North American Society for Trenchless Technology (NASTT)
NASTT's 2013 No-Dig Show

Sacramento, California
March 3-7, 2013

TM2-T3-01

Water Main CIPP Lining Taking-off in Anchorage

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ABSTRACT: The use of water main cured in place pipe (CIPP) lining is growing in Southcentral Alaska. In 2012, approximately 6,500 feet of water main CIPP liner was installed by the Anchorage Water and Wastewater Utility (AWWU) with approximately 13,000 feet planned for installation in 2013. Coupled with 3,700 feet installed by AWWU since 2009, and use of the technology by Joint Base Elmendorf Richardson, this equates to almost 27,000 feet of CIPP installed in the Anchorage area by the end of 2013.

AWWU owns an 834-mile water pipe network spanning 69 years of installations and comprised of 14 pipe materials. AWWU has seen a moderate increase in corrosion-related failure of its ductile and cast iron pipes. Pipes in Southcentral Alaska are buried 10 feet deep to prevent ground frost from freezing the pipes. The deep burial adds significantly to the footprint of an open cut excavation and replacement, and CIPP is a cost-effective alternative.

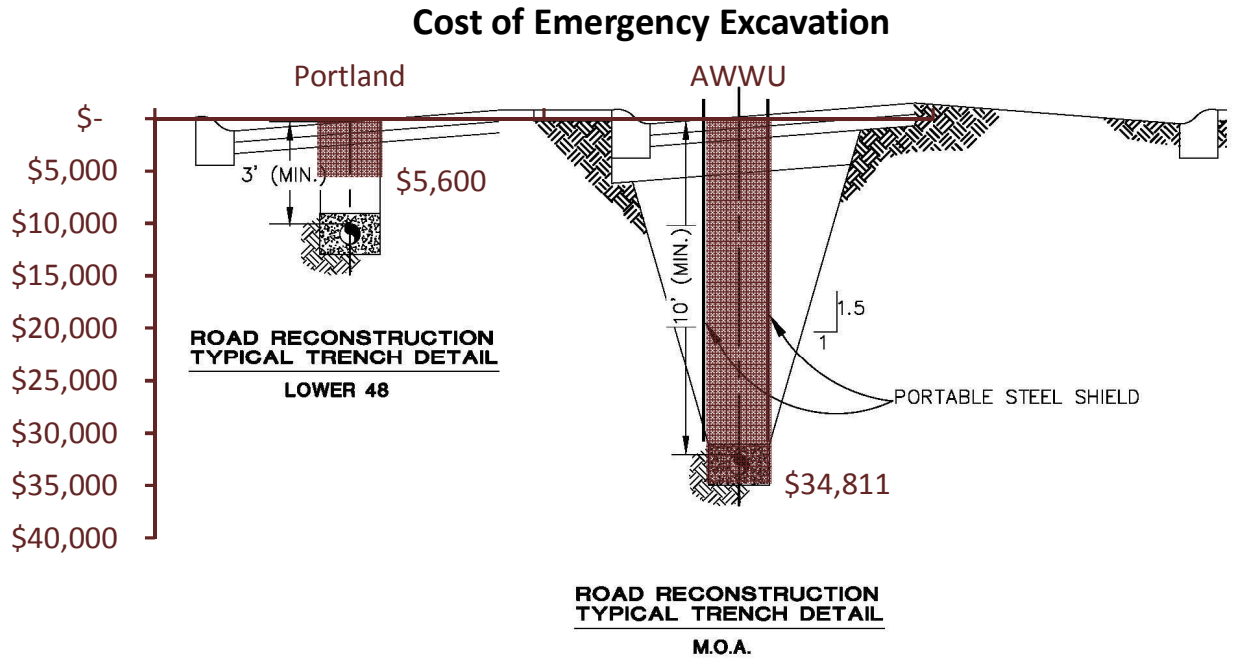
Standard specifications have been developed, and contractors are selected through a public low bid process in order to maintain high quality and optimize the cost/benefit of using CIPP lining. Only NSF/ANSI 61 approved liners are allowed in Anchorage. To achieve an overall system upgrade, all the fittings, hydrants, and valves are replaced when the main is lined. Robotic service connection reinstatement from inside the main is utilized for most installations.

This paper discusses the host pipe characteristics, why AWWU has chosen CIPP to upgrade their water pipes, and design and construction processes.

1. INTRODUCTION

AWWU's water system is constructed with over 672 miles of ductile iron (DI) and cast iron (CI) pipe. Approximately 540 miles of the DI and CI water mains are distribution sized (less than 16-inches). The majority (420 miles) was installed prior to 1985 and is 30 to 60 years old. AWWU has seen a moderate increase in corrosion-related failure of its ductile and cast iron pipes. Unexpected emergency repairs on corroded and leaking water mains are expensive compared to other similarly sized utilities in the Lower 48. AWWU maintains a record of the repair locations and their causes, and uses this information in conjunction with other data to identify and prioritize water mains for rehabilitation. AWWU uses a variety of construction methods for the R&R of its water mains, both conventional open cut excavation and trenchless technology. AWWU has previously used pipe bursting, HDD, and modified PTMT to replace existing water mains. AWWU began using cured in place pipe (CIPP) lining in 2009, and recently, CIPP has replaced open cut excavation as the leading rehabilitation method. In most cases, the water mains slated for CIPP lining are cast iron pipes that are approaching 50 years old and have a history of multiple breaks and emergency repairs.

Figure 1: Costs of Emergency Excavations



2. FACTORS CONTRIBUTING TO CIPP USE IN ANCHORAGE

Like many utilities, AWWU has seen an increase in operating costs, the need for increased capital expenditures, and thereby a need to increase customer rates. In an effort to minimize rate increases, AWWU has been proactive in the management of its assets and has trimmed its capital budgets to meet its basic needs. The pipes in Anchorage are buried 10 feet deep. The deep burial adds significantly to the footprint and cost of an open cut excavation and replacement (Figure 1). Depending on the characteristics of a project, the total project cost for an open cut replacement can run between $500 and $1000 per linear foot pipe. AWWU ends up paying substantially for infrastructure (roads, storm drain, lighting, etc.) that are not its customers responsibility. AWWU has actively sought technologies that decreases its customer's burdens and/or allows for additional projects to be completed with limited capital budgets.

Anchorage, like many other northern communities, has a limited construction season. Generally, the right-of-ways are open for construction between the end of May and the middle of October. Any landscaping must be planted by early September if it is to have a chance to grow and take root prior to freezing conditions. With a limited construction season, and risks inherent with open cut excavations, the completion of projects within one construction season is a challenge. Extension of projects into multiple seasons impacts AWWU's resources to manage and complete other needed projects.

3. ANCHORAGE WATER CIPP PROJECTS

AWWU completed their first water main CIPP project in 2009, and by the fall of 2012 they had finished 11 projects with 10,200 feet of lined pipe for a total construction cost of $6.1 million. Three more CIPP lining projects are planned for 2013. A brief description of the various projects is described in Table 1. In addition to the AWWU projects, approximately 4,000 feet of water CIPP work was completed on the nearby Joint Base Elmendorf Fort Richardson (JBER) military base in 2009.

Anchorage is included in a hand-full of U.S. City's that have completed over 10,000 feet of water main CIPP lining (the water main CIPP lining process has been utilized in Canada for approximately15 years and significantly

exceeds the volume installed in the U.S. at this time). Approximately 83 percent of the lining work in Anchorage has been completed in residential areas and 17 percent is in business and commercial areas. All of the upgraded mains have been 12 inches in diameter or less.

The construction season for water CIPP lining work lasts for five months, starting in mid-May when the ground thaws, and ending in mid-October when low temperatures cause freezing problems with the above-ground temporary water systems. No attempts have been made to date in Anchorage to install a CIPP water liner during winter conditions; largely due to concerns related to temporary water systems freezing.

Table 1. Anchorage CIPP Project List

Project Name	Year	Length (ft)	Diameter (in)	Host Pipe Type	Host Pipe Problems	Type Area
Juneau Street	2009	1,058	8	Cast iron	Breaks	residential
H-K Alley	2009	736	8	Cast iron	Breaks	business
Folker-Wright	2011	689	6 & 8	DI & CI	Corrosion	business
Melvin	2011	1,114	6	Cast iron	Breaks	residential
30th Ave	2012	600	6	Cast iron	Breaks	residential
Rose Street	2012	582	6	Cast iron	Breaks	residential
32nd Ave	2012	484	6	Cast iron	Breaks	residential
20th Ave	2012	989	12	Ductile iron	Ext. corrosion	residential
3-4 Alley	2012	960	6	Cast iron	Breaks	business
New Seward	2012	1,644	12	Cast iron	Breaks	business
Cope Street	2012	1,270	6	Cast iron	Breaks, external corrosion	residential
Bayshore Ph I	2013	4,850	6-8	Cast iron	Breaks, external corrosion	residential
Bayshore Ph II	2013	4,056	6-8	Cast iron	Breaks, external corrosion	residential
Calais	2013	4,000	6	Cast iron	Breaks	residential

4. CIPP STANDARDS, PROCUREMENT AND DESIGN

Project Implementation: The traditional design-bid-build project implementation method has been used on all the water CIPP projects completed for AWWU. A construction contractor is selected based on the lowest bid price. The contractor prepares his bid price based on a design that was prepared by an engineer. AWWU has used engineering consultants to prepare the designs, and has recently started preparing some of the CIPP designs with their own in-house engineering staff.

Although AWWU has a long-range, multi-year plan for upgrading their water system, the CIPP pipe rehabilitation work is completed on a project- by-project basis. Each CIPP project is designed and bid as an individual stand-alone contract that can be bid on by any qualified contractor. The typical AWWU lining project has been less than 2,000 feet in length, although in 2013, three projects will be underway that are over 4,000 feet long.

Figure 2. CIPP lined cast iron water main

Typical Standards: A new CIPP liner (Figure 2) must meet the following standards when installed in the AWWU water system:

- NSF/ANSI 61 certification.
- Fully structural liner meeting AWWA M28 Class IV.
- The liner strength and wall thickness must meet the requirements of ASTM F1216.
- Lining contractor CIPP supervisor must have installed a minimum of 2,000 feet of the liner being used.
- Installation shall follow the CIPP manufacturer's process.
- Host pipe shall be cleaned of loose scale and rust and all standing water removed.
- Liners are pressure tested to 150 psi.
- Service connections of 2 inches and less must be reinstated from inside the pipe with a robotic cutter.
- A portion of unsuccessful robotic reinstatements are anticipated and work to excavate and reconnect these services is paid for by the Owner at the unit price in the bid proposal for this work.
- A site visit by a manufacturer's representative is required during construction (waived in some cases).
- Samples of the liner material installed on each project are tested for tangent flexural modulus of elasticity and flexural stress to confirm that the design strengths have been achieved. [confirm terms here]
- Samples of the liner material installed on each project are measured for wall thickness to confirm that the design wall thickness has been achieved.
- Liners are designed with an assumed life expectancy of at least 50-years

CIPP Design Documents: The Contract Documents for the AWWU water CIPP projects contain bidding instructions, general conditions, standard specifications, special provision specifications, a bid proposal and design drawings. Specifications and drawings are prepared with sufficient detail to generate competitive bids.

The technical specification used by AWWU to describe the water main CIPP work was first developed in 2009. The specifications have been continually updated as the lining work in Anchorage has matured. Other technical specifications prepared for the water pipe lining projects include CCTV inspection (pre and post rehabilitation) and temporary water systems.

Figure 3. Thrust blocks are precast in some cases to minimize water shut-down times.

CIPP drawings use the plan and profile format commonly seen in new pipe designs. Determining the elevation and location of the existing water pipe is important to help avoid excessive digging. Record drawings are not always accurate. Existing valve boxes are used to confirm horizontal and vertical locations at specific points. Water mains with bends and grade breaks can be a challenge to describe accurately in some cases. Design details that are unique to the water CIPP designs include special pipe thrust restraint methods, tie-ins to the existing unlined mains and temporary water connections to commercial water services that are 4 inches in diameter and larger.

5. CONSTRUCTION

High operating pressures, drinking water quality requirements, gaining access to the water main and service and fitting reconnections are all unique to water main CIPP rehabilitation work in comparison to sewer CIPP lining.

General Construction Characteristics: In the AWWU water system, a new CIPP liner installation has the following general characteristics:

- All tee fittings, hydrants and valves are replaced, resulting in a completely refurbished water main.
- Water service pipes and key boxes are not replaced.
- Access pit locations and dimensions are kept flexible if possible, and may be changed by the contractor to suit his methods.
- When the project is more complex, some pits will be designated on the design drawing.
- Water mains with bend fittings can require additional access pits. Liner insertion is challenging with multiple bends and robotic cutting equipment cannot negotiate through most bends.
- A temporary water system must be constructed and put into use while the main is out of service.
- In an unrestrained water pipe system, new thrust blocks (Figure 3) and restraint devices are used at the CIPP project boundary to help keep the surrounding water pipe network in service and reduce the size of the temporary water system.
- Pits are excavated to gain access to the main as shown in Figure 4. Normally the pits are spaced about 400 feet apart and are often located at tees and hydrants.
- Water services over 2 inches cannot be reinstated robotically and must be excavated to reconnect.

Figure 4. Typical liner access pit

Construction Timeline: On an Anchorage CIPP project an existing water main is usually taken out of service for six to seven days. The main will be shut off after the temporary water system is put into operation and access pit excavations are underway. Figure 5 and Figure 6 show a temporary water system under construction. Host pipe inspection and preparation are completed the first day. On day two, the new liner is inserted and cured. Day three is spent pressure testing the new liner and reinstating services robotically. On day four, the main is cleaned of service reinstatement debris and reconnected to the water system. Chlorination and disinfection can be completed on day four in some cases. In Anchorage, bacteriological testing is done twice; an initial sample is taken and then a confirmation test is done again 24 hours later. Bacteriological testing results are available on the sixth or seventh day. The successfully lined water main is put back into service after the second successful bacteriological test is received.

Figure 5. Buried temporary water piping in a business district.

Figure 6. Elaborate pipe for a fire-flow sized temporary water system.

Temporary Water Systems: Alaska has state-wide regulations that govern above-ground and temporary water systems to accommodate the numerous remote sites and bush communities that use them. A temporary water system constructed in Anchorage is reviewed and approved by the State environmental agency. Temporary water systems used on the AWWU lining projects are built with butt-fused HDPE headers and HDPE service pipes to each dwelling. Backflow preventers are installed on each service and at the hydrant connection. The entire temporary system is pressure tested, disinfected, and goes through two bacteriological samples and testing. Temporary water

systems that serve buildings with sprinkler systems usually have 10-inch HDPE headers and 6-inch connections. The larger diameter temporary water systems are expensive and are often buried just below the surface at numerous places to allow access through the construction area. Recently, temporary water systems for residential areas have averaged $23/foot and systems with fire flow capacity for business/commercial areas have averaged $130/foot.

Host pipe preparation: To prepare the pipe for lining, the host pipe is cleaned to remove loose deposits, rust and standing water. A water jet or mechanical means such as chain cutter may be used, depending on the type of deposits on the pipe interior. Cast iron fittings and some service taps in the AWWU system are prone to accumulating mineralization buildup. These are cleaned with aggressive tools. Ground water that is leaking into the main must be stopped to keep the pipe free of standing water. In some cases, short CIPP spot repair kits like those used in sewer pipes are used to repair these types of host pipe defects. Water back-flowing from house services can be a nuisance. Old shutoff valves and key boxes can leak. This was eventually remedied by requiring in the design that a new shutoff valve be installed in the water service pipe in every house on the water lining project.

Figure 7. Water service plugs

Commercial service connections: Services over 2 inches in diameter are reconnected via an excavation pit. A reliable method for robotically reinstating these larger services has not been developed to date. In most cases, the temporary water connection to the commercial building is done in the same pit as the permanent water main connection to minimize the excavation footprints and save costs.

Liner installation: This process varies slightly depending on the liner manufacturer. The processes include 1) a wet-out phase when the fabric is impregnated with resin (Figure 8), 2) an inversion or pull in phase (Figure 9) and 3) a cure phase when the liner is pressed firmly against the host pipe and cures to full strength.

Service reinstatement: Service connections of 2 inches and less in diameter are plugged with a plastic cap (Figure 7) before lining and are drilled out with a robotic cutter after the liner has been installed. Most of the water service connections in the AWWU system are constructed with threaded taps that protrude into the water main interior. Some saddles were used in the AWWU system for services larger than one inch. The taps have a higher reinstatement success rate. They protrude and are easier to find when covered with a liner and they have more consistent inside diameters that can better accept a temporary plug. Sometimes the robotic reinstatement is not successful for various reasons including: 1) the tap is covered with a shark-fin, 2) the tap does not show up well behind the liner and is difficult to accurately find, 3) the plug becomes dislodged during insertion or does not seal well against the tap or saddle, and resin leaks by and plugs the service pipe. In these cases the connection must be excavated and repaired. In Anchorage we have observed a success rate of approximately 95 percent for residential services, meaning on five out of 100 services the interior reinstatement is not successful and they must be dug up. In business areas with services at or larger than 1.5 inches, the success rate has been approximately 30 percent.

While service reinstatement allows for the timely placement of the water main back into service, there is concern by some within AWWU's O&M department about long term implication of only performing reinstatement of the services in-lieu of full service line replacement. Service line related failures outnumber mainline breaks within

Anchorage by a factor of almost 3:1. The desire for now is to continue with service reinstatements at the main and to continue to evaluate the costs implications of upgrading the entire water service.

Figure 8. Wet-out and sizing equipment. Courtesy of Sanexen Aqua Pipe.

Figure 9. CIPP insertion into an AWWU cast iron main.

CIPP completion tasks: This phase of the work includes a number of steps; 1) samples of the liner material are taken for laboratory testing, 2) the liner is pressure tested to 150 psi, 3) services are reinstated, 4) the main line is cleaned of debris, 5) the newly lined pipe is reconnected to the water system, 6) services are backflushed, 7) disinfection is done, 8) chlorinated water is flushed from the service pipes, 9) bacteriological testing is done and 10) the CIPP lined main is put back into service. In Anchorage, highly chlorinated water trapped in the service pipes is flushed toward the dwelling and retrieved there. This is done to prevent possible contamination of the water main from water entering the main from the dwelling plumbing.

CIPP costs in Anchorage: Overall project construction costs for residential water CIPP lining projects have averaged $410/foot in the last four years. Project construction costs for business/commercial water CIPP lining projects have averaged $810/foot. In Anchorage, a water CIPP lining project will have a construction cost that is approximately 70 percent of an equivalent open cut project to remove and replace the water main.

6. CONCLUSION

Based on AWWU's experience over the last four years with the rehabilitation of its water distribution pipes, the use of CIPP lining provides a significant savings and reduced impact in comparison to traditional open-cut replacement. A successful CIPP project starts early with proper planning in the initial design. Successful projects also include proactive coordination with the impacted customer and implementation of a temporary water system that minimizes water outages. In the future, AWWU will monitor the performance of water CIPP lining rehabilitation and will reevaluate this pipe repair method and the standards used in Anchorage as the process matures.