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Learning about UV CIPP versus Steam and Water Cure CIPP in Portland Oregon

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1. ABSTRACT

This paper will explain the steps the City of Portland (City) went through to gain experience with Ultraviolet Cured-In-Place-Pipe (UV CIPP) on three projects. Also, what was learned regarding how UV CIPP compared with steam and water cured CIPP in cost, quality, schedule, constructability, strength, and public reaction.

2. INTRODUCTION

The City of Portland has over 2500 miles of sewer pipes with most of them built prior to 1930 and they are in need of repair. The City started to rehabilitate pipes with Cured-in-Place Pipe (CIPP) since the 1980's to repair aging sewer and storm-water pipes, first with water cure and later steam cure when contractors began using this technology in the 1990's. CIPP has been a useful tool to rehabilitate the pipes from 6" to 60" in diameter. Over the years we have learned many lessons on the difference between steam and water cure CIPP, from the experienced and less experienced installers and workman.

The City of Portland's pipe rehabilitation program has varied over the years from emergency based replacement to programmatic basin focused pipe replacement. In 2011, we decided to put more emphasis on assessing our existing old sewer system. Having just finished with our $1.4 billion combined sewer overflow system improvements in 2010, money was then made available to begin an aggressive program to rehabilitate the worst of the worst pipes in Portland utilizing CIPP, pipe bursting, and open cut construction methods. This program was called the *Large-Scale Sewer Rehabilitation Program* (LSSRP). The LSSRP is a $250 million-dollar program to fix the structurally deficient pipes, mostly in the residential neighborhoods of Portland. We were installing 21 miles of pipe a year. CIPP was responsible for 15,000 to 30,000 linear feet or a quarter of the new replacement pipe annually. This volume of work allowed the City of Portland to experiment and try some newer products and technology, such as UV CIPP. We hoped by adding another tool to our tool box we could achieve our pipe rehabilitation annual goals.

3. HOW WE DID IT

Initially we researched UV CIPP at the NASTT No-Dig shows and read articles in Trenchless Technology Magazines. Feeling the need to know more, we put together an in house half-day session about UV cured

CIPP. We invited three manufacturers to Portland from the East Coast and Europe to provide training and answer questions about UV CIPP, for our engineers, inspectors and consultants. This event demystified the product. We also came to realize that we did not have any local UV CIPP contractors in the Pacific Northwest. To attract UV CIPP contractors to the area, we decided to dedicate a large project from our LSSRP program to get experienced contractors to bid and dedicate a UV CIPP project in Portland. Unfortunately, other priorities got in the way. Three years passed and we still hadn't designed and bid a UV CIPP project. Then came the following opportunities to develop, implement, and learn about UV CIPP:

- The first was an emergency project to repair a 42" concrete pipe with a severely corroded crown, downstream from a force main discharge adjacent to the Portland Airport (NE 112th & Holman).

- The second was a three-week window of opportunity to rehabilitate century old pipes under our light rail tracks in Portland Central business area (SW Yamhill & Morrison).

- The third was a change order to a project calling for a CIPP rehabilitation to be used in an 8" pipe under SE Powell, a major arterial (SE Powell Rehabilitation)

Working through these projects helped the City develop and refine specifications for UV CIPP in our Largescale program which first started with listing UV CIPP as an alternate bid item to thermal CIPP when we bid out CIPP work in the LSSRP program. Unfortunately, due to price and lack of local contractor the UV CIPP alternate was not selected by our contractors who won the contracts. Realizing the need to do more our engineers began extensive outreach to UV CIPP contractors, around the country, to be engaged in the City's sewer rehabilitation program and developments, which also helped the City's efforts in development of a large-scale project to be bid exclusively as UV CIPP.

4. PROJECTS

NE 112th & Holman –
This was an Emergency Project to replace a failed 42" reinforced concrete pipe downstream from a sewer pressure line discharge after a sink hole developed, shown in Figure 1. The reinforced pipe had deteriorated due to hydrogen sulfide (H2S) corrosion. This project was an emergency requiring a quick response due to the proximity to the Portland International Airport and because the sink hole closed the street used by semi-trucks serving the airport and also impacted accesses to three hotels. The City hired a Contractor, on time and materials basis, to excavate the sink hole and install a sewage diversion system. Our maintenance engineers then developed a design to first replace the failed pipe with fiberglass reinforced pipe, then to line the remainder of the downstream pipe run that was affected by the H2S with CIPP. Design layout shown in Figure 2. The 42" HOBAS pipe was procured, and CIPP subcontractors were contacted for quotes, while the sewage diversion pumping system remained in place and was maintained by the open cut Contractor. When the quotes came-in, the installer for water cured CIPP was less expensive but took six weeks longer to get manufactured as compared to the UV CIPP. The UV CIPP turned out cheaper, overall, when considering projected diversion costs and public disruption. A small local UV CIPP firm was hired by the open cut contractor. While the City was checking references and submittals of the UV CIPP subcontractor, the prime contractor installed the 42" HOBAS pipe in the sink hole area. On the day of the lining the open cut contractor performed most of the support work to help facilitate the progress of the UV CIPP. The UV CIPP subcontractor showed up at 6:00 AM ready to clean and CCTV the pipe. Cleaning and the pre-CCTV inspection was done by 8:00 A.M. The CIPP installation began by 8:00AM. The light train for curing the liner was pulled thru at approximately 1' per minute, shown in Figure 3, ends of the mainline were cut out by 10:00PM, and laterals reinstated by 12:00 AM (midnight). To maximize efficiency, the open cut contractor assisted the sub-contractor with the installation of the liner using winches, equipment and workman they had close by, resulting in 402 ft. of 42", 20 mm thick UV CIPP.

Figure 1: Sink hole over failed 42" sewer requiring a quick repair

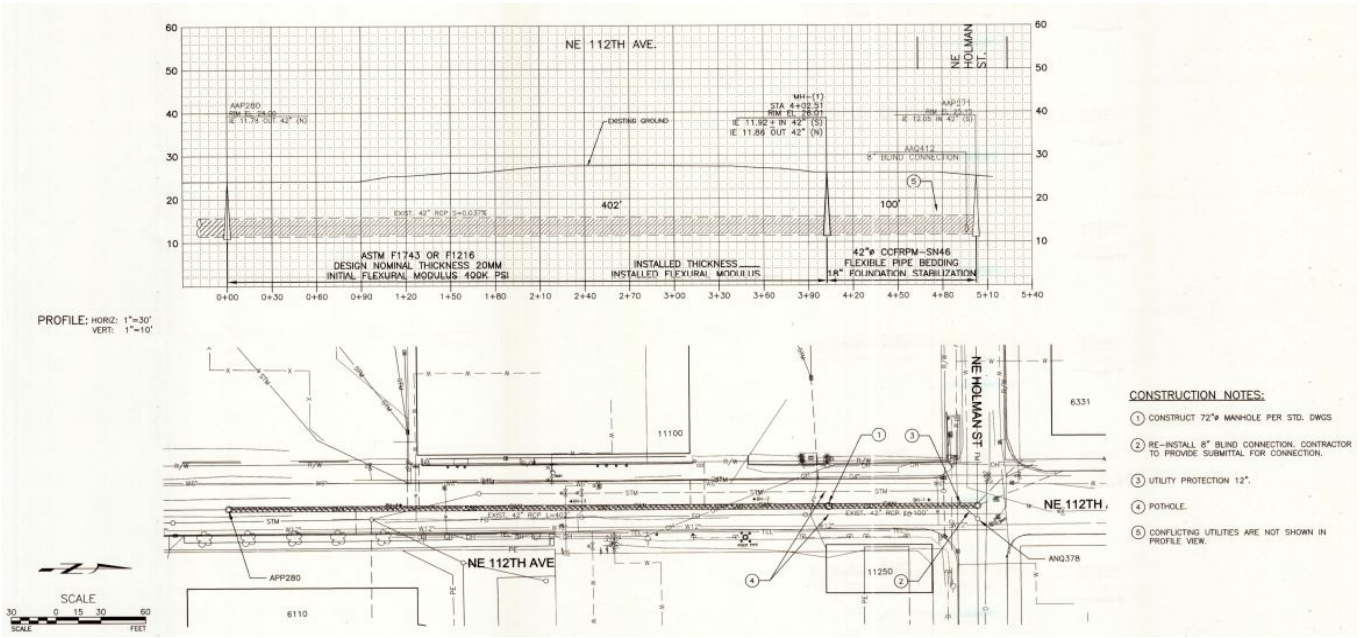

Figure 2: Design or Replacement of the failed 42" pipe

Figure 3: UV light Train Curing the 42" pipe on NE 112th & Holman

SW Yamhill & SW Morrison project, or better known as three weeks in May –

The SW Yamhill & Morrison Sewer Repair Project came into being when the Bureau of Environmental Services (BES) found out that the TRIMET Max light rail trains, located in Portland's Central Business District were going to be closed for upgrades. These planned upgrades were scheduled to occur over a three-week period, working 24 hours / day, in May of 2017. This created an opportunity for BES to rehabilitate some of the oldest sewer in the City, located underneath train tracks, during the closure. This project had a short timeline: the design, and procurement had to be completed in three months. The City looked at several options for contracting and determined that the best option was to design and administer the contract under the Urgent Pipe Contract more formally called the Price Agreement for Urgent Rehabilitation of Sanitary and Storm Sewers (PAURSS). Under the PAURSS contract the City completes a draft design and submits it to the contractor for pricing based on prearranged unit prices and estimated costs. The contractor returns an estimate and a final price is negotiated based on the scope. For this project, the scope of work required replacement of mainline sewers on two parallel streets SW Yamhill and SW Morrison Street, from Naito to SW 13th Ave; see Figure 4.

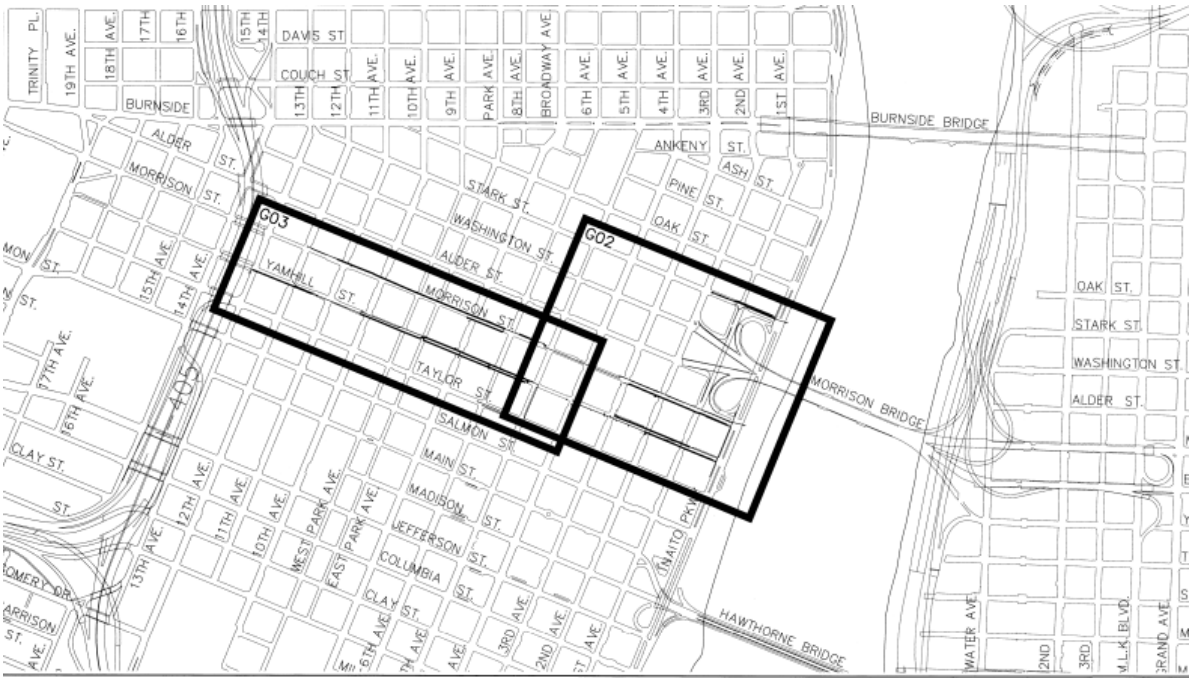

Figure 4: SW Yamhill & SW Morrison Project Area

The length proposed to be replaced was 6,000 LF of 100 to 140-year-old deteriorated sewer pipes. The pipes were in dire need of repair showing signs of cracks, breaks, holes, offset pipes, root and grease obstructions. In the initial considerations, the work included open cut and CIPP type of work, but due to time constraints CIPP was the only option. Thru scope refinement, the project scope and estimate went from $1.0 million to $3.5 million. As the cost rose, concerns rose over handing a $3.5 million-dollar contract to a single prime contractor and a single major subcontractor. When considering the City's goal of 20% minority subcontractor participation, this contract was not meeting the Cities aspirational goals for contracting. To address this concern, we encouraged the prime contractor, JW Fowler, to subcontract as much work as possible to minority and women owned firms. Additionally, the prime contractor was concerned with the 3-week time constraint window, and having one subcontractor not be able to complete the project on time. If they have an equipment breakdown, or a weather issue arose, they were concerned about the ability to maintain or divert flow. as a result, the CIPP subcontract work was to be split between two sub-contractors. The work on SW Morrison St. was to be completed by Michels and work on SW Yamhill was to be completed by Final Liner, a small woman owned firm that does UV CIPP. This resulted in all mainline pipes on SW Yamhill Street to be lined using UV CIPP, and pipes on SW Morrison Street to be lined with conventional Polyester Thermal Cure CIPP. Some of the project challenges included lining mainline pipe segments that are adjacent to historic buildings varying from five to 20 stories, with major utilities, and vaulted basements protruding well into the right-of-way (in some cases to the face of curb). These challenges posed major implications with sewage diversion, in some cases impossible with the time constraints the project was up against. JW Fowler worked around the clock, 24 hours/day and 7 days/week, from March to May installing cleanouts and preparing flow diversions. In addition, JW Fowler and the City were meeting with building owners to design and plan sewage diversions where deemed feasible.

When the three weeks in May arrived approximately 14 mainline segments, out of the 24 mainline segments planned, were available to be lined. Michels came in and lined one line after the next and left, after completing 6 of 12 segments. Final Liner, with JW Fowler's assistance, lined 8 of 12 segments over the three weeks that were available. At the end of the three weeks in May, there were 1,445 Linear Feet of UV CIPP installed, ranging from 9" diameter to 20" diameter, and a total 1,700 Linear feet of Thermal Cure CIPP was installed ranging from 10" diameter to 16" diameter; 1,355 linear feet of Thermal cure CIPP and 1,120 linear feet of UV Cured CIPP were uninstalled. Because either lateral could not be located or laterals could not be accessed for installing a sewer diversion in the time available work could not proceed; independent of whether the liners were UV Cure CIPP or Thermal Cure CIPP. To make things worse Finaliner experienced theft of the light train equipment, and lost some of their more experienced staff/ workforce. These posed additional challenges to completing the project within the time constrains.
In the following months, the unused and wetted-out thermal cure CIPP liners expired and were discarded. The City is continuing to work with the prime contractor, and building owners, to complete the flow diversion plans required to finish the installation of the remaining UV CIPP liners. At the time of this paper, the City has 10 liners to complete, four of which are UV CIPP and six are thermal cure. The work is tentatively scheduled to be completed in early 2018.

Figure 5: Inserting 10" UV CIPP Liner on SW Yamhill St. Located Underneath Train Tracks

Tabor Powell Phase II Sewer Rehabilitation –
The Tabor Powell project is a Large-Scale Sewer Rehabilitation Project. The project is located in SE Portland and NE Portland. The boundaries of these combined projects are I–84 on the north, NE/SE 43rd Ave. on the west, NE/SE 67th Ave. on the east and SE Holgate Blvd. and SE Long St. on the south. This project is to rehabilitate sewer using the Cured-in Place pipe (CIPP) method to approximately 28,000 feet of deteriorating combination sewer located throughout Tabor and Powell neighborhoods. The sewer pipe in this project was constructed between 1910 and 1955. The sewer pipe sizes range from 8 inches to 36 inches with depths that range from 7 to 21 feet.

This project was targeted for UV CIPP only. The design documents were developed through the project delivery team in concert and with consulting engineers Brown and Caldwell. Outreach was made to 9 UV contractors, resulting in 5 bidders. The contract was awarded to Precision Trenchless out of New York, and the project is in the construction phase at time of this paper.

5. COMPARING - UV CIPP AND THERMAL CURE CIPP

Liner Cost –
When looking at average costs of what the City of Portland has seen, on the most common pipe diameters, the cost of UV CIPP is trending to be higher; see Figure 6.

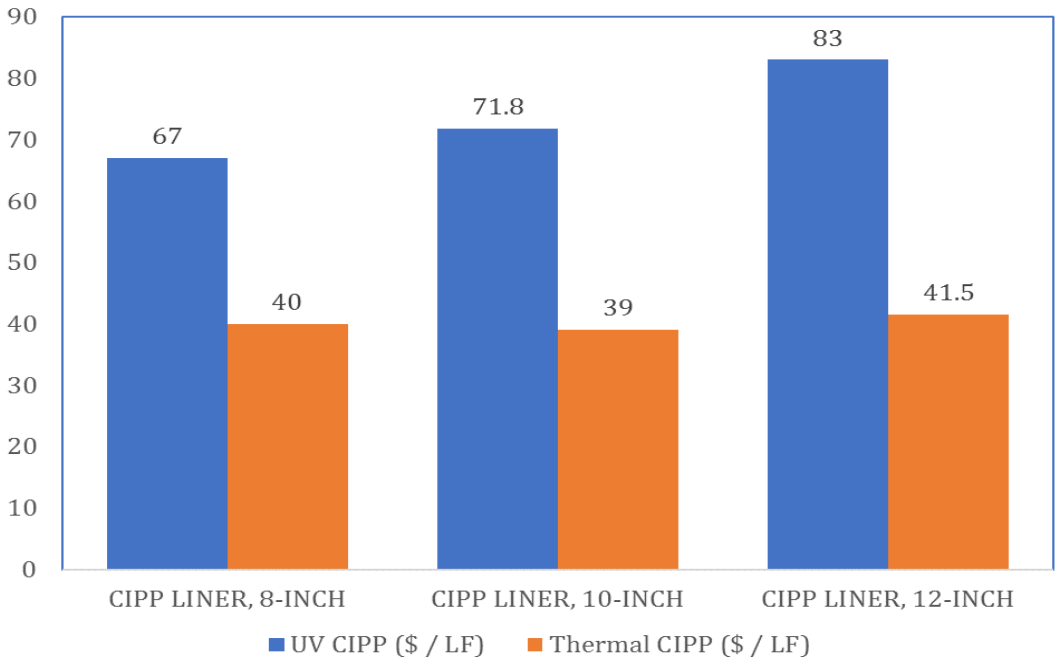

Figure 6: UV and Thermal Cure CIPP Unit Cost Comparison

Liner Strength Properties –
The typical strength of the UV CIPP trends much higher than that of the thermal cure CIPP, see Figure 7. The data shown is an average strength of liners installed of the UV CIPP for a single installer, and the thermal cure of two different local installers.

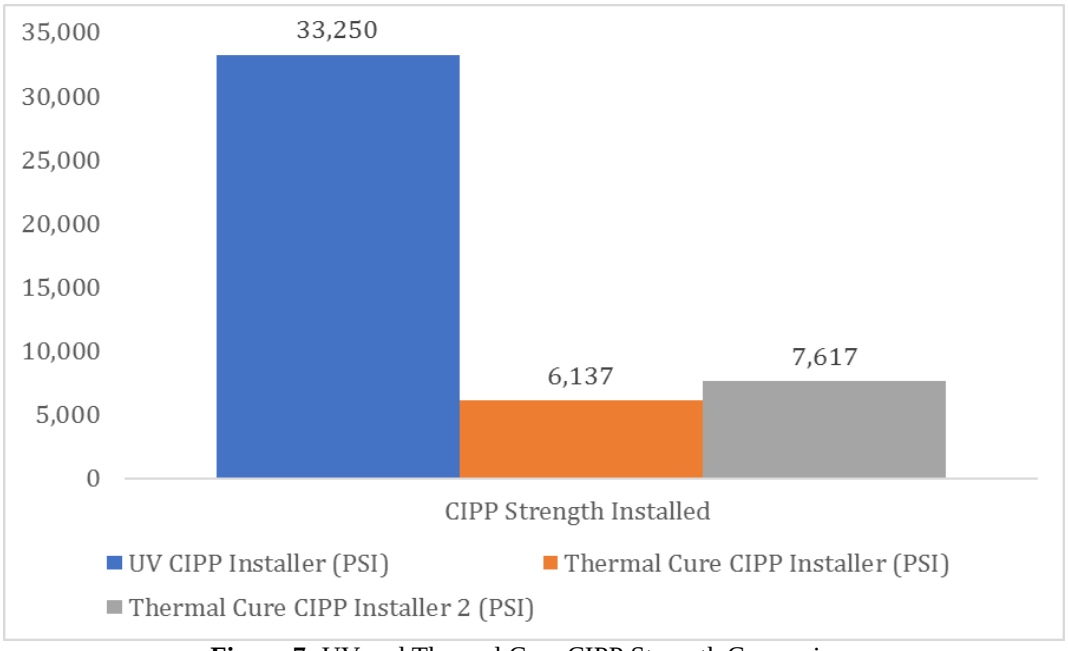

Figure 7: UV and Thermal Cure CIPP Strength Comparison

Similarly, when looking at the typical flexural modulus of the UV CIPP it trends were much higher than thermal cure CIPP, see Figure 8. The data shown uses an average flexural modulus of liners installed of the UV CIPP, for a single installer, and the thermal cure of two different local installers.

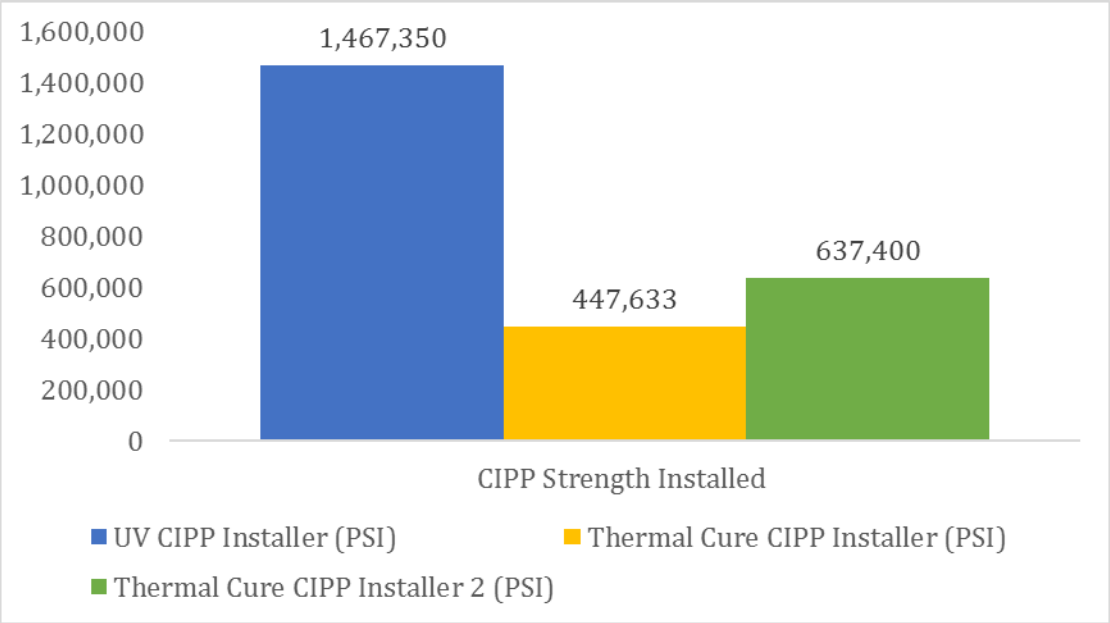

Figure 8: UV and Thermal Cure CIPP Flexural Modulus Comparison

Liner Constructability –

When looking at projects we are often challenged with selecting construction methods that best fit the desired outcome while balancing between risk, cost, schedule, and impacts. When looking at the differences between CIPP Thermal Cure and UV cure we categorize them from the perspective of pros and cons, otherwise known as advantages and disadvantages. Here are some of the comparisons that were observed –

Thermal Cure:

Pros. –

a) The standard polyester product is flexible, and can mold to the existing pipe and can go through pipe segments with small degrees of turns, radius, or direction changes in the mainline pipe alignment.
b) Once the product is installed the laterals are relatively easy to locate as most of the time there is a dimple in the liner surface providing indication of the lateral location.
c) A transitional liner is not uncommon.
d) There are many experienced installers, with multiple crews, who know what they are doing.
e) The City of Portland knows the challenges using thermal cure CIPP and has developed protocols for successful projects from over 30 years of experience, we don't have that level of comfort and institutional knowledge for UV CIPP.
f) Thermal cure CIPP is available in a variety of resin types: polyester, vinylester, epoxy, and reinforced fabrics fiberglass, fiberglass and polyester.

Cons. –

a) The condition of the host pipe needs to be within a range of degradation, due to the lower strength liner or burst pressures. Advance work may be required to correct some of the mainline deficiencies, like pipe loss or gaps, and voids.
b) Construction footprint is larger than that of UV cure.
c) When installing the liner, there is limited viewing ability to see what the liner looks like, after putting into position, until its cured and a post CCTV inspection has been done.
d) The workability, or work time, of the thermal cure CIPP is much less than that of the UV CIPP. If a challenge arises, on the day of the inversion, there is less flexibility to adjust to the condition at hand. Liners could prematurely harden.
e) When the liner is wetted out, it has a short shelf life.

f) Cure time can be longer, then that of UV cure.
g) Custom liner sizes can take a while to manufacture.
h) There are concerns about Styrene odor with traditional styrene systems.
i) Hot water and steam present safety risks for workers.
j) The liners can prematurely harden in hot weather, or when refrigeration is challenged.
k) Liners do not always cure completely, due to heat sinks, water circulation or equipment malfunction and you often don't know until you cut the ends.
l) Because of the increased thickness of Thermal liners to UV this can be a heavier product to transport.

UV Cure:

Pros. –

a) The product is more rigid, allowing the ability to span locations of mainline with larger amount of pipe loss, presence of gaps and/or voids exist. May require less advance work to be done on the mainline host pipe.
b) Construction footprint is small, making it more convenient and less impactful to the public.
c) When installing the liner there is pre-curing viewing ability allowing you to see how the liner looks, in position, prior to starting the cure.
d) The workability, or work time, of the UV CIPP is much longer than of the thermal cure CIPP. If a challenge arises, on the day of the inversion, the liner cure could be delayed. If the liner is not used, and is properly stored, it typically has a 6-month shelf life.
e) Cure time is much faster than of the thermal cure, however the total liner install time is heavily dependent on the experience of the crew on-site doing the work.
f) On custom size, UV liners can typically be manufactured quicker than the thermal cure CIPP.
g) Cure time for the section is immediate once the light train passes as opposed to Thermal cure where the entire length must be brought up to temperature for cure to occur.

Cons. –

a) Cost of the UV CIPP is roughly 60% more than thermal CIPP for small diameters.
b) The product has little flexibility to expand and requires a feasibility analysis on mainline segments with turns, radius, or direction changes in them.
c) The light train cannot go thru most bends.
d) Locating and noting the locations of all laterals is extremely important. Once the product is installed there is no dimple in the liner surface, the locations need to be reinstated based on measured distances and notes recorded. In cases of less experienced installers, this often creates overcutting on the lateral reinstatements.
e) A transitional liner is less common, and often requires an access point to be dug and a manhole added at the transition point.
f) Fewer smaller contractors exist that install the UV CIPP lining on a less regular basis. The smaller contractors require assistance from more experienced open cut contractors and can be less efficient. They have little or no experience with City of Portland requirements.
g) Sizes and thicknesses of liners are limited.

6. Conclusion

How does UV CIPP compare with steam and water cure CIPP in the areas of cost, schedule, constructability, strength, and public reactions. I would offer the following conclusions:

- UV CIPP has higher physical properties than standard steam or water cure CIPP at equivalent thicknesses due to the reinforced liner. Unlike water and steam cure CIPP which allow for a variety of resin types including Epoxy, Vinyl ester, and Polyester systems, UV comes with one resin and fabric. The resin systems are very similar between heat and UV cured processes. The liner is what is attributing to the majority of the physical properties.

- UV CIPP typically costs more than the standard steam and water cure CIPP especially at smaller diameters. Without specifying it, or considering other factors like material procurement schedule or strength of the material, UV CIPP would not have been used in Portland.
- UV CIPP can be quicker to cure. However, our experience was that the quicker cure time was offset by the crews taking longer to setup the line. The UV contractors schedule was affected by their ability to manage the non-lining elements of the work like CCTV, diversion, traffic control, and staging. When it came to contractor availability effects on schedule, we found that the UV contractors had less jobs so they would commit to a time frame to be in Portland, but because they had a smaller number of crews getting them back to do work was more difficult. The larger, standard CIPP contractors would not commit to a time frame as they tried to fit you in, but when they came they came in force, lining quickly, and if there were issues to resolve they could free up a crew once cost/responsibility was resolved.
- UV cure CIPP is a constructible tool for pipe rehabilitation with its significantly higher strength and flexibility with installation time. With those constructability advantages, there is some mystery about what it takes to build a UV CIPP, whereas thermal cure CIPP installation challenges and solutions are well known making it predictable.
- UV CIPP didn't exhibit a better public reaction when installed side by side to thermal CIPP, but I will tell the lining operation of the thermal CIPP was easily identified by the smell when walking the job site.
- Piloting a new trenchless technology like UV CIPP takes the efforts of many beyond the authors of this paper, Stephen Hawkins for pushing it forward on the NE 112th Projects, Valerie Jowoekin for organizing the half day UV training, Colleen Harold and Brown and Caldwell for their work on specifications for large diameter rehabilitation projects, Fahim Rahman, Scott Clement, Susan Hjorten, Nick Naval, Curt Obermier as well as many inspectors and technicians. Coupled with a management that is open to maybe spending some money, taking on some risk to the benefit of their rate payers, and moving the technology forward.

The process of first trying out UV cure CIPP in a non-competitive bidding market, then moving to targeting a project as UV only, is a good way to gain experience as an organization, and to use this method as a tool on pipe rehabilitation. Moving forward UV CIPP is a good tool for specific installations, but not a replacement for thermal cure CIPP.