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

Orlando, Florida
April 13-17, 2014

Paper MM-T4-03

Pipe Bursting Water Lines with Confidence

Tracy Weaver, Portland Utilities Construction Company, LLC, Portland, TN
Michael E. Woodcock, Portland Utilities Construction Company, LLC, Portland, TN

Abstract
Pipe bursting has become quite recognizable as a pipe replacement technique for many pipeline applications. This recognition has led many engineers and municipalities whom have never used the methodology to replace water lines to consider its use for just such an endeavor. However, those that are only loosely acquainted with the technology or have never used pipe bursting in a water application often seek consultation with reputable contractors to fill the knowledge gaps or seek reassurance. These engineers and municipalities seek a more complete understanding of the process so that they can proceed to the drawing table with confidence that pipe bursting would indeed be a good solution for their particular project.

This paper seeks to pass along the nuts and bolts of how water line pipe bursting works and answer frequently asked questions about the water line pipe bursting process. Items of discussion include constructability and limitations, advantages of pre-chlorination versus temporary bypass and cost comparison. An overview of pipe line materials used for water line pipe bursting including HDPE and Fusible PVC will also be discussed.

Introduction

The following is an attempt to provide the information most frequently requested during conversations about water line pipe bursting with engineers, owners, and contractors. The idea is to present information relevant to analyzing the potential for pipe bursting water lines to those that wouldn't otherwise employ the technology as a solution due to lack of confidence stemming from simply not having employed the technology previously and the unanswered questions that remain. These lingering questions and doubts while not individually complex can be overwhelming when simply trying to envision how the process works. These lingering questions and doubts, however, can be the reason for hesitation on the decision to move forward with pipe bursting as the potential best solution for replacing that water line. Hopefully, the information provided will provide system owners and engineers enough knowledge to move forward confidently with the decision to employ pipe bursting to replace an existing water line and remove those lingering questions and doubts, when the technology is the right solution.

The Typical Conversation Between Owner/Engineer and Contractor

In general, when discussing water line bursting with those that are interested but hesitant to move forward with the pipe bursting of water lines, the conversation with a contractor typically follows a path similar to the following;

1. General pipe bursting questions that would apply to pipe bursting any pipe; water, sanitary sewer, storm sewer, or gas
2. What types of pipe can be installed by the pipe bursting process for water lines and what materials are used for fittings and service connections
3. Required equipment and tooling to accomplish water line bursting
4. Site considerations surrounding the particular project in question.

5. Pre-chlorination versus setting up a Temporary Bypass in relation to the particular project
6. Estimated cost of pipe bursting water lines versus open cut replacement

While these conversations don't always follow this exact sequence, there is a certain pattern to these conversations, because this is the logical progression for discovering whether or not pipe bursting is a good solution for a particular water project. During this conversation, we can often discuss what many call the "frequently asked questions" for water line pipe bursting.

General Pipe Bursting Concepts, Advantages, and Limitations

When considering the pipe bursting of water lines versus an open cut option for replacing a water line, a firm understanding of the general concepts, advantages, and limitations of the pipe bursting technology is necessary. All of the general concepts, advantages, and limitations of replacing any kind of pipe with the pipe burst technology still apply, regardless of the product pipe being replaced. Consequently, a quick review of the general concepts and most frequently realized advantages and limitations of the technology is addressed here.

Advantages of Pipe Bursting Over Open Cut Replacement

Under many conditions pipe bursting has several advantages over open cut replacement of the same pipe. The following is a list of advantages typically and most often realized when pipe bursting rather than open cutting any product pipe.

1. Pipe bursting the existing pipe in place requires no new easements. Open cut replacement when not performed in the same ditch line often requires the acquisition of new easements.
2. Pipe bursting typically minimizes damage to the existing surface and surface improvements. The benefit when compared to open cut is often less restoration of asphalt and concrete streets & driveways and less restoration of landscaping and sod.
3. Pipe bursting typically reduces the amount of time it takes to replace the line segment compared to open cut replacement. Consequently, there is often less disruption to traffic patterns, business operations, and enjoyment of property for the community.
4. Most often the reduction in easement acquisitions and surface restoration (asphalt, concrete, landscaping, & sod) combined with the increased productivity of pipe bursting over open cut replacement results in a significant cost advantage to the pipe bursting technology.

These advantages are the primary reasons that pipe bursting has become the preferred option when open cut replacement is the alternative on most sewer replacement programs throughout the country. With these advantages, open cut replacement of the pipe simply cannot be justified when and where the pipe bursting technology is a viable option.

Existing Pipe Material That Can be Burst

The types of pipe material that can be burst are generally divided into two groups. These groups are "fracturable" and "non-fracturable" pipes. These designations characterize the way that the pipe materials are burst or split.

Fracturable pipes are most easily burst because the material simply breaks into pieces as the expander forces its way through while expanding the pipe fragments into the surrounding soil. Fracturable pipes do not require specific tooling, such as cutters, to accommodate the bursting process. Fracturable pipes include cast iron pipe, vitrified clay pipe, concrete pipe, asbestos cement pipe, thinner walled PVC pipe, and others.

Figure 1 - Fracturable Pipe

Non-fracturable pipes do not fragment and therefore must be split or cut with specific tooling and then expanded to accommodate the bursting process. Typically bursting or splitting non-fracturable pipe requires some variation of a cutter system, which generally requires the use of a static bursting system. Non-fracturable pipes include ductile iron pipe, steel pipe, HDPE, thicker walled PVC pipe, and others.

Figure 2 - Non-fracturable Pipe

Range of Sizes That Can be Burst and Upsizing
Pipe bursting can be used to replace pipes as small as ¾" and as large as 48", with larger sizes theoretically possible. Advancements in equipment size and power along with improved techniques are being made for both the smaller and larger pipe sizes.

Pipe bursting has the ability to replace an existing pipe with a new pipe that has the same or larger diameter. Pipe bursting and pipe reaming are the only trenchless technologies that allow the replacement of the host pipe with a larger pipe. This "up-sizing" is one of the most important features of the pipe bursting technology and many times the driver in its selection as the preferred technology. The degree of up-sizing is the difference between the inside diameter of the host pipe and the outside diameter of the newly installed pipe. It is common to accomplish a single up-size (one nominal size larger) and a double up-size (two nominal sizes larger) from the existing diameter of the host pipe. Even triple up-sizing (three nominal sizes larger) is possible.

Soil Conditions/Geotechnical Conditions
Most soil or geotechnical conditions can be dealt with by the various pipe bursting technologies. It is simply a matter of providing the right tooling and amount of force to overcome the challenge posed by the soil or geotechnical condition. Therefore, it is important to understand which soil types are more or less favorable to the pipe bursting process so as to choose the proper sized equipment with the appropriate amount of force. Also, some of the more challenging soil conditions that supply friction or drag to the new pipe may require injecting bentonite and polymer lubricants into the soil behind the burst head.

The most favorable ground conditions for pipe bursting projects are where the ground surrounding the existing pipe can be compacted easily as it is being displaced by the pipe bursting operation. This compaction will limit the outward ground displacements to a zone close to the pipe alignment. It is also favorable if the soil surrounding the pipe will allow the hole to remain open while the replacement pipe is being installed. This will lower the drag on the replacement pipe and thus lower the tensile stresses to which the pipe is exposed during installation.

The least favorable ground conditions for pipe bursting projects are densely compacted soils and backfills, rock trenches, soils below the ground water table, and soils that expand as they are sheared (such as angular sands). Each of these soil conditions tends to increase the force required for the bursting operation and to increase the zone of influence of the ground movements.

The level to which the existing soil can be compacted and pipe friction to be reduced will have significant effects on pull lengths. Pull lengths average between 350' and 500'. However, with good soil conditions much longer lengths can be obtained. Conversely, poor soil conditions can limit pull lengths to shorter than average lengths.

Ground Heave
Ground heave occurs when the pipe bursting process displaces the surrounding soil to the extent that the displacement travels through the surrounding soil to the ground surface. When the force is great enough, it can cause the surface of the ground to heave or hump. This is particularly troublesome when improvements have been made to the ground surface, such as asphalt or concrete paving. It is important to understand that ground heave is a possibility on the more shallow lines and how the variables of soil type, up-sizing, and depth can impact the probability of getting ground heave.
Because the bursting head or expander has a larger diameter than the replacement pipe, the process of pipe bursting will displace the existing pipe and surrounding soil to some extent each and every time the process is used. The soil displacements expand from the source through the surrounding soil in the direction of least resistance. The displacement tends to be localized and to dissipate rapidly with increased distance from the source. Typically the movement is upward because the soil on top of the pipe is less compacted than the soil under the pipe, especially at shallower depths. The more compacted the existing soil is the greater distance the displacement travels before dissipating. The greater the size difference between the diameter of the expander and the diameter of the existing pipe (up-sizing), the more displacement is created. Consequently, large up-sizes create more displacement.

The three most important variables in the ground heave equation are soil type, up-size, and depth. These variables work together to dissipate the soil displacement created by the pipe bursting process or allow it to reach the surface. The combination of densely compacted soils, large up-sizing, and a shallow pipe can create ground heave.

Waterline Pipe Material, Fittings & Service Connections
After satisfying ourselves that the general concepts, advantages, and limitations of the pipe bursting technology allow us to move forward with the consideration of pipe bursting as a sound option for replacing the water line in question, we can now consider what material options are available to us.
First, we must consider the mainline pipe material. The three primary options for the mainline material are high density polyethylene (HDPE) pipe, fusible polyvinylchloride pipe (FPVCP), and restrained joint ductile iron pipe (RJDIP). In order to make this decision, consideration must be given to the options available to each mainline material for fittings and service connections.

High Density Polyethylene (HDPE) Pipe
HDPE pipe comes in two variations based upon its outside diameter; Iron Pipe Size (IPS) and Ductile Iron Pipe Size (DIPS). When it comes to water line bursting with HDPE, Ductile Iron Pipe Size (DIPS) piping is most common because its outside diameter is most compatible with fittings and valves currently used by system operators. Also, when installing HDPE pipe for water lines by the pipe bursting process, the two options most often considered are DR 9 and DR 11. The pressure ratings for each are as follows;

1. HDPE DR 9 has a pressure rating of 200 PSI
2. HDPE DR 11 has a pressure rating of 160 PSI

Selection of the appropriate pipe DR and pressure rating will depend on the system operating pressures and other operations specifics, as well as any other design considerations specific to the project.

Fittings & Tees Typically Used With HDPE Pipe
There are basically two options available for fittings and tees as it relates to HDPE as the mainline pipe material. Those options are as follows;

1. Mechanical Joint (MJ) fittings with restrainer-style glands (Megalugs) and stainless steel inserts
2. Mechanical Joint (MJ) adaptors inserted into MJ fittings

MJ fittings are a standard in the water industry. Another standard product is the restrainer-style glandfor fittings that locks down on the product pipe and doubles as the retainer gland wedging the gasket into the fitting. When using a combination of MJ Fittings and restrainer-style glands with HDPE pipe, stainless steel inserts must be driven into the plain end of the HDPE pipe to maintain the malleable HDPE pipe firmly pushed out against the restrainer-style gland system. DIPS HDPE, which has the same outside diameter as ductile iron pipe, must be used to employ the restrainer-style gland with stainless steel inserts method.

Figure 3 - Restrainer Style Gland **Figure 4 – Stainless Steel Insert** **Figure 5 – MJ Fitting w/Restrainer Gland & Stainless Steel Insert (Installed)**

MJ adaptors can be used in lieu of the restrainer-style glands and stainless steel insert system mentioned above. The MJ adaptor is a combination restrainer gland and gasket that is butt fused or electrofused to the plain end of the HDPE pipe and is inserted/bolted into the MJ Fittings.

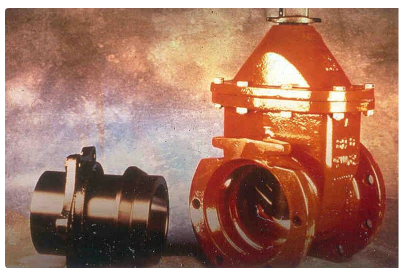

Figure 6 – MJ Adapter & Valve **Figure 7 – Electrofuse Coupling**

Service Connections Typically Used With HDPE

There are a host of saddles that can be used for making service connections to the HDPE pipe. These saddles can be broken down into two primary varieties.

1. Mechanical Saddles
2. Electorfuse Saddles

The Mechanical Saddles used for HDPE are of the same variety that most utility districts currently use in their system and simply need to have the appropriate outside diameter size range of the HDPE pipe installed. Electrofuse Saddles vary depending upon the size of the HPDE pipe installed. On smaller diameters they can have a saddle strap that completely encircles the pipe. While on larger sizes there are options available to simply attach to the HDPE pipe without straps. The electrofusion process requires some preparation of the HDPE pipe and a special machine to power the electrofusion process.

Figure 8 – Mechanical Saddle

Figure 9 – Electrofuse Saddle

Fusible Polyvinylchloride Pipe (FPVCP)

Fusible polyvinylchloride pipe (FPVCP) is similar to the traditional PVC pressure pipe, made to the AWWA standards C900 and C905that has been used in the water market for years. FPVCP is made per the same standards, therefore the outside diameter of the pipe is the same as traditional bell and spigot PVC. FPVCP installed by the pipe bursting process is typically DR 14 or DR 18. The pressure ratings for each are as follows;

1. FPVCP DR 14 has a pressure rating of 305 psi, and
2. FPVCP DR 18 has a pressure rating of 235 psi.

Selection of the appropriate pipe DR and pressure rating will depend on the system operating pressures and other operations specifics, as well as any other design considerations specific to the project.

Figure 10 - Fusible PVC Pipe

Fittings Used With FPVCP

Standard MJ fittings with restrainer-style glands for use with PVC pipe are the most prevalent method used to connect and restrain FPVCP. Since the outside diameter of FPVCP is the same as traditional bell and spigot only a traditional PVC transition gasket is required to fit into standard MJ fittings. Many utility districts enjoy this particular feature of FPVCP. If at a later date any modifications or repairs need to be made to FPVCP, the utility district can simply use the materials and methods that they are accustomed to using. No need for stainless steel inserts, electrofusion couplings, electrofusion equipment, or butt-fusion equipment.

Figure 11 - Mechanical Joint Fittings & Restrainer Glands

Service Connections Used With FPVCP

The pipe supplier for FPVCP recommends specific tolerances for tapping FPVCP based on pipe diameter size. An appropriate standard PVC mechanical saddle or tapping sleeve is required to make service connections to FPVCP. Also, for service taps larger than the recommended sizes based on pipe nominal diameter, a bell restraint or axially restrained tapping saddle is required to mitigate any axial stresses on the pipe from the pipe bursting operation. Direct tapping FPVCP, or directly threading the corporation stop into the pipe is not allowed.

Figure12 – Mechanical Saddle on FPVCP **Figure 13 – Mechanical Saddle for FPVCP**

Restrained Joint Ductile Iron Pipe (RJDIP)
Restrained joint ductile iron pipe (RJDIP) has been used for water lines since its inception. For those that prefer or need this product as a replacement pipe material, pipe bursting can accommodate its installation. However, RJDIP must be used in order to accommodate the pipe bursting process, which will pull the pipe in place using the restrained joints to hold the pipe together during the burst. RJDIP installed by the pipe bursting process is Class 250 or class 350. The pressure ratings of each are as follows;

1. Restrained Joint Ductile Iron Pipe Class 250 has a pressure rating of 250 PSI for 30” through 36”.
2. Restrained Joint Ductile Iron Pipe Class 350 has a pressure rating of 350 PSI for 4” through 24”

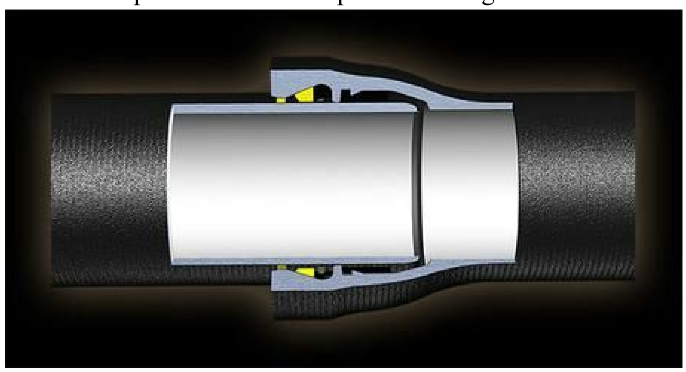

Figure 14 - Restrained Joint Ductile Iron Pipe

Selection of the appropriate pipe class and pressure rating will depend on the system operating pressures and other operations specifics, as well as any other design considerations specific to the project.

Fittings Used With RJDIP
Standard MJ fittings with restrainer glands is the most common method used to connect to RJDIP. No transition gasket is required. Many utility districts enjoy this particular feature of RJDIP. If at a later date any modifications or repairs need to be made to the RJDIP, the utility district can simply use the material that they are accustomed to using. No need for stainless steel inserts, electro-fusion couplings, electro-fusion equipment or butt-fusion equipment.

Service Connections Used With RJDIP
Standard saddles and direct tapping can be used to make service connections to RJDIP.

Figure 15 - Mechanical Saddle

<u>Required Equipment and Tooling Used to Pipe Burst Waterlines</u>
The equipment and tooling used to accomplish water line bursting can be used to pipe burst any other product pipe such as sanitary sewer, storm sewer, and gas. There are however some specific requirements that must be adhered to for the water bursting process that are not necessarily required when bursting those other product pipes.

Static Bursting System
Pipe bursting water lines is traditionally done with a static bursting system. Pneumatic bursting systems are rarely used for bursting water lines. The reasons for this are as follows;

1. Pneumatic bursting equipment requires hoses that supply air and oil to the pneumatic hammer to run through the new product pipe while it is being installed. The oil from these hoses will contaminate the new pipe and make passing the required Bacteria Tests much more difficult.
2. Rigid pipe such as Fusible PVC C-900 and Restrained Joint Ductile Iron pipe cannot be installed by a pneumatic bursting system. The localized impact of the pneumatic system places too much impact at the connection between the expander and the rigid pipe. These pipe materials must be installed by a static bursting system.

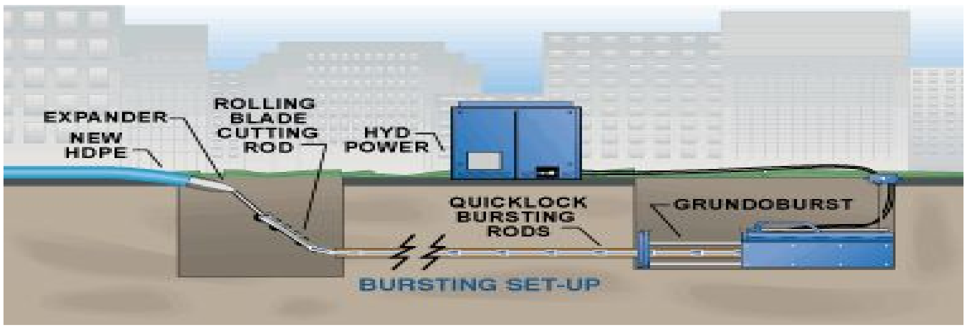

Figure 16 - Static Bursting Equipment Set Up

Expander or Burst Head
The burst heads and pull heads are designed specifically for each of the three materials being installed. This is because each material has a unique set of physical properties and reacts differently to the forces being exerted. Also, the RJDIP uses a Restrained Joint bell fitted into the expander in order to attach to the pipe because the expander cannot be directly bolted to the pipe as it can be with the FPVCP and the HDPE.

The traditional burst head that is interchangeable between pneumatic and static equipment can be used to install HDPE pipe. These traditional burst heads are readily available and owned by most pipe bursting contractors as HDPE is the primary pipe being installed by the pipe bursting process when water, sanitary sewer, storm sewer, and gas are considered.

Figure 17 – HDPE Burst Head

Figure 18 – FPVC Burst Head

The manufacturer of FPVCP recommends a pull head specifically designed to distribute the pull forces being exerted on the pipe. This pull head is attached directly to the pipe while the expander/burst head is pulled out in front of the pull head, but attached by a connector rod. The manufacturers of the bursting equipment have developed a burst head that can be attached directly to the FPVCP, but it is not currently endorsed by the pipe supplier.

When installing Restrained Joint Ductile Iron Pipe, the combination of a Restrained Joint bell and an expander/pull head is used. The combination uses the Restrained Joint bell to attach to the RJDIP being installed. The bell and the expander combine to open the void through which the pipe is pulled.

Roller Cutters
Roller Cutters are often pulled out in front of the burst head to pre-cut the host pipe and any in-line repair clamps or fittings. These fittings, if not pre-cut, would not be easily broken and displaced by the burst head and most often would bind up the burst head bringing the burst to a screeching halt. Since water lines are most often not televised prior to bursting like other types of pipe, the location of repair clamps and fittings is normally not know. The ability to simply cut through these items without prior knowledge is essential to the success of the bursting process.

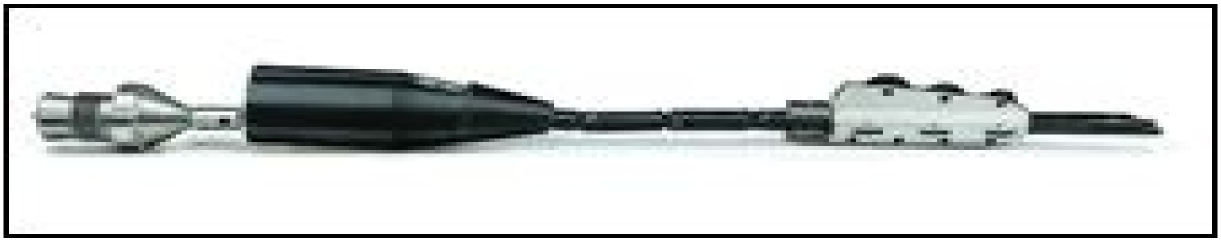

Figure 19 - Expander & Roller Cutter Assembly

Site Considerations
Projects by definition are a unique set of circumstances that have and will never be completely replicated. However, there are some reoccurring themes of interest that can be addressed.

Previous Repairs to the Existing Water Line
Most water systems that are in need of replacement have had at least some previous repairs made to the existing pipe. These repairs are typically made using either stainless steel repair clamps or solid sleeves. The locations of these repairs are rarely known. Owners and engineers are often concerned that unknown repair locations would hinder the pipe bursting process and feel the need to investigate the location of these previous repairs. They often times find that there were few or no records made of these previous repairs. Anxiety over this issue could lead to the fear that their water line replacement project may not be a good candidate for replacement by pipe bursting because of these unknown repairs.

The fact of the matter is that stainless steel repair clamps and MJ solid sleeves can easily be dealt with by the use of the various cutters available. The cutter technology available simply cuts the repair clamp or fitting in advance of the burst head removing the potential hindrance. While it is helpful to know the location of the previous repairs, it is not critical to the pipe bursting process to have this information. Consequently, investigating the locations of these previous repairs by digging through old records or CCTV is not necessary.

Bend Radius of Existing Pipe - Bursting Around Curves
Most water lines are not laid in completely straight lines at exactly the same elevations. Many times existing water lines follow the curve of the roads and streets or required radiuses of varying degrees for whatever reason, causing horizontal radiuses. Also, water lines often follow the contour of the existing terrain, causing vertical radiuses. When considering pipe bursting as an alternative, these bends or radiuses are cause for concern and do have an impact on the lengths of pulls available for pipe bursting. However, the pipe bursting process can accommodate more radius than most would think.

The ability to traverse these curves is a function of the ability of the static machine's rods to navigate through the existing pipe. This ability is affected to a certain extent by the size of the rod. The general rule of thumb is that the rods will traverse the existing horizontal and vertical radiuses to the extent that the original pipe was laid without the use of mechanical joint bends. In other words, the pipe bursting process can navigate the radiuses that can be handled by deflecting the bell and spigot joints of the existing pipe when it was originally laid. If a mechanical joint bend was required to facilitate the radius when the pipe was originally laid, then an excavation/insertion pit will have to be dug at that point to facilitate the pipe bursting process.

Impact of Depth on the Water Line Pipe Bursting Process

The depth (or lack thereof) of the existing pipe does have an impact on the pipe bursting process. Water lines tend to be buried at shallower depths, with some water lines having only 36" of cover. This lack of depth can cause some ground heave as discussed earlier. Also, the lack of depth of some water lines places them at the same elevations as gas mains, storm sewer lines, and sewer lateral lines among others. Therefore, there is more potential for utility conflicts when bursting water lines than for deeper systems like sanitary sewer mains. Consequently, more information is required to show these potential conflicts. Also, potholing or daylighting of the potential conflict points will be required to alleviate the potential utility strikes. Potholing removes the soil between the two pipes so as alleviate the possibility of displaced soil from pushing into and breaking the nearby utility during the pipe bursting process.

Temporary Water Service System or Pre-chlorination Procedure

In order to replace an existing water main by the pipe burst method, the issue of maintaining adequate water service to the residences and businesses is a critical factor. There are basically two options for doing this. The first option is to simply set up a temporary water system to maintain service. The second option is to use a pre-chlorination process that would allow the newly installed main to be disinfected and pass the bacteriological tests prior to its installation so that services could be reinstated immediately after installation. This process requires the main and its service connections to be completely out of service for approximately six hours. The two methods are detailed as follows;

Temporary Water Service System

The use of a temporary water service system is the standard way to maintain residential and business service while the pipe bursting operations are completed. This method provides the least amount of service disruption. The key considerations for this method are materials, logistics, and benefits.

Temporary Water Service Materials

Of course, the size of the temporary service main can vary greatly depending upon service requirements of the particular project. The materials for the temporary service main are typically butt-fused HDPE pipe or restrained joint PVC pipe. The lengths of temporary water service systems can also vary greatly from a few hundred feet to a mile or two at a time. It is a good practice to have in-line valves at strategic locations for the future convenience of water control.

There are multitudes of ways to tap the temporary main whether it is HDPE or restrained joint PVC. It is important to have some sort of shut-off valve at the intersection of the temporary service connection and the temporary main. The temporary service is generally connected to the existing service piping or the existing meter. If this is not possible or practical, the temporary water service can be tied into an outside water spigot.

Figure 20 – 2" HDPE Temporary Water System W/ In-line Valve & Electrofuse Saddles W/ ¾" HDPE Service Lines

Temporary Water Service Logistics

The temporary water system is generally laid on top of the ground, through driveway culverts, along curbs, and across driveways all depending upon the site conditions. Creativity and ingenuity is required to provide the temporary water service and maintain it out of the public's way and harm's way. Generally speaking, where there is a will there is a way. Some of the more common scenarios are as follows;

Driveway Crossings & Road Crossings

Driveway and road crossings can be one of the more challenging aspects of the temporary water system. Many times there are existing storm drains or culvert pipes that can be used as a conduit to get the temporary system from one side to the other. Another simple solution is to create a small speed bump out of cold mix that would ramp the vehicles over the temporary system. Another simple solution is to strap planks to the either side of the main to bridge and protect the pipe. Directional drilling the pipe has also been incorporated as a solution. In other instances, a shallow and narrow excavation is required to bury the temporary system just under the surface to allow traffic to flow unimpeded.

Figure 20 – Driveway Crossing w/ Cold Mix

Figure 21 – Driveway Crossing with 6x2 Planks Strapped to 2" Restrained Joint PVC (Yellowmine)

Fire Protection

Another consideration for temporary water systems is the fire protection issue. The local fire marshal should be consulted to discover which fire hydrants can be taken out of service and the proper procedures for doing so. It is possible to set up temporary hydrants on the temporary water system. Typically, keeping existing fire hydrants in service or setting up temporary hydrants will have an impact on the size of the temporary system required and/or the lengths and locations of the set up.

Bacteriological Testing

Prior to transferring customer services to the temporary main, the main must be disinfected and pass a bacteriological test. Once the appropriate test results are achieved, the residential and business services can be connected to the temporary service main.

Pre-chlorination System

Pre-chlorination is the process of disinfecting the new water line and passing a bacteriological test prior to installing the water line. The procedure for doing so is exactly the same as would be done for a water line installed by traditional excavation methods in accordance with AWWA standards. The procedure is simply performed before installation. After the pipe is installed, the pipe is super-chlorinated and thoroughly flushed again as a precautionary measure. The newly installed main is put back into service within hours of installation, thus eliminating the need for temporary water service.

Pre-chlorination Procedure

The Pre-chlorination Procedure is actually quite simple. As previously stated, the same process that would normally be employed after pipe installation is simply employed prior to installation thus removing the need for the procedure to be completed post installation. Since the newly installed water line has already passed the required tests and been accepted by the owner, customer services can be placed back into service immediately after replacing the main by pipe bursting. The Pre-chlorination Procedure is outlined as follows;

1. Prior to installation the new pipe is disinfected according to AWWA standards and has passed the required bacteriological test.
2. The job site is prepared and water services excavated and exposed for quick reconnection after pipe is installed by pipe bursting process. This procedure is usually done a day in advance of pipe bursting.
3. The pre-chlorinated pipe is installed by the pipe bursting process.
4. A slug of chlorine is introduced to the newly installed pipe before it is connected to the existing pipe.
5. Once the valves are opened the slug is pushed through the new pipe until it is received at the opposite end.
6. The new pipe is flushed and then reconnected to the existing main.
7. The new pipe is then placed into service and all services are reconnected.

During the installation procedure, customers are typically out of service for approximately six hours.

Advantages and Disadvantages of Temporary Water Systems versus Pre-chlorination

One of the primary advantages of the temporary water system over the pre-chlorination system is that customer service disruption is minimized. Service is only disrupted for the amount of time that it takes to transfer the service, which is usually less than an hour. Another advantage of the temporary system over the pre-chlorination system is that once the temporary system is in place, it is in place for any and all delays that occur during the pipe bursting process. The temporary system removes the pressures to finish in a timely manner and the complaints that ensue if and when the work is not finished as scheduled.

One advantage of the pre-chlorination system over the temporary water system is that it is theoretically less expensive. The cost of setting up a temporary water system can add several thousands of dollars of cost to the project. Also, the use of pre-chlorination system avoids the disruption to the community caused by the presence of the temporary water system. The temporary water system in some cases can prevent the community from normal activities ranging from mowing their lawn to simple enjoyment of their property. The temporary system can also be unsightly and be considered a trip hazard. Another advantage of the pre-chlorination system is the absence of concern over possible tampering with the temporary water system. The system is exposed and measures should be taken to keep malcontents from turning the system off after hours.

It can and has been argued that one method is better than the other. The simple fact is that there are times where one method will suit the project better than the other and there will be times when it simply doesn't make much difference. One thing to keep in mind is that the pre-chlorination process has been widely accepted in many states and mildly resisted in others.

Cost of Water Line Bursting

The final component of the discussion, and possibly the most important for some, revolves around the estimated cost of water line pipe bursting. Again every project is unique and the costs to perform different projects vary significantly. Consequently, it is sometimes best to simply look back at the last project completed and discuss those costs and prices, as an example. This is especially productive if the project was generally considered a typical pipe bursting project and/or similar to the project under consideration.

With that in mind the most recent water line bursting project awarded to Portland Utilities Construction Company, LLC was the Central Valley Road Water Line Replacement Project. The overall cost of the project including pipe installation, valves, hydrants, fittings, and restoration was $85.00 per LF. The primary item, of course, was installing 10" DR 18 DIPS Fusible C-900 by Pipe Bursting. The unit price/cost for this item was $60.00 per LF. This item and price included mobilization, and temporary water service in addition to the pipe installation. An alternate bid for 12" DR 9 DIPS HDPE by Pipe Bursting was also required. The alternate bid for this item was $62.00 per LF. The engineer and owner considered these two pipe materials and sizes to be equals. A complete list of unit prices for this project is presented in Appendix 1.

As discussed previously, the primary cost advantages that pipe bursting has over open cut installation are related to costs not incurred for surface restoration and backfill material when pipe bursting. A typical scenario to consider is the replacement of 500' of an existing water line installed under asphalt. The cost to replace the asphalt for this scenario (500' LF x 5' Wide – 6" Thick) would be $36.66 per LF for open cut replacement. If required, the cost for backfill stone material for this scenario would be $16.50 per LF for open cut replacement. Conversely, the cost to backfill with stone and re-pave the 20 LF insertion pit required to pipe burst the same 500 LF of pipe would be $0.66 and $1.47 per LF, respectively. (Please see Appendix 2 for calculations.)

Cost of Asphalt Restoration	Total Cost	Unit Cost
Open Cut Option	$18,332.82	$36.66 Per LF
Pipe Burst Option	$734.00	$1.47

Table 1 – Comparison of Asphalt Restoration Costs Between Open Cut and Pipe Burst Options for 500 LF of pipe replaced.

Cost of Stone Backfill	Total Cost	Unit Cost
Open Cut Option	$8,250.00	$16.50 Per LF
Pipe Burst Option	$330.00	$0.66 Per LF

Table 2 – Comparison of Stone Backfill Costs Between Open Cut and Pipe Burst Options for 500 LF of pipe replaced.

The savings (in this scenario) in Backfill Stone of $7,920 ($8250 - $330) and in Asphalt of $17,598.82 ($18,332.82-$734) to pipe burst this line over open cut replacement are significant and most often swing the pendulum in favor of pipe bursting. In tandem those two items alone amount to a $51.03 per LF savings. Again this cost savings and math have been realized on the wastewater side for over 20 years.

Conclusion

The need for efficient and economical solutions to renewing, replacing, and up-grading our water systems are no longer a problem to be dealt with in the future. Even the general public is becoming aware of what industry veterans have known for years.

While pipe bursting is gaining more and more traction on the water side of our industry, there are many that are still getting their arms around the technology and simply need to be assured before they can take that leap of faith with the technology. Possibly a conversation with an experienced contractor to answer frequently asked questions is just what is needed to allow owners and engineers to pipe burst water lines with confidence.

Appendix 1 – Bid Tabulation

Consolidated Utility District
709 New Salem Road
Murfreesboro, TN 37219
Contract 213 – Central Valley Road Water Line Replacement Phase I

Water Line Additions

Item	Qty.	Unit	Description	Unit Price	Total Amount
1A	10,300	LF	Furnish and Install 10" DR 18 DIPS Fusible PVC WL by Static Pipe Bursting	$60.00	$618,000.00
2	100	LF	Furnish & Install 10" CL52 DI Water Line	$100.00	$ 10,000.00
3	100	LF	Furnish & Install 6" CL52 DI Water Line	$75.00	$ 7,500.00
4	100	LF	Furnish & Install 2" PEX Water Line	$40.00	$ 4,000.00
5	50	LF	Furnish & Install 2" Stainless Steel WL	$64.00	$ 3,200.00
6	100	LF	Furnish & Install 2" DR 9 HDPE WL	$35.00	$ 3,500.00
7	1700	LF	Furnish & Install 1" Service Line	$20.00	$ 34,000.00
8	13	EA	Furnish & Install 10" Gate Valve Box	$2,100.00	$ 27,300.00
9	13	EA	Furnish & Install 6" Gate Valve Box	$1,300.00	$ 16,900.00
10	2	EA	Furnish & Install 2" Gate Valve w/2" Operator	$1,100.00	$ 2,200.00
11	1	EA	Furnish & Install 12" Tapping Tee & Valve	$8,500.00	$ 8,500.00
12	11	EA	High Security Fire Hydrant	$3,300.00	$ 41,800.00
13	1	EA	Furnish & Install 2" Blow-Off Assembly	$5,000.00	$ 5,000.00
14	45	EA	1" Service Reconnections/Relocations	$1,200.00	$ 54,000.00
15	30	CY	Furnish & Install Class "B" Concrete	$225.00	$ 6,750.00
16	800	TN	Furnish & Install Crushed Stone	$19.00	$ 15,200.00
17	3000	LB	Furnish & Install DI MJ Fittings	$4.00	$ 12,000.00
18	50	TN	F & I Asphalt Pavement Replacement	$235.00	$ 11,750.00
19	50	EA	F& I 10" Megalug Restrained Joint	$135.00	$ 6,750.00
20	50	EA	F& I 6" Megalug Restrained Joint	$70.00	$ 3,500.00
			Total Bid Using Item No. 1A		$891,850.00

Alternate Substitution Bids

Item	Qty.	Unit	Description	Unit Price	Total Amount
1	10,000	LF	Furnish & Install 12" DR-9 DIPS HDPE Water Line By Static Pipe Busting	$62.00	$638,600.00
2	100	LF	Furnish & Install 12" Class 52 DI WL	$120.00	$ 12,000.00
8	13	EA	Furnish & Install 12" Gate Valve & Box	$2,500.00	$ 32,500.00
19	50	EA	F & I 12" Megalug Restrained Joint	$290.00	$ 14,500.00
			Total Alternate Substitution Bids		$927,400.00

Appendix 2 - Calculations

Calculations for Asphalt Restoration and Stone Backfill

Asphalt Cost For Open Cutting 500 LF Of Water Main and Repaving 500 LF - Calculated as follows:
500 LF X 5' Wide / 9 to Convert to Square Yards = 277.77 SY
277.77 SY X 660 (110 LBS per 1" per SY)/2000 LBS to Convert to Tons = 91.66 Tons of Asphalt
91.66 Tons of Asphalt x $200 per Ton (Average Cost per Ton for Patch Work) = $18,332.82
$18,332.82/500 LF = $36.66 per LF to Replace Asphalt

Stone Backfill For Open Cutting 500 LF of Water Main and Backfilling 500 LF with Stone - Calculated as follows:
500 LF X 5' Wide X 3(Backfill Depth) = 277.77 Cubic Yards
277.77 Cubic Yards X 1.65 to Convert CY to Tons of Stone = 458.33 Tons of Stone
458.33 Tons of Stone X $18 (Average Cost of Stone) = $8,250.00
$8,250.00/500 LF = $16.50 Per LF for Backfill Stone

Asphalt Cost For Pipe Bursting 500 LF Of Water Main and Repaving 20 LF Insertion Pit - Calculated as follows:
20 LF X 5' Wide / 9 to Convert to Square Yards = 11.11 Square Yards
11.11 SY X 660 (110 LBS per 1" per SY)/2000 LBS to Convert to Tons = 3.67 Tons of Asphalt
3.67 Tons of Asphalt x $200 per Ton (Average Cost per Ton for Patch Work) = $734.00
$734.00/500 LF = $1.47 per LF to Replace Asphalt

Stone Backfill For Open Cutting 500 LF of Water Main and Backfilling 20 LF Insertion Pit with Stone - Calculated as follows:
20 LF X 5' Wide X 3 (Backfill Depth) = 11.11 Cubic Yards
11.11 Cubic Yards X 1.65 to Convert to CY to Tons of Stone = 18.33 Tons of Stone
18.33 Tons of Stone X $18 (Average Cost of Stone) = $330.00
$330.00/500 LF = $0.66 Per LF for Backfill Stone