INTERNATIONAL PIPE BURSTING ASSOCIATION

Guideline for Sewer Lateral Pipe Bursting

Prepared for:

The International Pipe Bursting Association (IPBA)
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March 2015

DISCLAIMER

These guidelines were prepared by the International Pipe Bursting Association IPBA, a division of NASSCO, and peer reviewed by industry professionals. These guidelines are not specific to any one product and should be considered a guideline only. Conditions for use may require additions, deletions, or amendments to these guidelines so as to conform to project specific site conditions. IPBA, a division of NASSCO, assumes no liability as to content, use and application of these guidelines.

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Preface

Pipe bursting is a mature and widely used trenchless method for renewal of deteriorated and undersized gas, water, sewer, utility conduits and other pipelines throughout the world. The need for current guidelines related to the use of this technology for lateral sewers was deemed important by the IPBA Leadership Team and the IPBA wanted to lend its collective expertise to the subject.

These guidelines describe current lateral pipe bursting practices used by engineers and construction professionals and have been prepared to assist municipal utility owners, private property owners, designers, plumbers, and contractors involved in pipeline replacement and/or rehabilitation projects to evaluate the capabilities of pipe bursting as an existing trenchless pipe replacement method.

These guidelines are based on information obtained from technical papers, existing guidelines and specifications, case studies, manufacturers' literature, and other related information, as well as from comments and reviews made by industry experts and the IPBA Leadership Team.

The following industry representatives are especially thanked for their reviews and comment:

John Galligan
The PipeShark, Inc.

Matt Timberlake
Ted Berry Company Inc.

Jay Garrett
Utah Pipebursting

Mike McCloud, Al Mackey, Hal Richard
City of Columbus, Ohio

Tom Carlisle
Underground Connections Inc.

Mike Woodcock
Portland Utilities Construction Company – PUCC

George Mallakis and the staff of
TT Technologies, Inc.

Brian Metcalf and the staff of
Hammerhead Trenchless Equipment

Michael Lien, John Rafferty and the staff of
TRIC Tools Inc.

Doug McLendon
Mid-Atlantic Trenchless

Paul Hajzus
Roddie, Inc.

Jim Theriault
Omni Eye, Inc.

Rob Morrow
Mocon Corp.

NASSCO

IPBA Mission

The mission of the International Pipe Bursting Association (IPBA) is to advance the acceptance of pipe bursting as the trenchless technology of choice for replacement of failing and under-capacity pipelines throughout North America through collaboration of industry professionals, educational efforts, training opportunities, sound standards, marketing efforts highlighting the practical benefits of pipe bursting, and governmental support of initiatives impacting utility construction.

Executive Summary

Sewer laterals reflect the history of the plumbing trade and the evolution of materials used and the engineering theories behind them. Underground lateral sewer pipes in many North American cities have been in place for over 100 years. The EPA states that there are over 750,000 miles of private sewer lateral pipes in the United States. Many existing private systems have functioned well beyond their reasonably anticipated service life and large proportions of underground pipes are significantly deteriorated and need costly maintenance and repair. Common problems involve root ingress, structural failure of the pipe material, corrosion and deterioration of pipe materials, failure or leakage of pipe joints, and reduction of flow due to deposits and debris build up inside the pipe. Damage to existing pipes can also occur by ground movements due to adjacent construction activity, pressure exerted from root growth near the sewer line, uneven settlement or other ground instability. This can lead to sewer backups into private homes and businesses, pipe failures, pipe blockages, sanitary sewer overflows (SSO) and infiltration and inflow (I&I) in sewer systems.

In recent years there has been a transition to setting a higher standard regarding what is "proper operation "of private sewer laterals and the sanitary sewer collection system as a whole. Historically, as long as a lateral conveyed sewage away from a building a lateral was considered to be operating properly, even if it required periodic drain cleaning to remove roots. The cost of such maintenance was often considered preferable to the cost and destruction of digging up landscaping, walkways, and paved areas. Concerns about both inflow and infiltration from private sewer laterals are now parameters to be weighed regarding when a lateral has failed, and increasingly have pulled in local, state and federal organizations as key stakeholders. A growing driver is the cost of providing adequate sewage treatment in a community, the wasted money and effort in treating clean storm or ground water, and the desire to clean up the environment. The costs of sewer cleaning are also rising, as well as the expense of treating sewage spills inside of buildings, due to growing concerns about molds and health effects. Furthermore there is an increase in the conversion of older home basements into living space. Thus a sewer backup into a home may do more damage and so is much more expensive to clean up today than it was a generation ago. All these factors combined mean that the point at which it makes sense to replace a sewer lateral comes about much quicker today than it did in the past

Pipe bursting is a well-established trenchless method that is widely used throughout the world for the replacement of deteriorated pipes with a new pipe of the same or larger diameter. Pipe bursting is an economic pipe replacement alternative that reduces surface damage and restoration as well as disturbance to business and residents when it is compared to traditional open cut construction.

History of Pipe Bursting

Pipe bursting was first developed in the UK in the late 1970s by D. J. Ryan & Sons in conjunction with British Gas, for the replacement of 3- and 4-inch cast iron gas mains. This method was patented in the UK in 1981 and in the United States in 1986; these patents expired in April 2005. Since the late 1970s pipe bursting has grown into a mature market both internationally and in North America for the replacement of lateral and mainline sewer systems.

The National Association of Sewer Service Companies (NASSCO) was established in 1976 and is the oldest such association with a trenchless focus. The International Pipe Bursting Association (IPBA) was founded in 2000 as a division of NASSCO with the purpose of developing standards for the use of pipe bursting in the sewer market in the United States. A re-organization of the association in 2010 brought together professionals from all aspects of the pipe bursting industry who developed a strategic plan to collaboratively promote pipe bursting throughout sewer, water, gas, and other underground utility markets including publication of the "2012 IPBA Guidelines for Pipe Bursting". The International Pipe Bursting Association Lateral Committee works to assist responsible pipe bursting applications in North America through industry education and publication of these guidelines.

General Description of Pipe Bursting

Pipe bursting is defined as a trenchless replacement method in which an existing pipe is broken either by brittle fracture or by splitting, using an internal mechanically applied force applied by a bursting tool. At the same time, a new pipe of the same or larger diameter is pulled in replacing the existing pipe. The back end of the bursting head is connected to the new pipe and the front end is connected to a cable or pulling rod. The new pipe and bursting head are launched from the insertion pit, and the cable or pulling rod is pulled from the receiving pit. The energy (or power source) which moves the bursting tool forward to break the existing pipe comes from pulling cable, chain, or rods, hydraulic power to the head, or pneumatic power to the head, depending on the bursting system design. This energy (or power) is converted to a fracturing force on the existing pipe breaking it and temporarily expanding the diameter of the cavity. The bursting head is pulled through the pipe debris creating a temporary annulus and pulling behind it the new pipe from the insertion pit.

The leading or nose portion of the bursting head is often smaller in diameter than the existing pipe, to maintain alignment and to ensure a uniform burst. The base of the bursting head is larger than the inside diameter of the existing pipe to be burst, to fracture it. It is also slightly larger than the outside diameter of the replacement pipe, to reduce friction on the new pipe and to provide space for maneuvering the pipe.

Main Classes of Pipe Bursting

Lateral Pipe bursting systems are primarily classified into two classes: (1) **pneumatic pipe bursting** and (2) **static pipe bursting**, which is based on the type of bursting tool used. The basic difference among these systems is in the source of energy and the method of breaking the old pipe and some consequent differences in operation. The selection of a specific replacement method depends on geotechnical conditions, degree of upsizing required, type of new pipe, construction of the existing pipeline, depth and profile of the existing pipeline, availability of experienced contractors and equipment, risk assessment, and other possible site specific issues.

Pneumatic Pipe Bursting

In the pneumatic system used for lateral pipe bursting, the bursting tool is a small diameter soil displacement hammer driven by compressed air. An expander is fitted to either the front or near the rear of the pneumatic soil displacement hammer. The pneumatic hammer assembly is launched into the host pipe via an insertion pit. The tool is connected to a constant tension winch located at the receiving point. The constant tension of the winch keeps the tool and expander in contact with the unbroken section of pipe and centered within the host pipe and when combined with the percussive power of the hammer helps maintain the hammer and expander inside the existing pipe. The percussive action of the hammering cone-shaped head is similar to hammering a nail into the wall; each hammer stroke pushes the nail a short distance. A pneumatic bursting tool cracks and breaks the existing pipe, with each stroke. The expander combined with the percussive action pushes the fragments and the surrounding soil away providing space for the new pipe. Reversible tools are available that allow the pneumatic hammer to back itself out through the installed pipe saving the expense of a reception pit. Once started, the burst continues to the destination manhole/receiving pit where the tool/expander assembly is retrieved. The process continues with little operator intervention until the head reaches the pulling shaft at which point it is separated from the new pipe. In regards to pneumatic pipe bursting operations, considerations should be made for the noise generated by the air compressor and pneumatic hammer. Generally the noise is concentrated near the open end of the replacement pipe due to the release of pressure associated with the pneumatic action through the new pipe.

Static Pipe Bursting

In the static pull system used for lateral pipe bursting, no hammering action is used, as a static pull force is applied to the cone-shaped expansion head through a cable, chain, or pulling rod inserted through the existing pipe. The cone transfers the horizontal pulling force into a radial force - breaking the existing pipe and expanding the cavity providing space for the new pipe. The most common applications use a cable or chain as they can be inserted through pipes with minor deflections and even bends in the line. With the cable or chain method the pulling device is setup and the cable or chain is inserted into the existing pipe from the pulling shaft. When the cable or chain reaches the insertion shaft, the bursting head is connected to it and the new pipe is connected to the rear of the head. A hydraulic unit in the pulling shaft pulls the cable or chain thus progressing the bursting head and fracturing the existing pipe and pushing the debris into the surrounding soil while pulling the new pipe behind it. The process continues until the bursting head reaches the pulling shaft, where it is separated from the new pipe. The rod systems are able to accomplish lateral pipe bursting with similar technique however cannot negotiate significant changes in pipe direction from bends or factory fabricated elbows or fittings.

Qualifications

The IPBA recognizes that growth of the lateral pipe bursting market in North America is reliant on continued success of projects, expanded knowledge and experience of the utility system owners and their consultants, trained field staff that are able to recognize and address issues rapidly, and by responsible use of pipe bursting technology by plumbers and contractors.

It is generally accepted that the contracting authority will use a baseline for determining contractor pre-qualification based on proven experience of projects of similar type, size, and class of difficulty. Standard minimum requirements commonly used are:

(1) Verification of training by the pipe bursting system manufacturer utilized stating that the operators have been fully trained in the use of the pipe bursting system by an authorized representative of the equipment manufacturer.
(2) Verification by the pipe supplier of training in the proper method for handling, joining, and installing the new pipe.
(3) A minimum of successful installations of pipe of a similar class (degree of difficulty), size, and scope.

Comparison of Pipe Bursting to Other Replacement and/or Rehabilitation Methods

Comparison with Traditional Open Cut Replacement
Open cut replacement may be a preferred option of pipe renewal when the pipeline is shallow and the trenching does not create inconvenience. However, under many conditions, pipe bursting has substantial advantages over open cut replacements.

The advantages are especially notable in lateral replacement for lines under structures and hardscapes, or mature trees, and with deeper lines where the greater depth increases the cost of open cut replacement through extra excavation, shoring, and dewatering, etc. Additionally as the underground utility network becomes more congested through the advancement and expansion of services like natural gas and high-speed cable, the difficulty and cost of open cut replacement increases as well.

There are also other advantages of pipe bursting over open cut replacement, which, while they may not show up on a contractor's job make-up sheet, they nevertheless have real financial or aesthetic costs. They include (1) less disturbance to landscaping, (2) shorter time for replacement, (3) less impact on mature trees (4) less environmental disturbance, and (5) reduced surface restoration expenses and other restoration benefits.

Comparison with Other Rehabilitation Methods
Trenchless technology is a type of subsurface construction work that requires little or no surface excavation and no continuous trenches. It is a rapidly growing sector of the construction and civil engineering industry; and can be defined as "a family of methods, materials, and equipment capable of being used for the installation of new or replacement or rehabilitation of existing underground infrastructure with minimal disruption to surface traffic, business, and other

activities." Trenchless rehabilitation methods are generally more cost-effective than traditional dig and replace methods.

The pipe bursting method is proposed as a favorable alternative to other lateral sewer rehabilitation methods such as cured in place piping (CIPP) that relines an existing pipe with a cured-in-place liner that conforms to the profile of the existing pipe ID while reducing it by the thickness of the lining material installed. While relining methods offer no-dig rehabilitation of an existing pipe they follow the grade and profile of the existing pipe. Pipe bursting can install a new pipe with a true profile (design ID). This ability can be advantageous, if used to correct offset joints, or deflections in the existing pipe. Another significant advantage of pipe bursting over other trenchless rehabilitation methods, such as CIPP or sliplining, is the ability to upsize existing laterals, thus increasing hydraulic capacity by use of a trenchless method. Pipe bursting is the only trenchless method that can increase the hydraulic capacity of a pipe by installing a new pipe of the same or larger inner diameter

Pipe bursting may be the only choice for trenchless improvement of an existing pipe in very poor structural condition or if other rehabilitation methods are rejected as unsuitable. Some partially collapsed pipes may not be suitable for pipe bursting. However, measures can be taken to mitigate this problem if the number and length of collapses are isolated. If the chain, cable or pulling rods can be inserted from receiving point to insertion point, the line can usually be pipe burst, unless other issues prevent the application.

Design Considerations

Design considerations evolve from many factors including but not limited to existing pipe size and material(s), common lateral construction practices in the area of work, local plumbing codes, ground geotechnical and groundwater conditions, original trench construction, degree of upsizing required, construction and depth of the existing pipeline, adjacent utilities, etc. The following discusses these issues and their relevance, and gives some general guidance about the selection of replacement pipe, bursting length, etc. As with any type of underground utility construction certain factors may limit the feasibility or effective use of a technology. Some items may limit pipe bursting significantly in feasibility from a technical aspect while others may limit its feasibility financially. It is important to know how to identify limiting factors and compare them to their relative effects on a specific project in the selection of methods process.

Range of Applications

Lateral Pipe bursting can be applied on a wide range of pipe sizes and types and in a variety of soil and site conditions. Lateral pipe bursting is used internationally for replacement of sewer, water, gas, storm, and other underground conduits with the size of pipes replaced by pipe bursting typically ranging from 2” ID to 8” ID.

Classifications of Difficulty

The IPBA classifies sewer lateral pipe bursting work into four classifications, A-B-C-D. These classifications are to be used as a general guideline in the design and preconstruction phase of a sewer lateral replacement by pipe bursting. It considers the typical training, experience, and equipment of a contractor who does sewer lateral replacement. (This is in contrast to a contractor who typically does sewer main replacement work. A separate classification chart exists for mainline pipe bursting. Refer to the 2012 IPBA Guidelines for Pipe Bursting for that chart.) If one or more of the listed conditions apply, the pipe bursting installation will be categorized within that classification. The success of the pipe bursting project is dependent on the qualifications of the project team, geotechnical conditions, existing pipe material and condition, burst length, depth of pipe, and degree by which the pipe diameter will be increased. The developmental classification is left undefined to recognize and support the continual expanding of the capabilities of the industry. For example, there is the issue of whether it is feasible to pipe burst through a 90-degree bend. If a discussion is initiated among a group of pipe bursting contractors with a wide range of experience, it can quickly be found that some of them have done such pipe bursting successfully. The discussion will further reveal how much those successful contractors understood and controlled all the variables which allowed them to confidently pipe burst through a 90-degree bend. That process is hard to put into a neat formula at this time. So presently it is listed under "Developmental" along with pipe over 8" and excavation greater than 20' (the point at which OSHA requires an engineer to design shoring), pulling multiple lines at once, etc. As these issues become better defined and standardized, they will be moved out of "Developmental" and into a classification that represents their challenge to the general sewer lateral pipe bursting industry.

Classification	Pipe size	Degree of upsize	Length	Bends in line to be pipe burst	Transitions in pipe material or size	Depth
A	Up to 4"	Size on size	50' or less	None	None	Less than 5'
B	6"	Single upsize	50' – 100'	Single bend in line of 45 degrees or less.	Single transition	Less than 10'
C	8"	Double upsize	Greater than 100'	Max 45 degrees at any bend. Total bends of 135 degrees or less.	Multiple transitions in pipe material and/or size	Less than 20'
D	DEVELOPMENTAL					

Increase of New Pipe Diameter

Whereas pipe bursting has the ability to replace an existing pipe with a new pipe that has the same or larger diameter, the following terminology is used in regards to the comparison of the newly installed pipe diameter to the existing pipe diameter. The "degree of upsize" is the difference between the existing pipe inside diameter (ID) and the newly installed pipe outside diameter (OD). (Actual ID will be dependent on type of newly installed pipe, pressure rating, and nominal diameter). Pipe ID and OD calculations are generally used in reference to nominal pipe size increases that are standard by utility type and/or pipe type. For example in lateral sanitary sewer pipe applications conventional systems utilize pipe IDs of (in inches) 3,4, 6, and 8, etc. Increase in required forces to complete a pipe burst with an upsize is relative to the volumetric displacement that occurs as the soil is displaced and compressed.

Size on Size - Refers to replacing an existing pipe with a new pipe of similar ID. An example would be the replacement of an existing 4" VCP with a new 4" Thermoplastic pipe.

Single Upsize - Refers to increasing an existing pipe with a new pipe that has an ID larger by approximately one nominal size. An example would be the replacement of an existing 4" VCP with a new 6" Thermoplastic pipe.

Double Upsize - Refers to increasing an existing pipe with a new pipe that has an ID larger by approximately two nominal sizes. An example would be the replacement of an existing 4" VCP with a new 8" Thermoplastic pipe.

Triple Upsize - Refers to increasing an existing pipe with a new pipe that has an ID larger by approximately three nominal sizes. An example would be the replacement of an existing 4" VCP with a new 10" Thermoplastic pipe

Conditions that Limit the Favorability of Pipe Bursting

Geotechnical Conditions

As with any underground utility project it is essential that accurate geotechnical data be provided as it is critical to the design of the pipe burst system and project approach. In geotechnical engineering, soils are considered a three-phase material composed of: rock or mineral particles, water and air. The voids of a soil, the spaces in between mineral particles, contain the water and air. The engineering properties of soils are affected by four main factors: the predominant size of the mineral particles, the type of mineral particles, the grain size distribution, and the relative quantities of mineral, water and air present in the soil matrix.

The most favorable ground conditions for pipe bursting projects are where the ground surrounding the pipe can be compacted readily by the bursting operation as it is displaced. This 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 expanded 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.

Somewhat more complex ground conditions for pipe bursting involve densely compacted soils and backfills, rock trenches, soils below the water table and soils that expand in volume as they are sheared, e.g. 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. For most soil conditions, it is simply necessary to provide the required power to effect the burst, displace the soil and pull the replacement pipe in over the length of the burst and to consider the potential effect of the ground displacements and vibrations on adjacent utilities and structures.

When the soil provides a high friction drag on the pipe and the replacement length is long enough to generate high tensile forces on the replacement pipe, bentonite or polymer lubrication based mixes may be injected into the annular space behind the bursting head to help keep the hole open and to reduce the frictional drag on the replacement pipe. If there has been erosion of the soil around the pipe, the bursting head and the following pipe will tend to displace toward the void or lower density region. If there is a hard soil layer or rock close to the pipe, the bursting head will tend to displace towards the softer soil. In shallow conditions, the ground will displace mostly upwards towards the ground surface and the new pipe will tend to match invert with the old pipe. If the pipe is deep relative to its diameter, the ground will tend to displace more radially around the old pipe and the new pipe will tend to be concentric with the old pipe. If the conditions change substantially along the length of the burst, this may cause some change in the grade and/or alignment of the pipe.

Groundwater Conditions

As with any underground utility construction project the presence of groundwater can increase the difficulty of bursting operations both from a practical and technical standpoint. In certain soil conditions, groundwater can have a buoyant and lubricative effect on the bursting operation, with groundwater flowing towards the open insertion pit and reception pit along the existing trench line. However in certain soil conditions groundwater will cause the annulus to close in quickly behind the expanding head thus increasing pipe drag and theoretically reducing the practical burst lengths.

During pipe bursting, the insertion and receiving pits are preferably kept dry allowing workers to operate equipment and safely connect the new pipe once installed. Specific requirements for dewatering of the pits should be part of the construction plan including proper discharge of the water removed from the pits. Although dewatering efforts add complexity to a pipe bursting project, when compared to an open cut excavation project that would require dewatering of the entire trench length, pipe bursting dewatering plans are often localized to just the insertion, receiving, and service points thus lowering project complexity.

Effect of Pipe Bursting on Surrounding Environment

Positioning of the Replacement Pipe

The replacement pipe naturally follows the line and grade of the original pipe under most conditions. The position of the new pipe generally depends on the soil characteristics, site conditions and installation procedures.

Depending on the degree of upsize, the position of the bursting head relative to the existing pipe can interfere with the bursting operation. Grade problems with the replacement pipe may be an issue when the pipes are laid on minimum grades and care should be taken to anticipate the ground movements and the replacement pipe position. In particular, the replacement pipe can easily deviate from the original grade near the starting or ending pit. The problem occurs when the new pipe is a stiff pipe (large diameter, thick wall), and the room in the insertion pit is too short to line it up fully with the original pipe.

Pipe bursting may reduce some types of sags in the existing pipe if the soil conditions around the existing pipe are uniform. However, if there is a soft zone beneath the existing pipe, the new pipe may be driven towards the soft zone and the sag deepened. Longer-than-normal bursting heads (often referred to as pilots) can help to maintain a straighter replacement pipe. A hard soil or rock base beneath the existing pipe may even inhibit the breakage of the underside of the pipe and cause the bursting head to break out at the top of the pipe, moving the replacement pipe substantially outside the envelope of the existing pipe. This problem has been improved in practice by redesigning the bursting head, and adapting it to promote splitting of the base of the existing pipe. Pipe bursting is a rehabilitation method and should not be expected to improve the grade and alignment of the existing pipe.

Disposition of Pipe Fragments

Pipe bursting generally creates pipe fragments of variable sizes. The pipe fragments generally tend to (1) settle at the sides and bottom of the replacement pipe in sand backfill, or (2) locate all around the perimeter of the replacement pipe in silt or clay backfill. The fragments tend to locate somewhat away from the replacement pipe, with a typical separation up to 1/4 inch. This indicates a "soil flow" during the bursting process: the bursting head with its diameter larger than the replacement pipe creates the annular space, which is subsequently filled with the soil.

A common misconception regarding the pipe bursting method is that the existing pipe fragments from cast iron (CI) or vitrified clay pipes (VCP) could cut or damage thermoplastic pipe during the pull-in operation or in subsequent years of operation. Scratching of the replacement pipe during installation is common but the problem is generally not serious. The scratching of the replacement pipe can be offset by choosing a higher than minimum pipe wall thickness (Diameter Ratio - DR) and by the design of the bursting tool. As an example Thermoplastic pipes can be scratched up to 10% of the pipe wall with no impacts on its strength or internal pressure rating.

Ground Displacements

Every bursting procedure is associated with ground displacements. Even when the replacement is carried out size-for-size, soil movements are created because the bursting head has a larger diameter than the replacement pipe. Ground movements are not exclusive to pipe bursting, and they can be significant in open trench replacements of pipes as well. This section explains the general behavior of the ground movements under particular site conditions, reveals what conditions can be of concern, and suggests some minimal requirements for pipe bursting operations. The soil displacements expand from the source through the soil in the direction of the least soil resistance. They are a function of both time and space. The displacements are the greatest during the bursting operation, and they can partially diminish over time after the burst. They generally tend to be localized, and to dissipate rapidly with the distance from the source.

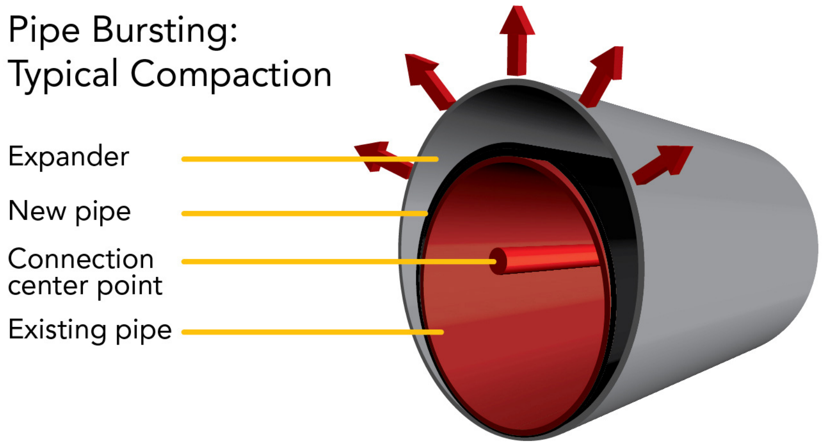


Figure 1

Ground displacements depend primarily on:

(1) Degree of upsizing. The volumetric displacement which is a calculation based on the difference between the ID of the existing pipe and the OD of the expander head being used
(2) Type and compaction level of the existing soil around the pipe.
(3) Original trench design
(4) Depth of bursting.

In a relatively homogeneous soil with no close rigid boundaries, the displacements are likely to be directed upwards at smaller depths while at increased depths they are expected to have more uniform direction.

It is a combination of many factors that determines whether the surface will heave or settle. If the existing soil is loose sand or relatively new trench backfill which is still settling, the bursting process can act to further settle the existing soil. Otherwise, if the soil is well compacted and the pipe not very deep, the bursting process is likely to create a surface heave, especially when significantly upsizing the existing pipe.

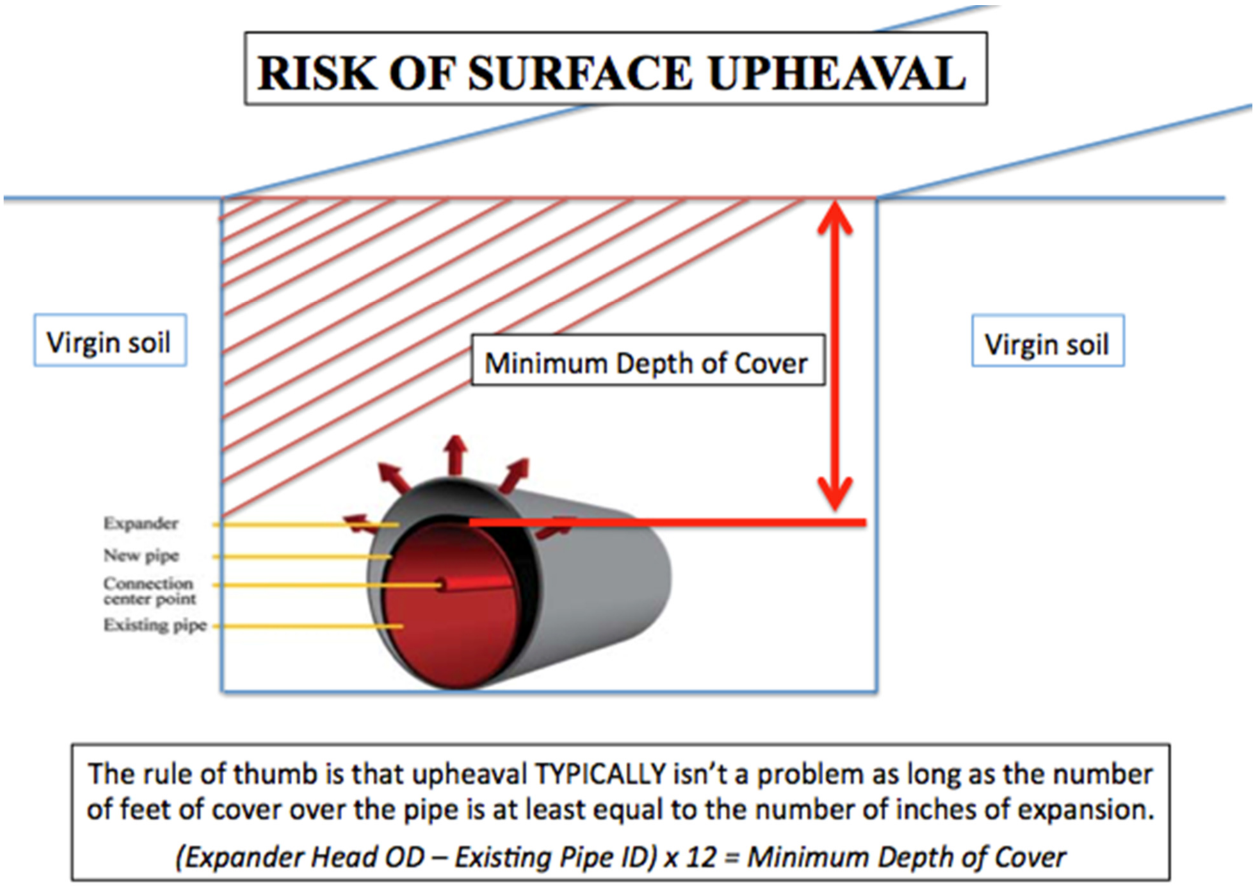
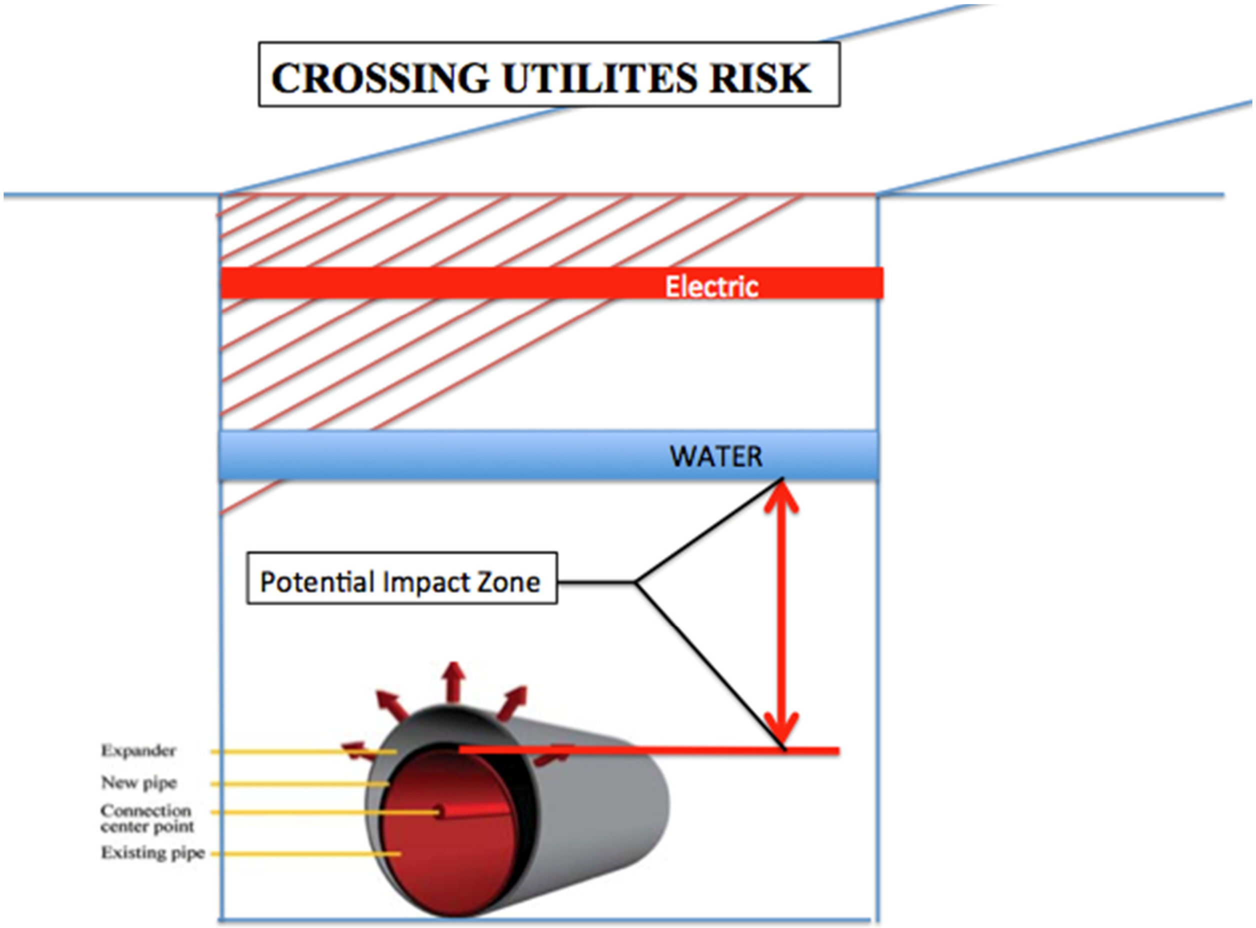


Figure 2

Effect on Nearby Utilities

Ground movements during the pipe bursting operation can damage nearby pipes or structures. Brittle pipes are the most susceptible to serious damage. The response of the adjacent pipe to the disturbance from the bursting operation depends on the position of the pipe relative to the direction of bursting and the volumetric displacement from the burst head. A parallel adjacent pipe is subject to transitory disturbance, as the bursting operation is progressing. If the adjacent pipe is diagonally crossing the line of bursting, it undergoes longitudinal bending as it is pushed away from the bursting line. Therefore it is critical that accurate utility locations are provided prior to the pipe bursting operation for all pipelines within the path of the burst.

The severity of disturbance on the adjacent pipe depends on the type of soil. If the pipes are located in the weak soil (backfill which has not been well compacted and is still below the level of compaction of the surrounding ground), the load transfer is less significant than through a strong, incompressible soil. In order to avoid individual study in each pipe bursting project, some safety guidance has to be followed to ensure protection of pipes in proximity of pipe bursting operation. As a general rule, both horizontal and vertical distances between the pipe to be burst and the existing adjacent pipe should be at least two diameters of the replacement pipe. The prerequisite in avoiding damage to adjacent utilities is to know their existence and location prior to the bursting. In addition to surface utility location techniques, a keyhole type vacuum excavation can be used to locate the utility lines in the zone of influence and verify their clearance from the pipe to be burst.



The potential impact zone for a crossing utility is based on the amount of expansion. Measured from the crown of the existing pipe it extends 10" for every inch of expansion.
(Expander Head OD – Existing Pipe ID) x 10 = height of potential impact zone

Figure 3

A common concern with sewer lateral pipe bursting is where multiple pipe lines were originally installed in the same trench. For example, neighboring sewer laterals may be run adjacent in the same trench with little to no separation between pipes. If one is being replaced due to deterioration with age, the adjoining one may be on the verge of failure as well. The act of pipe bursting one may be enough of a disturbance to cause the other to break. Sometimes the water or gas service to a building was installed alongside the sewer lateral. Generally these are not good candidates for pipe bursting. Beyond the technical issues, there may be code issues to consider when multiple utilities are in the same trench with little to no separation.

Ground Vibration
Pipe bursting can create to some extent vibrations of soil particles in the ground however it is unlikely to damage the nearby utilities or structures if they are at a distance of more than a few feet from the bursting head. The vibration levels due to bursting depend on the power (impact) applied through the bursting process, and therefore on the size and type of the existing pipe, and the degree of upsizing. While ground vibrations may be quite noticeable on the surface close to a bursting operation, the levels of vibrations are very unlikely to be damaging except at very close distances to the bursting operation. Ground vibration is more noticeable using pneumatic pipe bursting tooling. However the small size of tooling and pneumatic hammers for lateral pipe bursting applications limits the extent and effect of any vibration.

Existing Pipe

Material of Existing Pipes
Existing pipe types are most commonly classified as either "fracturable" or "non-fracturable" which characterizes the way they are "burst" or "split." Pipes made of most materials common to water, sewer, and gas construction since the late 1800s are able to be burst, however each type will have special considerations in regards to the method and specific tooling required to properly break and expand the existing pipe.

Fracturable Pipes include cast iron (CI), clay (VCP), concrete (CP), asbestos cement (AC), and others.

Non-Fracturable Pipes include ductile iron (DI), steel, galvanized iron, HDPE, PVC, and others.

Common types of lateral piping and their bursting characteristics are indicated below:

- **Clay Pipes** in diameters 4” to 8” commonly used in lateral sewers and other utilities and are good candidates for bursting. They are brittle and fracture easily.
- **Plain Concrete Pipes** have been used in all types of utilities construction and are good candidates for bursting. They are relatively brittle and tend to fracture easily in tension, especially when in a deteriorated condition. Thick plain concrete or reinforced encasements or repairs to the pipe can cause difficulty in bursting.
- **Cast Iron Pipes** have been used in all types of utilities construction until the 1970-1980’s and are good candidates for bursting. The pipes are relatively brittle even when in good condition. Ductile repair clamps, service saddles and fittings are common in CI piping systems and current pipe bursting technology can easily burst through them with proper

planning. Defining the specific class of the CI pipe is helpful in determining the actual designed wall thickness of the pipe and the bell end.

- **Ductile Iron and Steel Pipes** are not commonly used in lateral sewer construction and special considerations must be made prior to pipe bursting. They are strong and ductile, yet may be replaced using roller blade cutting assemblies. This is commonly referred to as "pipe splitting".
- **PVC, MDPE, HDPE and Other Plastic Pipes** are good candidates for pipe bursting and may be replaced using a combination of bursting and splitting techniques designed accordingly to the strength and ductility of the existing pipe. Determining the actual ID and OD as well as DR of the existing pipe is critical to proper sizing of the bursting tool.
- **Asbestos Cement Pipes** are generally good candidates for bursting. Care should be taken to determine the class of the existing pipe. Modifications to standard bursting heads should include cutter blades to split the pipe. The utility owner is cautioned to check with federal, state, and local standards in regards to handling and disposal of AC pipe and any associated permitting required. *Transite*® was a trade name for pipe manufactured using asbestos and cement materials.
- **Pitch Fiber Pipes (Orangeburg)** were used from the late 1860's through the 1970's in sizes ranging from 2" to 8" and are good candidates for pipe bursting as they are easily fractured and expanded. Pitch fiber pipes are very common in residential sewer lateral construction and failures are often seen as an out of round pipe profile as the pipe loses structural integrity and tree roots infiltrate the joints.
- **Corrugated Metal Pipes** – are generally not good candidates for traditional pipe bursting approaches. However advancements in technology and combination of traditional pipe bursting equipment with other means is constantly expanding the use of pipe bursting for corrugated pipes.
- **Wooden Pipes and Conduits** – pipes manufactured from wooden logs bored lengthwise are becoming much less common. However they do exist within regions with piping systems dating to the 1800s and can be good candidates for pipe bursting.

Depth and Profile

The depth of the host pipe affects the expansion of surrounding soil; this is often referred to as the "depth of cover" (DOC) and is the distance measured from the crown of the existing pipe to the finished surface.

The existing pipes depth is a critical design consideration for several reasons. Ground conditions tend to vary as increased depths are encountered. Existing variables can affect pipe bursting in regards to depth, including but not limited to: ground expansion difficulty and direction, soil density and mass, receiving and insertion point complexity, cost, safety, and insertion point size/length. More particularly, depth considerations apply directly to the anticipated burst forces required. These can be affected by the radial pressure applied to the new pipe if the soil void collapses (which can be estimated using the weight of soil forming the prism above pipe). The total force perpendicular to the pipe axis combined with the coefficient of friction between the pipe and the soil determines the frictional resistance against movement of the pipe, which must be added to the force required to fracture the existing pipe and displace the pipe fragments and soil outwards.

A pipeline's original profile is an essential condition to determining practicality and method of replacement. Pipe bursting follows the existing pipes original path through the ground or simply the path of least resistance. If a host pipe has variances in elevation beyond acceptable ranges particular attention must be given to specific variables such as; original trench design, burial depth, soil type, water table elevation, anticipated installation technique, anticipated burst forces and especially the acceptable elevation variance itself. In some cases short length elevation variances can be eliminated or reduced during pipe bursting operations, yet longer elevation variances tend to remain upon completion of pipe bursting in most situations. Individual situations with experience and site specific conditions can provide rather accurate hypothesis in regards to profile corrections.

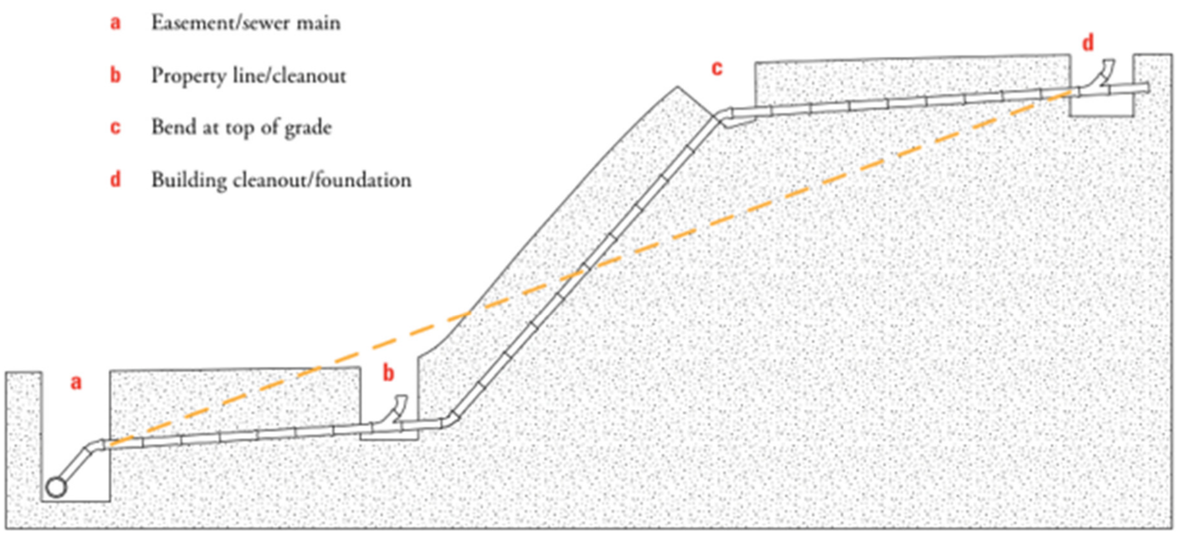
Surrounding Utilities

Surrounding utilities can affect the location of insertion and reception pits. As with any trenchless construction method, utilities that interfere with or may be damaged by the burst should be located and exposed prior to the burst.

Change In Direction In Existing Pipe

Sewer laterals run from the house or business to a municipal sewer main and are constructed on varying geography and often laid in a straight line from the property to the main. However it is not uncommon for there to be manufactured bends in the line in the form of an ell. In some instances bends such as 22° and 45° can be burst successfully and will result in a new line with a sweep and slight change in location from the original path. 90° elbows and similar changes in direction have been completed, however they require a much greater level of competency and planning.

Changes in direction of the existing line can occur laterally or vertically and consideration should be given for the path that the new pipe will take when being pulled through a change in direction including line and grade considerations and their effects. Special attention should be give to the reason the original pipe changes direction. Such knowledge may affect whether it makes sense to pipe burst through the bends. For example, the original pipe might change direction to avoid another utility.



Stitching up a steep grade

(Figure compliments of TRIC Tools, Inc.)

Figure 4

Figure 4 illustrates a common situation, in which the sewer lateral runs down a steep hill and has bends at both top and bottom of the slope. So if using cable in this example, if the burst is attempted from the main **a** to the building **d**, the cable will tend to follow the path of least resistance—indicated by the dotted orange line—and in most cases will slice out of the old sewer at street level (**a**–**b**), and/or cut into the earth excessively at the top of the grade **c**. This can be avoided by a process called "stitching." First, excavate at points **a**, **b**, **c**, and **d** as shown. Remove old pipe, couplings, and connections from all pits. Fuse the entire length of HDPE pipe from main **a** to building **d**, plus an extra 10 or 12 feet (3 or 4 meters). Attach the bursting head to the new pipe, and the cable to the head. Thread the cable from pit **a** to pit **b**. Position the HDPE pipe and bursting head at launch pit **a** and connect it to the cable. Then insert the puller in pit **b** and burst from **a** to **b** first. Thread the cable from **b** up to **c**, during or after the first pull. When the bursting head arrives at pit **b**, move the puller up to pit **c** and continue. When the bursting head arrives at pit **c**, move the puller up to pit **d** and finish the pull. Stitching maintains continuity of flow path by avoiding three separate launches. There is only one launch, with one entire length of pipe, pulled in three stages. Note also the resistance wall in pit **c**, which faces downhill *because it must be perpendicular to the host pipe path*. This is critical for stable, effective, and safe bursting. Do not use the ground surface to gauge the angle of the resistance wall. Use the pipe path instead, and cut a flat wall at right angle relative to the pipe.

House Traps

Some areas have house traps located outside the building. Sometimes these traps are located where it is difficult to excavate. An example is so close to a valued tree that digging to remove it will severely damage the root system and so eliminate many of the advantages of pipe bursting in such a situation. Therefore some pipe bursters have developed techniques to eliminate the need to excavate at the trap. After digging an insertion or receiving pit further away, they have hammered pipe up the old line and straight through the trap and vent line. Then they've pulled the wire rope or chain through the sides of the broken trap. This allows them to pipe burst straight through the trap with minimal damage to the tree roots. It can be difficult to do and may require the cooperation of the code inspector to locate the new trap or cleanout in a place other than required in a traditional excavation installation.

Old Pipe Repairs
The repair history of the line(s) to be burst should be noted carefully from building owner or video inspection. Repairs may involve heavy repair clamps and/or concrete encasements that can halt a bursting operation. Sometimes, repair clamps can be successfully burst using a cutting blade in combination with the bursting head.

Pipe Obstructions
Obstructions in the pipe such as heavy solids build up, heavy root intrusion where the root mass may also encapsulate the outside of the pipe, dropped joint, or collapsed pipe, may prevent the pipe bursting operation completely. If the obstruction cannot be removed from the pipeline by conventional cleaning equipment, it may be necessary to excavate and carry out point repairs prior to bursting. Otherwise, the bursting process may slow or stop, requiring remedial action.

Encapsulation of Non-Expandable Material
Anything which will not allow the pipe bursting head to pass through it will stop the burst. The most common examples are where the pipe passes through a concrete footer or where a transition joint was poured over with concrete. Another example is where the old piping was laid in a channel carved out of rock which is so narrow that the head can't pass through it.

Other Factors
Pipe bursting through pipes that have been laid in gradual radial curves has been successful using both static and pneumatic systems. Careful consideration of methodology is required. It is a critical design and execution consideration to plan for the anticipated radius of the curve and reflect it in the construction plan. The bend radius of the pipe bursting pull system must be considered. Mechanical bends such as 11.25°, 22.5°, 45°, or 90° must be identified prior to the pipe bursting operation. Static burst systems using rods are less able to negotiate a bend than a cable or a chain. Pneumatic systems may take a longer track through a bend based on the length of the internal hammer behind the bursting head. Guidance from the manufacturer of the pipe bursting equipment is the best source of direction on these issues.

Replacement Pipe

Thermoplastic Pipe
Thermoplastic pipe systems that are joined by thermal butt-fusion are currently the most popular for use in pipe bursting applications. These systems provide a monolithic pipe length, with fully restrained, gasketless joints that have the same material properties as the pipe itself. When

compared to the pipe, these joints are characterized by excellent pull force capability, full pressure rating, and zero leakage potential. There are two thermoplastic materials currently offered with this joining system; High Density Polyethylene (HDPE) pipe and Fusible Polyvinylchloride Pipe (FPVCP). Both systems are generally assembled from lengths of pipe (typically 40 to 50 feet long) shipped to the project site. These lengths are joined into the required strings of pipe for each pipe bursting run required. The pipe is then inserted as a monolithic length through an insertion pit and through the alignment to complete the burst.

HDPE pipe is commonly used for installation by pipe bursting of sewer laterals. The main advantages of HDPE pipe are its continuity, flexibility, and versatility. The continuity is obtained by the thermal butt-fusion joining methodology and reduces the likelihood of needing to interrupt the bursting process. The flexibility allows bending of the pipe for angled insertion in the field, and it can achieve tighter bend radii than FPVCP. HDPE's versatility means that it meets most requirements for gas, water, and wastewater pipeline applications. HDPE pipe is available in IPS (Iron Pipe Size) and DIPS (Ductile Iron Pipe Size) predominantly. There are various industry standards that guide the manufacture of HDPE pipe. The requirement for actual Inner Diameter (ID) or flow area and pressure rating should be clearly outlined in the specifications.

FPVCP is another pipe system that is continuously fused and installed by pipe bursting. The main advantages of the FPVCP system are its high tensile strength and use of common fittings.

Segmental Pipe

With special consideration and requirements a segmental pipe with mechanical locking design joints is a possible alternative if there is insufficient space to fuse and string a continuous length of pipe or if design requirements deem it necessary. Segmental pipes with mechanical couplings made of PVC and others are available for installation by pipe bursting without the need for an additional pipe restraint system; however the bursting head and the pipe installation technique will require modification in order to use these materials to burst successfully. Additionally, the burst head needs to be sized for the greatest Outer Diameter (OD) which is most commonly the OD of the mechanical locking joint.

Compressive joints without a restraint mechanism to carry longitudinal tensile load may be utilized by an altered bursting process and specific equipment. A sectional restraint is passed from the bursting head through the replacement pipe and clamped to the replacement pipe in compression to allow the replacement pipe string to be pulled from the rear of the pipe string rather than from the front. The installation is slowed because the pipe sections must be added during the bursting operation and the pulling arrangement readjusted for each pipe section added.

Construction Considerations

Typical Construction Process

Pipe bursting is typically performed in the following steps; however these vary by type of utility to be replaced as well as pipe bursting method selected. It is essential to include the entire project team in all aspects of the construction process whenever possible.

Planning Phase

1) Background assessment
2) Qualification of contractors
3) Screening of methods
4) Data collection
5) Evaluation and selection of method of construction
6) Permit requirements

Pre-Design

1) Collection and review of "as build" drawings, if available
2) Review of site conditions and surface survey
3) CCTV or other survey of existing pipeline condition, line, and grade
4) Utility locating
5) By-pass or temporary service plan
6) Selection of new pipe material to be installed
7) Develop bid documents
8) Schedule of work and definition of work hours

Pre-Construction

1) Selection of contractor
2) Award and execute contract documents
3) Pre-construction meeting with stakeholders
4) Subsurface survey
5) Review contingency planning
6) Job site logistics and layout
7) Methods for reconnection of service lines
8) Location of all excavations and pits required for pipe bursting
9) Dewatering plan
10) Site safety plan

Construction

1) Check with local authorities regarding local code requirements and inspections
2) One-Call mark-outs of utilities
3) Confirmation of utilities location and depth
4) Mobilization of equipment to site

5) Pre-Construction video or photo documentation of site conditions
6) Site safety review with work crews
7) Delivery of new pipe materials
    a. For continuous pipe installations pre-fuse the pipe into the desired length(s).
    b. For segmental pipe installations stage the pipe near the first insertion point.
8) Setup temporary service piping or by-pass
9) Pre-burst CCTV inspection for gravity pipelines.
10) Setup of insertion or receiving points as required in the construction plan
11) Setup of the static or pneumatic pipe bursting equipment
12) Prepare the existing pipe for bursting, cleaning as required
13) Burst the existing pipe, simultaneously installing the new pipe.
14) Allow pipe relaxation period
15) Remove pipe bursting equipment
16) Reconnect pipe ends, service connections, and other appurtenances.
17) Perform any follow up requirements which may be required, such as CCTV
18) Backfill per standards and restore jobsite

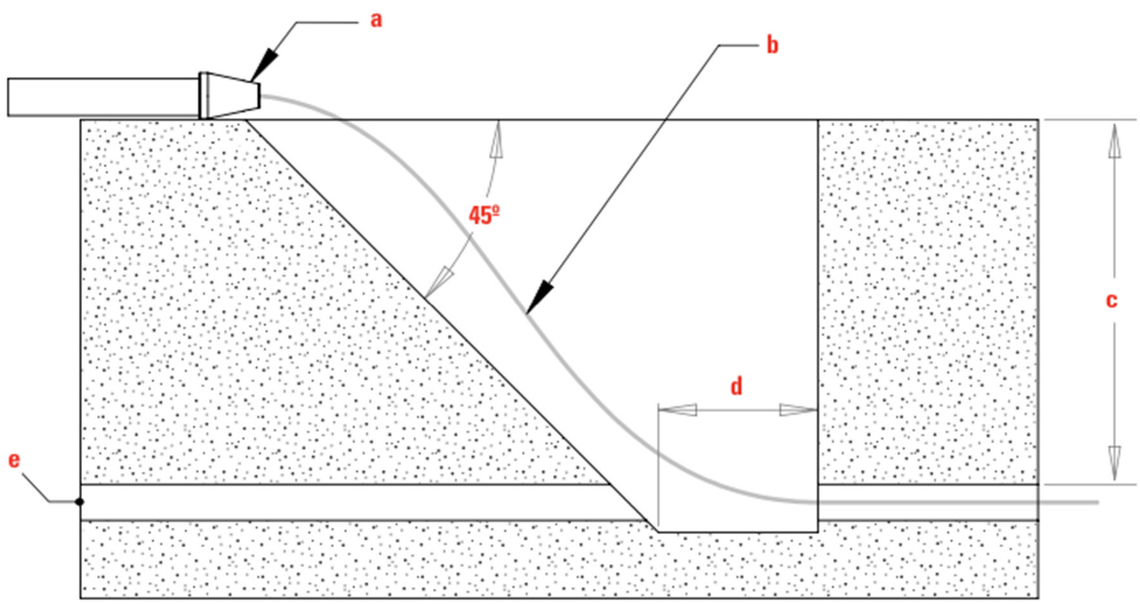
Insertion and Receiving Points Pits

There are variations in terminology used throughout the trenchless industry in regards to access points for pipe bursting. The following definitions are followed by the various names that are commonly used, throughout the trenchless industry.

Insertion Point

An insertion point is an excavation or an existing layout condition that allows new pipe accompanied with appropriate pipe bursting tooling to be inserted into the existing pipe. Insertion point(s) are required for all types of pipe bursting, whether continuous pipe lengths or segmental lengths are utilized for the new product. Insertion points can be an existing manhole, an excavation with a specified slope that accommodates the bend radii of new continuous product, or an excavation dug square and to ample length and width for new product to be installed utilizing the cartridge load pipe insertion method (DI, PVC, HDPE and VCP). The insertion pit must be large enough to allow the pipe to be inserted. For continuous pipes, this means that the pipe must be able to be fed from the surface into the existing pipe alignment without overstressing the pipe in bending. Manufacturers' guidelines on minimum bending radius need to be closely adhered to. The bend radius is the minimum required arc length of a pipe to safely accomplish a 90º turn.

Figure 5 shows the entry pit for the most commonly used pipe, HDPE. HDPE pipe is flexible, which is indispensable for pipe-bursting applications. The relationship between pipe diameter and wall thickness (known as DR or Dimension Ratio) determines the level of flexibility for each pipe size. A safe formula for the excavation of launching pits for all sizes of HDPE pipe is a 30 degree access angle, or ramp-down to pipe level. This translates to a surface cut that is roughly twice as long as the pipe is deep. However, smaller pipe sizes have smaller bending radii. The diagram below shows a typical launch scenario for sewer lateral pipe bursting. Due to the smaller bending radius of 4” pipe (common for sewer laterals) a steeper ramp-down can be used (here shown at 45 degree angle). Allow enough room under the old pipe at the point of entry (**d**) to allow flexing back to grade and to facilitate reconnecting the line after the burst.

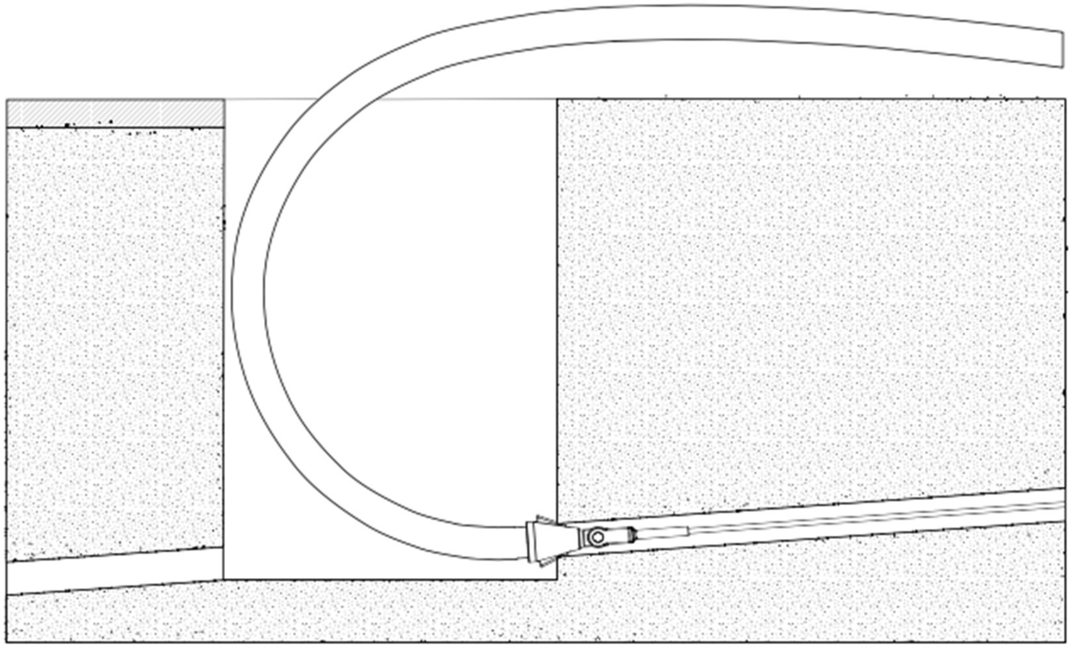


(Figure compliments of TRIC Tools, Inc.

Figure 5

a. 4”– 6” bursting head with attached HDPE pipe
b. Cable
c. Variable depth
d. 1’– 2’ horizontally level with existing pipe to be pipe burst
e. Existing (old) pipe

Launching pits that are deeper than they are long are often best negotiated by creating a “C” curve with HDPE pipe, as illustrated in Figure 6. This works best with smaller pipe diameters such as 4 inch and under, and in some cases 6 inch. Typically there is a shackle at the front of the bursting head or a pivot point where the pipe connects to the back of the bursting head for 4” and 6” lateral bursting. These act as hinges to facilitate the bursting head making a direct pipe entry. As the pull begins, assist the pipe as it flexes into the “C” shape. Then as the pull progresses, maintain a large curve in the new pipe as it enters the pit.



(Figure compliments of TRIC Tools, Inc.

Figure 6

Insertion points also exist on some projects that require no preparation to insert pipe i.e. (open ditch/daylighted culvert, etc.) The purpose of an insertion point is to simply get the new pipe and appropriate tooling into the existing pipe at the desired elevation. These points are often referred to as "pipe pits", "launch pits" and "insertion pits".

Receiving Point

A receiving point is an excavation or an existing layout condition that allows the new pipe and the appropriate associated tooling to be received and also allows the pipe burst tooling to be removed. Receiving points are also the access points for the machinery as well as the bracing necessary to apply the pulling loads during pipe bursting operations. This is the same for both static and pneumatic operations. Receiving points vary greatly depending on project specifics, and will vary in size depending on pipe bursting equipment used. The purpose of a receiving point is to simply pull the pipe, access the new pipe end and retrieve all associated tooling and equipment. For all static rod, chain and cable pull machines, the machine should be properly braced to resist the horizontal force necessary for the bursting operation. This may require the pit or manhole wall to have a thrust block with proper structural capabilities. Inadequate structural capacity of the pit wall or thrust block to resist the pull/push forces can cause wall deformation or failure and surface heave near the wall. Different pipe bursting systems have different requirements in terms of the space required in the receiving pit. Some systems may be able to operate within existing manholes and others may need to excavate a pit for the pulling frame.

These points are often referred to as "pull pits", "machine pits", "receiving pits", “reception pits” or "exit pits."

Service Connection Points
Service connections are most often made at a service pit which is an excavation or existing access point utilized to re-establish service connectivity. These are commonly located at existing branch locations and are utilized in project layout plan as receiving and insertion points when feasible in order to reduce the excavations required. Service pits are small by nature, yet are sized adequately for installation of new branch apparatus. Service pits are predominately excavated prior to the pipe bursting operation and careful attention paid to the control of the line and grade as the new pipe is installed through these points. These points are often referred to as "lateral pits" or "exit pits.”

Number of Pits and Length of Bursting

The location of insertion and receiving pits should be such that their number is minimized and the length of bursting is maximized consistent with the equipment available for the burst and the expected stress on the replacement pipe. The spacing of the pits shall be configured so that the "safe pulling force" (SPF) of the newly installed pipe is not exceeded.

In sewer replacement jobs, the burst length is usually from a building to a mainline sewer or property line. Although there is not a standard burst length that fits all applications burst lengths are most common 30-100 feet for lateral pipe bursting, however lengths often exceed these averages based on actual conditions and the safe pulling force of the pipe being installed. The IPBA classification rating relates the proposed burst length to the degree of difficulty that is common under most conditions.

Replacement Pipe Preparation

Replacement pipe should be handled at the jobsite in accordance with manufacturer’s specifications. Typical considerations are requirements for transporting the pipe to the jobsite including loading, stacking, and strapping the pipe to the transport hauler, onsite unloading, storing, and handling of the pipe, pulling of the pipe into the insertion pit while protecting it from damage, as well as cutting and joining of the new pipe material. The jobsite safety plan should address safe handling practices for the specific pipe type and size on the site.

Equipment Installation

When chain or wire rope/cable are used to pull the bursting tool through the pipe, the winch or hydraulic powered ram is placed into a reception pit, and the chain, cable or wire rope is pulled through the pipe and attached to the front of the bursting unit in an insertion pit.

When rigid pulling rods are used instead, they are inserted from the reception pit through the existing pipe until the pipe insertion point is reached. The rods are then attached to the bursting head, and pulled through the existing pipe.

Bursting Operation

The bursting of the old pipe should be performed as a continuous action if the replacement pipe is continuous. It is not desired to stop a pipe bursting operation once it is underway as the annulus begins to relax and close in around the newly installed pipe. Consideration should be made for working hours and local ordinances prior to the start of work.

The bursting of the old pipe temporarily halts in a static pipe bursting operation using pulling rods. In addition, when the pipe is installed in segments, the preparation of each successive pipe segment also interrupts the operation.

Reconnection of Services

Service connections can be reconnected to the sewer main by various methods. Saddles made of a material compatible with that of the pipe may be connected to the pipe to create a leak-free joint. Different types of fused saddles (electrofusion saddles, conventional sidewall fusion saddles) are installed in accordance with manufacturer's recommended procedures. Connection of new service laterals to the pipe also can be accomplished by materials approved by the project owner.

As HDPE is the most common pipe used in pipe bursting sewer laterals, consideration should be given to the contraction of the new piping once it is installed as it relaxes from the stresses of being pulled into place and possibly also contracts due to cooler temperatures in the ground. HDPE pipe has an expansion rate of 1" per 100' for every 10 degree change in temperature. Thus on a long pipe burst, it could make a significant difference whether the install occurs on a cold cloudy day or a hot sunny day when the pipe has been sitting on blacktop. The amount of stretch an HDPE pipe goes through during an install is dependent on the length of the burst, the relative size of the bursting head to the old pipe, the type and moisture content of the soil, and the speed of the install. Contractors have managed stretch by allowing the piping time to relax after being pulled into place while it may also adjust to the soil temperature. There is usually pressure to balance this relaxation time against the need to get the line back into service as soon as possible. Water poured down the old pipe during the burst has been used as a lubricant when it helps reduce the pull pressures. There is no science on whether this also helps to reduce stretch but it may. Lacking any other proven methods, many contractors make it a practice to bump the newly installed HDPE with a sledge hammer to confirm the piping is free to move in the belief that it will relax quicker if it is and that just bumping the piping will cause it to relax quicker. The biggest concern over HDPE pipe relaxing after installation is that it will shrink enough to pull out of a pipe fitting or flexible coupling. Thus the installing contractor should make certain that the new pipe is inserted as deep into fittings or couplings as possible so if there is a little post connection contraction, the pipe will not pull all the way out of the fitting/coupling.

Manhole Preparation

In the replacement of a sewer lateral by pipe bursting it is possible to utilize an existing manhole structure as a receiving point when the existing sewer lateral connects directly to the manhole. By utilizing an existing manhole the need for an excavation at the receiving point can be eliminated thus allowing the pipe bursting to take place with only an insertion pit excavation.

When an existing manhole is to be used, modifications must be made to receive the new pipe and pipe bursting tool. In most cases it will require either partial or complete removal of the manhole invert as well as the removal of some of the sidewall around the inlet of the existing pipe to allow the OD of the expander head to enter the manhole. In a pneumatic system the use of a reversible hammer allows the expander head to be removed at the manhole and the pneumatic hammer to be reversed through the newly installed pipe and removed at the insertion pit. Upon completion of the pipe burst the manhole invert and connection to the new pipe must then be rebuilt. There are a number of methods that are used to reconnect the new pipe to the existing manhole structure dependent on the type and size of pipe installed and should be clarified in the bid documents.

Testing of the Replacement Pipe

It is most common to perform a pre-and post CCTV inspection of a gravity sewer lateral being replaced. The newly installed pipe should be visibly free from defects, which may affect the integrity or strength of the pipe.

Potential Conditions Requiring Remedial Action

Pipe bursting of existing lines is not always successful, however in many cases remedial action can be taken if the project team has a true understanding of pipe bursting mechanics. Some of the potential conditions that may lead to remedial action are as follows:

A. Collapse of the existing pipe prior to pipe bursting.

Although a pre-burst inspection or evaluation of the pipe may have taken place the conditions of a failing pipeline can change rapidly. If the existing pipe either partially or completely collapses before the pipe bursting begins a relief pit or point excavation may be required to allow insertion of the pull rod, chain or cable and/or passage of the new pipe.

B. Existing pipe is in ground different than that shown in plans.

The method of pipe bursting may need to be changed or tooling used to break the existing pipe modified based on the actual pipe type and size in the ground.

C. Surface heave or settlement.

Unacceptable heave could develop on the surface when the depth of the cover is too shallow for the proposed expansion. Large volumetric displacement of the soil due to soils with a low compressibility may cause immediate heave during installation, however these may subside over time. Settlement may occur if there is an existing void above the advancing head. Additionally there are ground conditions where the pipe bursting will cause consolidation of the existing soils, thus causing potential for settlement in the trench line.

D. Unanticipated geometry of the existing pipe in the form of changes in direction or the curvature exceeding originally anticipated conditions.

In static pipe burst systems using rods, there is a maximum bend radius of the rods used to pull the bursting tool through the existing pipe. If the bend radius is exceeded damage to the rod or the pipe may occur thus halting the pipe bursting operation.

E. Line sags.

Line sags in the existing line are typically only a concern in gravity pipeline applications and may cause the new pipe to deviate from the proposed line and grade. Minor sags may be corrected by pipe bursting; however the final line and grade may follow the existing alignment. The use of a more rigid pipe material may assist with the bridging of minor sags.

F. Excessive bursting forces.

Unanticipated changes in conditions may cause the forces required to continue forward movement to exceed the forces available by the equipment used. Excessive forces are often caused by changes in existing pipe material not originally anticipated, significant changes in soil conditions, encasements, existing pipe being installed in pipe sleeves not originally anticipated or excessive drag on the new pipe.

G. Unforeseen obstructions.

Obstructions that are unexpected and not identified in the pre-burst inspection have the potential to halt the pipe bursting operation. Possible obstructions include mechanical clamps or repair couplings not shown in the "as build" plans, concrete encasements, restraining blocks, heavy roots encapsulating the pipe, and severely off set joints.

H. Adjacent utilities within the potential impact zone.

Utilities found to be within the impact zone are often not discovered until actively involved in a pipe bursting project. If the actual location, size, type, and proximity to the pipe to be replaced is not known they could cause the pipe bursting operation to be halted while the utilities are located or risk damaging them.

I. Damage to the new product pipe during installation.

Care must be taken by the field operations to prevent damage to the new pipe both before and during the pipe bursting operation. Damages can occur from improper handling, exceeding the bend radius at the insertion pit, abrasion from handling or dragging across sharp objects, exceeding the safe pull load of the pipe during installation, and from broken fragments of the existing pipe.

J. Unanticipated geotechnical conditions.

Significant changes in soil conditions over the length of pipe being replaced by pipe bursting can cause challenges and change the rate of insertion or forces required for expansion. The geotechnical report should include a cross representation of the entire work zone with particular attention given to the soils in and around the existing trench.

K. Narrow trench geometry.

Knowledge of the geometry of the original trench construction is an important consideration prior to undertaking a pipe bursting operation and selection of the pipe bursting tools. The resistance to expansion forces can add considerable forces to the operation and can cause the bursting head to displace unevenly.

L. Contaminated ground.

If soils are found that require special permitting or disposal it could affect the pipe bursting operation and schedule, there may also be a need to change pipe materials being installed as they may not be tolerant to conditions found in the ground.

M. Unstable pulling unit

The pull loads required for a static installation may require shoring of the face of the receiving pit A. If insufficient shoring is used, the soil mechanics cannot tolerate the pull load and the operation may need to stop while modifications are made.

Green Technology

From a global aspect, we are all grappling with the effects of carbon emission and are looking towards the construction industry to adopt methods that will reduce the large quantities of fossil fuels and their emissions. Recently there has been a trend towards adapting minimally intrusive trenchless methods and equipment for the replacement of underground utilities, particularly in congested urban easements. Current carbon quantification approaches focus mainly on the effect of added emissions due to traffic delays during construction road closures. While these methods provide excellent information, it is imperative that competing utility installation methods also be assessed to determine their “environmental friendliness.” Trenchless methods can reduce greenhouse gas emissions by as much as 90% when compared to traditional open cut excavation.

Traditional open-cut methods and equipment for the installation and replacement of underground infrastructure can be highly polluting. Pipe bursting offers an alternative that improves the carbon foot print of projects. Research has demonstrated that trenchless projects produce substantially fewer carbon emissions. A study conducted for the North American Society for Trenchless Technology (NASTT) by the University of Waterloo, located in Ontario, Canada, identified two ways in which a trenchless approach is more environmentally friendly. First, traffic fuel consumption is lowered. By avoiding traffic disruptions, trenchless projects prevent the delays and detours associated with conventional underground infrastructure projects. This lowers the amount of fuel consumed, and subsequently reduces carbon emissions. Fewer traffic delays also create social benefits, increasing the livability of our cities and minimizing disruption to residents. Second, trenchless jobsites produce fewer emissions. They require minimal construction machinery and equipment as there is no need for most of the excavation, compaction, back-filling and re-paving, which dramatically reduces fuel consumption. Also, trenchless works are typically more time efficient than open-cut alternatives, meaning that machinery is operated for shorter periods. Dr Ariaratnam compared the use of pipe bursting versus open-cut for a typical urban sewer rehabilitation project, and found that the pipe bursting took three days while open-cut took seven. The “No-Dig” approach, therefore, was over 50 percent more time efficient. Through these combined environmental benefits, Dr. Ariaratnam’s study found that trenchless construction methods resulted in 79 percent lower greenhouse gas emissions than open-cut pipeline installation, and can provide overall cost savings of 25 to 50 percent.

Pipe Bursting is a fundamental trenchless technology. System owners and the general public will receive the following benefits:

1. Reduced carbon emissions that include carbon dioxide, carbon monoxide, nitrogen oxide, total organic compounds, sulfur oxide and smoke and particulate matter.
2. Protection of the natural environment. Trees, landscape and other natural ecosystems benefit from the less disruptive technology as compared to open cut excavation, especially in urban areas.
3. Ability to utilize the existing space of the current utility and not introducing addition utility lines into an already congested underground system.
4. Significantly reduced traffic interruptions.
5. Reduces the amount of material excavated, reducing tipping fees and related movement of dirt as soil is often contaminated, requiring special and costly disposal. In addition, water or rain during open cut construction can cause soil erosion and run off, polluting streams, rivers, and sewers. Pipe bursting provides a minimal surface disruption avoiding these environmental pitfalls.
6. No-Dig also protects natural environments – trees and root systems are usually unaffected, while it also avoids disturbing the habitat of local fauna. On pipeline projects, pipe bursting can also be used to preserve fragile ecosystems such as coastal areas and wetlands, avoiding the disruption and damage caused by excavation.

7. Jobsites are also free of the dust caused by excavation, which can create air pollution and have a detrimental effect on the health of workers and residents.

Conclusions

Pipe bursting is a mature technology with a proven history for trenchless replacement of existing pipes. As the life cycle of the existing underground infrastructure expires and failures occur at an alarming rate, pipe bursting is one of the methods that will be used to effectively provide long term service for critical utilities that are essential to public life and health. As the only trenchless method that can increase the size of an existing pipe, pipe bursting is suited well to a growing need for additional capacity whether it be in the sewer, water, gas, or other utility market sectors. With an increased public awareness and limited funding available for critical infrastructure rehabilitation, it is necessary that we utilize methods that offer reduced social disruption and reduced environmental impact while preparing for future capacity needs.

As with any successful construction project, pipe bursting projects require good pre-planning, careful observation of job progress and the monitoring of key variables during construction. This will result in a good installation providing additional capacity and services to the owner and community for a multitude of years.

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Guideline for Pipe Bursting

January

2012