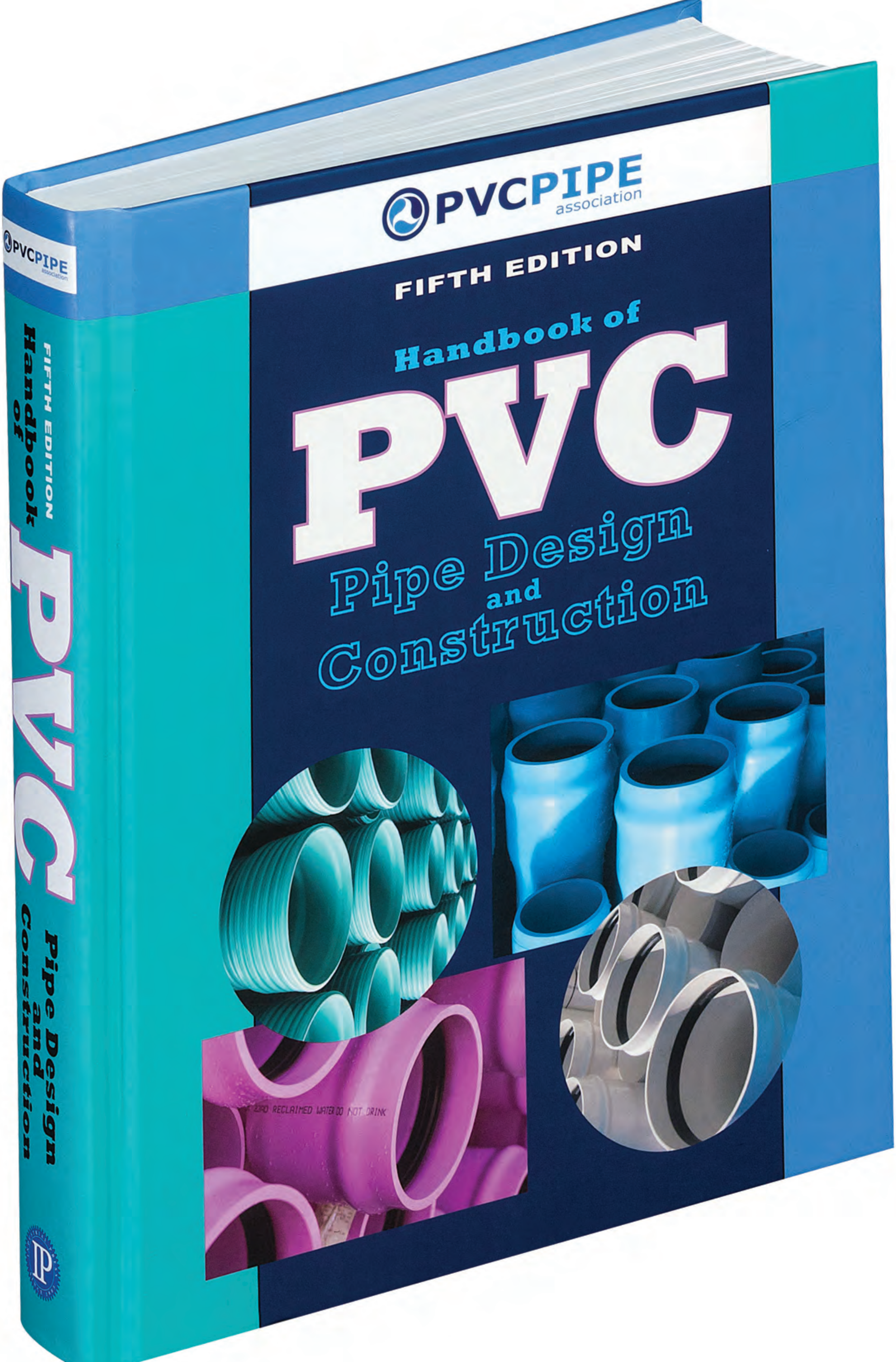
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CHAPTER 13

Trenchless Installation of PVC Pipe

Joining Methods

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Trenchless Construction—Casings

•

Trenchless Construction—Horizontal Directional Drilling (HDD)

•

Trenchless Rehabilitation—Sliplining

•

Trenchless Rehabilitation—Pipe Bursting

•

Trenchless Rehabilitation—Tight Fit Structural Liners

Table of Contents

13.1 Notation

DR = dimension ratio, dimensionless

E = modulus of elasticity of pipe material, psi

D_o = pipe outside diameter, in.

$P_{critical}$ = critical grouting pressure, psi

t = pipe wall thickness, in.

13.2 Introduction

As infrastructure ages there is constant need to repair and replace it; as cities grow there is a continual need for additional underground services in already densely populated, complex environments. There are also situations that make traditional excavation costly and difficult (such as that presented by rivers, streams, and swamps that must be crossed). In all these applications, trenchless (or "no-dig") pipe installation methods are being used effectively.

Construction in densely populated urban settings significantly increases both real construction costs and indirect social costs, including costs associated with interruptions to flow of traffic and obstacles to both businesses and the public. Construction of new underground infrastructure or 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 needed improvements underground.

While open-cut installation procedures continue to be the standard method of construction for municipal piping projects, trenchless technology may be more appealing and economically viable in some situations. Trenchless, or no-dig, installation is distinguished from open-cut installation in both the construction techniques and the materials it employs. Construction methods for trenchless installation progressed from the first contractor—who pushed a single length of PVC pipe with a backhoe under a sidewalk—to computer-operated directional drilling rigs, capable of pulling in thousands of feet of assembled PVC pipe in one pull. Meanwhile, PVC materials and pipes have evolved to accommodate various trenchless installation methods. Through extensive research and development, specialized PVC compounds, uniquely manufactured pipe profiles, and specialized pipe joints have been developed to allow pipe to be folded, fused, and joined together. Because unique loads are placed on trenchless pipe during installation, special attention must be given to the axial compressive and/or tensile forces imparted on the pipe. These forces arise from pulling and pushing during installation and from the external loads on the pipeline once it is fixed in place.

Trenchless installation of PVC pipe is continually improving and expanding to include a variety of techniques, which can be classified into two groups:

- *Trenchless construction*: The installation of an entirely new pipeline with minimal open-cut excavation.
- *Trenchless rehabilitation*: The repair of an existing deteriorated pipeline, improving its performance and longevity with minimal open-cut excavation.

Trenchless installation methods highlighted in this chapter are proven to be cost effective and reliable for the building, renewal, replacement, or installation of new pipelines; these methods are minimally disruptive to property and/or traffic. It is the responsibility of owners, designers, and contractors to familiarize themselves with the variety of assembly and installation methods and be trained accordingly by the manufacturer or technology provider.

13.3 Joining Methods

Currently, there are several types of PVC pipe products designed to withstand trenchless installation forces:

- internally restrained gasketed joint
- pin-and-groove gasketed joint
- spline-lock gasketed joint
- butt-fused joint.

13.3.1 Internally Restrained Gasketed Joint

Restraint internal to the bell (Fig. 13.1) is available in 4-in. through 24-in. sizes for bell-and-spigot pipe and fabricated PVC fittings. Assembly of an internally restrained joint entails the following steps:

1. Cleaning of spigot, bell, and internal restraint hardware.
2. Lubrication of joint components per manufacturer instructions.
3. Insertion of the spigot into the bell to the insertion line while ensuring the pipe is kept in straight alignment.
4. Activation of the restraint when the system is pressurized or when the pipe string is pulled.

13.3.2 Pin-and-Groove Gasketed Joint

Pin-and-groove gasketed joints (Fig. 13.2) are available in 4-in. through 12-in. sizes. Assembly of a pin-and-groove joint follows these steps:

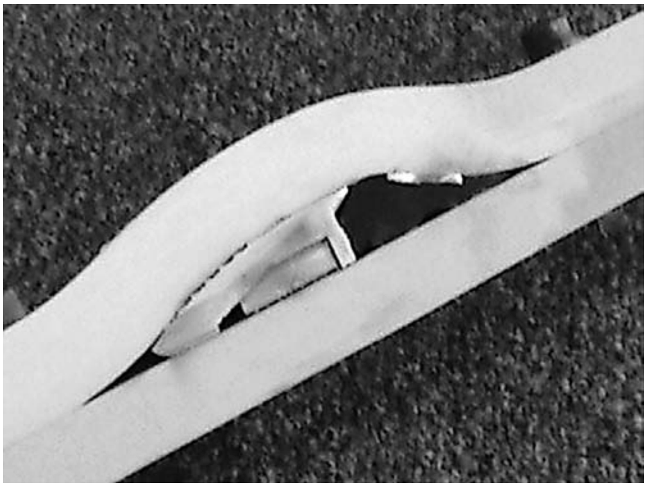

Fig. 13.1 Internally restrained gasketed joint.

1. Lubrication of spigot as in typical gasketed joint assembly.
2. Insertion of spigot into bell to the insertion line, which aligns bell holes with the spigot groove.
3. Placement of external ring over bell holes, with holes aligning.
4. Insertion of pins into holes until pins bottom out in grooves.

Fig. 13.2 Pin-and groove gasketed joint.

13.3.3 Spline-Lock Gasketed Joint

Spline-lock joints (Fig. 13.3) are available in both coupling and integral-bell versions in sizes 2-in. through 16-in. Joints are assembled as pullback progresses through these steps:

1. Insertion of pipe into coupling (or bell) using conventional lubricants and assembly techniques; spline grooves will automatically align.
2. Insertion of a nylon locking spline into mating grooves in pipe and coupling/bell. This provides continuous restraint with evenly distributed load.

Fig. 13.3 Spline-lock gasketed joint.

13.3.4 Butt-Fused Joint

Butt-fusible PVC pipe products (Fig. 13.4) are available in diameters ranging from 4-in. to 36-in. and provide monolithic, fully restrained joints with little or no exterior joint profile. The butt-fusion joining process consists of the following steps:

1. Accurate and secure aligning of pipe ends.
2. Precise facing and squaring of both ends of pipe simultaneously through a rotating dual cutting head.

Fig. 13.4 Butt-fused joint.

3. Heating of pipe ends with an electronically controlled plate until prescribed bead configuration is achieved.
4. Quick removal of the heater plate and bringing the pipe ends together, holding under pressure until the newly formed joint cools.

13.4 Trenchless Construction—Casings

When PVC water or sewer pipe is installed under highways, runways, or railways, *casings* may be needed for the following reasons:

- To prevent damage to structures due to soil erosion or settlement in the pipe zone caused by line failure or leakage.
- To permit economical pipe removal and replacement in the future.
- To accommodate regulations or requirements imposed by public or private owners of property where pipe is installed.

13.4.1 Casing Spacers

When PVC pipe is installed in casings, *casing spacers* (Fig. 13.5) must be used to prevent damage to the pipe during installation and to provide proper long-term line support. PVC pipe in casings should not rest on bells. For butt-fused PVC, casing spacers are not needed.

Casing spacers must be securely attached at the insertion line of the pipe on the spigot end to ensure that overinsertion does not occur. Caution should be used when attempting longer installations using this method, as the frictional forces of the installation may build to a greater force than the casing spacer at the insertion line can resist. Restrained joints suitable for compressive loads may also be used (or required) if installation forces exceed slippage resistance of casing spacers.

Care must be exercised to avoid damage to pipe or bell joints. Non-petroleum-based lubricants applied to casing interior or spacer exterior makes sliding easier.

Casing spacers must provide sufficient height to permit clearance between the pipe bell and the casing wall.

Table 8.10, in Chapter 8, gives maximum support spacing values for casing spacers. Casings are normally sized to provide an inside diameter at least 2 in. (50 mm) greater than the maximum outside diameter (OD) of pipe bell, casing spacer, or joint restraint device. Approximate maximum ODs of the pipe bell for various PVC products are provided in the tables of the Handbook's Appendix.

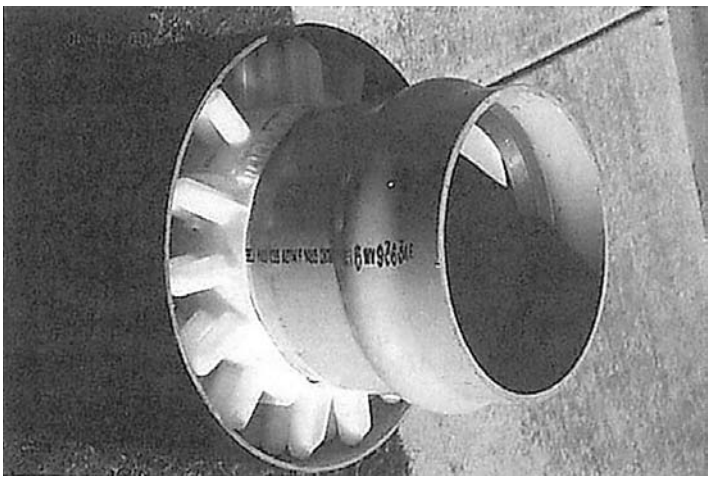

Fig. 13.5 Casing spacer.

13.4.2 Pulling Pipe through Casings

Restrained-joint PVC pipe can be pulled through casings. Pipes that are restrained by external mechanical joint-restraint devices (Chapter 11, Fig. 11.7) can also be pulled through casings, since the trenchless pull force is in the same direction as the thrust force caused by internal water pressure. The pull should be slow and steady to prevent any jerking movement. Placement of a protective wrap or pullhead on the spigot end of the pipe's first length minimizes any possibility of abrasion against the casing.

13.4.3 Pushing Pipe through Casings (Jacking)

Jacking pipe (pushing pipe through casing) should also be done at a slow and steady pace. It is critical that the end of the pipe that is pushed be protected from damage (e.g., by use of a wood cross-piece).

Placing a protective wrap around the spigot end of the first length will minimize any possible abrasion against the casing.

13.4.4 Filling or Grouting the Annular Space

The OD of the liner pipe is less than the inside diameter of 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 highly deteriorated. 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 annular space.

During the filling or grouting of the annular space, care must be exercised to keep the PVC pipe from floating out of its proper position. Wedges should not to be used to lock pipe into position during filling or grouting operations. If the annular space between the casing and PVC carrier pipe is filled, either by pressure grouting or blowing sand, caution should be exercised to ensure that excess grout pressure does not cause the pipe to distort or collapse. Table 13.1 lists *critical grouting pressure* ($P_{critical}$) and *allowable grouting pressure* ($P_{allowable}$) as a function of the pipe dimension ratio (DR). The allowable grouting pressure for profile wall PVC pipe is the same as that for solid wall pipe of the same stiffness. For example, profile wall PVC pipe with 46 psi pipe stiffness has the same allowable grout pressure as DR 35 pipe.

In addition to controlling grout pressures, it is important to control grout placement and temperature. The values in Table 13.1 assume uniform grout pressures in the annulus. Distortion may result if the level of the grout becomes too great on one side of the pipe compared to the other. Using a higher stiffness (lower DR) pipe can be advantageous in this case, as it offers greater resistance against distortion or collapse. If large amounts of grout—or grouts with a high heat of hydration temperature—are used, the heat of hydration must be taken into consideration, as excess heat will lower pipe stiffness. In this case, completely filling the pipe with water is a means of controlling distortion or buckling. Water also works as a heat dissipater for heat of hydration during grout curing. When water is used, end caps must be designed to withstand the hydrostatic pressures involved.

Equation 13.1

$$P_{critical} = \frac{2E}{(DR - 1)^3}$$

where:

$P_{critical}$ = critical buckling pressure, psi
E = modulus of elasticity of pipe material, psi
DR = dimension ratio, dimensionless = D_o/t
D_o = pipe outside diameter, in.
t = pipe wall thickness, in.

Table 13.1 Maximum recommended grouting pressures

DR	$P_{critical}$, psi	$P_{allowable}$, psi
51	7.5	3.7
41	14.6	7.3
35	23.8	12
32.5	29.9	15
28	47.5	24
26	59.8	30
25	67.6	34
23.5	82.1	41
21	117	58
18	190	95
17	228	110
14	426	210
13.5	479	240

$P_{allowable}$ is based on a SF against buckling of 2.0 (equal to DF = 0.5) at temperature of 73°F, using E = 400,000 psi.

Grouting pressures must be reduced for increased wall temperatures per Table 13.2.

Table 13.2 Temperature corrections for modulus of elasticity

Pipe wall temperature		Correction factor for modulus of elasticity
°F	°C	
90	32	0.93
100	38	0.88
110	43	0.84
120	49	0.79
130	54	0.75
140	60	0.70

Notes:
Interpolate between the temperatures listed to calculate other correction factors.
The maximum recommended wall temperature for PVC pipe and fitting is 140°F (60°C).

13.5 Trenchless Construction—Horizontal Directional Drilling (HDD)

Horizontal directional drilling (HDD) is the most commonly used trenchless process for installing new pipelines. This installation method has been extensively used for roadway and river crossings. Today, HDD is employed for numerous other applications where the benefits of trenchless installation can be realized. In recent years, developments in the precision of HDD machinery, specifically the ability to monitor and steer the pilot bore to high levels of accuracy to maintain line and grade, has enabled the trenchless installation of gravity sewer pipes. A typical drilling rig is shown in Fig. 13.6.

13.5.1 Preliminary Investigation

13.5.1.1 Utility Location Survey

The first critical component of all HDD projects is the establisment by the contractor of the location of all utilities close to the proposed path. All utilities in the vicinity of the drill path should be identified and clearly marked.

13.5.1.2 Geotechnical Survey

The contractor should review all geotechnical data provided and/or perform an on-site investigation of factors such as soil type, water table, and environmental hazards to ensure safe and effective installation. The contractor should also verify that selection criteria for reamer

Fig. 13.6 HDD drilling rig.

size and drilling fluids are correct. All applicable guidelines, regulations, and standards must be followed.

13.5.2 Installation Overview

HDD is performed with a drilling rig and involves three steps. Steps 2 and 3 are sometimes performed simultaneously:

1. The hole is bored.
2. The hole is reamed.
3. The pipe is pulled in.

13.5.3 Installation Details

13.5.3.1 Roller Stands or Timbers

Throughout installation, the pipe should be adequately protected to prevent deep scratches or gouges that could impair performance. Moving long lengths of pipe on roller stands or timbers or dragging pipe on grass or soft soil will help prevent potential damage to the pipeline.

Fig. 13.7 PVC pipe supported on rollers.

Supporting the pipeline on rollers also reduces the frictional drag coefficient and the pull force required to complete an installation. Figure 13.7 shows PVC pipe on a roller stand as it is being pulled into a horizontal directional drilling installation. PVC's hardness provides exceptional abrasion and gouge resistance. According to AWWA PVC pipe standards, nicks and scratches of less than 10% of the pipe wall thickness do not significantly reduce the strength of the pipe.

Rollers and other friction-reducing implements must be properly sized, spaced, and positioned for the pipe size and weight and for the environment. Proper pipe support design and location should also take into account horizontal alignment considerations and reactive forces to counteract the "straightening" of the pipe string (Fig. 13.8) as it is being pulled through a curve or deflection.

13.5.3.2 Pilot Holes

The HDD process uses sections of steel drilling rods connected to a steerable drill head. Guidance systems enable the rod to be steered and its direction of travel to be monitored.

Fig. 13.8 Preassembled PVC pipes.

Initially, a pilot hole is drilled with entry angle, α, and exit angle, β (Fig. 13.9). The entry and exit angles are dependent on the maximum radius of curvature allowed within the right of way provided. The radius of curvature must also meet or exceed the allowable bend radius of the PVC pipe system used. A larger radius of curvature reduces the stress transmitted to the pipe during the pullback operation. A trained operator relays guidance information to the drill rig operator and records the specific details of the drilling head using gyroscopic probe and interface, magnetic guidance systems, or electromagnetic systems. The team of operators can control inclination (depth) and azimuth (horizontal direction) to ensure a smooth and gradual radius of curvature.

13.5.3.3 Reaming the Pilot Hole

In horizontal directional drilling, special cutters called *reamers* are successively pulled through the pilot hole to produce a bore large enough for installation of a pipe of the required diameter. Simultaneously, drilling fluid is pumped into the hole to remove soil cuttings and to prevent soil collapse. The reamed hole allows drilling fluid to fill the annular space and to flow around the pipe. Soil type and water table may affect the borehole size. Generally, a finished borehole has the following characteristics:

- For pipe sizes up to 24 in., the borehole is 50% larger than the largest outside dimension of the pipe.
- For pipe sizes larger than 24 in., the borehole is 12 in. larger than the largest outside dimension of the pipe.

The largest outside diameter can be that of the coupling, the bell, or the fusion joint, depending on the type of joint used for the installation.

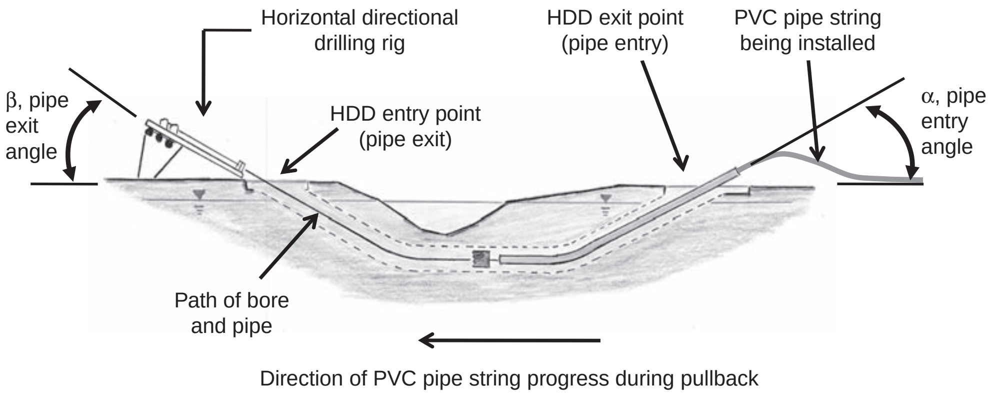

Fig. 13.9 Schematic of product pipe string being pulled back toward HDD rig.

13.5.3.4 Drilling Fluids

Drilling fluids are thixotropic materials comprising a base fluid, weighting agents, bentonite clay (to help remove cuttings from the borehole and to form a filter cake on the walls of the hole), and various other additives. Drilling fluids lubricate the drill rod, drill head, reamer, and pipe; they must be engineered to maintain an open reamed hole prior to pipe installation. Maintaining the density of the drilling fluid is part of a successful HDD installation. Ends of PVC pipe should be covered, capped, or plugged to prevent drilling fluid from entering the pipeline during installation.

13.5.3.5 Pullback

The installation step called *pullback* involves the connection of the pipe to the drill rod, followed by pulling the pipe back through the reamed hole. Figures 13.9 and 13.10 demonstrate the pipe being pulled into place.

In HDD, the direction of PVC pipe pullback is opposite the direction at which the pilot hole was drilled. A pulling head with a swivel eye to prevent torsional stresses connects the drilling rod or reamer to the leading end of the PVC pipe string. Pulling heads must comply with recommendations of the pipe manufacturer or the technology provider.

The pullback operation should happen as soon as a reamed hole is completed so stresses from thickening drilling fluids may be reduced and to minimize the possibility of borehole collapse. Pullback forces should be monitored to ensure they remain within

Fig. 13.10 Pipe string during pullback operation.

allowable limits. Safe pull forces vary with diameter and DR of the pipe provided and with the type of joint used.

Pullback with butt-fused PVC pipe is usually performed in continuous lengths. If necessary, intermediate fusions are performed during the pullback process. Segmented PVC pipe (internally restrained, pin-and-grooved bells, or spline-lock couplings) can be strung out in long lengths or installed one joint at a time as the drill rig pullback operation is in progress.

13.5.4 Design Considerations

13.5.4.1 Bending

HDD bore alignments are curvilinear in nature and require some amount of bending of pipe and joints. Each PVC pipe manufacturer or technology provider provides guidance on allowable minimum bend radii for their particular system. This guidance must be followed in the design of bore alignment, as well as during pipe layout and installation.

13.5.4.2 Pullback Force

Pullback force has four components:

1. Friction force between pipe and borehole.
2. Drag force—The friction force as pipe is pulled along the ground surface prior to entering the borehole. The force can be reduced by friction-reducing methods (such as pipe rollers).
3. Hydrokinetic friction force—The friction force between pipe and drilling fluid as the fluid is displaced during pipe insertion. The magnitude of this force is a function of the OD of the pipe versus the size of the borehole.
4. Capstan force at pipe bends—The increase in friction force when pipe is pulled around a curve. The force is due to the component of the pull force that acts normal to the curve.

Additional factors that may affect the required pullback force include variances in:

- drilling equipment
- drilling procedures
- borehole quality
- drilling-fluid density.

The heavier the drilling fluid is in the borehole, the greater the buoyant force lifting the pipe string. Buoyancy can be counteracted by filling the pipe with fluid to ballast the line. Monitoring and controlling the density of the drilling fluid is critical for minimizing the required pull force.

The combined effects of all of these frictional and resistive forces on the pipe create the pullback force required for successful pipe installation. The resultant pullback force required should not exceed the tensile capabilities of the pipe and/or joint with an appropriate safety factor.

Unlike some other thermoplastics, with PVC the magnitude and duration of pulls do not result in significant pipe elongation. Therefore, connections to PVC pipe can be made immediately following pullback. However, it is good practice to release tension in pulled-in pipe by pushing the pipe back after the pull-in is completed.

Information on how to calculate estimated pullback forces and safe allowable tensile stresses may be obtained by contacting the manufacturer or technology provider of the particular PVC pipe and restrained joining methodology selected for use.

13.6 Trenchless Rehabilitation—Sliplining

13.6.1 Overview

Sliplining is accomplished through insertion of a lining pipe into a host pipe that has leaks or is otherwise unsound. Unlike casings, sliplining installations allow PVC pipe to carry loads once the sliplining is installed inside an existing host pipe. Because it is limited by the size of the host pipe, PVC reline pipe is usually pushed or pulled directly into place (most times without the use of spacers). Prior to installation, the host pipe is cleaned of debris and service build-up (sediments and/or tuberculation) and surveyed for internal clearance, alignment, and obstructions. If the host pipe is a segmented pipe with bell-and-spigot joints, the deflection of the joints and the lay length of the host pipe must be considered when it is determined which pipe should be used in a slipline.

Joint spacing and deflection are used to determine the bend radius of the new pipe that will be inserted. In some cases, spot repairs are required on the host pipe in areas that the replacement pipe cannot pass. The largest PVC sliplining pipe that will fit is selected and inserted (dimensional information to aid in pipe size selection is provided in the Handbook Appendix). For long insertion lengths, approximately 2 in. of clearance between the host pipe inside diameter and the new pipe outside diameter is recommended. Hydraulic capacity can often be maintained despite the diameter reduction due to the lower Manning's sewer pipe flow coefficient (n) and the higher Hazen–Williams pressure pipe flow coefficient values (C) offered by PVC. Some PVC piping systems now offer zero-infringement joints, which lower the clearance dimensions required between the host pipe and the lining pipe. Sliplining pipes are usually grouted in place. Grouting recommendations are discussed in Section 13.4.4.

13.6.2 Design Considerations

13.6.2.1 Loading

Variations in loads in the trenched and trenchless portions of the slipliner must be considered and accommodated in the design of the system. Loading conditions are not identical since there are differences in the two regions' ring deformation and longitudinal pipe deflection.

13.6.2.2 Annular Space

As mentioned previously, annular space between outer and inner pipes may be grouted (see Section 13.4.4 for details). This adds strength to the annular cavity, enhancing resistance to collapse. Installation of load-bearing material such as fly ash, low density grout, flowable fill, cementitious grout, or polyurethane foam in this space significantly improves the structural integrity of the composite pipe. If the annular space is not grouted, hydrostatic loads may be exerted on the slipliner as the water table rises above the crown of the liner.

13.6.3 Installation

There are two general methods used for sliplining installations:

1. *Segmental sliplining*—Liner is installed one pipe length at a time.
2. *Continuous sliplining*—Liner pipe lengths are assembled, then installed in one long string.

13.6.3.1 Segmental Sliplining

Segmental sliplining is the least disruptive type of rehabilitation for gravity and storm sewers. With this method, bell-and-spigot and profile wall PVC pipe may be assembled in segments at entry points along the length of the deteriorated host pipe. Pipe is inserted directly into the host pipe by either pulling or pushing. Fused PVC is installed segmentally by fusing lengths together in the access pit and then inserting the fused string of pipe into the host pipe after each fusion is completed. Open-cut trenches are required to access the host pipe at strategic installation points when sliplining is done in a segmental application.

A section of the top half of the host pipe is often cut off to provide lead-in access. Often the access pit can be used for installing new PVC pipe in both directions. This is done by reversing the setup of the installation equipment. Where two segments of sliplining pipe meet at a point, the host pipe must be open-cut excavated there in order to expose the section of liner pipe that is to be connected. Laterals will need to be excavated, disconnected, and reconnected to the new PVC sliplining. Making connections to different materials also involves exposing both the lining pipe and the pipe to be connected with open cut excavation

13.6.3.2 Continuous Sliplining

In continuous sliplining, PVC liner pipe is preassembled in long lengths before it is pulled into the deteriorated host pipe. The pull-in can be done in one unsegmented length or in sections that require an intermediate joint or butt-fusion (Fig. 13.11). This method is more common with potable water pipelines, transmission mains, and forcemains. As is the case with gravity systems, the annulus that results in continuous sliplining may be grouted. When required, taps are made after the new pipe is pulled into the host pipe.

13.6.3.3 Pulling Heads

The pulling heads used in continuous sliplining applications do not increase the outside diameter of the new pipe, thus allowing the largest size pipe possible to be installed. The pull head must be designed to accommodate the recommended safe pulling force

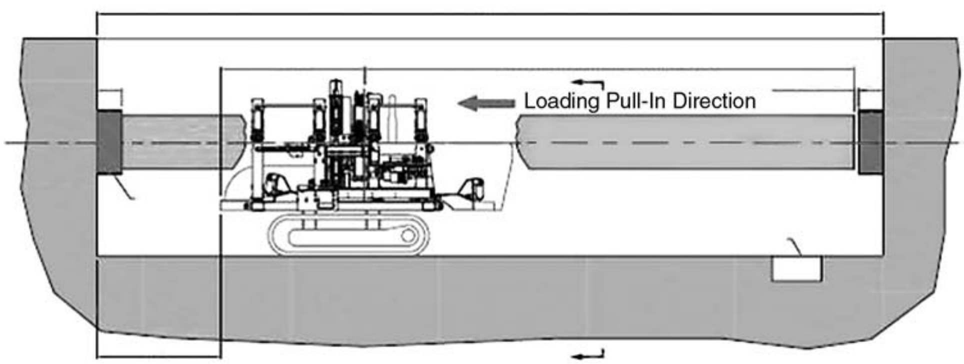

Fig. 13.11 Sliplining installation of butt-fused PVC segmental approach.

of the pipe being installed. The two primary components for the pull force required for sliplining are:

1. friction caused by the length of pipe being pulled above grade;
2. friction between the new pipe and the host pipe.

13.6.3.4 Installation Pits

Installation pits need to be excavated to a depth great enough for PVC pipe installation to proceed, without the pipe being bent tighter than the minimum bending radius of the liner pipe. In many cases, a significant amount of the alignment change for insertion can be accomplished above grade by supporting the pipe with rollers or equipment. This practice minimizes the length of pit needed. Pit length also dictates how much host pipe needs to be removed to allow for insertion (Fig. 13.12).

13.7 Trenchless Rehabilitation—Pipe Bursting

13.7.1 Overview

Pipe bursting is a method for replacing existing pressure or gravity pipelines. Much as is done in sliplining, an existing utility corridor is used in this procedure and the end result is replacement of old pipe with completely new pipe. However, pipe bursting has an advantage over sliplining: Sliplining requires the new pipe to be smaller in diameter than the existing pipe. In contrast, pipe bursting involves splitting or fracturing an existing

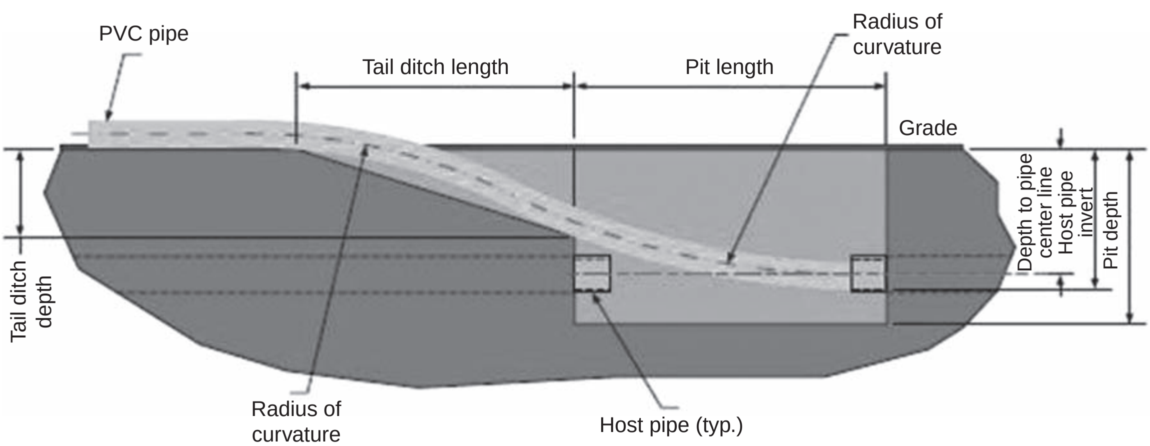

Fig. 13.12 Typical installation pit for continuous sliplined PVC pipe.

pipeline, pushing that pipeline out into the surrounding soil, thus creating an area large enough for a new pipeline of the same or larger diameter to be pulled in.

There are several methods by which existing pipe is split or fractured; these vary, depending on the kind of pipe being replaced and the equipment available to perform the operation. Figure 13.13 shows a pipe bursting layout and operation sequence.

Only joints designed for pulling are used for pipe bursting installations. Depth of pipe bursting installation and site-specific aspects of a project (e.g., groundwater levels, ground conditions, and previous pipeline installation conditions and methods) also play a role in the design of a pipe burst project.

13.7.2 Size Considerations

The diameter of pipe being burst typically ranges from 2 to 30 in., although bursting has been used on pipes of larger diameter. Pipe bursting is commonly performed size-for-size or one size above the diameter of the existing pipe. Larger upsizing (up to three pipe sizes) has been successful; however, the larger the pipe upsizing, the greater the force needed to burst the existing pipe and pull in the new pipe, thus, the greater the potential for ground movement (upheaval). The high strength of PVC relative to other thermoplastics minimizes upsizing requirements for maintaining the same flow area, since PVC provides a thinner wall for the same OD and pressure rating.

13.7.3 Types of Pipe Bursting

The two common categories of pipe bursting are:

- *Pneumatic*—In pneumatic pipe bursting, force is applied by a reciprocating hammer that is driven by compressed air. This method is not recommended for PVC pipe, since the rebound from the reciprocating action may damage the end of the pulled-in pipe.
- *Static*—In static pipe bursting, a bursting head is pulled through the existing pipe while the new pipe is pulled from behind. The pull is continuous and does not

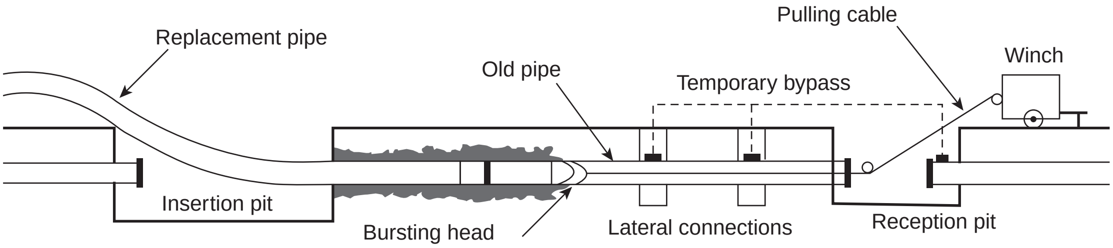

Fig. 13.13 Layout for a pipe bursting operation.

involve the reciprocating action of pneumatic methods. This method is recommended for PVC pipe and is widely used to burst failing clay, concrete, cast iron, ductile iron, and asbestos cement pipe.

13.8 Trenchless Rehabilitation—Tight Fit Structural Liners

13.8.1 Overview

Tight fit structural lining with PVC is accomplished by expanding a specially formulated PVC pipe that has been inserted into a host pipe (Fig. 13.14). The liner is brought to tight fit dimensions through a combination of heat and pressure.

13.8.2 Pressure Pipe Example: Fusible PVC Tight Fit Liner

For pressure pipe, the tight fit structural liner process is as follows:

1. Starting stock pipe is selected based on ID of host pipe and required pressure rating for new pipe. Starting stock pipe is analyzed to determine the amount of expansion needed. The pressure capacity of the expanded pipe is determined on a stand-alone, fully structural basis. No contribution from the degraded host pipe is used in this determination.
2. Starting stock sections are fused into a single length. Under most conditions, maximum recommended length is approximately 500 ft.

Fig. 13.14 Starting stock inserted into host pipe.

3. Prior to installation of the starting stock, the host pipe is cleaned and inspected. Cleaning removes any debris, sediment, or accumulated tuberculation to achieve the ID expected. Inspection is normally performed by video, allowing an assessment of host pipe for any restrictions or missing sections that could impact expansion.

   When completely expanded, the starting stock does not adhere to the host pipe, so a bondable surface is not required.

   The alignment of the host pipe must also conform to the bend radius of the selected starting stock pipe. (Bending is covered in Chapter 8.)
4. Starting stock pipe is inserted as in a slipline operation. Usually the liner is pulled into place with a winch, but it can be pushed as well.
5. Expansion hardware is installed and the line is filled with water.
6. Starting stock is heated in a controlled manner with hot water.
7. When the system reaches proper conditions, pressure is added in the form of additional hot water under pressure. This initiates the expansion.
8. Expansion completion is determined by several methods:
   - A calculated volume of expansion is determined prior to start. Although the host ID may vary, the amount of expansion achieved within a range of this calculated volume indicates that expansion is complete.
   - When expansion is completed, pressure rises (since the host pipe restricts further expansion).
   - At pipe ends and at any intermediate expansion point, visual inspection can verify that the liner has expanded against the inside wall of the host pipe.

Included in the expansion hardware is a sizing sleeve, which allows the pipe ends outside the host pipe to be expanded to a diameter that will accept a standard fitting for reconnection. In most cases this will be the OD of the host pipe, thus allowing the same size fittings to be used. Intermediate points can be exposed, host pipe removed, expansion sleeve installed, and an expanded portion of the liner sized for the cut in a tee or other fitting.

After expansion is complete (Fig. 13.16), the liner is pressure tested per standard pipe acceptance testing parameters. The application can also be used for gravity flow applications where a structural lining is needed.

13.8.3 Nonpressure Pipe Example: Folded PVC Tight Fit Liner

Lining with expanded-in-place PVC liner uses a specially formulated pipe that has been folded into a “C” shape and wound onto a coil. The length of pipe on the coil is designed to extend the length of a full manhole-to-manhole run. The lining maintains or increases flow capability by providing a Manning’s n value equal to 0.009 PVC, which offsets the slight reduction in flow area.

Fig. 13.15 Expanded structural liner with hardware removed.

Fig. 13.16 Expanded structural liner with end sized to accept host pipe fittings.

For nonpressure pipe, the process is as follows:

1. The liner pipe is heated in a steam trailer to soften the PVC material.
2. Once softened, the liner is winched down the existing manhole into the pipe to be rehabilitated (Fig. 13.17).
3. Winching continues until the liner reaches the next designated manhole.
4. After the liner pipe is winched into the existing pipeline, steam and pressure are applied to expand it tightly against the host pipe (Fig. 13.18).
5. Steam is replaced by air (while maintaining a constant pressure) and the liner is cooled.

Fig. 13.17 Heated liner being winched into a manhole.

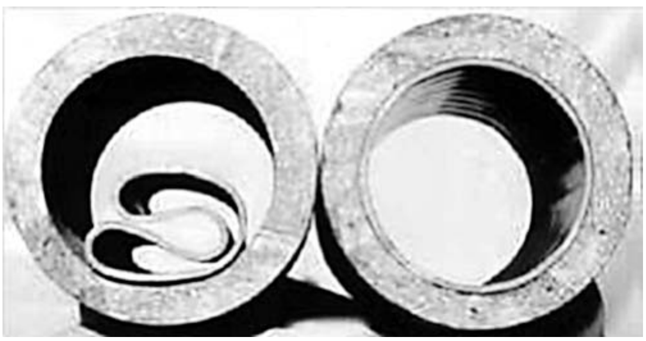

Fig. 13.18 Tight fit PVC liner; inserted is shown on left, expanded is shown on right.

6. The liner is trimmed at each pipe end and excess material is removed from the manhole.
7. House service connections are reopened with use of a robotic cutting device and closed-circuit television camera.
8. Liner installation is complete and the pipe is ready for use.

13.9 Sources

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