molded flange shaped gasket attached to the main liner tube. The gasket must be a minimum of 2.5mm and must retain this minimum thickness under installation pressures. The lateral tube shall include a compression O-ring gasket attached six-inches from the terminating end of the lateral tube.

4.6 *Mainline End Seal Test Data-* The hydrophilic gasket seals shall include test data that supports substantial expansion properties so to form a watertight compression end seal at the terminating ends of the CIP-lateral liner. The test protocol shall simulate subterranean conditions and hydraulic loading at surface. Gasket seal submittals must include tests data simulating hydration/ dehydration conditions for a period of 10,000-hours and the test results must successfully demonstrate and document long-term performance without deterioration, loss of material, flexibility, and expansion of the gasket during repeated cycles of hydration and dehydration.

4.7 *Bladder Assembly*- The liner assembly shall be surrounded by a second impermeable, inflatable, invertible, flexible translucent membrane bladder that will form a liner/bladder assembly. The translucent bladder shall facilitate vacuum impregnation while monitoring the resin saturation process.

5.0 RESIN SYSTEM

5.1 The resin/liner system shall conform to ASTM D5813 Section 8.2.2.

5.2 The resin shall be a corrosion resistant polyester, vinylester, epoxy or silicate resin and catalyst system that when properly cured within the composite liner assembly, meets the requirements of ASTM F1216, the physical properties herein, and those which are to be utilized in the design of the CIPP, for this project.

5.3 The resin shall produce a CIPP, which will comply with the structural and chemical resistance requirements of ASTM F1216.

Table 1 CIPP INITIAL STRUCTURAL PROPERTIES

Property	ASTM Test	Minimum Value PSI	(MPa)
Flexural Strength	D 790	4,500	(31)
Flexural Modulus	D 790	250,000	(1,724)

6.0 DESIGN CONSIDERATIONS

6.1 The CIPP shall be designed per ASTM F1216, Appendix X1.

6.2 The CIPP design for the lateral tube and main sheet shall assume no bonding to the original pipe.

6.3 The resin saturated lateral tube and the main sheet must place the resin in full contact with the host pipe. The cured liner must have any coating on the interior of the lateral piping.

6.4 The liner must be smooth and have an average roughness coefficient "n" factor of 0.013 or lower.

7.0 REFERENCES

7.1 ASTM F-2561 - Standard Practice for Rehabilitation of a Sewer Service Lateral and Its Connection to the Main Using a One-Piece Main and Lateral Cured-In-Place Liner.

7.2 ASTM F1216 - Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube.

7.3 ASTM D-790 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

7.4 ASTM D-792 Standard Test Methods for Density and Specific Gravity of Plastics by displacement.

7.5 ASTM D-2990 Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics

7.6 ASTM D5813 Standard Specification for Cured-in Place Thermosetting Resin Sewer Pipe.

ASTM F2561-11 references several complementing standards; one of which is ASTM F1216. The ASTM F1216 standard is referenced for purposes of tube design considerations for a CIPP. ASTM F1216 is not a lateral pipe standard and is not applicable to the sealing of lateral connections to mainline pipe and a branch pipe using CIPP. ASTM F2561 is the industry standard for renewing lateral pipes and main/lateral connections with CIPP and pre-molded compression gaskets.

8.0 INSTALLATION RECOMMENDATIONS

8.1 *Access Safety* – Prior to entering access areas such as manholes, an excavation pit, performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen shall be undertaken in accordance with local, state, or federal safety regulations.

8.2 *Cleaning and Inspection* – As per NASSCO Standards.

8.3 *Cleaning Accessing the Lateral Pipe* – A cleanout is required to be located on the exterior of the building. The cleanout fitting shall be TEE shaped so to allow upstream and downstream access to the lateral pipe. The cleanout shall be located within two (2) feet of where the finished liner is to terminate.

8.4 *Plugging* – The upstream side of the cleanout shall be plugged during insertion and curing of the liner assembly ensuring no flows enter the pipe and no air, steam or odors will enter the building. When required, the main pipe flows will be by-passed. The pumping system shall be sized for peak flow conditions. The upstream manhole shall be monitored at all times and an emergency deflating system will be incorporated so that the plugs may be removed at any time without requiring confined space entry.

8.5 *Inspection of Pipelines* – The interior of the pipeline shall be carefully inspected to determine the location of any condition that shall prevent proper installation, such as roots, severe offsets, and collapsed or crushed pipe sections. Experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television shall perform inspection of pipelines.

8.6 *Line Obstructions* – The existing lateral pipe shall be clear of obstructions that prevent the proper insertion and expansion of the lining system. Changes in pipe size shall be accommodated, if the lateral tube is sized according to the pipe diameter and condition. Obstructions may include dropped or offset joints of no more than 20% of inside pipe diameter.

8.7 *Resin Impregnation* – The liner assembly is encapsulated within the translucent bladder (liner/bladder assembly), the entire liner including the flat sheet shall be saturated with the resin system (wet-out) under controlled vacuum conditions. The volume of resin used shall be sufficient to fill all voids in the textile lining material at nominal thickness and diameter. The volume shall be adjusted by adding 5% to 10% excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe. No dry or unsaturated area in the mainline sheet or lateral tube shall be acceptable upon visual inspection.

8.8 7.8 *Liner Insertion* – The lateral tube and inversion bladder shall be inserted into the launching hose. The main bladder and flat textile sheet (main liner tube) shall be wrapped around a "T" launching device, formed into a tube and secured by use of rubber bands. A seamless molded flange shaped gasket shall be attached to the main liner tube by use of stainless steel snaps. The flanged gasket shall be inserted into the lateral pipe at the main/lateral juncture so that the brim of the flanged gasket is firmly seated against the mainline pipe liner. An O-ring end seal shall be positioned 6-inches from the terminating end of the lateral liner tube. The launching device is inserted into the pipe and pulled to the point of repair. The pull is complete when the lateral tube is exactly aligned with the lateral pipe connection. The lateral tube is completely protected during the pull. The mainline liner is supported on a rigid "T" launcher that is elevated above the pipe invert through the use of a rotating skid system. The liner assembly shall not be contaminated or diluted by exposure to dirt or debris during the pull.

8.9 *Bladder* – The main bladder shall be inflated causing the main sheet to unwrap and expand; pressing the main tube firmly into contact with the main pipe and embedding the flange shaped gasket between the main tube and the main pipe at the lateral opening. The lateral tube is inverted through the main tube aperture by the action of the lateral bladder extending into the lateral pipe to a termination point that shall be no less than 2-feet from the exterior cleanout. The bladder assembly shall extend beyond each end of the liner, so the liner remains open-ended and no cutting shall be required.

9.0 CIPP PROCESSING

9.1 *Curing* – After the liner has been fully deployed into the lateral pipe, pressure is maintained pressing the liner firmly against the inner pipe wall until the liner is cured at ambient temperatures or by a suitable heat source. The heating equipment shall be capable of delivering a mixture of steam and air throughout the liner bladder assembly to a uniform raise the temperature above the temperature required to cure the resin. The curing of the CIPP shall take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of the soil). The heat source temperatures shall be monitored and logged during the cure and cool down cycles. The manufacturer's recommended cure schedule shall be submitted and followed.

9.2 *CIPP Processing* – Curing shall be done without pressure interruption with air or a mixture of air and steam for the proper duration of time per the resin manufacturer's recommendations. The curing process is complete when the temperature of the CIPP reaches 100 degrees Fahrenheit or less.

10.0 FINISH

The finished CIPP – CIPP Shall be a homogenous CIPP liner assembly located within a lateral service pipe for a specific length, and extending into the main pipe to renew 18-inches of the main pipe at the main/lateral service connection. The CIPP shall be smooth with minimal wrinkling and shall increase flow rate. The CIPP shall be free of dry spots, lifts, and delamination. The CIPP shall include a textile taper at each end providing a smooth transition to the host mainline liner for accommodating video equipment and maintaining proper flow in the mainline. After the work is completed, the installer will provide the owner with video footage documenting the repair and the visual markings on the CIPP liner assembly identifying the building address. The finished product shall provide a verifiable non-leaking connection between the mainline liner and the CIP-Lateral liner.

11.0 RECOMMENDED INSPECTION AND TESTING PRACTICES

11.1 *Sampling* – As designated in the purchase agreement, the preparation of a CIPP sample is required. The sample shall be prepared by securing a flat plate mold using the textile tube material and resin system as used for the rehabilitated pipe.

11.2 *Pressure* – The pressure applied on the plate sample will be equal to the highest pressure exerted on the lateral tube during the inversion process.

11.3 *Length* – The minimum length of the sample must be able to produce at least five specimens for testing in accordance with ASTM D-790-03.

11.4 *Conditioning* – Condition the test specimens at 73.4 ± 3.6° F (23 ± 2°C) and 50 ± 5% relative humidity for not less than 40 hour prior to test in accordance with Practice ASTM D 618, for those tests where conditioning is required.

11.5 *Short-Term Flexural (Bending) Properties* – The initial tangent flexural modulus of elasticity and flexural stress shall be measured for gravity and pressure pipe applications in accordance with Test Method D 790 and shall meet the minimum requirements of Table 1.

11.6 *Gravity Pipe Leakage Testing* – If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an air test method where a test plug is placed adjacent to the upstream and downstream ends of the main sheet CIPP and at the upper most end of the lateral tube. This test should take place no less than 72-hours after returning the lateral pipe back into service. This test is limited to pipe lengths with no service connections. The test pressure shall be 4-PSI for a test time of three-minutes; the pressure shall not drop below 3.5 PSI.

12.0 WARRANTY

All CIPP liners shall be certified by the manufacturer for specified material properties for the particular repair. The manufacturer warrants the liner to be free from defects in raw materials for ten years from the date of acceptance. The contractor guarantees the work to be free from defects caused by faulty workmanship for a period of five years from the date of acceptance. During the warranty period, any defects which affect the integrity, strength or water tightness of the installed pipe shall be repaired at the contractor's expense.

– END OF SECTION –

SPECIFICATION

INSTALLATION PRACTICE FOR REHABILITATION OF A SEWER SERVICE LATERAL USING A ONE-PIECE MAIN-TO-LATERAL CURED-IN-PLACE LINER ASSEMBLY

Section 02770

CURED-IN-PLACE PIPE LINING - Laterals

1.0 INTENT

1.1 This specification covers material requirements, installation practices, and test methods for the reconstruction of a sewer service lateral pipe and the main connection without excavation. The pipe renovation shall be accomplished by the inversion and inflation of a resin impregnated, single-piece cured-in-place (CIPP) lateral and main connection liner outfitted with engineered, molded hydrophilic gasket seals that are designed specifically for sealing the CIPP/lateral connection interface and lateral termination. When cured, the liner extends over a predetermined length of the service lateral and the full circumference of the main pipe at the lateral connection. The materials and installation practices shall, at a minimum, adhere to the requirements of ASTM F2561-11 "Standard Practice for Rehabilitation of a Sewer Service Lateral and Its Connection to the Main Using a One-Piece Main and Lateral Cured-in-Place Liner"

1.2 This specification takes precedence over any other similar specification that may be found in other sections of the bid documents.

2.0 GENERAL

2.1 The reconstruction shall be accomplished using a resin absorbent textile tube of particular length and a thermo-set resin with physical and chemical properties appropriate for the application. The launching device and launching hose is winched through the mainline and positioned at the appropriate service lateral connection. The mainline bladder is inflated seating the hydrophilic molded gaskets and pressing the connection liner against the main pipe at the connection while the lateral tube inverts up into the lateral pipe by the action of the inversion bladder. The resin-saturated liner is cured with the molded gaskets embedded in-place between the host pipe and the new liner, and the inversion bladder and launching device are removed from the pipe.

3.0 APPROVED PRODUCTS

T-Liner® **Main-to-Lateral Lining System**
By LMK Technologies, LLC
1779 Chessie Lane
Ottawa, IL 61350
815-640-9302
www.lmktechnologies.com

Innerseal™
By Perma-Liner Industries, LLC
13000 Automobile Boulevard, Suite 300
Clearwater, FL 33762
1-866-336-2568

4.0 Installer and Product Requirements

4.1 All sewer products must provide a 50 year design life, stamped by a licensed Professional Engineer (P.E.) in order to minimize the owner's long term risk of failure. Only skilled contractors utilizing products that are manufactured in a controlled factory environment with substantial successful long term track records and/or manufacturer's certification of training completion will be considered.

4.2 Product installers must document the following minimum criteria to be deemed commercially acceptable:

Product	Unit	Minimum Requirement for Installer*
Main/Lateral Connections	EA	200
Lateral Liner	LF	250
Lateral Transitions	EA	10

*Installers who have less than the minimum required installation experience can qualify by employing a Manufacturer's Technical Trainer who meets the requirements.

4.3 For installers to be considered commercially proven, the above referenced minimum number of units of successful wastewater collection system installations must be documented to the satisfaction of the owner to assure commercial viability of the proposed liner system.

4.4 All sewer rehabilitation products submitted for approval must provide third party test results supporting the long term performance and structural strength of the product and such data shall be satisfactory to the owner. Test results are to include the main, laterals, and main/lateral connection materials and hydrophilic molded gasket seals. Test samples shall be prepared so as to simulate installation methods and trauma of the product. No product will be approved without testing verification for all components proposed.

4.5 The Installer (the licensed company or subcontractor bidding) must meet the minimum requirements above or be pre-approved by the owner. This is a company requirement; personal history is valuable, however will not be considered in evaluating the company's ability to meet the minimum requirements of this specification. The Contractor must have installed the same product (in the same constructed configuration) proposed for a minimum of one year. Installers who have less than one year installation experience can qualify by having a manufacturer's representative present during installation.

5.0 MATERIAL

5.1 Liner Assembly - The liner assembly shall be continuous in length and consist of one or more layers of absorbent needle punched felt, circular knit or circular braid that meet the requirements of ASTM F1216 and ASTM D5813 Sections 6 and 8. No intermediate or encapsulated elastomeric layers shall be in the textile that may cause delamination in the CIPP. The textile tube and sheet shall be constructed to withstand installation pressures, have sufficient strength to bridge missing pipe segments, and flexibility to fit irregular pipe sections. The resin saturated textile tube and sheet shall meet ASTM F1216, 7.2 as applicable, and the tube shall have 5% to 10% excess resin distribution (full resin contact with the host pipe) that when compressed and cured will meet or exceed the design thickness.

5.2 Mainline Liner Tube - The main liner tube shall be formed from a flat sheet of resin absorbent material suitable for CIPP. The forming of the tube is accomplished by one end of the textile sheet overlapping the second end and sized accordingly to create a circular lining equal to the inner diameter of the lined main pipe. The interior of the textile sheet shall be laminated with an impermeable, translucent flexible membrane. The textile sheet before insertion shall be permanently marked on the membrane as a “Lateral Identification” correlating to the address of the building the lateral pipe provides service.

5.3 Lateral Liner Tube - The exterior of the lateral liner tube shall be laminated with an impermeable, translucent flexible membrane. Longitudinal seams in the tube shall be stitched and thermally sealed. The lateral tube will be continuous in length. The lateral tube will be capable of conforming to offset joints, bends, bells and disfigured pipe sections. For pipe configurations that contain pipe diameter transitions, the transition liner tube must manufactured with the appropriate wall thickness according to the design guide in ASTM F1216.

5.4 Mainline Connection - The main tube and lateral tube shall form a one-piece assembly by stitching the lateral tube to the mainsheet aperture. The connecting end of the lateral tube shall be concaved matching the aperture and curvature of the main tube. The lateral tube and main tube shall be sealed by use of a flexible UV cured adhesive/sealant applied in a factory controlled setting. The main/lateral tube assembly shall take the shape of a “TEE” or “WYE” with corresponding dimensions such as a curved circle or a curved elliptical opening in the pipefitting.

5.5 Hydrophilic Gasket Seals - The mainline tube shall include a seamless molded flange shaped gasket attached to the main liner tube at the connection opening. The gasket(s) must be a minimum of 2.5mm in thickness and must retain this consistent thickness under installation pressures. The lateral tube shall include two molded O-ring gaskets attached six-inches from the terminating end of the lateral tube. The hydrophilic gasket seals shall be manufactured in a controlled factory with strict quality control and quality assurance protocols. A liquid sealant, adhesives or other fluid like materials having paste like consistency will not be accepted.

5.6 Mainline End Seal Test Data - The hydrophilic gasket seals shall include test data that supports substantial expansion properties necessary to form a watertight compression end seal at the main connection and the terminating end of the CIP-lateral liner. The test protocol shall simulate subterranean conditions and hydraulic loading at surface. Gasket seal submittals must include tests data simulating hydration/dehydration conditions for a period of 10,000-hours and the test results must successfully demonstrate and document long-term performance without deterioration, loss of material, flexibility, and no less than 190% expansion of the gasket over repeated cycles of hydration and dehydration. The cycles of hydration/dehydration are as follows:

The test shall include submerging the gaskets in water for a period of 2, 7, 30, 90, 180 and 416 days then removed, measured, and weighed. The gaskets shall remain out of water for the same period of time as they were submerged. This process is repeated until all samples within their respective cycles have been tested for 10,000 hours. Results must show that the gaskets continue to stay flexible by bending the sample and observing no cracking. Also the gaskets shall have no loss of material, never get smaller than their original dimensions and retain the ability to increase thickness a minimum of 190%.

5.7 Bladder Assembly - The liner assembly shall be surrounded by a second impermeable, inflatable, invertible, flexible translucent membrane bladder that will form a liner/bladder assembly. The translucent bladder shall facilitate vacuum impregnation while monitoring the resin saturation process.

6.0 RESIN SYSTEM

6.1 The resin/liner system shall conform to ASTM D5813 Section 8.2.2.

6.2 The resin shall be a corrosion resistant polyester, vinyl ester or epoxy resin and catalyst system that when properly cured within the composite liner assembly, meets the requirements of ASTM F1216, the physical properties herein, and those which are to be utilized in the design of the CIPP, for this project.

6.3 The resin shall produce a CIPP, which will comply with the structural and chemical resistance requirements of ASTM F1216.

6.4 CIPP Initial Structural Properties per Table 1

TABLE 1		
PROPERTY	**STANDARD**	**MINIMUM VALUE**
Flexural Strength	ASTM D790	4,500 psi (31 MPa)
Flexural Modulus	ASTM D790	250,000 psi (1,724 MPa)

7.0 DESIGN CONSIDERATIONS

7.1 The CIPP shall be designed per ASTM F1216, Appendix X1.

7.2 The CIPP design for the lateral tube and main sheet shall assume no bonding to the original pipe.

7.3 The resin saturated lateral tube and the main sheet must place the resin in full contact with the host pipe. The cured liner must provide coating on the interior of the lateral piping for an improved flow rate.

7.4 The liner must be smooth and have an average roughness coefficient “n” factor of 0.013 or lower.

8.0 REFERENCES

8.1 ASTM F2561 - Standard Practice for Rehabilitation of a Sewer Service Lateral and Its Connection to the Main Using a One-Piece Main and Lateral Cured-In-Place Liner.

8.2 ASTM F1216 - Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube.

8.3 ASTM D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

8.4 ASTM D792 - Standard Test Methods for Density and Specific Gravity of Plastics by displacement.

8.5 ASTM D2990 - Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics.

8.6 ASTM D5813 - Standard Specification for Cured-in Place Thermosetting Resin Sewer Pipe.

8.7 ADTM F4777 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

NOTE: ASTM F2561-11 references several complementing standards; one of which is ASTM F1216. The ASTM F1216 standard is referenced for purposes of tube design considerations for a CIPP liner. ASTM F1216 is not an applicable standard for the sealing of lateral connections where the lateral CIPP forms a verifiable non-leaking connection to the mainline CIPP. ASTM F2561 is the controlling industry standard for renewing lateral pipes and main/lateral connections using full-hoop CIPP liners and pre-molded compression gaskets.

9.0 INSTALLATION RECOMMENDATIONS

9.1 Access Safety - Prior to entering access areas such as manholes, an excavation pit, performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen shall be undertaken in accordance with local, state, or federal safety regulations.

9.2 Cleaning and Inspection - As per NASSCO Standards.

9.3 Accessing the Lateral Pipe - A cleanout shall be located on the exterior of the building. The cleanout fitting shall be TEE shaped so to allow upstream and downstream access to the lateral pipe. The cleanout when appropriate shall be located within two (2) feet of the terminating end of the lateral liner tube.

9.4 Plugging – The upstream side of the cleanout shall be plugged during insertion and curing of the liner assembly to ensure no flow enters the pipe and no air, steam, or odors will enter the building. Main flows shall be plugged and when required the main pipe flows will be by-passed. The pumping system shall be sized for peak flow conditions. The upstream manhole shall be monitored at all times and an emergency deflating system will be incorporated so that the plugs may be removed at any time without requiring confined space entry.

9.5 Inspection of Pipelines - The interior of the pipeline shall be carefully inspected to determine the location of any condition that shall prevent proper installation, such as roots, severe offsets, and collapsed or crushed pipe sections. Experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television shall perform inspection of pipelines.

9.6 Resin Impregnation -The liner assembly is encapsulated within the translucent bladder (liner/bladder assembly), the entire liner including the flat sheet shall be saturated with the resin system (wet-out) under controlled vacuum conditions. The volume of resin used shall be sufficient to fill all voids in the textile lining material at nominal thickness and diameter. The volume shall be adjusted by adding 5% to 10% excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe. No dry or unsaturated area in the mainline sheet or lateral tube shall be acceptable upon visual inspection.

9.7 Liner Insertion -The lateral tube and inversion bladder shall be inserted into the launching hose. The main bladder and flat textile sheet (main liner tube) shall be wrapped around a "T-Launcher" launching device, formed into a tube and secured by use of rubber bands. A seamless molded flange shaped gasket shall be attached to the main liner tube by use of stainless steel snaps. The flanged gasket shall be inserted into the lateral pipe at the main/lateral juncture so that the brim of the flanged gasket is firmly seated against the mainline pipe liner. The launching device is inserted into the pipe and pulled to the point of repair. The pull is complete when the lateral tube is aligned with the lateral pipe connection. The lateral tube is completely protected during the pull. The mainline liner is supported on a rigid T-Launcher device that is elevated above the pipe invert through the use of a rotating skid system. The liner assembly shall not be contaminated or diluted by exposure to dirt or debris during the pull.

9.8 Bladder -The main bladder shall be inflated causing the main sheet to unwrap and expand; pressing the main tube firmly into contact with the main pipe and embedding the flange shaped gasket between the main tube and the main pipe at the lateral opening. The lateral tube is inverted through the main tube aperture by the action of the lateral bladder extending into the lateral pipe to a termination point that shall be no less than two (2) feet from the exterior cleanout or predetermined termination point. The bladder assembly shall extend beyond each end of the liner, so the liner remains open-ended and no cutting shall be required.

10.0 **CIPP PROCESSING**

10.1 Curing - After the liner has been fully deployed into the lateral pipe; pressure is maintained pressing the liner firmly against the inner pipe wall until the liner is cured at ambient temperatures or by steam. The heating equipment shall be capable of delivering a mixture of steam and air throughout the liner bladder assembly to uniformly raise the liner temperature above the temperature required to cure the resin. The curing of the CIPP shall take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of the soil). The heat source temperatures shall be monitored and logged during the cure and cool down cycles. The manufacturer's recommended cure schedule shall be submitted and followed.

10.2 CIPP Processing - Curing shall be complete without pressure interruption with air or a mixture of air and steam for the proper duration of time per the resin manufacturer's recommendations. The curing process is complete when the temperature of the CIPP is reduced to 100 degrees Fahrenheit or less.

11.0 **FINISH**

11.1 The Finished CIPP - It shall be a homogenous CIPP liner assembly located at the main/lateral interface and extending into the lateral pipe to the maximum distance of two (2) feet downstream of the outside cleanout [or at the designated termination point if no outside cleanout is available]. The CIPP shall be smooth with minimal wrinkling and shall increase flow rate. The profile of the hydrophilic molded gaskets should be visible and verifiable during post-video inspection on liners 6mm or thinner thickness. The CIPP shall be free of dry spots, lifts, and delamination. The CIPP shall include a textile taper at each end providing a smooth transition to the host mainline liner for accommodating video equipment and maintaining proper flow in the mainline. After the work is completed, the installer will provide the owner with video footage documenting the repair and the visual markings on the CIPP liner assembly identifying the building address. The finished product shall provide a verifiable non-leaking connection between the mainline liner and the CIP-Lateral liner.

12.0 RECOMMENDED INSPECTION AND TESTING PRACTICES

12.1 Sampling - As designated in the purchase agreement, the preparation of a CIPP sample is required. The sample shall be prepared by securing a flat plate mold using the textile tube material and resin system as used for the rehabilitated pipe.

12.2 Pressure - The pressure applied on the plate sample will be equal to the normal pressure exerted on the lateral tube during the cure process.

12.3 Length - The minimum length of the sample must be able to produce at least five specimens for testing in accordance with ASTM D790-03.

12.4 Conditioning - Condition the test specimens at 73.4 ± 3.6º F (23 ± 2ºC) and 50 ± 5% relative humidity for not less than 40 hours prior to test in accordance with Practice ASTM D618, for those tests where conditioning is required.

12.5 Short-Term Flexural (Bending) Properties – The initial tangent flexural modulus of elasticity and flexural stress shall be measured for gravity and pressure pipe applications in accordance with Test Method D790 and shall meet the minimum requirements of Table 1.

12.6 Gravity Pipe Leakage Testing - If required by the owner, gravity pipes should be tested using an air test method where a test plug is placed adjacent to the upstream and downstream ends of the main sheet CIPP and at the upper most end of the lateral tube. This test should take place no less than 72-hours after returning the lateral pipe back into service. This test is limited to pipe lengths with no service connections. The test pressure shall be 4-PSI for a test time of three-minutes; the pressure shall not drop below 3.5 PSI.

13.0 WARRANTY

13.1 All CIPP liners shall be certified by the manufacturer for specified material properties for the repair. The manufacturer warrants the liner to be free from defects in raw materials for ten years from the date of installation. During the warranty period, any defects which affect the integrity, strength or water tightness of the installed pipe shall be repaired at the contractor's expense.

– END OF SECTION –

Installation of Seamless Molded Hydrophilic Gaskets (SMHG) for Long-Term Water tightness of Cured-in-Place Rehabilitation of Main and Lateral Pipelines

1. Scope

2. Practice

2.1 This practice covers the requirements for the installation of seamless molded hydrophilic gaskets (SMHG) in cured-in-place pipe (CIPP) rehabilitation of main and lateral pipelines.

3. Referenced Documents

3.1 *ASTM Standards*:[1]

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2240 Standard Test Method for Rubber Property – Durometer Hardness

F412 Standard Terminology Relating to Plastic Piping Systems

F1216 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

F1743 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)

F2019 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP)

F2599 Standard Practice for the Sectional Repair of Damaged Pipe By Means of An Inverted Cured-In-Place Liner

F2561 Standard Practice for Rehabilitation of a Sewer Service Lateral and Its Connection to the Main Using a One Piece Main and Lateral Cured-in-Place Liner

F4777 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

2.2 *NASSCO Guidelines:*

Recommended Specifications for Sewer Collection System Rehabilitation.

NASSCO Pipeline Assessment & Certification Program (PACP)

4. Terminology

4.1 *Definitions*–Unless otherwise indicated, definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600.

4.2 *Definitions of Terms Specific to This Standard:*

4.2.1 *Seamless Molded Hydrophilic Gasket (SMHG)* – a molded neoprene compression gasket that contains no seams and is positioned between the host pipe and the liner. The gasket absorbs water and expands to form a long-term watertight seal between the CIPP and host pipe, which prevents infiltration and exfiltration.

4.2.1.1 *SMHG End Seal Sleeve* – a neoprene compression gasket in the shape of an elongated sleeve. The SMHG End Seal Sleeve is engineered to maximize the sealing surface area and to be self-supporting when placed at the ends of the host pipe within 6 inches from the manhole. See Figure 1.

4.2.1.2 *SMHG Connection Seal* – a neoprene compression gasket molded with a tubular portion and a brim portion. The SMHG Connection Seal is engineered to be placed and to form a seal at the connection of the lateral pipe and main pipe. See Figure 2.

4.2.1.3 *SMHG O-Ring* – a neoprene compression gasket in the shape of a circular ring. The O-Ring is engineered to attach near the end of a liner that is either inverted or pulled into place to form a seal. See Figure 3.

4.2.2 *Host pipe* – the pipe to be rehabilitated using CIPP rehabilitation.

4.2.3 *Cured-In-Place Pipe* – a thermoset resin saturated into an absorbent textile pressed against an inner pipe wall and cured to form a new pipe within a pipe.

4.2.4 *Lateral Pipe* – branch pipe that provides sewer service from a building to the main pipe.

4.2.5 *Main Pipe* – main collector pipe of a sewer collection system

4.2.6 *Main/Lateral Connection* – location where lateral pipe and main pipe connect or meet

4.2.7 *Main/Lateral Connection Liner* –One-piece liner assembly consisting of a 16" long main tube or a main sheet formed into a 16" long tube and a lateral tube forming a main/lateral connection liner.

4.2.8 *Lateral Liner* – Liner tube used to renew a lateral pipe.

4.2.9 *Main Liner* – Liner tube used to renew a main pipe.

4.2.10 *Sectional Liner* – CIPP installed in a portion of the main or lateral pipe.

4.2.11 *Liner* – A resin impregnated cured-in-place pipe fabric tube that takes the shape of a main pipe, lateral pipe, or a main to lateral connection when installed.

4.2.12 *Leading edge* – the edge of the SMHG End Seal Sleeve that faces the direction of liner installation.

4.2.13 *Watertight* – for the purposes of this standard, the SMHG shall not allow water to pass through or around the gaskets from 72 hours after installation up until the end of the warranty period.

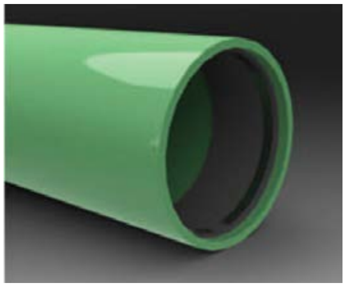

Figure 1: End Seal Sleeve

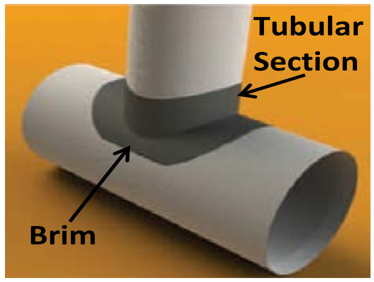

Figure 2: Connection Seal

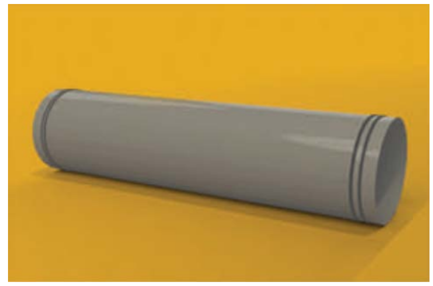

Figure 3: O-Rings

5. Summary of Practice

5.1 This is a practice for materials and the installation of a gasket with hydrophilic properties, positioned between the host pipe and the CIPP, which has been molded without seams into various shapes such as an elongated sleeve, Connection Seal, or O-Ring to form a long-term watertight seal to prevent infiltration and exfiltration.

5.1.1 The SMHG End Seal Sleeve is positioned at the upstream and downstream ends of a main pipe section typically 6" from a manhole connection prior to the CIPP installation. The SMHG End Seal Sleeve is held in place by a mechanical fastener. For large diameter pipe (diameter 18" and larger), the sleeve and its fastener are held in place by anchor screws. Once the liner is installed and cured the SMHG End Seal Sleeve ends up positioned between the host pipe and the CIPP at both ends of the main pipe within 6" of the manhole.

5.1.2 The SMHG Connection Seal is attached to the Main/Lateral Connection Liner after resin impregnation by two stainless steel snaps located on opposite sides of the SMHG Connection Seal. The SMHG Connection Seal can be manufactured as a Tee or Wye configuration. Once the liner is installed and cured the SMHG Connection Seal ends up positioned between the host pipe and the CIPP at the main and lateral connection.

5.1.3 The SMHG O-Rings are used to seal CIPP ends with limited access, such as the upper end of a lateral liner inverted from the main pipe. Another use would be at the upstream and downstream ends of a sectional liner located in a main pipe or in a lateral pipe. The SMHG O-Rings are attached on the liner near its ends before resin impregnation. O-Rings can also be positioned around flat sheet liners that are formed into a tube. Once the liner is installed and cured the SMHG O-Rings end up positioned between the host pipe and the CIPP. See Figure 4.

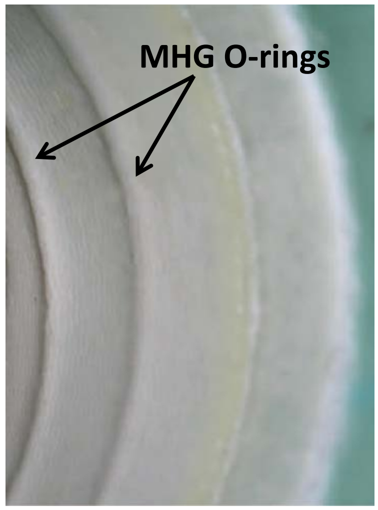

Figure 4: SMHG O-Rings after CIPP Installation

5.1.4 Applicable ASTM standards and/or manufacturer's recommendations shall govern the installation procedures for the various CIPP rehabilitation methods.

6. Significance and Use

6.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of main and lateral pipelines and manholes. As for any practice, modifications may be required for specific job conditions.

7. Materials

7.1 *Seamless Molded Hydrophilic Gasket (SMHG)*

7.1.1 The SMHGs shall be made with Neoprene rubber modified with hydrophilic properties. The gaskets will gradually expand when exposed to moisture such that it has a minimum 190% thickness increase and 800% cross sectional area increase after 10,000 hours.

7.1.2 The SMHGs shall be subjected to a 10,000-hour hydration/dehydration test. The test shall include submerging the gaskets in water for a period of 2, 7, 30, 90, 180 and 416 days then removed, measured, and weighed. The gaskets shall remain out of water for the same period of time as they were submerged except for the 416 day interval. This process is repeated until all samples within their respective cycles have been tested for 10,000 hours. Results must show that the SMHGs continue to stay flexible by bending the sample in half and observing no cracking. Also the SMHGs shall have no loss of material, and never get smaller than their original dimensions. The SMHGs shall retain the ability to increase in thickness a minimum of 190% and a weight increase of 800%.

7.1.3 The SMHGs shall have a Shore A Hardness of at least 45 when tested in accordance with Test Method ASTM D2240.

7.1.4 The SMHGs shall meet the minimum requirements of ASTM F477, Table 1, for low head application except for the volume increase after water immersion shall be as stated in section 6.1.2 of this standard.

7.1.5 The SMHG End Seal Sleeve shall have the following dimensions for the respective host pipe inside diameter (ID):

Chart 1 – SMHG End Seal Sleeve Dimensions

SMHG End Seal Sleeves			
Host Pipe ID (inch)	End Seal ID (inch)	Width (inch)	Thickness (inch)
6	5.6	3.5	0.06
8	7.5	3.5	0.08
10	9.5	3.5	0.12
12	11.5	3.5	0.12
15	14.25	3.5	0.12
18	17	3.5	0.12
21	20	3.5	0.12
24	22.75	3.5	0.12
27	25.75	3.5	0.18
30	28.5	3.5	0.18
36	34.25	3.5	0.18
42	40.25	3.5	0.24
48	46.25	3.5	0.24
54	52.25	3.5	0.24

The SMHG O-Ring shall have the following dimensions for the respective host pipe.

Chart 2 – SMHG O-Dimensions

SMHG O-Rings		
Pipe ID (inch)	O-Ring ID (inch)	Thickness (inch)
4	3.51	0.16
5	4.25	0.16
6	4.9	0.16
8	7.16	0.16
10	9.23	0.16
12	10.98	0.16
15	14.08	0.16
18	17.34	0.16
21	20.5	0.16
24	23.47	0.16
30	29.44	0.16
36	35.25	0.16

7.1.6 The SMHG Connection Seal shall have minimum values for the thickness, flange width, and length of tubular portion of 0.125", 2.5" and 1.6" respectively. The SMHG Connection Seal shall be molded in both a Wye and Tee configuration and in a manner in which it creates a circular shape in the portion that extends into the lateral when the flange portion is forced to curve around the CIPP. The SMHG Connection Seal will conform to the curvature of pipes from 6" diameter and up.

7.2 *Mechanical Fastener for End Seal Sleeve*

7.2.1 For host pipe diameters less than 18", mechanical fasteners shall be a flat bendable metal retaining clip with adhesive tape on one side that is inserted inside the SMHG End Seal Sleeve's leading edge to force the sleeve outward near its full diameter. This shall result in a snug fit in the host pipe.

7.2.2 For host pipe diameters 18" or greater, the mechanical fastener shall be a ratcheting metal retaining ring or other spring type mechanism. The ratcheted retaining ring includes a strip of material having a total length generally greater than the pipe diameter. A ratcheting worm gear or other spring type mechanism is attached to the strip and the strip is formed into a ring shape of variable diameters that is used to hold the sleeve in the correct position within the host pipe.

6.3 *Anchor Screws for End Seal Sleeve*

6.3.1 The Anchor Screw shall have the capability of mechanically anchoring the SMHG End Seal Sleeve into the host pipe.

6.3.2 The Anchor Screw shall be long enough to penetrate half the thickness of the pipe up to a maximum of 1 inch.

7. Procedure

7.1 *Cleaning and Inspection*:[2] The cured-in-place pipe rehabilitation shall conform to the Access Safety, Cleaning of Pipeline, and Line Obstructions sections of Practice F1216, Practice F1743, Practice F2019, Practice F2561, Practice F2599 whichever is most relevant.

7.2 *Seamless Molded Hydrophilic Gasket (SMHG):*

7.2.1 *SMHG End Seal Sleeve:*

7.2.1.1 *Measurement*-The pipe at the manhole shall be measured from 6:00 to 12:00 and from 3:00 to 9:00. The mean shall be the nominal inner diameter. The SMHG End Seal Sleeve shall be of the same or smaller inner diameter according to Chart 1. For non-circular pipes the circumference shall be measured.

7.2.1.2 *Placement*- The SMHG End Seal Sleeve shall be unpackaged and installed no more than 24 hours prior to CIPP installation. The SMHG End Seal Sleeves shall be installed while the mainline is being bypassed for the installation of the CIPP. If the CIPP installation has not begun within 24 hours of the SMHG End Seal Sleeve installation then they shall be removed. The first 6 inches of the inside of the main pipe shall be cleaned to remove all debris, deposits larger than ½" in diameter and visible grease deposits. The metal retaining clip shall then be placed at the leading edge inside the sleeve. An adhesive tape may be applied to the outer surface of the metal retaining clip. The adhesive tape shall be a thin flexible polyethylene (PE) film, coated on both sides with an aggressive synthetic rubber adhesive. It shall have excellent adhesion properties and good initial tack and shall create an immediate temporary bond to neoprene rubber and metal to prevent the metal retaining clip from slipping during CIPP installation. The SMHG End Seal

Sleeve shall then be placed so that its leading edge is no more than 6" inside the end of the main pipe, measured from the manhole connection. If the pipe's inner diameter is 18" or greater, anchor screws shall be used to hold the sleeve in place. In that case, a slot shall be placed in the metal circular retaining clip to allow anchor screws to be flush with the mechanical fastener. A minimum of four screws is recommended and shall be spread evenly along the circumference of the sleeve. Anchor screws shall be hand tightened to allow expansion of SMHG end seal.

7.2.1.3 *Pre-liner or Outer-bag* - If a pre-liner or outer-bag is used as part of the CIPP installation one SMHG End Seal Sleeve shall be placed into the host pipe prior to its installation and a second SMHG End Seal Sleeve shall be placed inside the pre-liner or outer-bag adjacent to the first SMHG End Seal Sleeve at the pipe ends within 6 inches of manhole. Therefore, the annular space between the pre-liner and the host pipe is sealed and the annular space between the CIPP and the pre-liner is sealed.

7.2.2 *SMHG Connection Seal:*

7.2.2.1 *Measurement* - The installation contractor shall determine the lateral diameter at the main pipe connection. There are a variety of techniques available to determine the lateral pipe diameter.

7.2.2.2 *Placement* - The SMHG Connection Seal shall be attached to the main/lateral liner after the resin saturation process by stainless steel snaps or other mechanical means that prevent it from moving. The lateral shall be plugged to eliminate any flows from interfering with the installation. Flow in the mainline shall either be bypassed or plugged until the inflation of the liner. The main/lateral one-piece liner shall be inserted into the main pipe and positioned at the main/lateral connection. The SMHG Connection Seal shall be positioned so that the brim portion is flush against the main pipe and the tubular portion extends into the lateral pipe.

7.2.3 *SMHG O-Ring:*

7.2.3.1 *Measurement*- The lateral or main pipe diameter at the anticipated location near the end of the liner shall be determined by the installation contractor. There are a variety of techniques available to determine the main pipe and lateral pipe diameters. The SMHG O-Ring shall be of the same or smaller inner diameter according to Chart 2.

7.2.3.2 *Placement*- To prevent movement during installation, the SMHG O-Ring shall be attached to the lateral liner or sectional liner prior to resin saturation. Two (2) SMHG O-Rings shall be placed at each end of the lateral liner or sectional liner. The first SMHG O-Ring shall be adhered using a single drop of cyanoacrylate that is specifically designed to bond with neoprene rubber. A single drop of cyanoacrylate shall be placed at six equally distanced spots around the circumference of the liner. Install the first O-Ring at 4 inches from the edge of the liner and the second O-Ring 6 inches from the edge of the liner. The O-Rings may also be attached by sewing, welding or manufacturing as part of the liner.

7.2.4 *Liner Installation*-The installation of the cured-in-place pipe shall conform to Practice ASTM F1216, Practice ASTM F1743, Practice ASTM F2019, Practice ASTM F2561, and Practice ASTM F2599 whichever is most relevant. Flow shall be bypassed or plugged until the liner is inflated. Procedures shall be used that are compliant to the National Association of Sewer Service Companies (NASSCO), ASTM F1216, National Association of Corrosion Engineers (NACE), and the Society for Protective Coatings (SSPC) standards and guidelines and those procedures shall provide quality assurance controls that meet the manufacturer's printed recommendations.

7.2.5 *Inspection and Acceptance* – The proper placement of the SMHG after installation shall be verified by visual inspection or by closed-circuit television (CCTV). The visual inspection of the finished rehabilitated CIPP shall reveal the impression of the correctly positioned SMHG. The gasket shall not be folded, twisted or rolled. See Figure 4. No infiltration shall be observed at the installed SMHG. Inspection to verify water-tightness shall take place during the period between 72 hours after installation up until the end of the warranty period.

8. Keywords

8.1 Anchor screws; Cured-in-Place liner; CIPP; Seamless Molded Hydrophilic Gasket (SMHG); End Seal Sleeve; Connection Seal; O-Ring; Mechanical Fastener; Leading Edge; Sectional Liner; Watertight Seal