UNI-BELL TECHNICAL PUBLICATION

SUSTAINABLE PIPE INFRASTRUCTURE –
IT'S OUR RESPONSIBILITY

PVC PIPE
THE RIGHT CHOICE FOR TRENCHLESS PROJECTS

INTRODUCTION

These "no-dig" procedures enable contractors to install pipe by tunneling or boring, thus greatly minimizing the social costs associated with the disruption to traffic, pedestrians, businesses and customers.

Construction in densely populated urban settings significantly increases real construction costs while greatly impacting the indirect social costs that are associated with interruptions to the flow of traffic and obstacles to both businesses and the public. The construction of new underground infrastructure, or the rehabilitation of old infrastructure, presents the utility engineer and contractor with the challenge of minimizing the impact of these disruptions on the surface, while making these needed improvements underground.

While open-cut installation procedures continue to be the standard method of construction for municipal piping projects, various trenchless technology developments are making these options more economically viable and appealing. These "no-dig" procedures enable contractors to install pipe by tunneling or boring, thus greatly minimizing the social costs associated with the disruption to traffic, pedestrians, businesses and customers. Trenchless construction typically involves small localized excavations from which the installation of pipe is completed by either pulling or pushing of the pipeline through pre-drilled bore holes or the existing pipe. Similarly, it is also possible to rehabilitate deteriorating municipal pipelines without digging up the entire line. The trenchless rehabilitation processes can often restore both the structural integrity and the flow characteristics of the pipe.

TRENCHLESS TECHNOLOGIES WELL SUITED FOR PVC PIPES

Sliplining, horizontal directional drilling (HDD), tight fit structural liner, and pipebursting are a few of the well-developed trenchless technology methods currently used for new construction and rehabilitation of pipelines. These construction techniques require piping products capable of withstanding large axial compressive and/or tensile forces. Through the development of several innovative joint designs, a number of PVC pipe producers offer pipe well suited for these trenchless pipe situations. The same properties that have made PVC the market leader among pipe materials for water and sewer applications in North America make PVC a material of choice in the performance of trenchless applications. The wide acceptance of PVC pipe among municipalities for open-cut construction also makes PVC pipe a preferred and familiar choice for trenchless installations in capital improvement projects as well as rehabilitation.

TIGHT FIT STRUCTURAL LINER

Tight fit structural lining with PVC is accomplished by expanding a specially formulated C900/C905/ASTM D2241 PVC that has been butt fused together in a continuous length. It is inserted into the host pipe and then brought to tight fit dimensions through a combination of heat and pressure. The lining maintains and/or increases flow capability by providing the C value of PVC that more than offsets the slight reduction in flow area.

PVC PIPE TRENCHLESS CONSTRUCTION OPTIONS

There are four trenchless technology methods for which PVC pipes offer the best option. These are Horizontal Directional Drilling (HDD), Sliplining, Tight Fit Structural Liner and Pipebursting. Table 1 summarizes the common trenchless methods, their applications, the reference specifications and the corresponding PVC pipe products that are available.

Table 1: Construction/Rehabilitation Process and PVC Solutions

METHOD		APPLICATION	STANDARD
Sliplining	Segmental	Gravity Piping System Rehabilitation	ASTM F 949
			ASTM F 794
			ASTM F 1803
	Continuous	Pressure Piping System Rehabilitation	AWWA C900/C905 CSA B137.3 ASTM D2241
Horizontal Directional Drilling (HDD)		New Pressure & Gravity Piping System Construction	AWWA C900/C905 CSA B137.3 ASTM D2241
Pipe Bursting		Pressure & Gravity Piping System Rehabilitation	AWWA C900/C905 CSA B137.3 ASTM D2241
Tight Fit Structural Liner		Pressure & Gravity Piping System Rehabilitation	AWWA C900/C905 ASTM D2241

Products utilize pipe that meet the referenced standard.

HORIZONTAL DIRECTIONAL DRILLING

Horizontal directional drilling (HDD) is the most commonly used trenchless process for installing water pipe. Traditionally these applications were reserved for only roadway and river crossings. Today, HDD is employed for a myriad of other applications where the benefits of trenchless installation can be derived.

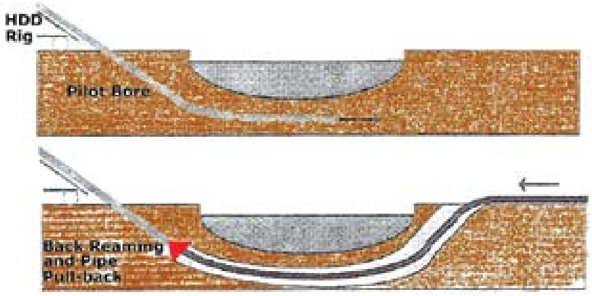

Fig. 1a: Horizontal Directional Drilling (HDD) Method

In recent years, developments in the precision of HDD machinery, specifically the ability to monitor and steer the pilot bore with high levels of accuracy that maintain line and grade, has also enabled the installation of gravity sewer pipes.

HDD, Figure 1a, is performed with a drilling rig, Figure 1b, and involves three essential steps. First a pilot bore is created, covering the distance over which the pipe is to be installed. Highly sophisticated electronics enable the drilling rods to be carefully guided and its direction of travel to be monitored. Reamers are then pulled back to obtain a diameter large enough to accommodate the diameter of the pipe. Simultaneously, drilling mud is pumped into the bore to stabilize the boring and to prevent soil collapse. In the final step, the new pipe to be installed is pulled back through the bore, Figures c & d.

Fig. 1b: Horizontal Directional Drilling (HDD) Method

Fig. 1d: Horizontal Directional Drilling (HDD) Method

Fig. 1c: Horizontal Directional Drilling (HDD) Method

SLIPLINING

Sliplining is a process for rehabilitating deteriorated large-diameter gravity piping systems or for the rehabilitating of pressure distribution and transmission lines.

Sliplining involves the insertion of a new pipe inside the defective host pipe, either in segments or as a continuous section of pipe.

Fig. 2a: Segmented Sliplining

Fig. 2b: Continuous Sliplining

PVC slipliners are designed to provide both structural support as well as an improved flow path to the deficient host pipe, and have been in wide use in North America for over two decades.

Segmental sliplining, Figure 2a, is the least disruptive type of rehabilitation for gravity sewer lines. Profile-wall PVC pipe, conforming to ASTM gravity pipe standards, with smooth joints (both inside and outside), are assembled in segments at entry points along the length of the deteriorated host pipe, and inserted directly into the host pipe by either pulling or pushing. A section of the top half of the host pipe is often cut off to provide lead-in access. The outside diameter of the liner pipe is less than the inside diameter of the host pipe, which leaves an annular space between the two. In many cases, this annulus is filled with a grout after installation, particularly if the host pipe is in a high state of deterioration. Grouting of the annular space provides additional support for the liner pipe, helps protect the liner pipe if the host pipe is in structural distress, and stops water infiltration through the host pipe annulus space. The loss in cross-sectional area is often offset by the improved flow characteristics of the new PVC pipe.

Continuous sliplining, Figure 2b, with PVC pipe is more prevalent in the rehabilitation of potable water distribution and transmission pipelines. In this process, the liner pipe, which is manufactured to AWWA C900/C905 and ASTM D2241 requirements, are assembled in their entirety prior to being pulled into the deteriorated host pipe as a continuous pipeline. As with gravity systems, grouting of the annulus is often employed to help stabilize the pipeline and increase the life expectancy of the line. When required, taps are made after the pull-in of the new pipe into the host pipe.

PIPE BURSTING

The diameter of pipe being burst typically ranges from 2 to 30 inches, although pipes of larger diameters can be burst. Pipe bursting is commonly performed size-for-size or one size upsize above the diameter of the existing pipe. Larger upsize (up to three pipe sizes) has been successful, but the larger the pipe upsizing, the greater the force required to burst the existing pipe and to pull the new pipe and the greater the potential for ground movement (upheave).

Fig. 3: Bursting Head

This is another rehabilitation method of replacing both pressure and gravity lines with new pipe and involves the breaking of an existing pipeline by brittle fracture, using mechanically applied force from within. While the deteriorated pipe fragments are forced into the surrounding ground, a new pipe of the same or larger diameter is pulled in to replace the original pipe. Pipe bursting is performed by the insertion of a conically shaped bursting head, Figure 3, into a deteriorated pipe and causing it to shatter by pneumatic or hydraulic action, Figure 4.

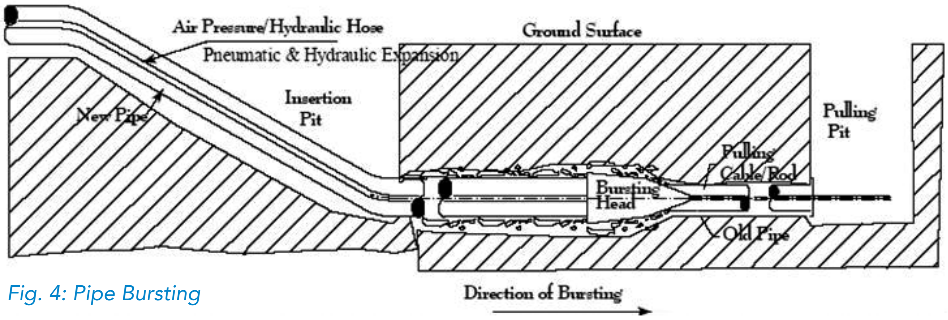

Fig. 4: Pipe Bursting

Pipe bursting can be applied on a wide range of pipe sizes and types and in a variety of soil and site conditions.

PVC PRESSURE PIPE STANDARDS FOR TRENCHLESS CONSTRUCTION

Specific information on available wall thickness and pressure class rating should be obtained from manufacturers. Products utilize pipe that meet the referenced standard.

PVC pressure pipes are routinely used for potable water distribution and transmission, as well as in sanitary sewer force mains. The hydrostatic design basis (HDB) of PVC pressure pipe is the sustained hoop stress value from which the long-term pressure rating of the material is established. HDB is the starting point for determining the pressure capacity of a given wall thickness. AWWA and ASTM standards for conventional PVC pressure pipe require an HDB of 4000 psi.

Table 2: PVC Pressure Pipe Standards for Trenchless Construction

STANDARD	AVAILABLE DIAMETERS (IN)
AWWA C900	4 - 12
AWWA C905	14 - 48
CSA B137.3	4 - 48
ASTMD2241	2 - 24

There are currently four PVC pressure pipe standards to which products for trenchless technology are manufactured. Table 2 summarizes the size ranges available for each of these common standards. Pressure Ratings (and Classes) up to 315 psi are available for diameters up to 16 inches, 235 psi for diameters up to 24 inches, and 165 psi for diameters up to 48 inches.

PVC GRAVITY PIPE STANDARDS FOR TRENCHLESS CONSTRUCTION

Profile wall pipe generally fall into three categories – open profile (OP), closed profile (CP), and dual wall corrugated profile (DWCP). OP pipe have their rib-enforcements exposed on the outside of the pipe and are manufactured to meet the requirements of ASTM F794. CP pipe make use of a closed profile that provides a continuous outer wall where the wall sections are hollow and are often described as an I-beam or honeycomb (refer to ASTM F1803). DWCP pipe have a smooth-wall waterway, braced circumferentially with an external corrugated wall (see ASTM F949 & F794).

While all PVC pressure pipe is manufactured ONLY to cell classification 12454 (tensile strength of 7000 psi, modulus of elasticity of 400,000 psi), some sewer pipe standards allow manufacture of both cell classifications 12454 and 12364 (minimum tensile strength of 6000 psi, minimum modulus of elasticity of 440,000 psi). Pipe manufactured to either formulation performs very well for sliplining applications.

Non-pressure PVC pipes have been in use in the U.S. since the early 1960s. Today, PVC gravity pipe is used in sanitary sewer, storm sewer and highway drainage and culvert applications. There are two main groups of PVC gravity pipe --- solid wall and profile wall. For sliplining, only profile wall pipes are utilized. There are three profile wall pipe standards for trenchless rehabilitation.

- *ASTM F794*
- *ASTM F949*
- *ASTM F1803*

Table 3: ASTM Gravity PVC Pipe Standards

STANDARD SPECIFICATION	WALL TYPE	CROSS SECTION	PERFORMANCE DESIGNATION	DIAMETER	STRUCTURAL REQUIREMENTS	CELL CLASS	JOINING SYSTEMS
ASTM F794	DWCP		Pipe Stiffness	4″ - 48″	PS = 46	12454/ 12364	Gasket-Joint
ASTM F949	DWCP		Pipe Stiffness	4″ - 36″	PS = 46	12454	Gasket-Joint
ASTM F1803	Closed Profile		Pipe Stiffness	18″ - 60″	PS = 46	12454/ 12364	Gasket-Joint
D3034 F679 (D2241 and AWWA sizes)*	Solid Wall		Pipe Stiffness	4″ - 36″	PS 46,115	12454	Gasket/ Butt Fused Joints

** Pressure Pipe*

PVC PIPE: ADVANTAGES FOR TRENCHLESS APPLICATIONS

***Water Quality:** PVC water pipe delivers water as clean and pure as it receives. It imparts no taste or odor to the water it transports, PVC is not a source of lead or other chemical contaminants associated with metal pipe, and does not react with even the most aggressive water. PVC's smooth non-biodegradable interior wall surface makes it more resistant to bio-film build-up.*

- **Corrosion Resistance / Durability:** PVC is inherently well suited for buried applications as it does not corrode internally or externally. This eliminates the need to specify a corrosion protection method that adds costs and increase risks. Unlike other products, with PVC, long-term durability is not compromised when encasement bags are punctured or torn, or when thin coatings or linings are damaged. PVC is corrosion resistant and not vulnerable to deterioration from low resistivity drilling muds commonly used with horizontal directional drilling and other trenchless construction methods. System design and installation are simplified with a homogeneous wall, and a durable pipe material that doesn't require liners or coatings. For sanitary sewers, PVC pipe is resistant to virtually all the chemicals found in domestic and industrial wastewaters. In addition, PVC is highly resistant to erosion or abrasion wear.
- **Strength:** When properly designed and installed, PVC pipes can handle external loads from over 120 feet of ground cover and are available with internal pressure ratings up to 315 psi) with associated pipe stiffness of more than 800 lbs/in/in. PVC pipes are also able to bend or flex without breaking, making them ideally suited to handle ground movements caused by unstable, shifting soils and earthquakes. Because PVC pipe is stiffer (higher modulus of elasticity) than other thermoplastic pipes, it offers a much greater capacity for maintaining grade and is less prone to ponding and sagging. In comparison to other methods of rehabilitation such as Cured-in-Place Pipe (CIPP), which do not necessarily provide structural renewal to the host pipe, sliplining with inserted PVC pipes adds structural renewal to the deteriorated host pipe.
- **Hydraulics:** PVC's immunity to internal corrosion also eliminates tuberculation –– the build-up of corrosion by-products that can reduce hydraulic capacity and increase pumping costs. PVC pipe's smoother internal wall surface minimizes fluid friction and flow resistance. The need for cleaning and maintenance are eliminated or reduced, thereby lowering operating costs. Numerous experimental and real-life data provide testimony of PVC's smooth internal flow characteristics in its long-term performance. For PVC pressure systems, a conservative Hazen-Williams "C" factor of 150 is widely accepted and used. This equates to a much lower lifetime pumping and maintenance costs. Similarly, the accepted value of Manning "n" for PVC gravity sewer pipes is 0.009. This is significantly lower than that of traditional piping materials such as clay or concrete.

PVC PIPE: ADVANTAGES FOR TRENCHLESS APPLICATIONS

- **Superior Strength-to-Weight Ratio:** Fewer pounds of material are required to manufacture a foot of PVC pipe versus a foot of metal or concrete pipe. That weight advantage is quite significant. Not only does it make PVC more economical on a per-foot basis, it also conserves resources, lowers shipping costs, simplifies and reduces the time needed for installation, and decreases the number and severity of injuries for installation crews. Collectively, these advantages result in lower installed costs.
- **Watertight Joints:** PVC pipes for most water distribution applications and sanitary sewers are designed with gasket-joints. These reinforced gaskets form a permanent seal. Water systems can expect zero leakage at joints. When used for sewers, watertight joints mean less chances of infiltration or exfiltration. Watertight joints significantly reduce the risks of a treatment facility from becoming overloaded. Consequently, a lower volume of water to treat substantially reduces operating costs. Watertight joints also reduce the likelihood that embedment soil will be washed away, potentially weakening the pipe or nearby structures such as paved roadways.
- **Crack Resistant Flexibility:** PVC pipes also have an ability to bend or flex when subjected to excessive loads. As a result, they develop fewer cracks and breaks – another source of leaks and a major entry point for tree roots surrounding embedment soils, two costly reasons why sewer systems get blocked and need extra maintenance. Water leaking into sewer pipes through cracks and breaks can also increase the volume of wastewater that treatment facilities must process. That, too, can drive up operating costs significantly.
- **Maintainability:** Due to the high acceptance of PVC pipe for water and sewer applications, PVC maintenance equipment, repair parts, and appurtenances are readily available in the utilities warehouse or at the local distributor. There is no need to be concerned with having the proper materials for emergency repairs or routine connections. Many alternative products require stiffeners and other equipment that does not allow the utility to make a quality repair or connection with standard off-the-shelf fittings properly sized for the pipe. PVC's coefficient of thermal expansion and contraction is four times less than that of alternative thermoplastic pipe materials such as polyethylene (HDPE), which minimizes concerns over proper restraint.

Longevity: *PVC has been utilized since the 1950s as both a water and sewer main material, longer than ductile iron and polyethylene. PVC's proven track record supports expectations of a very long service life. An independent AwwaRF research project entitled LONG TERM PERFORMANCE PREDICTION FOR PVC PIPES concluded that PVC pipes are capable of 100 + year performance.*

PVC PIPE ASSISTANCE

The rehabilitation of existing sewer and water infrastructure is a challenge faced by all utilities. PVC has a proven track record of long-term performance and leads the water and sewer industry in market share. Utilities, design engineers, and contractors are benefiting from the application of PVC pipe products to their pipeline rehabilitation and trenchless installation needs. If you would like more information or have specific questions regarding the application of PVC pipes for various trenchless and/or rehabilitation needs, you are invited to contact the Uni-Bell PVC Pipe Association or its member companies.

UNI-BELL MEMBER COMPANIES

REGULAR MEMBERS

CertainTeed Corporation
Diamond Plastics Corporation
IPEX, Inc.
Lamson Vylon Pipe Company
North American Pipe Corporation
Pipelife Jet Stream, Inc.
Contech Construction Products
Freedom Plastics, Inc.
JM Eagle
National Pipe & Plastics, Inc.
Northern Pipe Products
Royal Pipe Systems

ASSOCIATE MEMBERS

American Maplan Corporation
Cincinnati Extrusion, Inc.
ColorMatrix Corporation
EBAA Iron, Inc.
GPK Products, Inc.
Holland Colours Americas
KibbeChem, Inc.
Omya, Inc.
Plastics Extrusion Machinery, Inc.
Rohm & Haas Company
Shintech, Inc.
Specified Fittings, Inc.
Tigre USA, Inc.
Westlake Chemical Corp.
Arkema, Inc.
Cincinnati Milacron
Corma, Inc.
Formosa Plastics Corporation
Georgia Gulf Corporation
Harrington Corporation
Honeywell Specialty Chemicals
Krause-Maffei Corporation
OxyVinyls LP
Reagens, USA
S & B Technical Products, Inc.
Theysohn Vinyl Extrusion Technologies, Inc.
Underground Solutions

INTERNATIONAL AFFILIATE MEMBERS

Amanco Group
Interplast, Limited
Marley New Zealand Ltd.
Reliance Industries Ltd.
Wavin Overseas B.V.
Century Eslon Limited
Iplex Pipelines Australia
PETCO S.A.
Vinidex

AFFILIATED ASSOCIATION

The Vinyl Institute

The statements in this publication are those of the Uni-Bell PVC Pipe Association and are not warranties, nor are they intended to be warranties. Inquiries for information on specific products, their attributes and recommended uses and manufacturer's warranty should be directed to member companies.

Although every attempt is made to assure factual accuracy, Uni-Bell and Rainmaker Advertising accept no responsibility for unintentional errors, other than printing a correction in a future issue.

UNI-PUB-11-07

Published by:
Uni-Bell PVC Pipe Association
2711 LBJ Freeway Ste. 1000 • Dallas, Texas 75234
Ph: (972) 243-3902 • Fax: (972) 243-3907
www.uni-bell.org