

Horizontal directional drilling and pipe bursting are helping utilities stretch budgets, enhance safety, address infrastructure needs, and minimize disruptions.

BY SAMUEL T. ARIARATNAM

GO TRENCHLESS TO COMBAT EXCAVATION COSTS

AS POPULATION DENSITY increases, so does the congestion of underground infrastructure. With more utilities being installed in developed urban areas, it is expensive and risky to excavate around roadways, water channels, and utility corridors. But alternative construction methods are becoming more popular as municipalities try to stretch capital improvement budgets, reduce costs, and maximize public safety. Two such methods for installing and replacing drinking water pipelines are horizontal directional drilling (HDD) and pipe bursting.

HDD is particularly useful in urban environments and is typically used for pipe diameters of

less than 24 in. (610 mm), although the method allows installment of pipe diameters up to 54 in. (1,350 mm). The ability to navigate around known existing utilities and subsurface objects makes the process desirable in areas with multiple utilities. Pipe bursting is a trenchless construction method that's a cross between new construction and pipe rehabilitation. Pipe bursting is recognized as the only method of trenchless rehabilitation that can replace an existing line with a new pipe, providing total pipe replacement. In addition, the replacement pipe can be of equal or larger diameter than the existing pipe, thereby maintaining or increasing the utility line's flow capabilities.

PHOTOGRAPHS: VERMEER MANUFACTURING (TOP), TT TECHNOLOGIES (BOTTOM)



Water and sewer pipes traditionally have been buried by open-cut construction, but that is changing. Several techniques, such as HDD (top) and pipe bursting (bottom), permit new pipe to be buried with minimal excavation.

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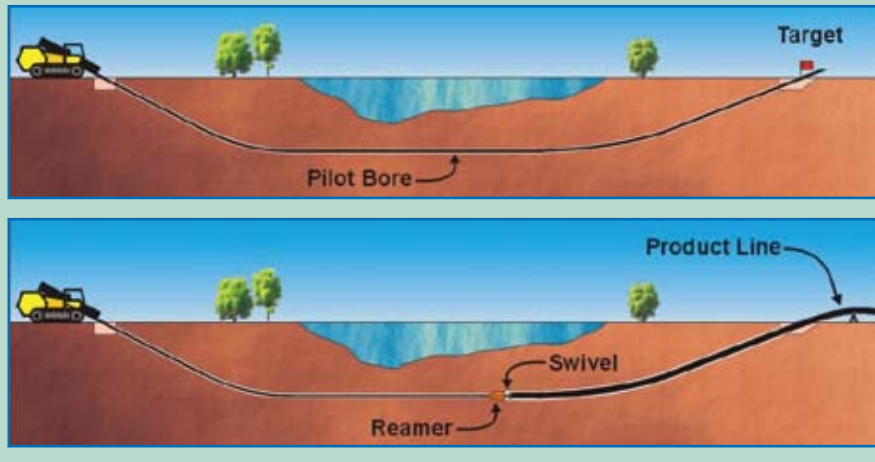
HORIZONTAL DIRECTIONAL DRILLING

HDD has made a significant impact in the utility and pipeline installation industries during the last decade, presenting several advantages over traditional open-cut construction methods. One obvious advantage is that it is a trenchless technology. Open trenching can be expensive, because a contractor must dig around existing utilities to achieve the required depth, subsequently impeding the operation. Sidewalks, pavements, brick paving, sod, and other surfaces also must be repaired or replaced after installation.

The HDD rig provides the torque, thrust, and pullback force required to drive the drill string (Figure 1). The drill drive assembly resides on a carriage that travels under hydraulic power along the frame of the drill rig. The bore is launched from the surface. The pilot bore proceeds downward at an angle until the required depth is reached, then the path of the

Figure 1. Pilot Bore Procedure

When the bore head reaches the designated exit point (top), the bit is replaced with a backreamer (bottom), which enlarges the hole to the right size while pulling the product pipe into place.



bore is gradually brought to the horizontal. The bore head is steered to the designated exit point where it is brought to

the surface along a curved bore path. A directional monitoring device—transmitter—located near the drill string's head

COMMON PIPE MATERIALS FOR TRENCHLESS TECHNOLOGIES

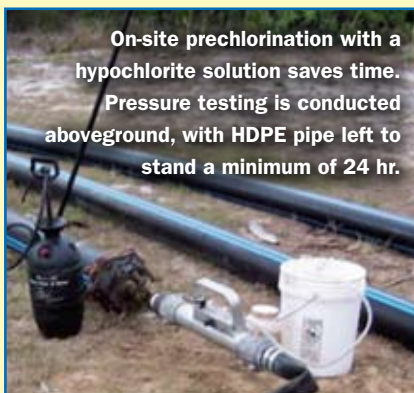
The most common pipe materials for horizontal directional drilling (HDD) or pipe bursting for municipal applications include high-density polyethylene (HDPE), restrained-joint ductile iron, and polyvinyl chloride (PVC).

HDPE. A viscoelastic pipe material, HDPE is joined by fusion to create a jointless bond. The fusion process must be conducted by trained, certified personnel to maintain the pipe system's integrity. Selecting the

appropriate pipe thickness will ensure that the pipe can handle installation tensile loading and operational pressures. Additionally, the operation should allow at least 4 hr for the installed pipe to relax before service laterals, valves, and manhole structures are connected. Numerous research projects examining the installation properties of HDPE using trenchless methods have been conducted; in all the studies strain gauges and load cells were installed to evaluate strain and pipe loading.

First introduced in the United Kingdom in the early 1990s, prechlorinated HDPE pipe for trenchless pipe replacement is gaining momentum in the United States. Prechlorinated HDPE was first approved in the US by the Florida Department of Environmental Protection in conjunction with the Florida AWWA in 2000. Prechlorination saves time and disruption of installing temporary services and can be accomplished on-site or in a secured site and delivered to the jobsite.

Ductile Iron Pipe. Gray cast-iron or ductile iron pipe is currently used in two of every three feet of water pipe in service. Ductile iron pipe retains all of gray iron's machinability and corrosion resistance qualities and provides additional strength, toughness, and ductility. Although its chemical properties are similar to gray iron, ductile iron incorporates significant casting refinements, additional metallurgical processes, and superior quality control. A flexible restrained joint allows trenchless construction method installation. The joint is used in buried piping systems in which axial thrust restraint is required for restraining bends and other fitting configurations. This maintains joint restraint and effectively distributes the thrust or pulling force around the face of the bell. This functionality makes restrained-joint pipe ideal for trenchless applications, including HDD and pipe bursting of water and sewer lines. Installations can be accomplished by a cartridge or assembled-joint method.



On-site prechlorination with a hypochlorite solution saves time. Pressure testing is conducted aboveground, with HDPE pipe left to stand a minimum of 24 hr.

ILLUSTRATION: SAMUEL T. ARIARATNAM
PHOTOGRAPH: EARTH TOOL

It is expensive and risky to excavate around roadways, water channels, and utility corridors.

tracks the drill head's position during the installation.

When the pilot string breaks the surface at the exit location, the bit is removed from the drill string and replaced with a backreamer. The pilot hole is then backreamed, enlarging the hole to the desired diameter while simultaneously pulling back the product pipe behind the reamer.

PIPE BURSTING

The pipe bursting process replaces a host pipe by fragmenting the conduit and installing the product pipe in its place. Generally, bursting is accomplished by pulling a cone-shaped bursting head through the host or original pipe while towing the new replacement pipe. As the head is pulled through the host pipe, the host pipe is burst and the original cavity is simultaneously expanded. The resulting void provides space for the new pipe and

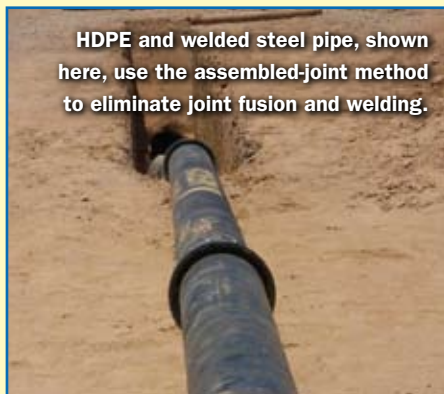
Figure 2. Static Pipe Bursting

As the host pipe bursts, the bursting head pushes the broken pipe pieces into the soil and creates a cavity for the new pipe.



reduces friction during installation. As the rods, cable, or chain are pulled, the bursting head fragments the pipe and pulls

the new pipe into place. Typical replacement pipe sizes range from 2 in. to 16 in. (50–400 mm) in diameter and 150–300 ft



HDPE and welded steel pipe, shown here, use the assembled-joint method to eliminate joint fusion and welding.

In the cartridge method, joints are connected one at a time during installation. This method is preferred in locations where there are limited rights-of-way or easements, which are required to string out the pipe on the ground prior to installation. This method can be used because of the ability to assemble the pipe quickly with limited installation-crew intervention.

The assembled-joint method involves connecting joints for the entire installation length and stringing out the pipe prior

to installation. With HDPE and welded steel pipe, the assembled-joint method is used because of the time required for joint fusion and welding. With both installation techniques for HDD and pipe bursting, the restrained-joint pipe sections are pulled into the borehole with spigots ahead.

PVC. PVC pipe can be installed for trenchless applications with a fused joint, a self-restrained lock joint, or a steel ring-and-pin gasket joint. Unlike HDPE, trenchless installations that use PVC pipe require no relaxation time before fittings or services are installed.

A fused joint is a method of installing a continuous, monolithic, gasket-free PVC pipe capable of being used in HDD and pipe-bursting applications. As with HDPE, care must be taken to ensure quality-control measures are undertaken during the fusion process to maintain pipe integrity. Fusible PVC pipe has excellent applications for prechlorinated installations using pipe bursting.

The self-restrained joint uses a spline and groove assembly and is pulled much the

same as restrained-joint ductile iron pipe. The bell-and-spigot restrained-joint configuration requires the pipe to be pulled backward with the spigot end first. During pipe-bursting applications, this allows each consecutive bell joint to serve as an additional pipe expander.

The steel ring-and-pin gasketed joint design provides up to 120,000 lb of pull strength for 12 in. (300 mm) of pipe. This jointed system has been employed successfully in both HDD and pipe bursting installations for drinking water.



Unlike HDPE, PVC pipe installations, such as this steel ring-and-pin gasketed joint design, require no relaxation time before fittings or services are installed.

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(50–100 m) long. Diameters up to 36 in. (900 mm) have been installed.

The two main bursting systems currently used in North America are the static and pneumatic systems, which differ in the way force is generated and transferred to the original pipe during the bursting operation.

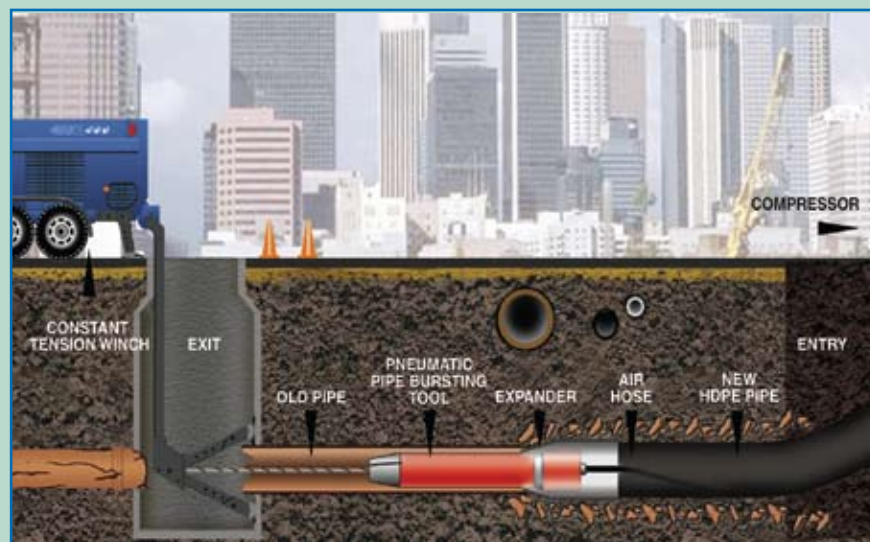
Static Systems. Static methods burst the original pipe, using forces developed from the geometry of the bursting head as it is pulled or pushed through the existing pipe. A pulling force is applied to the cone-shaped bursting head through rods, cable, or chain. The bursting head then is pulled through the pipe, causing the existing pipe to fail in tension by the radial force applied to the pipe wall from the cone within the pipe. As the host pipe bursts, the bursting head pushes the broken pipe pieces into the soil as it displaces the surrounding soil, creating a cavity for the new pipe (Figure 2, page 13).

Most static pipe-busting equipment is modeled after high-powered hydraulic jacks mounted horizontally rather than vertically. Smaller units usually use two hydraulic cylinders to develop the required pulling force, while larger units usually use four or more. A mechanism mounted in the center of the pistons grabs the chain or rod during the pulling operation. As the machine pulls the rod or chain, it is disconnected and the gripping assembly moves forward to grab another section of rod or chain. This process is repeated until the installation is complete. The static pipe-bursting process can be modified to facilitate installation of sectional pipe using a push-pull arrangement.

Pneumatic Systems. Pneumatic pipe-bursting methods use a bursting head that displaces the soil with a horizontal hammering force developed with air from a compressed air system (Figure 3). Compressed air allows the bursting head to develop a hammering rate of 180–580 blows/min. The cone-shaped bursting head is driven through the soil

Figure 3. Pneumatic Pipe Bursting

Compressed air and the bursting head's shape push the pipe fragments into the soil, providing the space necessary for the new pipe.



like a nail being driven into a wall. Each blow struck by the bursting head into the pipe creates an impact load and applies a “hoop” stress into the pipe, causing the pipe to burst in tension. The hammering action also creates force in the longitudinal orientation, causing failure in shear as the existing pipe is ripped. The head's shape and the percussive action push the pipe fragments into the soil, providing the space necessary for new pipe installation.

With the help of a tensional cable inserted through the pipe prior to bursting, the bursting head is guided through the pipe. The cable is attached to the bursting head and provides constant pulling tension through the use of a winch to keep the bursting head in contact with the host pipe, aligned with its path, and helping to pull the new host pipe into place. The main force that allows the progression of the bursting head through the pipe comes from the percussive hammering action of the pneumatic head. The air compressor and the winch are set at constant pressure and tension that require little operator intervention until the pipe

section is burst. To power the bursting head, compressed air lines must be run through the new product pipe.

FUTURE NEEDS

New and cost-effective construction methods need to be explored and adopted to address drinking water infrastructure needs. New pipelines are required to keep pace with population growth and deterioration. HDD and trenchless pipe replacement are trenchless construction methods that can help utilities maximize shrinking capital improvement budgets and address drinking water infrastructure needs in a minimally disruptive and environmentally friendly manner.

RESOURCES

- AWWA, *Rehabilitation Techniques for Water Mains*, DVD
- AWWA, *Rehabilitation of Water Mains*, second edition, 2001
- Ellison, D., A. Romer, R. Sterling, D. Hall, and M. Grahek, *No-Dig and Low-Dig Service Connections Following Water Main Rehabilitation*, AWWA, 2007