CHAPTER 8: VITRIFIED CLAY JACKING PIPE & TRENCHLESS INSTALLATION METHODS

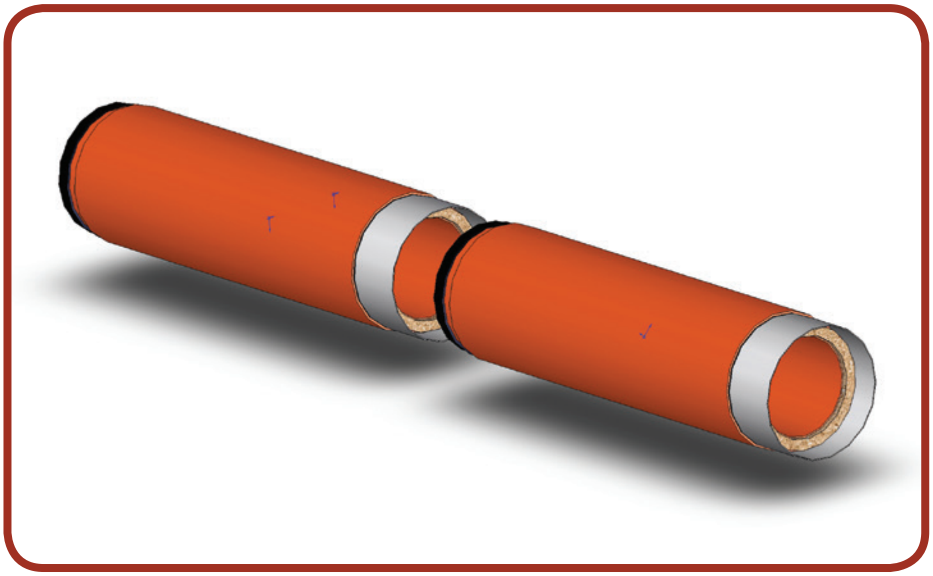

Figure 8-1: *Vitrified Clay Jacking Pipe has a low profile jointing system suited for trenchless applications*

Vitrified Clay Jacking Pipe

Figure 8-2: *Diamond ground pipe end for an elastomeric gasket and stainless steel collar resulting in a low-profile compression joint.*

Vitrified Clay Jacking Pipe has been the predominant pipe material used in the Pilot Tube Guided Boring Method (PTGBM) due to its high compressive strength, low-profile zero-leakage joint, availability in the typical 1 or 2 meter pipe lengths and elimination of an external casing pipe. With the guided accuracy of this system there is no need for a larger diameter steel casing and the grade-adjusted inner carrier pipe as is required by a non-guided boring technique. This saves the additional cost of excavation, transportation, removal of spoil and the purchase of two separate conduits, thus resulting in a lower overall project cost.

High Compressive Strength

Vitrified clay jacking pipe has an extremely high compressive strength (18,000 psi average), a feature needed to resist the high jacking forces generated as the pipe is pushed through the ground.

In smaller diameter pipe, the wall thickness of standard production pipe used for open trench construction is increased to provide a cross-sectional area on the pipe ends suitable for jacking. Standard intermediate and large diameter pipe provide sufficient cross-sectional area to handle the jacking force even after machining for the low-profile joint.

Abrasion Resistance

Anyone who has had to cut fired clay pipe knows it is difficult to do because of its rock-like characteristic. This quality is important in a pipe jacking application. In pipe bursting applications, sharp fragments of the existing host pipe do not cut or gouge clay jacking pipe during replacement. No jacking pipe has better abrasion resistance than clay pipe. This inherently natural quality of clay pipe is a great advantage over products that depend upon some form of exterior coating for corrosion protection. See Chapter 3 for further information on the abrasion resistant qualities of VCP.

Dimensional Accuracy

In a microtunneling application, the ends of the pipe are required to uniformly distribute the axial jacking load. It is common practice to use a ring of chip or particle board between the ends of the pipe to prevent pipe-to-pipe contact and to help distribute the load. Although beneficial, the rings could not do the job alone. It was necessary to make the ends of the pipe both square and parallel. The solution to this problem is simultaneous diamond cutting of the ends of the fired pipe using a lathe (see Figure 8-3).

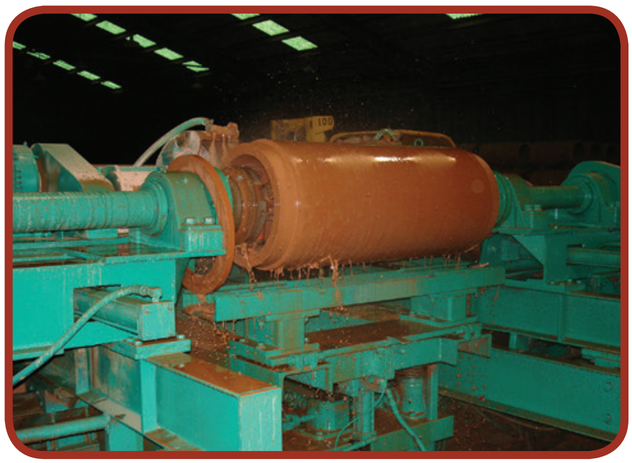

Figure 8-3: *Machining of Jacking Pipe on Lathe.*

With the ends of the pipe cut to machine shop tolerances, the jacking force can be uniformly transmitted from the jacking frame located in the launch pit through each succeeding pipe all the way to the receiving pit. In practice, the operator makes minor corrections to the cutting head as it is steered through the ground. This further emphasizes the benefit of high compressive strength.

Corrosion Resistance

A successful jacking pipe should have exceptional corrosion resistance. Trenchless methods are being selected over open cut installations in inaccessible and high traffic areas, for extreme depths or poor soil conditions. No designer or agency will want to go to the expense of installing a tunneling project only to have the pipe corrode either due to a hostile effluent or aggressive soils. Clay pipe stands alone in this respect. It does not require a coating, liner or wrap because its chemical resistance is inherent in the pipe itself. See Chapter 3 for more information on the corrosion resistant properties of VCP.

Tight Low-Profile Compression Joints

A requirement of a good jacking pipe is a strong, reliable jointing system. The joint must have a straight profile on the outside. Any projection beyond the barrel is unacceptable because of the resistance it would generate as it proceeded through the ground. A good joint for a trenchless installation requires a compression member and a collar of high quality stainless steel material.

Fortunately for the US industry, nondomestic members of the National Clay Pipe Institute in England and Australia had already ventured into pipe jacking and completed considerable early evaluation. The Japanese and German clay pipe industries had also made significant contributions in this regard.

Figure 8-4: *Jacking pipe utilize a series 316 stainless steel collar at each compression joint.*

Building on this background, the US industry turned again to diamond grinding to form a precision rebated surface on both ends. A slim profile rubber gasket and a stainless steel collar were developed to complete the jointing system (see Figures 8-2, 8-3, 8-4, 8-5 and 8-6).

Jacking Pipe Summary

Clay pipe has the high compressive strength to resist the considerable jacking force and possesses the needed abrasion resistance to prevent external damage as the pipe is pushed through the surrounding ground. Additionally, clay pipe has the chemical resistance for longevity and tight joints to prevent leakage. Special low-profile joints are designed to facilitate jacking.
ASTM C1208/C1208M *Vitrified Clay Pipe and Joints for Use in Microtunneling, Sliplining, Pipe Bursting and Tunnels*, is the first ASTM standard specification explicitly developed for vitrified clay jacking.

Figure 8-5: *Jacking pipes staged at the launch pit on a pilot tube project utilizing a powered cutter head.*

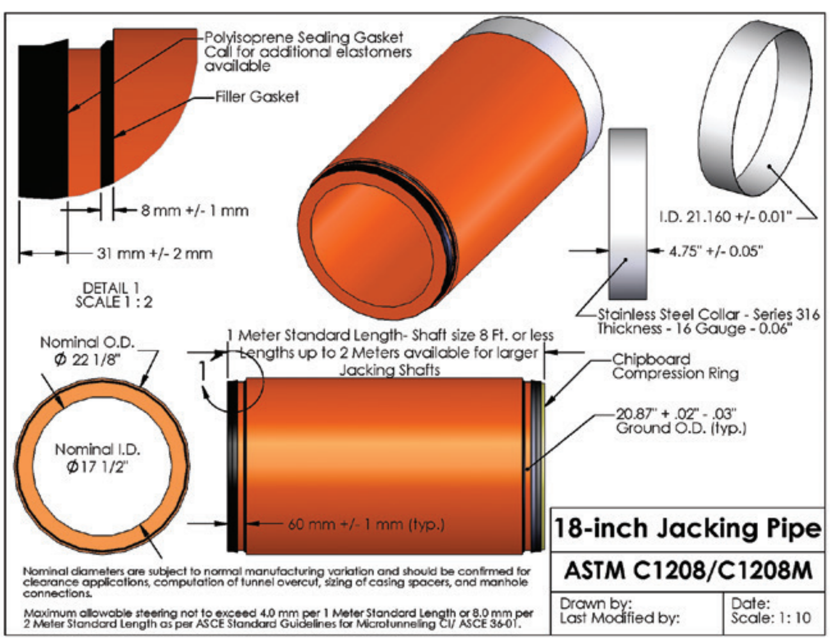

Figure 8-6: *Example Jacking Pipe shop drawing for 18-inch pipe.*

Trenchless Installation

What follows is a brief discussion of the methods of trenchless installation using vitrified clay jacking pipe. For a complete reference manual, the ASCE (American Society of Civil Engineers) offers Manual of Practice 133 (Pilot Tube and Other Guided Boring Methods). MOP 133 provides detailed descriptions of the pilot tube and guided boring methods by providing chapters on project planning, site and geotechnical assessment, shaft design, pipe characteristics and design, contract documents and construction aspects.

Pilot Tube Guided Boring Method (PTGBM)

First introduced to North America in 1995, the Pilot Tube Guided Boring Method (PTGBM) has been steadily increasing in popularity. Over the years, this installation process has also been called Pilot Tube Microtunneling (PTMT), Guided Boring Method (GBM) and Guided Auger Boring (GAB).

In accordance with the ASCE manual of practice, NCPI has elected to use the term PTGBM. The pilot tube method of installing sewer pipe is essentially a hybrid of three trenchless boring techniques:

1. Slant faced steering head similar to that of a directional drill,
2. Guided accuracy of a conventional microtunnel machine,
3. Auger type spoil removal system similar to a horizontal bore.

A few reasons for the popularity of PTGBM include:

- low equipment costs
- relatively small topside footprint
- pinpoint accuracy
- small jacking pits

Figure 8-7: *8 Ft. round jacking shaft and pilot tube frame.*

The initial capabilities of the technology were in the range of 4- to 12-in. OD pipes with single drive lengths up to 250 ft. The technology has grown. Today pipes up to 48-in. OD are installed with drive lengths in the 400 ft. range. Pilot Tube installations as long as 580 ft. in a single drive have now been completed. Accuracy in line and grade of ¼ inch is possible. Better optical guidance systems and power hydraulics in the jacking frames have made these larger diameters and longer drive lengths possible. The technology can perform in a variety of displaceable soils conditions though cobbles and boulders pose some difficulties.

Today, this technology has evolved to include mainline installations with pipe diameters up to 48 inches OD. The primary reason for this growth is the achievement of the same accurate on-line and on-grade installation as conventional microtunneling, but with significantly reduced costs. Projects are often less costly than conventional open-cut methods and solve engineering problems such as utility obstacles, poor soils, deep installations and high ground water. Costly lift stations and maintenance costs associated with them are also often eliminated from projects.

The societal advantages to this trenchless method include the elimination of traffic delays, road closures and street repairs as well as increased safety and reduced need for disposal of contaminated soils.

Guided boring methods have been used successfully in weak soils where other methods such as open-cut and auger boring failed. Consultants and owners are quite impressed and pleased with the pinpoint accurate rifle-barrel-straight installations that result from this installation method.

The reliable line and grade accuracy associated with pilot tube make it possible to place pipelines in close tolerances to existing utilities. The pilot rods installed in the first step have the capability to discover unknown underground obstacles prior to full commitment of the bore, eliminating an unplanned retrieval shaft, which would be required in most other trenchless methods. Also, a survey can be performed on the pilot tube at the reception shaft to verify the intended line and grade.

If an alignment/grade error is discovered or an obstacle is encountered during the installation, the pilot tubes can be retracted and reinstalled before proceeding to the second step of the installation.

PTGBM Installation Process

First Step

The first step in all the pilot tube installation methods is the precise installation of the pilot tube on line and grade (see Figure 8-8). The hollow stem of the pilot tube provides an optical path for the theodolite to display the head position and steering orientation. This step establishes the center line of the new installation as the remaining step(s) will follow this path of the pilot tube.

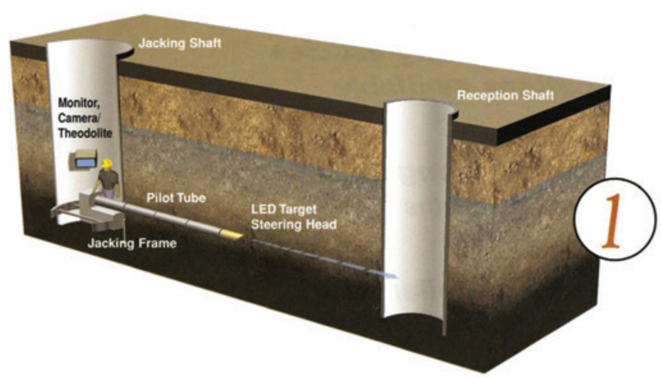

Figure 8-8: *Step 1 – Installation of pilot rods*

Once step 1 is complete, the theodolite and monitor guidance system may be removed from the jacking pit as they are no longer required.

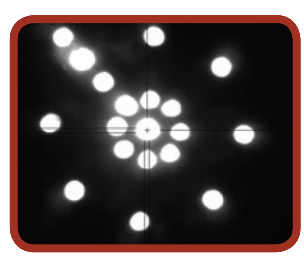

Figure 8-9: *Pilot tube monitor screen*

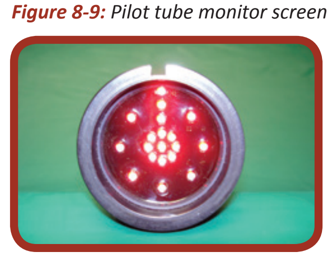

Figure 8-10: *LED illuminated target*

Guidance System: PTGBM adopts the use of an LED target, digital theodolite, monitor screen and a "real time" camera based accurate guidance system (see Figures 8-9, 8-10, and 8-11). The video camera, mounted above the theodolite, transmits the image of the battery powered LED illuminated target located in the steering head to the monitor screen visible to the operator. The straight line indicated on the center of the target designates the direction and path the slant faced steering head will follow.

Hollow steel pilot tubes which fasten to each other via a threaded hex connection are available as a double or single wall tube depending on the manufacturer. On some double walled tube systems, the inner tube will rotate with the steering head during advancement for torque reduction. On other double walled systems, a bentonite lubricant may be pumped through the annular cavity between the tubes to the steering head to assist with soil friction. These pilot tubes range in length from 30 inches to 2 meters dependent on the size of the jacking frame and shaft diameter.

Figure 8-11: *Theodolite with camera*

A slant faced steering head similar to that of a directional drill houses the LED illuminated target. Steering heads of different degrees of angle are available for various types of ground conditions. During the installation process the ground is displaced by the steering head / pilot tube and directed on line and grade by rotation during advancement. At this point of the installation step 1 is complete. A survey can be performed on the pilot tube at the reception shaft to verify line and grade accuracy of the initial survey and setup. If a survey or setup error is found, the pilot tubes can be retracted and reinstalled before proceeding to the second step of the installation.

Second Step

The second step (in the 3 pass and 3 pass modified methods) is to follow the path of the pilot tube with a reaming head, which is sized to the outside diameter of the final product pipe being installed (see Figure 8-12). The front of the reaming head fastens to the last pilot tube installed in the same manner in which the pilot tubes fasten to each other. Behind the reaming head follow auger casings of the same diameter as the head transporting the spoil to the jacking shaft for removal. The spoil can be removed by a muck bucket or vacuum truck depending on the soil type. This step is complete when the reamer and auger casings reach the reception shaft and all spoil is removed.

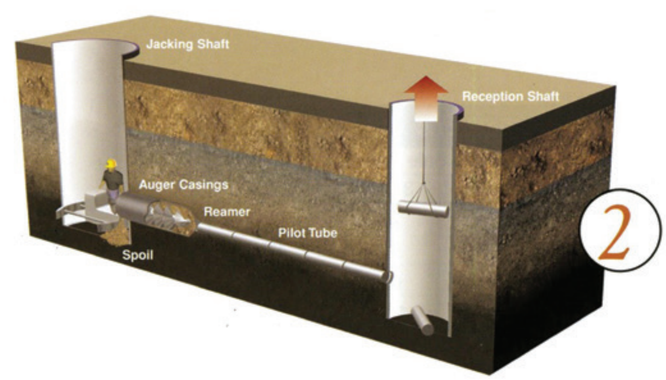

Figure 8-12: *Step 2 – Installation of auger casings*

The second step (the final step in the 2 pass method) is to follow the path of the pilot tube with the 2 pass reaming head advanced by the final product pipe. This reaming head funnels the excavated material into auger casings coupled together inside the product pipe and conveyed through to the jacking shaft for removal. These auger casings are then retracted from the inside of the carrier pipe via the jacking shaft. This method has an advantage to contractors as they are able to install multiple sizes of sewer lines while utilizing the same set of auger casings. The disadvantage to this 2 pass system is the decreased diameter auger casings will limit the maximum diameter of excavatable cobbles and hardened material. When the 2 pass method is utilized, the pipes are set into the jacking frame with the auger casings inside. The auger casings are attached to the reamer (if it is the first pipe to be installed) or previous casing for spoil transport. The product pipe is sized equal in diameter to the reamer and carries the axial load required for advancement.

Different types of reaming heads are available for a variety of displaceable soil conditions as well as heads capable to control flow when working with as much as 10 to possibly 15 feet below the water table (ultimately depending on the soil type). A swivel is required connecting the pilot tube to the reaming head when a rotating cutter head is used for harder ground.

Third Step

The third step (final step in the 3 pass method) is to replace the auger casings with the final product pipe (see Figure 8-13). The reaming head and auger casings are advanced into the reception shaft and removed as the product pipes are installed. There is no spoil to be removed in this step as the product pipe has the same outside diameter as the auger casings.

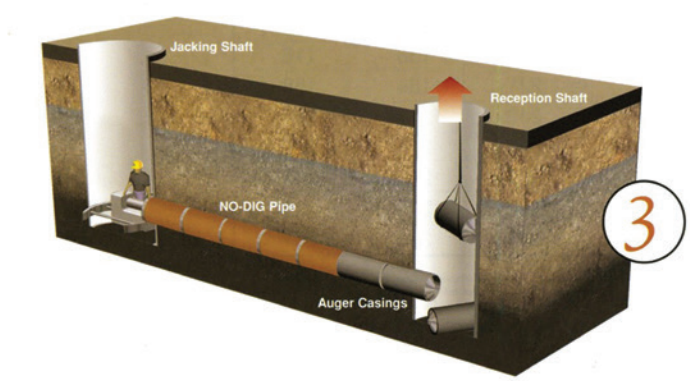

Figure 8-13: *Step 3 – Pipe installation*

The third step (final step in the 3 pass modified method) is to install a powered cutter or reaming head (see Figure 8-14) behind the auger casings, which is advanced by the product pipe. This method is the newest innovation to the Pilot Tube Methods. These hydraulically driven heads increase the bore to match the larger product pipe diameter. The excavated spoil around the previously installed auger casings is discharged via the reception shaft by reversing the auger direction. This step is complete when the powered cutter head reaches the reception shaft.

Figure 8-14: *Powered Cutter Head (PCH)   Photo courtesy of Akkerman, Inc.*

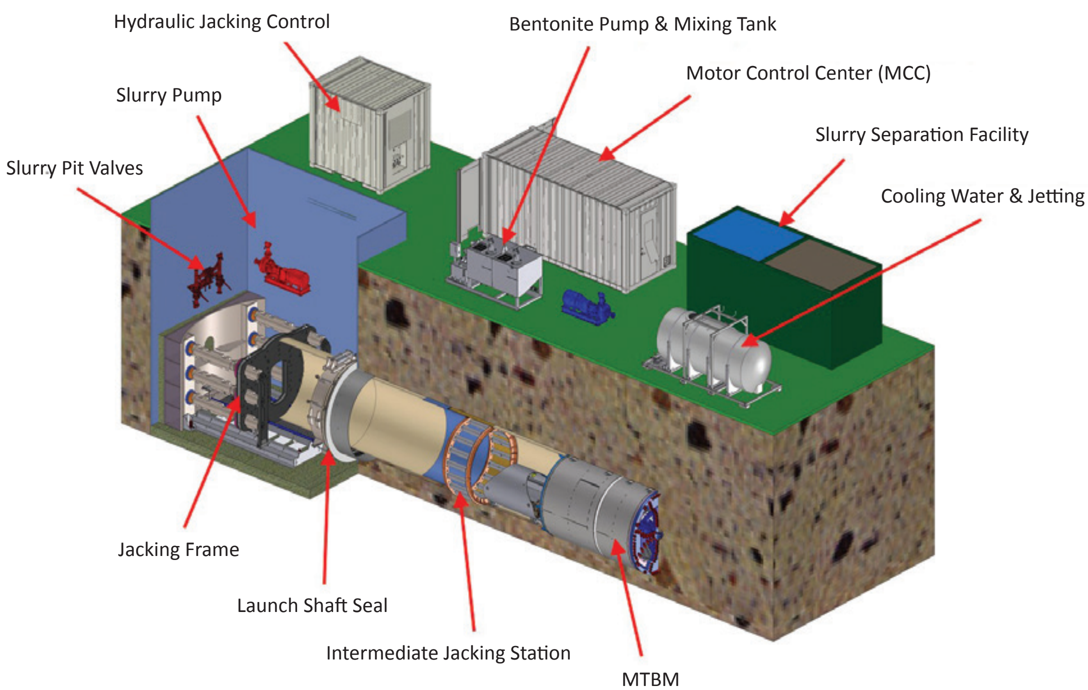

Figure 8-15: *Slurry Microtunnel Set-up*

Slurry Microtunneling

Microtunneling is a method of installing sewer pipe without the need of excavating trenches. A launch shaft is excavated at the location of a future manhole. A thrust wall is installed to resist the jacking force. A microtunnel boring machine (MTBM) is jacked into the ground at the proper horizontal and vertical alignment. Once the MTBM is in place, clay jacking pipe is used to advance the tunneling equipment through the ground. The excavated soil is conveyed back through the pipe in liquid form via slurry tubes and removed at the launch shaft. An equipment operator maintains close control of the line and grade through the articulated action of the cutting head and laser guided steering system. The operation continues until the MTBM and pipe emerge into a receiving shaft, which is normally the location of a future manhole.

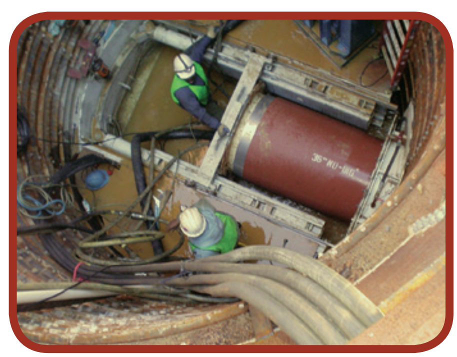

Figure 8-16: *Slurry Microtunnel Jacking Shaft*

Municipalities, engineers and contractors use slurry microtunneling for the installation of sewers in congested and confined areas, deep trenches, unstable soils and in those places where conventional excavation would be economically prohibitive, socially disruptive or unsafe.

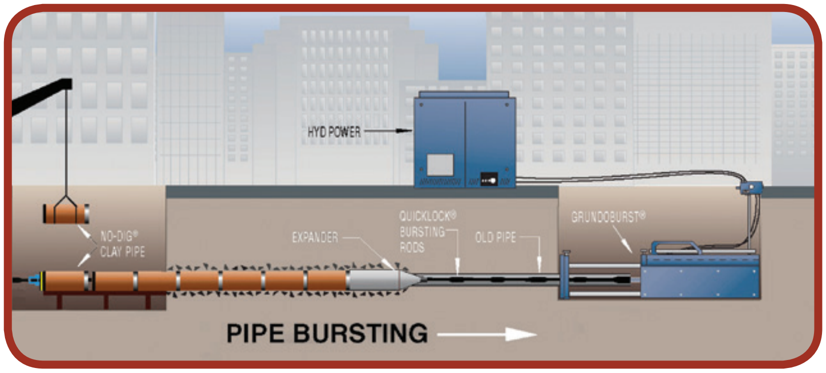

Figure 8-17: *Static Pipe Bursting process of pulling in Jacking Pipe*

Static Pipe Bursting

This method uses an expander, which can be either pulled or pushed through an existing pipeline. The existing pipe is fractured and displaced and the broken pieces are expanded into the surrounding soil while a pipe of the same diameter or larger is pulled or pushed into place. This technology offers the benefit of increasing hydraulic capacity without disrupting busy metropolitan areas.

Figure 8-18: *Launch pit showing cylinder pack, bursting rods, pipe sections, and expander.*

Over the last several years VCP has become more popular as the replacement pipe on static pipe bursting projects. Because the pipe sections have compression fit joints and are designed to be 'jacked' during installation, a bursting system was designed to push each pipe joint "home" as well as keep the column of assembled pipe sections in compression during bursting. A ride along hydrostatic machine (cylinder pack) attached to bursting rods inside the new pipe sections keep the column of assembled pipe segments in compression as the bursting progresses. As the bursting head is pulled forward splitting the existing pipeline and expanding the fragments into the surrounding backfill, the rear cylinder pack pressure plate keeps the assembled pipe sections in compression. Damage to the external wall is eliminated when using a replacement pipe material with a high resistance to abrasion.

The pipe bursting method keeps the jobsite footprint as well as shaft sizes relatively small and compact. Utilizing any segmented jacking pipe eliminates the need for a long lay-down area on the project site as would be required with welded or fused pipe. This is highly beneficial in high-traffic urban settings where long strings of joined pipe can be problematic. Inhibited traffic flow, blocked driveway access and local business disruption before and during the bursting operation can be minimized using this method.