LEE’S SUMMIT USES PIPE BURSTING TO BROADEN ITS ASSET MANAGEMENT TOOLBOX AND REHABILITATE POTABLE WATER DISTRIBUTION SYSTEM

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ABSTRACT: The City of Lee’s Summit, Missouri looked at rehabilitating certain portions of its existing potable water distribution system having a high break history due to exterior corrosion. Approximately 12,800 linear feet of 6-inch DR 18 Fusible C-900® polyvinyl chloride (PVC) pipe replaced existing 4-inch and 6-inch cast iron and ductile iron water mains at various locations throughout its system as part of the Small Diameter Water Main Rehabilitation Project. Some water mains were upsized, but a majority of the water mains were replaced size-for-size. The contractor for the project, Wiedenmann & Godfrey Construction, Inc., of Belton, Missouri, used the 800G from TT Technologies, Inc. to complete the pipe bursting. Several methods for water main rehabilitation were examined including pipe bursting. By using pipe bursting, the City minimized excavation in residential areas by simply installing a new main using the path of the existing water main. Pipe bursting also reduced the amount of surface restoration including driveways, street pavements and lawns.

Several pipe materials were considered for the water main rehabilitation project. Polyethylene and Fusible C900 were allowed in the specifications to be installed by pipe bursting. Wiedenmann & Godfrey chose to install Fusible C900. One factor leading Wiedenmann and Godfrey to select Fusible C900 was being able to connect to ductile iron fittings without restraining the joints. Thrust restraint at fittings was provided by thrust blocking.

This paper reviews the City of Lee’s Summit’s experiences with pipe bursting potable water distribution piping and the pipeline materials specific to its use in relation to the Lee’s Summit Water Main Rehabilitation Project. This will include design decisions, construction concerns, and general lessons learned from this type of installation and rehabilitation methodology.

1. INTRODUCTION

The City of Lee’s Summit, Missouri is located in the southeast corner of the Kansas City, Missouri metropolitan area and has nearly 93,000 residents covering an area of approximately 65 square miles. The town of Strother was founded in 1865 by William B. Howard and included 11 blocks that today include the downtown business district. In 1868, the City was renamed and incorporated as the “Town of Lee’s Summit.”

Paper D-4-02 - 1
The water system in Lee’s Summit consists of 580 miles of water mains, 8 storage facilities, 4 pump stations, 5,110 fire hydrants and 13,000 water valves. Four billion gallons of water are sold to customers each year. Since Lee’s Summit has no water treatment facilities, water is purchased from Kansas City, Missouri and Independence, Missouri.

Water mains within Lee’s Summit are primarily cast or ductile iron. Soil in Lee’s Summit typically includes clay and has a tendency to create corrosion concerns with metallic pipe. The Water Utilities Department typically completes 175 water main repairs per year. The average break frequency is slightly less than one break per three miles of water main per year. Water mains selected for rehabilitation typically have several breaks within 1,000 feet of water main over several years.

As more water main breaks occurred, the Lee’s Summit Water Utilities Department decided to replace water mains with the greatest break frequency history. Since the water mains selected for replacement were located in residential areas, a trenchless form of rehabilitation was planned to minimize disruption to residents. The Small Diameter Water Main Rehabilitation Project was the first capital improvement project for water main rehabilitation and the second project that ultimately used pipe bursting to replace a water main in Lee’s Summit.

2. REHABILITATION METHODS

Two trenchless methods were considered for rehabilitation and included water main lining by Insituform Technologies®, Inc. and pipe bursting. Initially, it was assumed both methods would require temporary water mains to supply water service to customers while the liner or pipe was installed, chlorinated, tested and service connections reinstated.

The liner installed by Insituform Technologies, Inc. considered for water main rehabilitation is a polyester reinforced polyethylene (PRP) liner called Thermopipe® made from a polyester hose with a layer of polyethylene along the inside and outside surfaces of the hose. Thermopipe is folded into a “C” shape before it is installed by being pulled through a cleaned water main. Air and steam are blown into the lining to create a close fit with the existing water main. One advantage of installing Thermopipe is that for a 6-inch diameter or greater pipeline, a robot can be sent through an installed liner to reinstate existing service connections, without the need to excavate each individual service location. Thermopipe can also be installed through pipe bends. Since most water mains that required rehabilitation were 6-inch in diameter, surface disturbance due to reinstating the services would be greatly reduced by installing Thermopipe.

Static pipe bursting was also considered for rehabilitating water mains. In static pipe bursting of existing cast and ductile iron pipe, a bladed cutting wheel setup is pulled through the existing pipe that slices or fractures the host pipe. Immediately behind it, an expander head pushes the split, fractured and fragmented pieces into the surrounding soil. Following the expander, a new pipe is pulled through the remains of the old pipe and the void created by the process.

Lee’s Summit evaluated two popular pipe bursting pipe materials for water systems, polyethylene and polyvinylchloride (PVC) plastics, and specifically evaluated High Density Polyethylene (HDPE) and Fusible PVC™ pipe. Both materials are thermoplastics, which eliminated the concerns for continuing corrosion to the system, and both HDPE and Fusible PVC pipe join segments or lengths together by thermal butt-fusion. This process generically utilizes industry standard construction equipment to prepare two plain-end pieces of pipe, heat the ends of the those sections to create a fusible bead of plastic on each end and then hold those two ends together under pressure until they are able to cool and create the thermally butt-fused joint. While the process is generally similar, there are proprietary differences between the processes for HDPE and Fusible PVC pipe due to the differences between the two plastic materials themselves. The resultant fusion joint is constituted of the pipe material itself, is fully restrained, and therefore creates a monolithic pipeline from the segments that are strung together by the technology. There is no mechanical coupling or gaskets incorporated, therefore the joint and pipe have the same strength and this allows the tensile capacity of the plastic to be utilized in bending and tension, which is why these specific pipe materials are so popular in pipe bursting and other trenchless technologies. While there are specific
differences between the two plastics, Lee’s Summit determined that both products would meet the intent of the project design and bid both materials as construction options.

Lee’s Summit had previous experience with pipe bursting water mains. The first capital improvement project to use pipe bursting to replace a water main in Lee’s Summit was the North System Improvement Project. The project was undertaken to increase water supply to northern Lee’s Summit and included a pipe burst of roughly 1000 linear feet of existing pipe using 12-inch HDPE pipe as the rehabilitation pipe material. Specifications for the project allowed either HDPE pipe or Fusible C-900 pipe to be installed. The contractor had good experience installing HDPE and no experience installing Fusible PVC so HDPE was selected for installation. Construction began in 2007 and continued to the spring of 2008. Pipe bursting occurred through a dam where trench excavation was not an acceptable method for replacing the existing water main. This project was designed by a local engineering consultant and was a successful installation.

3. PROJECT DEVELOPMENT

Water mains at 13 locations were included in the plans for rehabilitation. Plans and specifications were developed in-house for the work that was required. Most of the water mains were installed in the 1970’s or later and consisted of 4-inch or 6-inch cast or ductile iron pipe. All 13 water mains were located in residential areas, which made trenchless installation an attractive option to minimize disruption to residents and to reduce restoration costs. Twelve of the water mains would be replaced by trenchless installation. One water main was upsized two pipe sizes and would be replaced using traditional dig-and-replace construction.

After reviewing the two trenchless methods, the City decided to allow only pipe bursting. The City was more familiar with pipe bursting than installing Thermopipe as a method for rehabilitating water mains. Also, water mains lined with Thermopipe require special fittings for making repairs or new connections. The pipe materials allowed to be installed by pipe bursting were either HDPE or Fusible C-900 pipe. Dig-and-replace construction was limited to locations where pipe bursting was not possible such as through pipe bends. Most pipe bends replaced during the project were located around cul-de-sac bulbs. Pipe installed around cul-de-sac bulbs was replaced size-for-size and was typically 4-inch in diameter. Pipe installed by open trench excavation was bell and spigot PVC pipe.

Since Lee’s Summit standard specifications do not include pipe bursting or the installation of fused pipe, specifications from the North System Improvement Project were used to develop the Small Diameter Water Main Rehabilitation Project specifications. The record drawings for the water mains were used as a reference to determine the limits of the water mains, location of fittings, fire hydrants and blowoff assemblies. Graphical information system (GIS) information was used to develop plan sheets. However, field measurements were needed to correct the GIS data so that valves, fire hydrants and blowoff assemblies were shown as close to the correct location as possible.

Knowledge about pipe bursting was gained by speaking with staff from other cities and water utilities that have experience with pipe bursting, and specifically pipe bursting water mains. Information was also gained by speaking with representatives of TT Technologies, Inc., which is a major manufacturer of pipe bursting equipment. The Plastic Pipe Institute and Uni-Bell were good sources for information regarding thermoplastic pipe materials and installation. Information regarding Fusible C-900 pipe, and Fusible PVC pipe in general, is available from Underground Solutions, Inc. The American Water Works Association (AWWA) Standards C900 and C906 were the used for PVC and HDPE pipe material specification respectively, for the new water mains. AWWA C651 was also used for this project as the standard for chlorinating the new water mains.

Four open house meetings were held to notify residents who would be affected during construction. Meeting locations were selected near project locations throughout the City. About 600 invitations were sent to residents who were expected to have disrupted water service during construction. At the meetings, City Staff had the opportunity to meet with the residents and answer specific questions about the project. The most often asked questions included how long water service would be disrupted and the plans for ground restoration and remediation after the work was completed.
The City also considered pre-chlorinated pipe for use in the project by working with the Missouri Department of Natural Resources (DNR) to develop a specification for the installation of pre-chlorinated pipe. Pre-chlorinated pipe has been approved and installed in other states but had not been approved for use in Missouri at the time of the project. The Michigan Department of Environmental Quality (DEQ) listed several requirements a contractor must meet in order to install pre-chlorinated pipe in Michigan, based on successful pre-chlorinated projects installed there. These requirements were sent to the Missouri DNR for review. The Missouri DNR agreed to allow the installation of pre-chlorinated pipe at one location if the contractor followed requirements similar to those developed by the Michigan DEQ. The Missouri DNR also wanted to observe the installation of pre-chlorinated pipe before allowing it to be installed at other locations.

One location was selected as a test section for the Missouri DNR to observe the installation of pre-chlorinated pipe. An alternate was added to the bid package for the installation of pre-chlorinated pipe. The base bid included water main installation by pipe bursting with the use of temporary water mains, with the cost of the temporary water mains included in the cost of the primary water main installation.

Wiedenmann and Godfrey Construction, Inc., was awarded the project. Since Wiedenmann and Godfrey did not bid the alternate for the installation of pre-chlorinated pipe, pipe bursting was completed with the use of temporary water mains throughout the project. Wiedenmann and Godfrey also chose to install Fusible C900 since connections could be made to ductile iron fittings without restraining the joints. Thrust restraint at fittings was provided by thrust blocking. Since HDPE pipe required restrained joints when connecting to ductile iron fittings, construction costs would have been greater if fused mechanical joint adaptors were installed. Since the water mains were in residential areas, there were many fittings and valves to install.

4. CONSTRUCTION

Wiedenmann and Godfrey planned on beginning the pipe bursting in March, 2009, but this schedule was pushed back due to freezing temperatures and pipe bursting could not begin until a month later in April, 2009. Many activities were performed before the actual pipe bursting operation began. For example, delivered, 40 foot long nominal lengths of Fusible C-900 pipe were fused into long strings of pipe at a fusion and layout location near the construction site. The fused pipe was then pulled from this location to the construction site and the individual insertion locations as required.

Test shutdowns of the water mains were performed to make sure the valves used to isolate the construction area worked properly. Existing utilities were marked. ‘Straddle-style’ thrust blocks were cast to restrain existing pipe at the ends of the pipe burst segments that were to remain energized during pipe bursting activities. Temporary water mains were placed, chlorinated, tested and connected to residents’ water service lines. Existing fittings and valves were removed from the section to be burst. Figure 1 shows a temporary water main used in the first pipe burst to provide continued water service during construction.
Figure 1. Temporary water mains used during pipe bursting

The contractor used 2-inch Yelomine™ pipe to build the temporary water mains which were connected to the existing copper service lines using ¾-inch polyethylene tubing. The temporary mains were installed and tested before being connected to the existing service lines. Two 2-inch by 6-inch boards connected by a geotextile material were used to protect the water mains at driveway crossings. Only two repairs to the temporary water mains were required during the project. The first was damaged by a lawn mower and the second was damaged by an automobile.

The first temporary water main installed extended about 1200 feet long and supplied water to about 30 customers. The temporary water main was tapped into energized water mains at both ends. A few residents supplied by the temporary water main were asked how the temporary water main worked. The residents noticed no drop in water pressure supplied to their home. Throughout the project, no comments were received by City Staff regarding the temporary water mains.

Pipe bursting began without any issues, however, during one pipe burst section early on, the bolts connecting the Fusible C-900 pipe to the integral expander head pulled through the pipe. Larger bolts were then used to connect the expander to the pipe to prevent this type of failure. Figure 2 shows the pipe bursting equipment used for the first pipe burst. For this pipe bursting equipment arrangement, the expander head connects directly to the pipe being installed, which immediately follows the cutting wheel arrangement that is opening up the host pipe.
After the first pipe burst, work went smoothly until work began on a water main composed entirely of ductile iron. The pipe burst included about 620 feet of 6-inch ductile iron pipe. Wiedenmann and Godfrey discovered two difficulties in pipe bursting sections of ductile iron. First, the bladed cutting wheels were cutting a jagged opening in the ductile iron pipe. The expander following the cutting wheels tended to turn while sliding along the torn edge of the old pipe. A few times, the expander would twist enough to fracture the Fusible C-900 pipe immediately behind the expander. Wiedenmann and Godfrey had to dig to find the end of the PVC pipe in order to complete the burst. Another issue resulted from the mortar lining from the existing ductile iron pipe as it would fracture during pipe bursting. The mortar fragments would collect in front of the expander and begin developing significant resistance to being pulled. Wiedenmann and Godfrey solved both problems by using a larger expander to provide a larger opening for the new pipe to be pulled through.

At several locations, the end of a pipe burst was perpendicular to a street curb. At these locations, the contractor set the bursting machine against the back of curb to provide support during pipe bursting. Figure 3 shows a pipe bursting pit that is perpendicular to a curb.
Fusible C-900 pipe is flexible but care must be exercised in not overbending the pipe past the pipe supplier’s recommended limits when positioning, handling or inserting the pipe. As a result, the insertion pits for installing Fusible C-900 pipe tend to be longer than what is required to install similarly sized HDPE pipe, which is more flexible, by pipe bursting. Figure 4 shows the alignment of Fusible C-900 pipe being pulled into an insertion pit.

Site restoration typically included sidewalk and driveway replacement, pavement repair and sodding. Figure 5 shows the restoration of the excavation and construction area shown in Figure 1. As work progressed at one
location, the contractor would install a temporary water main at the next construction site so no time was lost waiting for chlorination and testing.

Figure 5. Surface restoration after pipe bursting operation is complete

5. CONCLUSIONS

Approximately 12,800 linear feet of Fusible C-900 pipe was installed between April and November 2009 by pipe bursting methodology. Over 15,000 linear feet of pipe was installed with this project including pipe bursting and open trench excavation. There were a few challenges encountered with the project during construction that were solved by the contractor and/or City Staff. By the end of the project, these lessons learned had created a very smooth and efficient restoration and rehabilitation effort for this section of the City’s distribution system. There were very few complaints from residents about this project and the interruptions that it created for water service and construction operations. Based on the experience and customer feedback, Wiedenmann and Godfrey and City Staff consider this to be a successful project by minimizing disruption to residents and completing the project under budget.

Pipe bursting appears to be a more cost effective method for replacing water mains than dig-and-replace construction in residential areas. To compare costs of pipe bursting verses dig-and-replace construction, lump sum items such as mobilization, traffic control, demolition, clearing and grubbing which cover the entire project are not included. The lump sum items accounted for about 13 percent of the construction cost. The cost comparisons shown include pipe installation and all surface restoration. Several locations using only pipe bursting had an average construction cost of $91 per foot. Water main replacements located in one area of Lee’s Summit using a combination of pipe bursting and dig-and-replace construction had an average installation cost of $103 per foot. The cost for replacing one water main with 645 feet of 6-inch PVC pipe and 357 feet of 8-inch PVC pipe using only dig-and replace construction was $136 per foot.
5. REFERENCES


AWWA C900-97, 1997, “Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Transmission and Distribution”, AWWA, Denver, CO.

AWWA C906-07, 2007, “Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm), Through 12 In. (1,600 mm), for Water Distribution and Transmission”, AWWA, Denver, CO.