i. **Product and Installation Guide for Fusible PVC® Pipe**

Fusible PVC® pipe is a thermally butt-fused polyvinyl chloride (PVC) piping product for use in water, wastewater, industrial, and conduit infrastructure projects and applications. Underground Solutions, Inc. (UGS) combines a patented PVC pipe formulation with a patented fusion joining process to create a fully restrained PVC pipe without a gasket or mechanical coupling. Plain-end pipe lengths are delivered to a project site where they are assembled using standard fusion equipment into longer, completely restrained pipe lengths. Fusible PVC® pipe is popular for use with trenchless applications such as horizontal directional drilling (HDD), sliplining, pipe bursting, and jack-and-bore carrier pipe use. It is also a versatile direct bury pipe leveraging the benefits of a fully restrained joint without the use of a mechanical restraint or joining technology. Fusible PVC® pipe is also acceptable for use in a wide variety of industry standard configurations, including both pressure and non-pressure applications. This may include water mains, gravity sewer and force mains, recycled or reuse water, irrigation and raw water, storm drains, electrical and fiber optic conduit, and casings.

![Examples of Fusible PVC® pipe products in various industry standard configurations.](image)

Recommended handling and installation practices for Fusible PVC® pipe are straightforward and well within current construction practice in terms of required equipment, appurtenances, procedures, and labor skillset. For operators and installers accustomed to working with PVC pipe, Fusible PVC® pipe will only require adjustment to the longer lengths of pipe (including both delivered and assembled pipe) and the proper way to handle and install the product. For operators and installers accustomed to working with high density polyethylene (HDPE) pipe, Fusible PVC® pipe is joined in a similar method, however, the requirements for handling, installing, and connecting the pipe will be different.

This document contains technical information that applies to the delivery, handling, installation, and testing of Fusible PVC® pipe. Users of this guide should be proficient in basic installation practices for larger diameter pipe infrastructure,
Introduction

particularly for buried pipe installations. It is the user’s responsibility to assure that the appropriate contractual stipulations, jurisdictional codes, and project requirements are met when installing Fusible PVC® pipe.

<table>
<thead>
<tr>
<th>Pipe Type</th>
<th>Sizes (Nominal OD)</th>
<th>Series</th>
<th>Dimension Ratios (DR)</th>
<th>Uses</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fusible C-900®</td>
<td>4” – 12”</td>
<td>DIPS</td>
<td>DR 14, 18, 25</td>
<td>Potable Water</td>
<td>Blue</td>
</tr>
<tr>
<td>Fusible C-905®</td>
<td>14” – 36”</td>
<td>DIPS</td>
<td>DR 14, 18, 21, 25, 32.5, 41</td>
<td>Potable Water</td>
<td>Blue</td>
</tr>
<tr>
<td>FPVC®</td>
<td>4” – 36”</td>
<td>DIPS, IPS, or Schedule</td>
<td>DR 14, 18, 21, 25, 26, 32.5, 41; Sch.40, Sch.80</td>
<td>Non-Potable Water or Potable Water Use Outside of AWWA C900/C905 Standard Dimensions</td>
<td>Blue, Purple, Green, White, Grey</td>
</tr>
</tbody>
</table>

Fusible PVC® pipe is segmented into three product lines and trade names.

If questions arise regarding the use of the product, please contact your local UGS representative. Contact information can be found on the web: [http://www.undergroundsolutions.com/contact-underground-solutions.php](http://www.undergroundsolutions.com/contact-underground-solutions.php), or by calling Underground Solutions, Inc. at (858) 679-9551.
## ii. Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td>ii</td>
<td>Table of Contents</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Shipping and Receiving</td>
<td>Rev. 7</td>
</tr>
<tr>
<td>2</td>
<td>Thermal Butt Fusion</td>
<td>Rev. 7</td>
</tr>
<tr>
<td>3</td>
<td>Fusible PVC® Pipe Connections</td>
<td>Rev. 6</td>
</tr>
<tr>
<td>4</td>
<td>Testing and Disinfection</td>
<td>Rev. 6</td>
</tr>
<tr>
<td>5</td>
<td>Tapping Fusible PVC® Pipe</td>
<td>Rev. 6</td>
</tr>
<tr>
<td>6</td>
<td>Pulling Parameters</td>
<td>Rev. 6</td>
</tr>
<tr>
<td>7</td>
<td>Cutting Fusible PVC® Pipe</td>
<td>Rev. 7</td>
</tr>
<tr>
<td>8</td>
<td>Horizontal Direction Drilling</td>
<td>Rev. 9</td>
</tr>
<tr>
<td>9</td>
<td>Sliplining</td>
<td>Rev. 8</td>
</tr>
<tr>
<td>10</td>
<td>Pipe Bursting</td>
<td>Rev. 7</td>
</tr>
<tr>
<td>11</td>
<td>Direct Bury</td>
<td>Rev. 6</td>
</tr>
<tr>
<td>12</td>
<td>Special Considerations</td>
<td>Rev. 7</td>
</tr>
</tbody>
</table>
Section 1
Shipping and Receiving

1.0 Delivery, Acceptance, Off-loading, and Storage of Fusible PVC® Pipe

Fusible PVC® pipe is typically cut into pipe lengths of 40 or 45 feet for delivery to the customer. Some shorter lengths may also be ordered for specific project needs. Understanding what is to be delivered and the manner by which it will arrive will aid the customer to be properly prepared to take delivery of the pipe order and prepare for the construction of the project. Generally, Fusible PVC® pipe will be loaded, offloaded, strapped, lifted, and otherwise handled in the same manner that 20 foot lengths of bell and spigot PVC pipe is handled. AWWA Manual of Practice M23\(^1\) and AWWA C605\(^2\) cover receiving, storage and handling procedures that are generally acceptable for Fusible PVC® pipe except as noted herein. Additional information regarding these same subjects is available in the Handbook of PVC Pipe.\(^3\)

The Most Important Items When Accepting, Off-Loading, and Storing Fusible PVC® Pipe:

1. Follow all safety precautions for off-loading and handling pipe delivered to the project site.
2. Always report damage or unexpected pipe types or quantities PRIOR to off-loading the truck.
3. Use appropriate equipment, such as fork lifts and nylon straps to move and handle the pipe – NEVER use wire rope, chains or other devices that could damage the pipe.
4. Properly store and protect pipe that will not be used for more than one year from ultraviolet radiation (sunlight).

Safety First!

Fusible PVC® pipe, both as delivered to the project site and when assembled into long lengths represents a large, heavy material that requires attention during handling, movement, and installation on a project site. Moving lengths of pipe improperly creates a hazard that can result in personal injury or even death. Always follow best practice safety procedures as provided by Underground Solutions, Inc., as well as all entities having jurisdiction for the project.

1. Before removing straps from pipe, park truck on stable and level ground.
2. At a safe distance, inspect load for any shifting or other unstable condition.
3. Do not stand within 45 feet of a stack of pipe on a truck that is not physically secured unless you are the person responsible for securing it and have been instructed to do so.
4. Stay in cab of truck or 45 feet away from forklift/material handling equipment when unloading.
5. Never walk under any suspended load.
6. Never climb on a load to gain access to the top or sides, and never get on top of an unsecured load.
7. Be aware that PVC pipe surfaces are smooth and can be slippery, especially when wet or in snowy and icy conditions.
1.1 Delivery of Product Pipe

The customer must provide appropriate access and coordination of the project site for successful delivery of the product. Typical delivery vehicles will be 18-wheel tractor trailers that are primarily used for roadway freight transport. Their ability to access remote and questionable haul routes is limited.

Fusible PVC® pipe will either arrive in a wrapped bundle (see Figure 1.1) configuration, or in an unwrapped bundle (see Figure 1.2) configuration. Typically, stock Fusible PVC® pipe will be wrapped. Pipe that has been run specifically for a project, which usually includes shorter extrusion runs, or less standard pipe sizes and wall thicknesses, typically will not be wrapped. All Fusible PVC® pipe deliveries are typically bundled or strapped together into standard bundles.

Figure 1.1. Example of typical pipe delivery, including delivery truck and pipe that has been wrapped in bundle(s).
Figure 1.2. Example of typical pipe delivery, including delivery truck and pipe that has not been wrapped, but is still arranged and packaged in bundles.

Nesting pipe, or the practice of placing smaller pipe diameter sizes inside larger pipe diameter sizes may also be used on certain occasions (see Figure 1.3). Contact your local Underground Solutions, Inc. representative for more information on nested pipe arrangements and delivery options.

Figure 1.3. Example of a ‘nested’ pipe arrangement. Nesting pipe deliveries are done on a specific project basis.
Bundle size is dependent on the nominal pipe size for the delivery. Table 1.1 provides a guide to the typical bundle size for delivered pipe, based on the nominal pipe diameter. If nested bundles are used, please contact Underground Solutions, Inc.’s Operations Group for information on offloading. Specific information regarding any product pipe delivery may be obtained by contacting the assigned Underground Solutions, Inc. Operations Group Project Manager, or calling (858) 679-9551.

![Typical Bundle Size Table](image)

**Table 1.1. Typical pipe shipment details. This information is also available online at www.undergroundsolutions.com; as well as in a handy slide-rule format. Contact your Underground Solutions, Inc. representative for more details.**

### 1.2 Review and Acceptance of Pipe Delivery

*An delivered shipment checklist has been provided at the end of this section to aid in reviewing a pipe shipment when it arrives on site.*

When a load arrives for delivery, the first step is to verify whether the appropriate pipe diameter size, wall thickness (or DR), and overall quantity is correct. The size(s), DR(s), and quantity ordered should match the bill of lading and be checked to ensure that it matches the actual load. The next step is to inspect each pipe bundle and pipe length for load shifting or pipe damage. These two steps must be performed before the pipe is unloaded from the shipment vehicle. (see Figure 1.4). All issues must be written on the bill of lading or noted as an attachment and signed. Notify Underground Solutions, Inc. of any issues immediately. **This is very important** – an incorrect shipment or shipping damage claim cannot be made once the pipe has been off-loaded. Also, a claim with the shipping company is not likely to be honored for damage that is discovered after the pipe is off-loaded. Contact your assigned Underground Solutions, Inc. Operations Group Project Manager, or calling (858) 679-9551.
Inspect the pipe shipment prior to unloading for proper pipe size, type and color. Check for pipe damage or any other inconsistencies with the pipe load. Contact UGSI immediately if discrepancies are found.

**Figure 1.4. Critical items to remember when inspecting a delivered pipe shipment.**

When inspecting the pipe shipment:

1. Verify that the delivered load is the same as the bill of lading and that it matches the pipe diameter(s), wall thickness(es)/DR(s), and quantity specified or ordered.

2. Examine the load. If the load is intact, inspection during the offloading process should be sufficient to assure the pipe is in good condition (see Figures 1.1, 1.2, and 1.3 for examples of typical expected state of load upon delivery).

3. If damage is evident when examining the load, such as load-shifting, broken or misapplied packaging or strapping, etc, then each piece should be inspected for damage (see Figure 1.5 for an example of load shifting).
Figure 1.5. Example of ‘load shifting’ that has occurred during transport.

If there is a shipping related issue with the pipe that has been delivered, prior to offloading, file a claim with the carrier that delivered the pipe and call your assigned Underground Solutions, Inc. Operations Group Project Manager, or call (858) 679-9551 immediately. If damage or workmanship issues with the delivered pipe are discovered after delivery, Underground Solutions, Inc. should be notified immediately upon discovery of the issue, but not more than 7 days after the pipe has been delivered.

1.3 Off-Loading of Product Pipe from Delivery Vehicle

Offloading of the product pipe from the delivery vehicle is the responsibility of the customer to which the pipe is being delivered. Underground Solutions, Inc. as an entity or employees of Underground Solutions, Inc. will not offload the pipe.

Safety First!

Be aware that pipe represents a large, heavy material that can be awkward to handle and unload from shipping vehicles. Improper unloading lengths or bundles of pipe can result in personal injury or even death. Always follow best practice safety procedures, including but not limited to the following items for unloading:

1. Before removing the straps, inspect the entire load including the banding and packaging system, and make sure the bundles are stable and have not shifted. If the pipe load has shifted, it must be stabilized before the straps can be removed and the pipe off-loaded.
Section 1
Shipping and Receiving

2. Once it has been determined the load is secure, remove the tension from the belly straps first, followed by the top straps. Keep an eye on the load to make sure the load does not shift while the tension is relieved.

3. When the tension has been removed from all the straps, remove the top straps and place them in a safe location (that is, where they will not create a hazard) and do not allow the truck to be unloaded until everyone is in a safe location well away from the load.

4. When everyone is in a safe location at least 45 feet from any point of the load then the equipment operator can remove the bundles of pipe that are above the belly strap.

5. After those bundles have been safely moved away from the truck then proceed to remove the belly straps and place them out of the way where they do not create a hazard.

6. Once everyone has reached their previously established safe point the equipment operator can remove the remaining bundles of pipe.

7. After the pipe is unloaded and the loading zone is safe, the straps can be gathered and prepared for storage.

8. A forklift or other suitable equipment may be used to unload pipe. Always follow these safety guidelines, but also assess each jobsite for other potential hazards and take appropriate steps to avoid them.

Always make sure that the equipment used to handle pipe lengths or bundles is adequately rated for the expected load. Follow all guidance and recommendations from the equipment manufacturer when performing such operations. Typical bundle sizes and weights are provided in Table 1.1 to aid in the appropriate selection of offloading equipment.

Beware of boards that may have come loose during shipment creating a potential hazard. Do NOT use hooks, chains, wire ropes, or any other handling device that might damage the pipe as this will void the warranty! Care should be exercised when handling the pipe to not cut, gouge, scratch or severely abrade the pipe.

When forklifts or front loaders equipped with forks are used, the fork tapered ends should be checked to be sure they are not thicker than the gap between the strapped together units of pipe. The spread of the forks should be set at the maximum distance. See Figure 1.6 for basic illustrated guidance on lifting devices.
Section 1
Shipping and Receiving

Figure 1.6. Critical items to reference in terms of lifting devices.

Do not run forks too far under the units, as fork ends striking adjacent units may cause damage. Make sure that the forks are fully engaged and always lift from the middle of the bundle (see Figures 1.7 and 1.8). If left bundled, unloading of individual bundles can be done with a forklift so long as it has sufficient load capacity to safely handle each bundle.
Figure 1.7. Illustration of proper piece of equipment fitted with tapered forks moving pipe bundle.

**WARNING** - Pipe and Pipe bundles may be extremely heavy and possibly unstable. Use caution in handling, loading, unloading, and moving. Assure proper handling equipment is used and secured before attempting to move pipe or pipe bundles.
Section 1
Shipping and Receiving

Figure 1.8. Pictures of proper equipment fitted with tapered forks moving pipe bundles.

Do NOT use the steel forks of a fork lift to move or attempt to move a length of Fusible PVC® pipe by inserting it into the end of a pipe. This will result in damage to the end and the interior of the pipe (see Figure 1.9).
Figure 1.9. **DO NOT attempt to move or handle pipe lengths by inserting the steel fork of a fork lift into the pipe end. Irreparable damage to the pipe inner surface may result.**

If a forklift is not available, a spreader bar with nylon or kevlar straps capable of handling the load should be used. Recommended lift points when using straps are at the points approximately 1/3 of the length measured from each end of the unit (see Figure 1.10). **DO NOT PICK A SINGLE LENGTH OF PIPE UP BY THE MIDPOINT – POTENTIAL OVERBENDING AND DAMAGE COULD RESULT.**

![Diagram of proper strap placement](image)

Figure 1.10. *Illustration of proper strap placement for full support of pipe piece.*

During unloading and handling, be sure that the pipe does not strike anything. Significant impact could cause damage. Care should be taken to insure that pipe is not dropped or damaged. Pipe should be carefully lowered, not dropped. **If pipe is rolled or dropped off of delivery vehicles when unloading, this will void the warranty.**
In preparation for pipe installation, placement of the unloaded pipe should be as close to the area where fusion will take place as practical. Pipe should be placed on level and stable ground. Soft or unleveled ground will require additional uniform support under the pipe. Inadequate support can cause excessive distortion of the pipe. See Figure 1.11 for an example of pipe bundles that have been advantageously staged next to the fusion area for a project.

![Pipe staged adjacent to fusion process](image)

**Figure 1.11. Example of pipe staging near stationary fusion area.**

### 1.4 Long-term Pipe Storage

From time to time, pipe will need to be stored either in a storage yard or on a project site for an extended period of time prior to installation. When this is the case, proper storage of the pipe is required to prevent damage or adverse effects prior to assembly and final use.

Pipe should be stored at the job site in the unit packaging provided by the manufacturer, if possible. Caution should be exercised to avoid any excess deformation of the pipe. Use racks or dunnage to support the pipe or pipe bundle. Supports should be spaced evenly and adequately to prevent excessive pipe bending (see Figure 1.12 for schematic and Figure 1.13 for a project site example). Maximum recommended stacking of rows by relative pipe diameter size can be found in Table 1.2
When exposure in excess of one year to direct sunlight is unavoidable, the pipe should be covered with an opaque material while permitting adequate air circulation above and around the pipe to prevent excess heat accumulation. The interior of the pipe, as well as all end surfaces, should be kept free from dirt and foreign matter. Where possible, block animal and insect entry. If pipe interior is flooded or otherwise becomes dirty, it will need to be cleaned prior to assembly and installation. Particular attention must be paid to the pipe end surfaces that will be part of the fusion process for pipe joining. Rotate the stock by bundle to counteract excessive long term loading on the pipe that is stored on the bottom of the stacks.
Section 1
Shipping and Receiving

<table>
<thead>
<tr>
<th>Pipe Diameter (inches, nominal)</th>
<th>Maximum Number of Rows Stacked on Top of Each Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 or less</td>
<td>5</td>
</tr>
<tr>
<td>12 to 21</td>
<td>4</td>
</tr>
<tr>
<td>24 to 30</td>
<td>3</td>
</tr>
<tr>
<td>33 to 36</td>
<td>2</td>
</tr>
</tbody>
</table>

*Table 1.2. Maximum number of stacked rows per nominal pipe diameter size.*

Follow the good practice guidelines for storage in AWWA M23, including, but not limited to:

1. When pipe unit rows are stacked on top of each other, assure that the bundle remains stable and not susceptible to tipping over, or collapse.
2. Store pipe away from active locations (construction traffic or activities) that may inadvertently damage the pipe.
3. Pipe should not be stored next to heat sources such as heaters, boilers, steam lines, or engine exhaust.

Long term exposure to ultraviolet (UV) radiation, as in sun light, will fade the color of the pipe’s surface and in extreme cases cause discoloration or ‘browning’ of the pipe surface. Pipe that has been exposed to direct sunlight or UV radiation for one year or less is fine for use, even if slight fading or discoloration is observed. Most pipeline projects take less than a year to complete, thus this recommendation gives the contractor appropriate flexibility to work with the pipe stock and fusion requirements. If the pipe will be stored for more than one year, UGS recommends that the pipe be protected until it is installed. More information on long-term pipe exposure to sunlight can be found in the PVC Pipe Association’s Technical Report, Uni-TR-5-03. Properly stored and protected pipe will be suitable for future use, regardless of the pipe extrusion date or pipe age.
Section 1
Shipping and Receiving

References


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This document does not purport to address all of the safety concerns, if any, associated with the handling, installation or use of Fusible PVC® pipe or with the various application techniques described herein. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

The information contained herein is believed to be reliable, but no representations, guarantees or warranties of any kind are made as to its accuracy, completeness, suitability or the results to be obtained. Underground Solutions, Inc. shall not be liable for, and the customer assumes, all risk and liability for the selection, handling, installation, application, use and maintenance of Fusible PVC® pipe. UGS MAKES NO WARRANTIES IN CONNECTION WITH THIS DOCUMENT, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, OR THE SUITABILITY OF FUSIBLE PVC® PIPE FOR ANY PARTICULAR APPLICATION, OR ANY WARRANTIES ARISING THROUGH USAGE OF TRADE OR FROM COURSE OF DEALING. Nothing contained herein is to be considered as permission, a recommendation, or an inducement to practice any patented invention without permission of the patent owner.
Delivered Shipment Checklist

The following Checklist is recommended for use in the review a delivered pipe load for conformance to the order and the project prior to taking delivery of it. Responsibility for the care of product is passed from commercial carrier to the receiver when the pipe is unloaded.

Prior to unloading the shipment from the delivery vehicle:

<table>
<thead>
<tr>
<th>Verified By:</th>
<th>Is This the Pipe that You Expected to Receive?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Verify that the Bill of Lading correctly matches what is specified for the project.</td>
</tr>
<tr>
<td></td>
<td>Verify that the delivered pipe size(s) match the Bill of Lading.</td>
</tr>
<tr>
<td></td>
<td>Verify that the pipe wall thickness(es) or DR(s) match requirements.</td>
</tr>
<tr>
<td></td>
<td>Verify that color(s) of the pipe(s) match requirements.</td>
</tr>
<tr>
<td></td>
<td>Verify that the quantity (quantities) of pipe(s) match Bill of Lading and requirements.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Verified By:</th>
<th>Is the Load Damaged in Any Way?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Verify that pipe packaging, boards, strapping, etc. are intact and functional.</td>
</tr>
<tr>
<td></td>
<td>Verify that the pipe load has not shifted during transport.</td>
</tr>
<tr>
<td></td>
<td>Verify that ‘smoke tarping’ or exhaust protection is in place, functional, and not torn (if required).</td>
</tr>
<tr>
<td></td>
<td>Verify that pipe has not been deformed by the load securements or transport.</td>
</tr>
<tr>
<td></td>
<td>Check pipe at bundle banding locations for deformation or damage.</td>
</tr>
<tr>
<td></td>
<td>Verify that pipe has not been nicked, scratched, gouged, or otherwise damaged by securements.</td>
</tr>
<tr>
<td></td>
<td>Verify that that no significant abrasion damage is present under tie downs and elsewhere.</td>
</tr>
</tbody>
</table>

If any of these items are not verified upon initial inspection, do a detailed inspection of the load for damage prior to unloading. Any damage found should be photographed, confirmed with the truck driver or delivery person, and noted on the Bill of Lading. Pipe can be unloaded with contingency based on closer inspection of those pipes not visible in the shipped configuration.
Section 2
Thermal Butt Fusion

2.0 Thermal Butt Fusion Process and Requirements for Fusible PVC® Pipe

Fusible PVC® pipe is assembled using a thermal butt fusion process to create monolithic lengths of PVC pipe. Fusible PVC® pipe is a fully restrained pipe system, with a low-profile, high strength joint that has equivalent tensile and pressure properties to the PVC pipe being joined.

The Most Important Items When Joining Fusible PVC® Pipe with Thermal Butt Fusion:

1. Only licensed and trained fusion technicians that pass the qualification requirements are able to join Fusible PVC® pipe using thermal butt fusion.
2. The fusion machine must be appropriately sized based on the diameter size of the pipe being fused.
3. A fusion datalogger and software specific to PVC thermal butt fusion MUST ALWAYS be used.
4. Consider the fusion process and requirements whenever planning for construction activities that will involve Fusible PVC® pipe.

2.1 The Basics of PVC Thermal Butt Fusion

The fusion process utilizes a proprietary combination of heat, pressure, and time. The process is patented. Only those contractors, end-users, and individuals who are trained and licensed by Underground Solutions, Inc. to perform the fusion process with Fusible PVC® pipe are qualified to do so. The basic process for PVC fusion is detailed in Underground Solutions, Inc.’s TB 8-533, “Process Steps: PVC Butt Fusion.”[1] Figure 2.1 shows a typical thermal butt fusion set up for PVC pipe. If interested in becoming licensed to fuse Fusible PVC® pipe, contact your local Underground Solutions, Inc. representative.

Figure 2.1. Typical thermal butt fusion equipment set-up for Fusible PVC® pipe.
Section 2
Thermal Butt Fusion

2.2 Detailed Information Regarding the Fusion Process and Requirements

If you are licensed to fuse Fusible PVC® pipe and have specific questions regarding the fusion process or setup, please reference the latest materials provided by Underground Solutions, Inc. per your fusion license agreement and training, or contact your local Underground Solutions, Inc. representative.

The following information related to the fusion process is provided for those working with the fusion process on project sites. It provides details on how the fusion process will interface with a typical project and the critical items to cover when working with Fusible PVC® pipe fusion.

2.3 General Equipment and Requirements for Thermal Butt Fusion Process

The PVC thermal butt fusion process requires a specific set of equipment and personnel to perform fusion accurately and efficiently. The highest and most efficient rate of production occurs when the fusion technician and equipment are properly supported during the process. Loading pipe segments into the fusion machine and pulling assembled lengths of pipe through the machine are the major elements of support required. Other needs include fueling of fusion equipment, loading and unloading equipment, and fusion site set up.

Safety Alert! Individual and joined lengths of Fusible PVC® pipe can have substantial size, weight, and momentum when being moved. Exercise caution when moving, loading, and handling pipe to avoid injury or death.

The fusion technician must have a fusion qualification for the size of pipe being fused issued by Underground Solutions Inc. The qualification must be current. Under no circumstances shall a fusion technician who is not properly licensed and qualified be allowed to fuse Fusible PVC® pipe for a project.

The equipment to perform fusion includes an appropriately sized fusion machine for the pipe being fused, support rollers for the pipe on either side of the machine, a fusion datalogger with PVC based software, a properly calibrated infrared pyrometer, and some small hand tools. Table 2.1 includes a general guide for the fusion machine required to perform thermal butt fusion on various diameter sizes of Fusible PVC® pipe. Table 2.2 includes a general guide for the roller size requirements for each fusion machine.

<table>
<thead>
<tr>
<th>Fusion Machine Required for Each Pipe Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Pipe Size (inches)</td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>8 to 10</td>
</tr>
<tr>
<td>12 to 16</td>
</tr>
<tr>
<td>18 to 20</td>
</tr>
<tr>
<td>24 to 30</td>
</tr>
<tr>
<td>36</td>
</tr>
</tbody>
</table>

*Table 2.1. General fusion machine size required per pipe diameter size for Fusible PVC® pipe.*
2.3.1 Fusion Machine Specifics

Figures 2.2 and 2.3 show a ‘wheeled’ and a ‘tracked’ (respectively) fusion machine that are typical for thermal butt fusion of Fusible PVC® pipe. The major components of each fusion machine are labeled.

The hydraulic system of the fusion machine must meet certain requirements to properly join PVC pipe by thermal butt fusion. The hydraulic system must be leak free, without drips or seepage, and all air must be bled from the system. The system pressure must meet the factory set point. The facing, heating, and fusion pressure reducing valves (PRV’s) must be of the appropriate pressure range for the machine and pipe being fused and be operable over the full range of each. Both hydraulic pipe lifts and their controls must be in good working condition and function properly. For track mounted machines, the hydraulic drives and controls must be in good working condition as well. For machines that use hydraulic clamps for the pipe, the controls, hoses, and cylinder must be leak free and in good working condition. For the hydraulic carriage travel, the correct cylinder size is essential (see Table 2.1).

Table 2.2. Appropriate support roller model number for fusion machine used as well as the required number of rollers needed to support the fusion process.

<table>
<thead>
<tr>
<th>McElroy Fusion Machine Model Number</th>
<th>Fusion Support Roller – Model Number</th>
<th>Number of Rollers Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>T28/28</td>
<td>812501</td>
<td>2</td>
</tr>
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Figure 2.2. Typical ‘wheeled’ thermal butt fusion equipment for Fusible PVC® pipe.
Section 2
Thermal Butt Fusion

The facer plate (see Figures 2.2 and 2.3) is also hydraulically operated, and on some larger fusion machine models is hydraulically extracted from between the pipe ends after facing. The facer plate must be equipped with blades that will maintain sharpness through multiple facing operations. The facer blades must be positioned for the pipe size being fused and kept free of PVC shavings build-up. All facer stops for both the front and back sides must be the correct size and installed properly.

The heat plate (see Figure 2.4) consists of a heating core with Teflon coated butt plates on both sides. The butt plates must be free of scratches and gouges, free from foreign matter on the surface, and the coating must be intact in the surface contact areas for the pipe size being fused. Larger fusion machine models will have a heat plate, along with a digital temperature controller, designed and fabricated specifically for Fusible PVC® pipe.

**Figure 2.3.** Typical ‘track’ thermal butt fusion equipment for Fusible PVC® pipe.

**Figure 2.4.** Typical heat plate shown (left) next to its storage sleeve and stand. A heat plate with coating damage and residue build-up (right) that SHOULD NOT BE USED.
Section 2
Thermal Butt Fusion

The fusion equipment requires a means to power its functions. Diesel or gasoline is used for fusion machine models that operate under their own power, which is common for larger fusion machine models. Some smaller machines operate directly on electrical power. Some smaller fusion machine models are available in electric, gasoline, or diesel power. Electrical power can be provided on a project by means of a generator or temporary electric power source at the required voltage and amperage. See Table 2.3 for general details on the power needs of fusion machine models.

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Table 2.3. Fusion Machine input needed on the project site. This is to be provided by the contractor on the project.

The contractor for a project is responsible for the following in terms of working with a fusion contractor, sub-contractor or supplier of the thermal butt fusion process:

1. All labor, equipment, and materials required to unload and stage pipe and fusion equipment at the site and as well as restage as necessary throughout the project.
2. All labor, equipment, and materials for loading and unloading pipe into the fusion machine, positioning fused pipe, pipe handling, required pipe testing, and pipe installation.
3. All utilities at the job site including power and diesel fuel for fusion equipment.
4. Any additional labor, equipment, and materials required to fuse based on actual weather conditions.
5. Pipe rollers required for installation and any intermediate fusion joints.
6. All excavation, traffic control, permits, bonds, repairs, etc.

2.3.2 Fusion Datalogger and Joint Recording Specifics

A datalogger (see Figure 2.5) is required to record the pressures and time for each step of the PVC thermal butt fusion process. The datalogger shall be capable of loading and executing the Underground Solutions, Inc. PVC thermal butt fusion software. This software will: 1) calculate correct heating and fusion gage pressures; 2) provide drop down menus for fusion machine selection, pipe size selection, and other fusion joint information; 3) include key step reminders for the fusion procedure; 4) allow the technician to review and confirm correct machine settings; 5) provide a summary plot of pressure versus time for the fusion process; 6) provide an analytical joint review with guidelines for the major pressure and time fusion procedure steps.
Section 2
Thermal Butt Fusion

Figure 2.5. Example Datalogger for use with the thermal butt fusion process for Fusible PVC® pipe.

Under no circumstances shall a fusion technician thermally butt fuse Fusible PVC® pipe without a properly functioning datalogger approved by Underground Solutions, Inc. The fusion technician needs an accurate method to measure the heat plate temperature and cool down temperature. A properly calibrated infrared pyrometer is used for these functions. Under no circumstances shall a fusion technician thermally butt fuse Fusible PVC® pipe without a properly functioning infrared pyrometer approved by Underground Solutions, Inc. Underground Solutions, Inc. recommends that an extra datalogger and an extra infrared thermometer/pyrometer, meeting the requirements of the fusion process, be available at each project site. This provides redundancy should the equipment fail and also provides means to verify the accuracy of the infrared pyrometer (by verifying with the spare).

2.4 General Thermal Butt Fusion Process

Thermal butt fusion joints are started by taking two plain end pieces of Fusible PVC® pipe, loading them into the fusion machine, and clamping them so they are aligned axially to each other. The pipe ends are then faced in the fusion machine, and are heated simultaneously with a properly set heat plate to create a softened layer of PVC material on each pipe end. The softened ends are brought together and held under pressure until the fusion area cools to below 100 °F or 5 °F above ambient pipe temperature, if ambient pipe temperature is above 100 °F. After the first fusion joint is created, subsequent fusion joints are performed on one end of this assembled pipe length until the required length of Fusible PVC® pipe has been assembled.

Each fusion machine has two sets of two jaws that clamp the pipe ends in place. One set of jaws is stationary to the machine. The second set of jaws is on a carriage that moves along the longitudinal axis of the pipe. The pipe ends are brought together and held under pressure for the various steps of the fusion process. When assembling pipe using thermal butt fusion process, individual pipe lengths should be loaded into the moving carriage side of the machine, and the assembled pipe length should be held on the stationary side.
Section 2
Thermal Butt Fusion

Fusible PVC® pipe lengths are loaded into the fusion machine to assemble a longer length of fused pipe with the fusion process. Depending on the weight of the pipe, this may require powered equipment. Individual pipe lengths are typically 45 feet long and will vary in weight based on the diameter and wall thickness of the pipe. Information on individual pipe length weights and pipe bundle weights are available from Underground Solutions, Inc. to allow for the proper sizing of handling equipment. The Underground Solutions, Inc. slide rule provides weights by foot, by length, and by bundle. Information is also available at www.undergroundsolutions.com, as well as in Section 1 – Delivery, Acceptance, Off-Loading, and Storage of Fusible PVC® Pipe. Contact your local Underground Solutions, Inc. representative for more details and to obtain a slide rule.

When handling the pipe lengths as part of movement and loading into the fusion machine, care should be taken to protect the pipe from impact and damage. Care should be taken to identify and eliminate abrasion or damage to the ends of the pipe, either from dragging on the ground or impact damage (see Figure 2.6). The pipe should be free of dirt and other foreign matter, particularly at the ends. If the pipe is damaged as part of handling, remove the damaged section per Underground Solutions, Inc.’s recommendations. When pulling the assembled pipe length from the fusion machine, use the appropriate connection methods for the size and weight of the assembled pipe length. See Section 6 – Pulling Parameters of Fusible PVC® Pipe for details on repairing damage and proper pulling procedures of the assembled pipe length.

Figure 2.6. An example of pipe end damage from impact loading during handling of individual pipe lengths on a project site. Other examples include abrasion damage, scratches, gouges, mud and dirt, and excessive heat.
Section 2
Thermal Butt Fusion

2.5 Production Support for Fusion Process

Providing appropriate equipment and manpower is the best method to achieve desirable results for fusion production. The following information covers some of the basic methods of fusion set up and production, including the best support methods.

2.5.1 Stationary Fusion Method

By far, the most common method of thermal Butt fusion is the stationary method. In this method, a fusion machine is set up in a single location with individual pipe lengths fed into the equipment on the hydraulic carriage and jaws side of the fusion machine. The assembled pipe length is then drawn out of the fixed jaws side of the fusion machine (see Figures 2.7 and 2.8).

Two primary operations are required to support the stationary fusion method. The first operation is the loading of pipe segments into the carriage side of the fusion machine. This requires equipment to handle the individual pipe lengths and load them into the machine, along with an available operator of that equipment. Every fusion joint will require the operator to load one individual pipe length into the fusion machine.

The second operation is the required personnel and equipment to pull the assembled pipe length away from the fusion machine. The equipment must be able to move the longest length of assembled pipe string including all drag forces associated with that movement. Communication capability, such as radios, cell phones or other means, need to be in place to allow the fusion technician at the fusion machine and the operator pulling the pipe string to appropriately position the next fusion joint.

Figure 2.7. Diagram of the stationary fusion method. Individual pipe lengths of Fusible PVC® pipe are fed into the process on the hydraulic carriage and jaws side of the fusion machine. The assembled pipe length is then pulled away from the fusion machine on the fixed jaws side.
Section 2
Thermal Butt Fusion

Figure 2.8. Example of stationary pipe fusion assembly area.

Pulling the assembled pipe lengths away from the fusion machine with equipment should follow the best practices of moving assembled pipe lengths as provided in Section 6 - Pulling Parameters of Fusible PVC® Pipe. Make sure to follow the appropriate recommendations for pulling options used when pulling the pipe length away from the fusion machine. **DO NOT OVER-BEND THE PIPE STRING WHEN PULLING IT AWAY FROM THE FUSION MACHINE.** This is especially critical as pipe diameter becomes larger. Friction reducing rollers or skids may be used to facilitate pulling the pipe string.

On longer pipe length assemblies, higher production is achieved by having separate equipment and operators to load pipe into the fusion machine and to pull the pipe string away from it. A single operator and piece of equipment, such as a front loader, is capable of moving back and forth from each activity on shorter project lengths, but may slow down the fusion production rate when tasked with performing both activities.

### 2.5.2 Fuse-and-Pull Methods

The fuse and pull method also utilizes a stationary fusion machine, but instead of creating assembled pipe lengths that are staged for installation at a later time, the fuse-and-pull method moves the assembled pipe immediately into the final installed position as it is being assembled. This process works very well for constrained layout areas where there is insufficient or limited space for assembled pipe length staging and storage. It also works best for sliplining or direct bury installation methods. There are two types of fuse-and-pull methods, one is “at-grade” fuse-and-pull and the other is “in-pit” fuse-and-pull.

The fuse-and-pull method requires a specific means of pulling the assembled pipe string based on the installation being performed. Information on pull heads and pipe connections for pulling assembled pipe
Section 2
Thermal Butt Fusion

lengths is included in Section 6 - Pulling Parameters of Fusible PVC® Pipe. The fuse-and-pull method still requires individual pipe lengths to be loaded on the hydraulic carriage and jaws side of the fusion machine as indicated in the stationary fusion process description.

2.5.2.1 At-Grade Fuse and Pull Method

The at-grade fuse-and-pull method utilizes a stationary fusion set-up ‘at-grade’ or on the ground surface. The assembled pipe length is then immediately directed and pulled into the final alignment after passing through an insertion excavation or insertion pit. See Figures 2.9 and 2.10 for a diagram and an example of an at-grade fuse-and-pull set up.

Figure 2.9. Diagram of an at-grade fuse-and-pull pipe fusion assembly set up.

Figure 2.10. Project example of an at-grade fuse and pull pipe fusion assembly set up.
2.5.2.2 In-Pit Fuse-and-Pull Method

The in-pit fuse-and-pull method proceeds in the same manner as the at-grade fuse-and-pull method, however, the fusion machine is set up in an excavation pit to better facilitate the insertion of the pipe (see Figures 2.11 and 2.12).

**Safety Alert!** Whenever fusion is performed in a subterranean and/or confined space, safety protocol related to confined space entry must be followed. These requirements can be found in the OSHA Standard, “Permit Required Confined Spaces,” Subpart J, CFR 29 1926, Subpart AA.(2)

![Diagram of an in-pit fuse-and-pull pipe fusion assembly set up.](image)

The individual pipe lengths, which can be modified depending on the excavation or pit size, are fed into a static machine positioned in-pit. The assembled pipe string is then pulled away from the stationary machine directly into a slipline or jack and bore casing installation.
Section 2
Thermal Butt Fusion

Figure 2.12. Project example of an in-pit fuse-and-pull pipe fusion assembly set up.

There are several important items required when using the in-pit fusion method on projects:

1. The excavation or pit should be appropriately sized for the fusion equipment to be used. See Figure 2.17 and Table 2.4 at the end of this section for specific information on the required pit size for a given fusion machine, and the length of pipe used to complete the fusion joints. Ensure the free and clear distance in between any required trench box or shoring meets these minimum dimensions based on the fusion machine being used.

2. The excavation size will also limit the individual length of pipe that can be loaded into the fusion machine. Since pipe is delivered to the project site in 40 or 45-foot individual pipe lengths, it is desirable to have an excavation pit that can be used to fuse lengths that are either this long, or are evenly divisible into these lengths. For instance, if 45-foot pipe lengths cannot be accommodated, then 22.5 foot lengths should be considered and the individual pipe lengths can be cut in half. If 22.5 foot lengths are too long, then the 45 foot lengths can be cut into thirds to make 15 foot lengths.

3. **Safety Alert!** Appropriate safety measures must be provided for the fusion technician working within the excavation. This includes shoring, fresh air circulation, fall hazard
Section 2
Thermal Butt Fusion

2.5.3 Intermediate Fusion Joints

Where there is not enough space on a project to completely assemble the required pipe length to be installed, two or more pre-assembled pipe lengths may be joined together with a thermal butt fusion joint during installation. This is called an intermediate fusion joint. Intermediate fusion joints vary from production fusion joints in that they require the movement of a length of pipe longer than 40 or 45 feet with the hydraulic carriage and jaws as part of the fusion procedure. The fusion machine has hydraulic capacity to handle higher drag forces on the hydraulic carriage and jaws side. There is a limit to how much drag force can be provided, which limits the length of pipe that can be to be joined using this method. Pipe rollers are recommended on the hydraulic carriage and jaws side pipe length to reduce drag during the fusion procedure.

Contact your Underground Solutions, Inc. representative for assistance in planning for intermediate fusion joint assemblies for a project. Often, preplanning methods for eliminating the requirement of an intermediate fusion joint can be recommended.

More information regarding intermediate fusion process for Fusible PVC® pipe can be found in Operational Bulletin OB-8-275 – “Recommended Intermediate Fusion Procedures for Fusible PVC® Pipe”.(3)

2.6 Special Requirements for the Butt Fusion Process

2.6.1 Warm Weather Fusion Information

Most underground pipeline construction work is performed in the warmer months, and can even take place in temperatures that exceed 110 °F. When fusing pipe in warmer temperatures or prolonged sunshine, cool down times for fusion joints will be longer than in colder weather.

Using a canopy or pop-up enclosure to shade the fusion machine and the fusion joint (see Figure 2.13) can help reduce cool down times and limit high pipe surface temperatures.
Section 2
Thermal Butt Fusion

Figure 2.13. Example of fusion area protection using a canopy during warm, sunny weather.

Important: UGS does NOT allow or recommend any method to accelerate joint cooling, including 1) the use of fans directed at the joint, 2) the use of water or water soaked rags, or 3) any other means of accelerating the cooling of the joint. The joint must cool uniformly across the thickness of the pipe. Artificial cooling methods only act to cool the outside of the pipe and joint, while the inside remains insufficiently cooled. The only way to ensure a consistent, integral joint is to allow the pipe and fusion to cool under ambient conditions to the required temperature.

2.6.2 Cold Weather Fusion Requirements

Because the fusion process is a thermal process, there are minimum requirements for the temperature variations on a project. One such situation is excessively cold weather.

Pipe to be fused should be maintained at a minimum temperature of 40°F or higher. If the pipe is colder than 40°F, it should be preheated before the fusion process. Likewise, the fusion environment should also maintain a minimum temperature of 40°F during the thermal butt fusion process. There are various methods to ensure that the pipe and fusion process are maintained at the correct minimum temperature. All involve supplying heat to the pipe and fusion environment. See Figure 2.14 for an example of a cold weather fusion process enclosure and heater.

More detailed information regarding cold weather fusion procedures for Fusible PVC® pipe can be found in Operational Bulletin OB-8-274 – “Cold Weather Fusion.”(4)
Section 2
Thermal Butt Fusion

2.6.3 Inclement Weather Fusion Requirements

Foreign matter and water are detrimental to the fusion process and must be eliminated from the joint at all times. The biggest threat from foreign matter and water on a project site comes from inclement weather. Rain and snow must be kept out of the fusion process. Dust, dirt and other foreign matter must be prevented from blowing into the fusion process during wind events.

Some weather events will require the fusion process to be suspended. The licensed fusion technician should be given the flexibility to decide when it is appropriate for producing quality fusion joints and when it is necessary to suspend fusion activity until inclement weather has subsided.

When it is appropriate to continue the fusion process in inclement weather, adequate protection for the fusion process is often achieved with a simple protective enclosure set up around the fusion machine work area. Pop-up canopies generally provide adequate protection from rain and most snow events. Side protection, provided by tarps or other more robust enclosure type elements, will protect the fusion process from wind born water or foreign matter. See Figure 2.15 for an example of a thermal butt fusion protection enclosure from inclement weather.
2.6.4 Removal of the Fusion Bead or ‘Debeading’

The excess material that forms on the internal and external surface when the bead is created is not integral to the structural integrity of the fusion joint and can be mechanically removed if so desired. Removing the bead, whether internally or externally, adds certain steps and requirements to the fusion process.

2.6.4.1 External Debeading

Removing the bulk of the external bead generally does not add any time or cost to the fusion joint process. While the fusion joint is cooling in the fusion machine, the fusion technician can remove the bead on the joint that has just been completed (see Figure 2.16).

Figure 2.15. Example of a snow and wind protection enclosure used to protect the fusion process.
Section 2
Thermal Butt Fusion

The bead should be removed with a motorized, high speed router, equipped with a flat bottomed, rotating router bit to remove the bulk of the bead by machining the plastic. Underground Solutions, Inc. recommends leaving 1/8” to 1/4” of the bead at the surface of the pipe. A jig can be set up on the router to ensure that the required material is removed while protecting the joint and pipe from damage (see Figure 2.16).

Debeading the external fusion joint beads is not required, but can be helpful for pipe handling and movement, such as when the fused pipe string slides over uneven surfaces or along the ground. It is also advantageous for installation methods such as sliplining, pipe bursting, or horizontal directional drilling (HDD) – where the external bead could increase drag if it were present.

2.6.4.2 Internal Debeading

Removing the bead on the inside of the pipe is not required for water and wastewater pressure applications. For pressurized flow, the bead has virtually no impact on the hydraulics of the pipeline when using a ‘C’ factor of 150 for flow estimates. See Technical Bulletin TB 8-546 – “Internal Fusion Bead Hydraulics”(5) for more detailed information regarding the impact of the internal bead on pressurized flow and hydraulic losses. For non-pressure flow at typical slopes, the bead also has minimal bearing on the flow carrying capacity of the pipeline. Underground Solutions, Inc. does NOT recommend internal debeading in these applications.

In cases where internal debeading is required, it is accomplished with equipment specifically designed for the internal debeading of PVC pipe. Internal debeading is often required for electrical...
Section 2
Thermal Butt Fusion

conduit applications involving cable or wire installation, or casing pipe installations, and is available for these uses. Contact your local Underground Solutions, Inc. representative for more information on internal debeading.
Figure 2.17. Diagram of minimum pit dimensions required for in-pit fusion of Fusible PVC® pipe.
## Section 2
### Thermal Butt Fusion

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*The “Clear Height” is the room required above the fusion machine to operate it effectively, including jaw, heat plate, and facer plate swing paths, if required.

Table 2.4. Pit dimensions required for in-pit fusion of Fusible PVC® pipe based on individual starting stock pipe length. All measurements are in feet. See Figure 2.17 for graphical representation of measurements.
Section 2
Thermal Butt Fusion

References


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This document does not purport to address all of the safety concerns, if any, associated with the handling, installation or use of Fusible PVC® pipe or with the various application techniques described herein. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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3.0 Fusible PVC® Pipe Connections

Fusible PVC® pipe is joined together using butt-fusion joints, however, it may be necessary to utilize other connections to integrate Fusible PVC® pipe sections into an overall pipe system. There are two ways to make pipe to pipe connections, one is to use a fitting, and the other is to use an appropriately sized bell of another pipe. This section will cover these methods of connecting Fusible PVC® pipe to other pipe sections and also cover other forms of connections specific to PVC pipe itself.

General information regarding PVC pipe connections is available from the Handbook of PVC Pipe (1), American Water Works Association documents C605 (2) and M23 (3), and other sources.

**The Most Important Items When Making Connections:**

1. Follow all safety precautions when moving, lifting, supporting pipe, and making connections.
2. Make sure that connections are properly sized and coordinated with the requirements of the installation, including restraint, pressure carrying capacity, and type.
3. Thrust restraint for Fusible PVC® pipe and the connections used with it should be considered based on the overall system design. Fusible PVC® pipe is a restrained system that transfers thrust to the connections at either end of an installation. All connections must be designed and installed to handle the maximum anticipated operating and test loading.
4. All fittings and connection types must be installed per the manufacturer’s requirements and recommendations.

**Safety First!**

Always follow the requirements and recommendations, as well as the cautions and warnings, of the manufacturer of the connections being used.

Fusible PVC® pipe, both as delivered to the project site and when assembled into long lengths represents a large, heavy material that requires attention during handling, movement, and installation on a project site. Moving lengths of pipe improperly creates a hazard that can result in personal injury or even death. Always follow best practice safety procedures as provided by Underground Solutions, Inc., as well as all entities having jurisdiction for the project.

3.1 Fittings

Appropriately sized fitting(s) or coupler(s) can be used to connect two lengths of pipe. Fittings can also be designed to create a bend, to transition from one pipe diameter to another, or to provide for another pipe connection - such as a ‘tee’ fitting.

3.1.1 Typical Fittings for Pressure Pipelines
Section 3
Fusible PVC® Pipe Connections

Fusible PVC® pipe systems use standard fittings for pressure pipelines that utilities typically have in stock and their crews are readily trained to install.

3.1.1.1 Ductile Iron Fittings

PVC water pipe standards, particularly waterworks pipe standards, include ductile iron pipe sizes, that is, outside diameters that coincide with those for ductile iron pipe. It is very common to use ductile iron fittings with PVC pressure pipe systems. Ductile Iron fittings for use with PVC are typically specified to AWWA/ANSI C110/A21.10(4) or AWWA/ANSI C153/A21.53(5), as well as AWWA/ANSI C111/A21.11(6).

Applicable ductile iron fittings may include compact bends, reducers/increasers, tees, wyes, end caps, solid sleeve connectors, repair couplings, and others. Ductile iron fittings should be sized to match the PVC pipe diameter and pressure capability as required for the project.

Ductile iron fittings come with one of two connection types that are applicable with Fusible PVC® pipe; the most common is a mechanical joint, the second most common is a flange joint.

If linings and coatings are used to inhibit corrosion on a ductile iron fitting, always make sure that the lining or coating does not interfere with the connection of the pipe.

3.1.1.1.1 Mechanical Joint

The mechanical joint has a bell-type insertion point that accepts the pipe to be connected and includes a gasket that provides for a watertight seal. This gasket is pressed against the pipe and fitting with the use of a follower or retainer gland to effect the internal pressure seal (see Figure 3.1).
Section 3
Fusible PVC® Pipe Connections

Figure 3.1. Example of a mechanical joint ductile iron fitting with a standard mechanical joint follower, or retainer gland.

Mechanical joints may be unrestrained or restrained. Use of a normal follower or retainer gland only seals the gasket and does not provide restraint (Figure 3.1). Use of a restrainer gland, which seals the gasket and also grips the pipe to restrain the fitting from sliding off the end of the pipe, provides a restrained joint (see Figure 3.2 and 3.3). There are several types along with several different manufacturers of these restrained glands depending on the size of the pipe and required application. Always follow the manufacturer’s installation and assembly recommendations for their use with PVC pipe.
Ductile iron fittings are typically sized for ductile iron pipe. IPS sized Fusible PVC® pipe can be joined to ductile iron fittings by using a transition gasket in certain sizes. Several manufacturers, such as Romac Industries, Inc., have gaskets that will bridge the slight outer diameter differences from ductile iron size to IPS size pipe. However, always contact the manufacturer for appropriate sizes and availability as not all diameters can be accommodated with a transition gasket alone.

### 3.1.1.1.2 Flanged Joint

A flanged joint uses a flat-faced ring (flange) that accepts another matching flat-faced flange to join the pipes. A gasket between the two flanges provides for a water-tight seal when they are bolted together. For PVC pipe, the matching flat-faced ring that makes the flange connection and seals to the pipe is called a flange coupling adaptor (FCA) (see Figure 3.4).
Section 3  
Fusible PVC® Pipe Connections

Figure 3.4. Example of a Fusible PVC® pipe flanged joint connection, using an FCA.

The bolted together flanges restrain the joint, however, the FCA must also be restrained to the PVC pipe for the composite connection to function as a restrained joint.

There are several types of FCA’s along with manufacturers depending on the size of the pipe and required application. Always follow the manufacturer’s recommendations for all products including applicability for use with PVC pipe and proper installation.

3.1.1.2 PVC Pressure Pipe Fittings

PVC pressure pipe fittings are available for use with PVC pipe, including Fusible PVC® pipe products. There are two types of connection methods for PVC pressure pipe fittings. The first is to utilize a gasket that seals between the pipe and fitting and effects the internal pressure seal. The second is to utilize a solvent cement joint with an interference fit fitting to provide the required internal pressure seal.

3.1.1.2.1 Gasketed Joint

PVC pressure pipe fittings that utilize a gasket seal are specified in AWWA C900 (7) and AWWA C905 (8), and are included in other standards as well (see Figure 3.5). These fittings can be size and pressure capacity limited and therefore may not apply to all sizes and pressure classes of Fusible PVC® pipe available. They are also not restrained. In order to
Section 3  
Fusible PVC® Pipe Connections

restrain a gasketed PVC fitting, mechanical harness type restraints and/or thrust blocks must be used.

Figure 3.5. Example of a gasketed PVC fitting.

There are several manufacturers of gasketed PVC pressure pipe fittings and several different types and manufacturers of restraint hardware. Always follow the manufacturer’s recommendations for all products including applicability for use with PVC pipe and proper installation.

3.1.1.2.2 Solvent Cement Joint

Solvent cement-able PVC pressure pipe fittings may be used when specified (see Figure 3.6). These fittings are size and pressure capacity limited and therefore may not apply to all sizes and pressure classes of Fusible PVC® pipe available. Specifications for solvent cement joining procedures must be followed and include ASTM D2855 (9) and ASTM D2672 (10).

Figure 3.6. Example of a solvent cement joined PVC pressure pipe fitting.
Solvent cement joints must be carefully evaluated to ensure that their restraint capability is sufficient to handle the maximum anticipated pressures, loads, and/or stresses for a given application.

**NOTE:** Solvent cement joining depends on the field application, solvent cement selection, and joining method being followed. This is particularly true as the size of the joints increases (diameter) and conditions in the field become less favorable for the process (colder temperatures, precipitation, etc.). Only those trained with solvent cement joining should attempt these types of pipe connections. There are several types and manufacturers of solvent cement PVC pressure pipe fittings. **Always follow the manufacturer’s recommendations for all products including applicability and proper installation.**

### 3.1.1.3 Fusible PVC® Pipe Sweeps

Underground Solutions, Inc. presently provides fusible sweeps in diameters up to 16-inches and direction changes up to 22 ½° for use with Fusible PVC® pressure pipe systems (see Figure 3.7). When thermally butt fused to segments of Fusible PVC® pipe, sweeps accommodate tight-radius bends in the pipeline alignment. Check with Underground Solutions, Inc. for availability and application.
Figure 3.7. Fusible sweeps used in an alignment of Fusible PVC® pipes.

Fusible sweeps have specific application and require preplanning and construction sequencing to utilize them effectively. Work closely with your Underground Solutions, Inc. representatives to assure that fusible sweeps are planned for and utilized correctly. Contact your local Underground Solutions, Inc. representative for more information regarding fusible Sweeps.

3.1.1.4 Specialty Fittings

Other types of fittings are available to connect to Fusible PVC® pipe. These are designed to join the pipe to other specific pipe materials, pipe configurations, or existing systems. Some are used to allow for valve installation (see Figure 3.8). Others may be used to accommodate specific operational loadings such as deflection and expansion.
3.1.2 Typical Fittings for Non-Pressure Pipelines

Fusible PVC® pipe systems utilize standard fittings for non-pressure pipelines. Most owners and utilities stock these fittings and have crews that have already been trained for installing them, much like the pressure fitting applications.

3.1.2.1 PVC Non-Pressure Pipe Fittings

PVC non-pressure pipe fittings are prevalent for use with PVC pipe, including sewer-dimensioned Fusible PVC® pipe products. They are commonplace and readily available for use in PVC non-pressure systems. There are two types of connection methods for PVC non-pressure pipe fittings. The first, and most common, is to use a gasket that seals between the pipe and fitting and the second is to use a solvent cement joint to seal the pipe and fitting connection.
Section 3
Fusible PVC® Pipe Connections

3.1.2.1 Gasketed Joint

PVC non-pressure pipe fittings that use a gasket seal are specified in the non-pressure pipe standards for PVC pipe - ASTM D3034(11) and ASTM F679(12), and in ASTM F1336.(13) These fittings can be size limited and may not apply to all sizes and stiffnesses of pipe available.

There are several manufacturers of gasketed PVC non-pressure pipe fittings. Always follow the manufacturer’s recommendations for all products including applicability and proper installation.

3.1.2.1.2 Solvent Cement Joint

PVC non-pressure pipe fittings that utilize a solvent cement seal are specified in ASTM standards D3034 and F1336. These fittings can be size limited and may not apply to all sizes and stiffnesses of pipe available.

There are several types and manufacturers of solvent cement PVC non-pressure pipe fittings. Always follow the manufacturer’s recommendations for all products including applicability and proper installation.

NOTE: Solvent cement joining depends on the field application, solvent cement selection, and joining method being followed. This is particularly true as the size of the joints increases (diameter) and conditions in the field become less favorable for the process (colder temperatures, precipitation, etc.). Only those trained with solvent cement joining should attempt these types of pipe connections. There are several types and manufacturers of solvent cement PVC pressure pipe fittings. Always follow the manufacturer’s recommendations for all products including applicability and proper installation.

3.1.2.2 Fusible PVC® Pipe Fusible Sweeps

Fusible sweeps may be used on non-pressure Fusible PVC® pipe systems. See the information contained in the pressure pipe section for more details on fusible Sweeps.

3.1.2.3 Specialty Fittings

Other types of fittings are available to connect Fusible PVC® non-pressure pipe. Various fittings are designed to connect to other types of pipe materials or existing systems, or to accommodate specific operational loading such as deflection and expansion capability.

All of these specialty fittings typically use the same types of connections as described in the non-pressure pipe fitting section. Attention should be paid to connection type requirements and
Section 3  
Fusible PVC® Pipe Connections

specific applications. Always follow the manufacturer’s recommendations for all products including applicability, proper design loading, and proper installation.

3.2 Bell-end Pipe

One of the inherent advantages of using Fusible PVC® pipe is that it is made to the same standards as other PVC pipe systems. This allows Fusible PVC® pipe to be mechanically joined directly to other PVC pipes as long as they are made to the same diameter size and standard of manufacture.

Connecting Fusible PVC® pipe directly to another PVC pipe of the same diameter size and standard of manufacture is relatively easy. As with any field cut PVC pipe, the following steps must be followed: 1) bevel the end of the Fusible PVC® pipe to match that of the spigot end of the receiving pipe; 2) place an insertion mark or witness line on the Fusible PVC® pipe end – the location of the mark must match that of the pipe to which it will be connected and is determined by measuring the location of the insertion mark on the spigot end of the receiving pipe; 3) use the recommended, approved PVC pipe joint lubricant to lubricate the spigot end of the Fusible PVC® pipe; and 4) insert the pipe spigot end into the bell end, stopping when the lip of the bell-end aligns with the insertion/witness mark. Typically, the pressure class or stiffness of the receiving bell-end pipe is the same as that of the Fusible PVC® pipe. If Fusible PVC® pipe is being inserted into a bell of a pipe other than PVC, the Fusible PVC® pipe spigot end may still need to be field chamfered or beveled on the end. Be sure to follow the instructions of the belled pipe producer for details on making an appropriate field bevel and insertion depth.

Underground Solutions can provide bell sections, which when fused to the end of a Fusible PVC® pipe string, allow for a bell-to-spigot connection (see Figure 3.9). Always obtain the proper insertion/witness line depth for marking the adjoining pipe spigot from Underground Solutions, Inc. Then follow the spigot-to-bell end assembly instructions above. General information regarding the assembly of gasketed bell and spigot pipe is also provided in the PVC Pipe Association Handbook of PVC Pipe. Bell-end Fusible PVC® pipe is not a stock item and must be ordered for projects that require its use.
3. Fusible PVC® Pipe Connections

Fusible PVC® pipe may also be inserted into the bell of the same size outer diameter ductile iron pipe. If this is attempted, the spigot end of the Fusible PVC® pipe should not be chamfered, but only rounded, and the spigot should be bottomed out in the ductile iron bell – in other words, fully inserted. Do not insert a ductile iron pipe spigot into a PVC pipe bell under any circumstances. More information is available regarding this type of connection between PVC pipe and ductile iron pipe in the Handbook of PVC Pipe, Section 10.3.3, and the PVC Pipe Association Technical Brief, “Transitioning Between Ductile Iron and PVC Pressure Pipes.”

3.3 Important Information Regarding Thrust Restraint Design with Fusible PVC® Pipe

Fusible PVC® pipe systems are used for many different types of applications, not just direct bury projects. When using Fusible PVC® pipe for pressure applications, careful evaluation should be performed regarding thrust force design, particularly if the restrained sections that are being counted on for pipe to soil friction resistance are installed in areas or by methods that limit or eliminate pipe to soil friction contact, such as installation in an empty casing. If the application involves HDD, slipline or casing installations without a treated annulus, or pipe bursting, verification should be performed that the required thrust design is adequate.

The fusion joint of Fusible PVC® pipe systems is a fully restrained joint. Connections to fittings and other pipe sections must be restrained if required to balance thrust forces. In addition to thrust forces that result from internal pressure, consideration should also be given to thermal loading, Poisson effect loading from internal pressure, and potential residual installation loading.

Contact your local UGS representative for more information and to verify if thrust forces are properly considered for the installation at hand.
3.4 Tapping and Other Connections to Fusible PVC® Pipe Systems

Tapping Fusible PVC® pipe is covered specifically in Section 5 – Tapping Fusible PVC® Pipe. Please refer to this section for specific information about this type of connection.

If other connection methods or types are being considered, please contact your local Underground Solutions, Inc. representative for more details and recommendations.
Section 3
Fusible PVC® Pipe Connections

References


(14) PVC Pipe Association Technical Brief, “*Transitioning Between Ductile Iron and PVC Pressure Pipes.*” Uni-Bell PVC Pipe Association, Dallas, TX. Online: [www.uni-bell.org](http://www.uni-bell.org).
Section 3
Fusible PVC® Pipe Connections

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This document does not purport to address all of the safety concerns, if any, associated with the handling, installation or use of Fusible PVC® pipe or with the various application techniques described herein. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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Section 4
Testing and Disinfection

4.0 Field Testing of Installed Fusible PVC® Pipe

This section covers field testing of installed PVC pipe and includes items that are specific to Fusible PVC® pipe. Three general types of testing are covered: (1) field hydrostatic testing; (2) field leakage testing; and (3) field deflection testing. The basic principles of post-installation, field testing are covered in various standard industry publications (see Table 4.1). Field hydrostatic pressure and leakage testing for PVC pressure pipelines is described in detail in AWWA C605 and AWWA M23. Field leakage testing for non-pressure PVC pipelines is described in detail in ASTM F1417 and Uni-Bell PVC Pipe Association Uni-B-6. Deflection testing for non-pressure pipelines is described in the Handbook of PVC Pipe and Uni-Bell Technical Report 1 (UNI-TR-1).

<table>
<thead>
<tr>
<th>Pipe Testing Types and Corresponding Standards</th>
<th>Applicable Standard(s)</th>
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</thead>
<tbody>
<tr>
<td>Field hydrostatic pressure and leak testing</td>
<td>AWWA C605(1) &amp; AWWA M23(2)</td>
</tr>
<tr>
<td>Field leakage testing – non-pressure pipe</td>
<td>ASTM F1417(3) &amp; Uni-Bell PVC Pipe Association Uni-B-6(4)</td>
</tr>
<tr>
<td>Deflection testing</td>
<td>Handbook of PVC Pipe(5) &amp; UNI-TR-1(6)</td>
</tr>
</tbody>
</table>

Table 4.1. Various testing types and corresponding reference standards for use with Fusible PVC® pipe.

The Most Important Items When Field Testing Installed Pipe:

For field hydrostatic and leakage testing of pressure pipelines:
1. Safety is the first priority. All safety precautions must be followed.
2. Take precautions to eliminate free air inside the pipe, including attention to filling sequence, air relief valves, flushing, and other best practices. Excessive test pressure pumping times can be a sign of entrapped free air.
3. Prepare a plan for all field testing that covers procedure, communication, labor assignments, and contingencies.
4. Test trenchless sections of an installation BEFORE they are connected to the existing pipe system.

For field leakage and deflection testing in non-pressure pipelines:
1. Safety is the first priority. All safety precautions must be followed.
2. Prepare a plan for all field testing that covers procedure, communication, labor assignments, and contingencies.

Safety First!

Fusible PVC® pipe, both as delivered to the project site and when assembled into long lengths represents a large, heavy material that requires attention during handling, movement, and installation on a project site. Moving lengths of pipe improperly creates a hazard that can result in personal injury or even death. Always follow best practice safety procedures as provided by Underground Solutions, Inc., as well as all entities having jurisdiction for the project.
4.1 Field Hydrostatic Testing

Field hydrostatic testing is completed by applying an internal pressure to a pipeline for a set period of time. For pipeline installations using trenchless methods, it is recommended that the field hydrostatic test be completed on the trenchless section BEFORE connection to the rest of the pipeline system. Field hydrostatic testing should only be performed after the pipeline has been completely installed. The primary guidance documents for field hydrostatic testing of PVC pressure pipe include AWWA C605, AWWA M23, and the Handbook of PVC Pipe.

**AT NO TIME SHOULD AIR BE USED FOR A HIGH PRESSURE TEST. COMPRESSED AIR REPRESENTS A STORED ENERGY SOURCE THAT MAY CREATE AN INHERENT SAFETY HAZARD AND CAN LEAD TO CATASTROPHIC PIPELINE FAILURE, PERSONAL INJURY, OR DEATH DURING THE TEST.**

4.1.1 Basis of the Field Hydrostatic Test

The two primary testing requirements for a field hydrostatic test are: 1) a required internal pressure; and 2) the length of time the pressure must be held. The required pressure and testing time should be confirmed with the owner or its designated representative.

4.1.1.1 Determination of Field Hydrostatic Test Pressure

AWWA C605 states, “The hydrostatic pressure test shall not be less than 1.25 times the stated anticipated maximum sustained working pressure of the pipeline measured at the highest elevation along the test section and not less than 1.5 times the stated sustained working pressure at the lowest elevation of the test section. However, in no case shall the test pressure exceed the rated working pressure for any joint, thrust restraint, valve, fitting or other connected appurtenance of the test section.”

The appropriate test pressure is based upon the maximum sustained working pressure of the pipeline as defined above in AWWA C605. The maximum sustained working pressure is unique to each project, pipeline, and utility system.

The range of field hydrostatic testing pressures recommended by AWWA C605 provides for potential elevation changes in the pipeline and the subsequent pressure variations. The test pressure in the pipe is a combination of: 1) the dynamic pressure generated by the test pump; plus 2) the static pressure generated by water column weight associated with elevation changes along the pipeline. For clean water, every 2.31 feet of elevation change above the low point in the pipeline adds an additional 1 psi of head pressure at the low point in the pipeline. Static head pressure can be calculated based on the elevation difference between the low or high point in the pipeline and the test gauge location using Eq. 4.1.

\[
\text{Static Pressure Difference (psi)} = \left( \frac{\text{Elevation of Test Gauge (ft)}}{2.31} \right) - \left( \frac{\text{Elevation of High or Low Point (ft)}}{2.31} \right)
\]

Eq. 4.1
For example, if the test pressure is 150 psi at a low point elevation of 1,000 ft. and the pipe test gauge location is at an elevation increase of 23.1 feet to elevation 1,023.1 ft., the pressure difference will be -10 psi (1,000 ft. – 1,023.1 ft. = -23.1 ft / 2.31 = -10 psi) at the high point test location, therefore it will see a total pressure of 140 psi (150 psi – 10 psi = 140 psi). Likewise, if the pipe test gauge location pressure is 150 psi at a high point, such as at one end of a horizontal directional drill (HDD) installation at elevation 1,046.2 ft., and the pipe has a low point elevation at the bottom of the installation of 1,000 ft., the pressure difference will be +20 psi (1,046.2 ft. – 1,000 ft. = 46.2 ft. / 2.31 = 20 psi), and therefore the low point will see a total test pressure of 170 psi (150 psi + 20 psi = 170 psi).

4.1.1.2 Determination of Field Hydrostatic Test Duration

AWWA C605 states, “The duration of the hydrostatic test shall be 2 hr.” The required test time should be confirmed with the owner or its designated representative.

4.1.2 Preparation for Field Hydrostatic Test

The pipeline to be tested is installed in its final alignment. As such, the pipeline will be properly bedded, backfilled, and appropriate thrust restraint(s) installed as necessary. All free air must be removed or vented from the pipeline prior to the test. A close inspection of the pipeline prior to field hydrostatic testing is required to be sure that all project specifications for installation and testing have been met.

All free air in the pipeline must be removed prior to the field hydrostatic test. This is a universal safety requirement, regardless of pipe material, and is the single most important step to ensure the safe field hydrostatic testing of any pressure pipeline. Similar guidance is provided by the design and installation manuals that govern other pipe material use and hydrostatic testing.\(^7\)\(^\text{11}\)

4.1.2.1 Required Pipeline Preparation

The pressure test is conducted after final installation of a Fusible PVC® pipeline. The pipeline should be installed and, in the case of direct-bury construction, completely backfilled. In some cases, properly restrained mechanical connections made to the pipe may be left exposed to verify visually that they are not leaking during the test. With horizontal directional drilling, pipe bursting, and slipline applications, the pipe installation is completed and the pipe ends are left exposed.

If the pipeline requires service connections, taps, air release valves, or other appurtenances, these should be installed prior to the test. The determination of which appurtenances to include in the test is based on the rating of the in-line or attached fittings or devices. The published pressure capacity or capability of each component must be reviewed to determine if it can safely handle the test pressure. If an appurtenance is not rated to handle the required test pressure, it should be removed or isolated during the test. In situations where the appurtenance cannot be removed or isolated, the test pressure should be lowered to accommodate the appurtenance. For example,
Section 4
Testing and Disinfection

a pressure relief valve that, by design, is set to release at a pressure slightly above operating pressure but less than the required testing pressure will dictate that a reduced test pressure be used.

All thrust restraining devices in the pipeline must be rated to handle the test pressure and be installed and be operational prior to the pressure test. Thrust blocks should be properly cured, and restraint harnesses or glands properly installed per the manufacturer’s instructions. If the pipeline relies on soil-to-pipe frictional drag to engage the thrust restraint mechanism, the pipeline must be properly bedded and backfilled (see Figure 4.1).

Pipeline movement from improperly installed or designed thrust restraints may cause damage up to, and including, pipeline failure and could be an inherent safety risk for personnel performing the test.

Consideration must be given to the end caps that are used for isolating a portion of the pipeline for the test to be conducted. Use of restrainer glands is appropriate, but, if restrainer glands are not used, proper thrust restraint MUST be provided to counteract the internal pressure in the pipeline at the location of the end caps. For example, a 150 psi pressure test on a 12-inch PVC water line generates over 16,000 pounds of axial thrust at the end cap.

Figure 4.1. Illustration of several fitting locations, exposed to determine potential leakage, but properly restrained to mitigate thrust forces.
4.1.2.2 Removal of Free Air from the Pipeline

**ALL FREE AIR MUST BE REMOVED FROM THE PIPELINE PRIOR TO TESTING. AIR IS COMPRESSIBLE, PRESENTING A POTENTIAL SAFETY HAZARD DURING THE TEST THAT CAN LEAD TO CATASTROPHIC PIPELINE FAILURE.**

Excess free air in the line during the field hydrostatic test is an important safety concern. Air and/or gases are compressible. If a failure occurs during the pressure test, the energy stored in the compressed air/gas creates a serious safety hazard. Catastrophic pipeline failure may result. Testing hardware may become compromised during a test and create a safety hazard.

Excess free air in the pipeline will also make conducting and passing the pressure test more difficult. Air changes significantly in volume with changes in pressure. Conversely, water changes little in volume under changes in pressure. The most common indicator of excessive free air in the pipeline being tested is the length of time it takes for a test pump to reach test pressure. Test pressure is normally reached within a few minutes in a properly filled and vented pipeline. A test pump running for an extended period below test pressure is a sure sign that the pipeline needs to be purged of free air before continuing with the field hydrostatic test. **IN THAT CIRCUMSTANCE, REMOVE THE PRESSURE COMPLETELY AND EVACUATE THE ENTRAPPED FREE AIR BEFORE PROCEEDING.**

4.1.2.2.1 Venting Free Air from the Installed Pipeline

Venting is accomplished when the line is initially filled with water and is the process by which free air is allowed to escape from the pipeline. **It is important to fill the pipeline slowly to allow the free air to be vented and avoid entrapment. AWWA C605 recommends a maximum filling velocity of 1 foot per second (fps). Filling should take place starting at the low point in the pipeline and proceed to the highest point.** See Tables 4.3 and 4.4 at the end of this section for maximum filling rates for common pipe sizes.

Venting should take place at all high points in the pipeline as well as end caps, testing hardware, and/or other locations as appropriate. Air relief or release valves, if installed as part of the pipeline project, should be checked to make sure they are functioning if used to vent free air during the pressure test. Corporation valves may also be installed at appropriate locations to manually release free air pockets that may develop (see Figure 4.2). Unvented high points should have a temporary air release valve added to assure proper venting.
Section 4
Testing and Disinfection

Proper venting of the pipeline during the initial filling operation will minimize the flushing and incremental free air removal required prior to testing.

![Image](image)

**Figure 4.2. Utilizing a corporation stop at a tap location to vent free air from a pipeline prior to testing.**

When filling a typical ‘U’ shaped pipe profile alignment often encountered with HDD installation methods (if the pipeline was not completely filled using a ballasting operation during installation), the line should be filled slowly to allow for as much free air as possible to escape at both ends of the installation. **It is always a best practice to rigorously flush an HDD installation to remove as much of the potentially entrapped free air along the bottom of the alignment as possible.**

### 4.1.2.2 Flushing Free Air from the Installed Pipeline

After filling the pipeline at 1 fps, flushing the pipeline moves water through the pipe at a high enough velocity to move remaining free air and free air pockets to vent locations. **AWWA C605 recommends a minimum flushing velocity of 3 fps to adequately flush free air pockets.** AWWA C605 also recommends a minimum of 3 volume changes be used during the flushing process. See Tables 4.3 and 4.4 at the end of this section for minimum flushing rates for common pipe sizes. This means that if the pipeline holds 30,000 gallons of water when filled, the volume of water used during the flushing exercise should be at least 90,000 gallons, and it should be applied at the correct flushing rate to achieve the correct velocity in the pipeline. Reference Tables 8.3 and 8.4 of Section 8 – Horizontal Directional Drilling Installation with Fusible PVC® Pipe for more information on water volumes corresponding to various sizes of Fusible PVC® pipe. Flushing operations should be stopped several times, such as after a single volume change has been completed. This
Section 4
Testing and Disinfection

allows the free air that has moved along the pipeline by the flushing to accumulate at the high points and be vented. The length of the stoppage during flushing can vary by pipe volume and alignment, but a minimum guideline is 1 hour. It is common practice to let the pipeline sit overnight as one stoppage, for example.

If not done while the system is connected, flushing operations require an approved disposal method for the flushed water. The recommended flushing procedures in AWWA C605 and AWWA M23 should be followed.

If the standard recommended venting and/or flushing velocities cannot be achieved, other means of removing free air from the pipeline will need to be used. This may include the use of a soft foam “pig” or swab that is forced through the pipeline with water to push out the free air. See Section 12 – Ongoing Maintenance and Special Installations with Fusible PVC® Pipe for more details. Contact your Underground Solutions, Inc. representative if you are unsure about how to safely flush free air out of the pipeline.

4.1.2.2.3 Testing Hardware Set Up and Ensuring Free Air Removal

Normally, testing is done with the pipeline isolated from the balance of the system. To do this, end caps with taps for filling or draining water, measuring pressure, and connecting the test pump must be installed along with appropriate restraints (see Figure 4.3).

![Figure 4.3. Typical end cap and testing set-up including test pump and piping.](image-url)

The end caps are connected to the pipe using restraining glands designed for PVC or an equal type of PVC restraint. These glands must take into account the required field hydrostatic test pressure. Only use restraint systems that have a clearly defined maximum pressure rating. Special or additional restraints may be required to meet the required...
Section 4
Testing and Disinfection

pressure rating. Contact the restraint hardware manufacturer for verification of the testing capability and applicability of all restraint hardware used.

Particular attention must be paid to ensure that all free air is vented or otherwise removed from the pipeline section at the end cap(s) and all testing hardware. Depending on the orientation of the pipeline and end cap and the position of the end cap tap, a significant amount of free air can be trapped at the end cap location. This can occur when testing an HDD installation where the pipe ends exit the ground at an angle. Here are two methods for thoroughly venting free air at the end of the pipe where the testing end cap is installed:

1. Utilize a ductile iron end cap containing two taps. One tap must be located at the edge of the inner diameter pipe cross-section and oriented so that it is at the highpoint of the pipe end. This tap will serve as the connection for the venting line and allow nearly all the free air to vent from the line. The other tap is used to fill the pipeline with water (see Figure 4.4).

Figure 4.4. Testing set-up including two taps in the end cap, one for administering the test and one for venting free air.
Section 4
Testing and Disinfection

2. Install a PVC tap saddle, separate from the testing hardware, at the ends of the pipe orientated at the highest point of the cross-section to vent free air from the line (see Figure 4.5).

Figure 4.5. Testing set-up including a tap and valve used to manually vent free air from the top of the pipe near the end cap location.

4.1.3 Field Hydrostatic Test Steps and Troubleshooting

The following basic steps should always be followed for a field hydrostatic test on a PVC pressure pipeline:

1. Complete final installation of the pipeline.
2. Determine the required test pressure and verify with the owner or owner’s agent.
3. Determine the required test duration and verify with the owner or owner’s agent.
4. Determine what appurtenances (valves, instruments, connections, etc.) need to be installed prior to the test. Confirm their pressure rating is compatible with the selected test pressure and complete their installation.
5. Fill the pipeline with water from lowest elevation if possible, venting free air from the pipeline at all available and necessary locations at the maximum recommended fill rate of 1 fps.
6. Use flushing techniques at a minimum of 3 fps to remove any remaining free air.
7. Connect pressure pump to the system.
8. Pressurize the pipeline with the test pump to the required test pressure. The most common indicator of free air in the pipeline being tested is the length of time it takes for a test pump to reach test pressure. Test pressure is normally reached within a few minutes in a properly filled and vented pipeline.
9. Isolate the test pump from the pipeline for the duration of test so that the pipe stands as a closed vessel.

10. Determine whether the pressure drop meets requirements of the test. (See Section 4.2 for information regarding leak testing in conjunction with the hydrostatic pressure test.)

If it takes a long time to bring the line up to test pressure, this may be a sign that there is free air entrapped in the pipeline. If the pressure fluctuates due to temperature changes, this may be another sign that there is free air entrapped in the pipeline. Stop the test immediately and reapply the proper flushing or free air purging procedures before attempting the test again.

Contact your local Underground Solutions, Inc. representative if you have any questions or challenges specific to hydrostatic pressure testing of any Fusible PVC® pipeline.

### 4.2 Leakage Testing for PVC Pressure Pipe

If a pipeline is predominantly comprised of Fusible PVC® pipe joined with butt-fusion joints, it will not have any gaskets to allow for leakage. Leakage testing and “test allowance” is intended for those sections that contain gasket-seal connections and fittings. A method that has been used to modify the “test allowance” for a pipeline comprised of both Fusible PVC® pipe joints and gasketed connections is to use a leak-rate-per-gasket based on the “test allowance” in AWWA C605 and AWWA C600[12]. Table 4.2 includes allowable leakage values, per gasket, based on a stated test pressure and nominal pipe size. This table can be used to calculate an allowable leakage rate for a given pipe segment by determining how many gaskets are present in the segment to be tested and multiplying that number by the appropriate value from the table based on the test pressure and pipe diameter. This information is valid for both PVC and ductile iron pressure pipe joints and fittings.

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*Table 4.2. Hydrostatic test make-up water allowance per gasket for PVC pressure pipe based on the allowances included in AWWA C605.*
Section 4
Testing and Disinfection

If excessive leakage water is required for a pipeline that is predominantly comprised of Fusible PVC® pipe with butt-fusion joints, this could also be a sign that there are still unacceptable quantities of free air in the pipeline. Follow proper flushing or free air purging procedures before attempting the test again and before putting the line in operation.

4.3 Disinfection of Fusible PVC® Pipe

Potable water pipelines are disinfected prior to being put into service. Standard procedures for disinfecting PVC pipelines are included in AWWA C605 and AWWA M23, and these procedures are applicable to assembled and installed Fusible PVC® pipe as well.

Some disinfection methods require that chlorine be placed in the pipeline as it is being assembled. The use of chlorine tablets, which are glued into place inside each individual length of PVC pipe as it is installed, is acceptable for use with Fusible PVC® pipe during the thermal butt-fusion process. Assure that the tablets are placed at arm’s length away from the end of the pipe where the thermal butt-fusion process will take place, that the tablets are secured firmly in place, and that there isn’t any water within the pipe and in contact with the tablets. The use of chlorine powder is strictly prohibited during the thermal butt-fusion process, whether it is during the assembly of the pipe length or with an intermediate fusion.

4.4 Above Ground Field Hydrostatic Testing of PVC Pressure Pipe

In practice it is very difficult and unsafe to field hydrostatic test pipelines with water at the required test pressures above ground. When the pipe is above ground and not installed in its final alignment, it has yet to experience the axial and bending stresses that are to be applied to the pipe and joints. The best time to perform a field pressure test is after the installation stresses have been applied to the pipe and joints and the pipe is in its final alignment.

One test that may be reasonably performed on above-ground piping is a low pressure air test. A low pressure air test is done at 4 psi or less of pressure. This test may be used to verify that the pipe has not been damaged or vandalized prior to installation.

4.4.1 Safety Issues with Above-Ground Pressure Testing

Water must be used for field hydrostatic testing. Air CANNOT be used for high pressure testing.

If attempting to field hydrostatic test the pipeline aboveground, with water, the fused pipe will be staged at grade, hundreds of feet in length, with elevation changes likely. This makes filling the pipeline with water and removing free air in a temporary alignment and position time consuming, difficult, and dangerous. The pipe is unsupported for its complete length, allowing it to move. As pressure is added to the line the pipe will try to straighten itself, causing potential movement. This movement is difficult to control and an unsafe situation may develop. Finally, should an issue develop during the test with air present in the line, end caps, testing hardware and exposed pipe may become fast moving objects, creating a hazardous condition.
Section 4
Testing and Disinfection

4.4.2 Above-Ground Pressure Testing Does Not Verify Joint Integrity

A test prior to installation will not detect any adverse effect that the installation axial and bending forces and associated stresses have on fusion joint tensile and pressure capability. The only meaningful pressure test is one performed after installation on a pipeline that is ready for acceptance into the system.

4.4.3 Low-Pressure Damage and Vandalism Check

One test that may be performed on a thermally butt-fused pipeline prior to installation is a low-pressure (less than or equal to 4 psi) air test. While this test will not provide any verification of fusion joint integrity or internal pressure carrying capacity, it will verify that no serious damage has been sustained by the pipe, including impact from construction/handling equipment or vandalism. This test will only indicate a significant issue with the pipe, such as a full wall breach or fracture, especially if there is the possibility that it would not otherwise be discovered prior to installation (e.g., via visual examination). Above-ground, low pressure air testing should be performed per the guidelines in Section 4.5, Leakage Testing for Non-Pressure Pipe. Testing hardware and end caps may be adjusted as appropriate for an above ground damage and vandalism check. Air pressure used should be 4 psi, but should NEVER EXCEED 9 psi.

4.5 Leakage Testing for Non-Pressure Pipe

It is normal to test the integrity of a gravity sewer installation to confirm that there is little or no infiltration or exfiltration from a pipeline installed with gasketed, bell and spigot joints. This is typically done with low-pressure air. There are two best practice standards that describe the testing of non-pressure sewer pipe with low-pressure air: ASTM F1417 and UNI-B-6. These standards should be followed for testing methodology, procedure, and acceptance criteria as appropriate.

Generally, the test is performed by installing pipe plugs on either end of the pipe section to be tested. One is equipped with an air inlet and the other has a valve to release air. One of the plugs, or the piping that an air compressor attaches to, has a gauge to record the pressure in the pipe during the test.

This test should only be completed at very low pressures. 4 psi is the recommended test pressure with air. Pipelines comprised entirely of Fusible PVC® pipe properly joined using butt-fusion will not leak nor lose pressure during a low pressure air test done at constant temperatures. Air expands and contracts with thermal fluctuations, so slight changes in pressure may occur due to temperature fluctuations.

4.6 Procedures for Deflection Testing

Deflection testing for non-pressure or pressurized pipes verifies that excessive deflection, “ovaling,” or “egging” of the pipe cross-section has not occurred due to embedment compaction or external loading on the pipeline. The primary method for this testing is passing a ‘go, no go’ mandrel, sized for an allowable deflection in the pipe, through the pipeline (see Figures 4.6 and 4.7). Other methods of measurement for deflection are also possible, such as laser profiling and
direct measurements if the pipe is large enough to allow access. Measurements or the success of a 'go, no go' mandrel would verify whether the pipe has deflected beyond the maximum deflection allowed within the pipe. PVC non-pressure pipe has an allowable deflection of 7.5% of the referenced diameter. PVC pressurized pipe has an allowable deflection of 5% of the referenced diameter. Pressure pipelines subject to operating pressures normally have sufficient internal pressure to counteract external loading that could cause deflection. Pressure pipelines may not always be put immediately into service and a deflection test for a pipeline not under pressure for an extended period of time may be required.

Detailed discussion of this testing, as well as installation of PVC pipe for non-pressure use, is covered in UNI-TR-1 and the Handbook of PVC Pipe. See the PVC Pipe Association’s technical brief, “Sizing of Deflection Mandrels for AWWA C905 Pipe”[13] for an explanation and examples of base diameter calculations for PVC pipe.

If some form of mandrel deflection testing is to be employed with Fusible PVC® pipe products, the internal fusion bead height must be taken into account. The ‘go, no go’ mandrel must be sized based on the inner diameter of the pipe at the fusion bead. Contact your local Underground Solutions, Inc. representative for more information.

![Diagram](image.png)

**Figure 4.6. Example shop drawing of a ‘go, no-go’ mandrel (courtesy of UNI-TR-1).**
Figure 4.7. Example of a ‘go, no-go’ mandrel that is used to check for excessive deflection in pipe.
### Filling and Flushing Rates for Common Fusible PVC® Pipe Sizes, 4-12 inch

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<th>Flushing Rate</th>
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*Table 4.3. Filling and flushing rates for common pipe sizes, 4 inches through 12 inches.*
# Section 4

## Testing and Disinfection

### Table 4.4. Filling and flushing rates for common pipe sizes, 14 inches through 36 inches.

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Section 4
Testing and Disinfection

References


Section 4
Testing and Disinfection

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This document does not purport to address all of the safety concerns, if any, associated with the handling, installation or use of Fusible PVC® pipe or with the various application techniques described herein. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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5.0 Tapping Fusible PVC® Pipe

Tapping into a water or wastewater pipeline to add a connection to the pipeline system is a common procedure for the installation and operation of a water or wastewater system. Tapping is performed in both pressure and non-pressure systems. It is performed in some cases when the line is first installed before being placed into service, as well as when the pipeline has been operational for years.

The PVC Pipe Association (formerly Uni-bell PVC Pipe Association) offers specific guidance for tapping PVC in several publications. The Handbook of PVC Pipe (1) offers an overview of tapping options and considerations for tapping PVC pipe. It also references UNI-PUB-8, Tapping Guide for AWWA C900 PVC Pressure Pipe, (2) which offers further specific guidance for tapping PVC pressure pipe. There are also other standard industry sources that should be reviewed prior to tapping PVC pipe. These include publications by the American Water Works Association (AWWA), including standard C605 (3) and Manual of Practice M23. (4)

Tapping practice for Fusible PVC® pipe follows the same basic industry guidance. Fusible PVC® pipe is assembled by thermal butt fusion into a completely restrained, monolithic pipe section. This pipe length can transmit axial loading along its length due to pressure, thermal changes, bending, and friction. Due to this axial loading, care must be taken when tapping the line so that the axial stress-carrying capacity of the pipe is not significantly reduced.

This section reviews some of the key items to remember when tapping Fusible PVC® pipe. Most of these key items are addressed in the same manner for all PVC pipe. The aspects of tapping that are specific to Fusible PVC® pipe are also discussed. As required for any pipe material, safety precautions and practices must also be followed when tapping Fusible PVC® pipe.

The Most Important Items When Tapping PVC and Fusible PVC® Pipe:

1. Implement and follow all safety precautions including those detailed in Section 5.1.
2. Take precautions to eliminate air inside the pipe, including attention to filling sequence, air relief valves, proper flushing, and other best practices.
3. When advancing the cutter through the pipe wall, it is critical that the cutter bit is allowed to ‘cut’ its way through the wall – **DO NOT FORCE THE CUTTER THROUGH THE FINAL PORTION OF THE WALL.**
4. Make sure to use the appropriate saddle or sleeve – specifically designed and sized for PVC pipe of the diameter being tapped.
5. Use the appropriate cutter bit – designed for PVC and make sure it is **SHARP AND UNDAMAGED!**
6. Don’t rush – particularly on thick-walled pipe – take your time and reduce overheating the pipe wall.
7. Follow tap size recommendations.
8. No **direct tapping** allowed for Fusible PVC® pipe.
Section 5
Tapping Fusible PVC® Pipe

5.1 Safety Precautions to Stress

Safety precautions must be observed when working with cutting tools and tapping equipment for PVC pipe. Safety measures must be followed to assure that a pipe failure occurring during a tapping event of a pressure pipeline does not threaten the safety of those working on the project. The following precautions are repeated here from The Handbook of PVC Pipe.[1]

1. When tapping a pressure pipeline, a second worker should always be present, away from the location of the tapping event, watching the tapping procedure.
2. Personal protective equipment for the person tapping the pipe should include goggles or a face shield.
3. An easy exit pathway should be available for the person tapping the pipeline, including ladders or other means to evacuate an excavation.
4. When tapping a pressure pipeline, a protective blanket, covering the area of the tapping location is a worthwhile precaution to limit potential flying debris.
5. When tapping a pressure pipeline, a plan should be in place to quickly isolate and depressurize the pipeline should there be an issue with the tap.

5.2 Tapping Fusible PVC® Pressure Pipe

5.2.1 Types of Tapping for Fusible PVC® Pressure Pipe

Tapping operations will either occur when the pipeline is subject to or not subject to internal pressure. Tapping without internal pressure or when the pipeline is empty is often called ‘dry tapping.’ Tapping with internal pressure or when the pipeline is filled with water is often called ‘wet tapping.’ Fusible PVC® pipe may be dry tapped or wet tapped as long as the appropriate procedures and equipment are used.

There are generally two types of tapping procedures for PVC pipe: Direct tapping, which places a threaded connection directly into the pipe wall; and saddle or sleeve tapping, which uses a saddle or sleeve around the pipe to facilitate the connection. Both types of tapping procedures are applicable for wet or dry tapping.

5.2.1.1 Direct Tapping – NOT ALLOWED WITH FUSIBLE PVC® PIPE!

Using the direct tapping method, the shut-off valve or corporation stop, is threaded directly into the pipe wall. Cutting threads into the pipe wall creates stress concentration points in the wall of the pipe when axial stress is applied. Therefore, this method is NOT recommended for use with Fusible PVC® pipe.

5.2.1.2 Saddle or Sleeve Tapping

In this method, the pipe to be tapped is supported by a tap saddle or sleeve. The saddle/sleeve contains the threaded connection for the shut off valve or corporation stop. No threads are cut into the pipe wall. The saddle or sleeve is sized to fit the PVC pipe’s outer diameter exactly and is
When tapping Fusible PVC® pipe, **ONLY** use saddles or sleeves sized **SPECIFICALLY** for PVC pipe.
5.2.2 Tapping Equipment

Tapping machines normally come in two types: manually operated or small, motor-driven machines for two-inch and smaller saddle taps; and motor-driven machines for larger taps. There are many manufacturers of tapping machines and ONLY those designed for PVC pipe should be used. Tapping is a precision process requiring precision equipment and methods.

**DO NOT ATTEMPT TO TAP FUSIBLE PVC® PIPE USING EQUIPMENT DESIGNED FOR OTHER PURPOSES OR PIPE MATERIALS OTHER THAN PVC!**

Per standard industry recommendations, PVC pipe **IS NOT TO BE** tapped with hand-held drills or wood drill bits, spade bits, twist bits, or hole-saws!

The most important feature of the tapping equipment is a **proper PVC cutter bit**. The cutter bit should be designed specifically for use with PVC pipe. If there is any question as to the applicability of the PVC cutter bit, please contact your Underground Solutions, Inc. representative.

The following sections contain some specific information related to tapping equipment and cutters. This information is provided to highlight the important features and components of the tapping equipment when performing taps on Fusible PVC® pipe. This information is not meant as a substitute for the proper set-up and guidance for working with the equipment described here. **ALWAYS FOLLOW ALL OPERATIONAL AND EQUIPMENT REQUIREMENTS PER THE MANUFACTURER OF THE EQUIPMENT BEING USED.**

5.2.2.1 Smaller Diameter Tapping Equipment

The following section provides example tooling for taps that are two inches or less in size. Several manufacturer’s products are included, but are not intended to be an exhaustive list of those products that are applicable. Contact your Underground Solutions, Inc. representative to verify the applicability of specific tooling for tapping processes.
Figure 5.3 shows a typical tapping machine for use with Fusible PVC® pipe. An example set of tapping machines for use with nominal tap sizes of ½-inch through two-inch is included in Table 5.1.

<table>
<thead>
<tr>
<th>Manufacturer of Tapping Machine</th>
<th>Name</th>
<th>Model No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reed Manufacturing Company</td>
<td>Feed Tap Kit</td>
<td>FTP2000UNIV</td>
</tr>
<tr>
<td>Ford Meter Box Company, Inc.</td>
<td>Model 77 Drilling Machine</td>
<td>DMO-NL</td>
</tr>
<tr>
<td>Mueller Co. LLC</td>
<td>Mueller® E-S™ Drilling Machine</td>
<td>39330</td>
</tr>
</tbody>
</table>

Table 5.1. Listing of specific tapping machine model numbers for a sample of manufacturers.

Figure 5.4 shows a typical fluted PVC shell cutter for use with Fusible PVC® pipe. An example set of PVC shell cutters for use with nominal tap sizes of ½-inch through two-inch is included in Table 5.2.
Section 5
Tapping Fusible PVC® Pipe

Figure 5.4. Example of a shell cutter for use with PVC and Fusible PVC® pipe.

<table>
<thead>
<tr>
<th>Shell Cutters from a Sample of Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturer</strong></td>
</tr>
<tr>
<td>Reed Manufacturing Company</td>
</tr>
<tr>
<td>PL688</td>
</tr>
<tr>
<td>11/16”</td>
</tr>
<tr>
<td>Ford Meter Box Company, Inc.</td>
</tr>
<tr>
<td>11/16”</td>
</tr>
<tr>
<td>Mueller Co. LLC</td>
</tr>
<tr>
<td>11/16”</td>
</tr>
</tbody>
</table>

Table 5.2. Listing of specific cutter model numbers from a sample of manufacturers of smaller diameter tapping equipment.

5.2.2.2 Large Diameter Tapping Equipment

The Mueller® CL-12™ and the Romac TapMate™ are the preferred machines for taps larger than two-inches. This is primarily due to the PVC-specific cutter and pilot bits that are available with these models. Other models and manufacturers with large diameter capacity do not have PVC-specific cutter bits, relying instead on hole-saws or standard metal bits to cut PVC. Figure 5.5 shows a sample of tapping machine cutter bits and Table 5.3 includes shell cutter bit and pilot drill bit information for applicable tapping equipment. Please direct all large diameter tapping questions to your local Underground Solutions, Inc. representative.
Section 5
Tapping Fusible PVC® Pipe

Figure 5.5. Example of a large diameter tapping machine for use with Fusible PVC® pipe. Shell cutter and pilot bit are illustrated in inset.

Cutter and Pilot Bits for a Sample of Manufacturers

<table>
<thead>
<tr>
<th>Manufacturer and Model</th>
<th>Nominal Tap Size or Lateral Size</th>
<th>Part Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mueller Co., LLC – Mueller® CL - 12™ Drilling Machine</td>
<td>4”</td>
<td>6”</td>
</tr>
<tr>
<td></td>
<td>537061</td>
<td>537062</td>
</tr>
<tr>
<td></td>
<td>681919</td>
<td>681919</td>
</tr>
<tr>
<td>Romac Industries, Inc. - TapMate™</td>
<td>350-01-2032</td>
<td>350-01-2048</td>
</tr>
<tr>
<td></td>
<td>350-04</td>
<td>350-04</td>
</tr>
</tbody>
</table>

Table 5.3. Listing of specific cutter and pilot bit model numbers for a sample of manufacturers and tapping machine models for larger diameter tapping equipment.

5.2.3 Tapping Saddles

Tapping saddles for use with Fusible PVC® pipe MUST BE DESIGNATED FOR USE ON PVC PIPE. Under no circumstances should tap saddles that are designed for other pipe materials be used.

Tapping saddles should be installed per the manufacturer’s instructions and recommendations.

Tapping saddles are used for the installation of a corporation stop on a tapped pipe. Typically, saddles are used when the size of the tap is two-inches or less. Larger taps require a tapping sleeve.

The tap saddle is made to a specific inner diameter to match the outer diameter of the pipe. The preferred tap saddle fully supports the pipe and is sized so that when bolted together it cannot be over-tightened on the pipe (see Figure 5.6). Over-tightening of a saddle on the pipe can create additional stress at the location...
of the tap and can cause a failure. Manufacturers of these types of saddles include, but are not limited to, Ford Meter Box (Models S70, S71, S90, and S91), Powerseal (Model 3403), Mueller® (Models H-13000 and S-13000), and E.J. Prescott, Inc. (Catalog J26). Solid stop-type saddles such as these are typically used for pipe diameters up to and including 12-inch. If other saddle types are elected for use, ensure that the model selected is designed specifically for PVC pipe, is the correct size for the outer diameter of the pipe being used, and is installed per the manufacturer’s instructions.

Figure 5.6. Example of a tapping saddle for use on PVC pipe 12-inches and less that features a positive stop when tightening.

Tapping saddles for use on pipe with diameters larger than 12-inches utilize stainless steel straps or other support methods instead of a solid ring type of construction. For these types of saddles (see Figure 5.7), ensure that there is no binding of the straps or any foreign objects between the pipe and the straps that would cause uneven stress on the pipe when the straps are tightened. Always tighten the saddle to the required torque values with a calibrated torque wrench. There are many manufacturers of these types of saddles. Assure that the model is designed specifically for PVC pipe, is the correct size for the outer diameter of the pipe being used, and is installed per the manufacturer’s instructions.
Tapping Fusible PVC® Pipe

Figure 5.7. Example illustration of a tapping saddle for use on PVC pipe that features strapping that must be tightened to a prescribed torque value.

Regardless of the saddle used, the manufacturer’s installation instructions must **ALWAYS** be followed.

5.2.4 Tapping Sleeves

Tapping sleeves are used for larger diameter taps on larger diameter pipe. The sleeve is a two-part assembly that bolts together and grips the pipe to be tapped. Because of this, the installation is different than the tap saddle. The bolts must be installed per manufacturer’s torque requirements. The tap sleeve can be over-tightened, placing excess stress on the pipe and tap leading to potential pipe failure.

**In order for the tap sleeve to function properly, OVER-TIGHTENING MUST BE AVOIDED.**

Figure 5.8 shows a typical unrestrained tapping sleeve. It is important to note that this type of tapping sleeve, like those previously discussed, will **not** transfer axial stress from one side of the tap to the other side.
Section 5
Tapping Fusible PVC® Pipe

Figure 5.8. Typical unrestrained tap sleeve. Flange outlet shown as example. Other types of outlets are also available per the tapping sleeve manufacturer. This is an UNRESTRAINED tap sleeve and will not transfer axial stress around the tap location.

There are many manufacturers with various models of tapping sleeves available. Be sure that the specific model you select is designed for PVC pipe, is the correct size for the outer diameter of the pipe being used, and is installed per the manufacturer’s instructions.

5.2.5 Tap Locations – Where to Place the Tap

UGS recommends that each tap location be placed no closer than 12 inches from the nearest fusion joint such that no portion of the saddle, sleeve, or restraint mechanism is located within six inches of a fusion joint. This is to ensure that the saddle, sleeve, or restraint mechanism will seal and function correctly. This is consistent with industry guidance regarding placement of taps which the PVC Pipe Association advocates should be no closer than 12 inches from a bell and spigot joint. (2)

The industry provides good practice guidance for locating successive taps on a pipeline. Taps should be at least 18 inches apart and, should they be spaced this close together, they should be located on the opposite sides of the pipe. Thus, no two taps should be closer than 36-inches apart on the same ‘line’ along the pipe barrel. (2)

In addition to the above dimension and location guidance, allow a minimum of six inches between the ends of any saddles, sleeves, and mechanical restraints at successive tap locations. Also, consider the room required to physically cut or install the tap when considering the placement of successive taps.
All Fusible PVC® pipe is installed at the minimum allowable bend radius or longer radii, based on the guidance provided for each nominal pipe size (see Tables 5.4 and 5.5). There are no restrictions for taps to be installed on a curved section as a result.

### Table 5.4. Minimum allowable bend radii for DIPS standard outer diameter pipe sizes. DIPS stands for Ductile Iron Pipe Size.

<table>
<thead>
<tr>
<th>Nominal Pipe Size (inches)</th>
<th>Minimum Allowable Bend Radius (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>138</td>
</tr>
<tr>
<td>8</td>
<td>189</td>
</tr>
<tr>
<td>10</td>
<td>231</td>
</tr>
<tr>
<td>12</td>
<td>275</td>
</tr>
<tr>
<td>14</td>
<td>319</td>
</tr>
<tr>
<td>16</td>
<td>363</td>
</tr>
<tr>
<td>18</td>
<td>406</td>
</tr>
<tr>
<td>20</td>
<td>450</td>
</tr>
<tr>
<td>24</td>
<td>538</td>
</tr>
<tr>
<td>30</td>
<td>667</td>
</tr>
<tr>
<td>36</td>
<td>798</td>
</tr>
</tbody>
</table>

### Table 5.5. Minimum allowable bend radii for IPS or Schedule standard outer diameter pipe sizes. IPS stands for Iron Pipe Size.

<table>
<thead>
<tr>
<th>Nominal Pipe Size (inches)</th>
<th>Minimum Allowable Bend Radius (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>94</td>
</tr>
<tr>
<td>6</td>
<td>138</td>
</tr>
<tr>
<td>8</td>
<td>180</td>
</tr>
<tr>
<td>10</td>
<td>224</td>
</tr>
<tr>
<td>12</td>
<td>266</td>
</tr>
</tbody>
</table>

### 5.2.6 Tapping Procedure: Tap Saddle and Hand-Operated Tap Machine

When tapping with a hand-operated tap machine using a tap saddle, the following steps are normally followed. Always follow the explicit instructions of the tap saddle and tap machine manufacturers. Any lubricants used with the tapping operation should be water soluble, compatible with potable water requirements, and compatible with PVC.

1. Determine the location for the tap on the pipe. Use prudent judgement following the recommendations provided here. Follow the pipe owner and operator’s guidance for tapping the pipe near fittings or an existing tap.

2. Assure that an appropriate tap saddle is being used. Be sure that it is designed for PVC pipe and is sized correctly for the pipe being tapped.

3. Locate the tap saddle on the pipe and evenly tighten it around the pipe. Monitor the torque with a torque wrench and tighten bolts to the proper torque for PVC pipe per the saddle manufacturer’s instructions. If there is more than one bolt to tighten, assure that the bolts are tightened in the proper order. **DO NOT OVER-TIGHTEN or exceed the torque recommendations of the tap saddle manufacturer.**
4. Screw the inlet side of the corporation stop into the saddle threads using the appropriate sealing aids on the threads (anti-seize, Teflon tape, etc.) per the manufacturer’s instructions. Open the valve stop after the corporation stop is secured to the saddle.

5. Install the appropriate PVC shell cutter bit on the tapping machine. Make sure that the cutter bit is designed specifically for PVC pipe and that it is the correct size for the tap being performed. **Ensure that the cutter is SHARP!** If there is any doubt about the cutter’s cutting ability or age, furnish and use a new cutter bit per the manufacturer’s guidance.

6. Using the appropriate adapter and gasket, attach the drilling machine to the stop outlet threads. Follow the drilling machine manufacturer’s instructions.

7. Lower the boring bar to the pipe outer surface.

8. Rotate the cutter while exerting finger pull pressure on the feed handle. The amount of pressure used should be approximately equal to pulling out a desk drawer. The rotation of the cutter to feed should be one full rotation of the cutter to 1/8 turn of the feed yoke.

9. Continue the tapping operation until the tap is complete. Do not stop and extract the cutter until the tapping operation has been successfully completed.

10. **When the cutter is almost through the pipe wall, assure that the cutter is not ‘pushed or forced’ through the remaining pipe material!** Allow the cutter to continue cutting until completely through the pipe wall.

11. Upon completion of the tap, withdraw the cutter.

12. Close the stop valve.

13. Remove the tapping machine.

14. Examine the cutting coupon left in the cutter head. The coupon should reflect a smooth, clean cut, with no tear-out or push-through as illustrated in Figures 5.9 through 5.11. If the coupon contains heavy grooving, has wads of re-melted cuttings clogging the flutes of the cutter, or shows push-through or mushrooming, get a new, sharp cutter before making any more taps, and slow your feed rate. Always take care to eliminate push-through.

### 5.2.7 Tapping Procedure: Tap Sleeve

When tapping a larger diameter pipe and/or installing a tap equal to or larger than two inches, tap sleeves are used (in most cases with a power operated tapping machine). The tap machines can be operated by hand, air motor, or hydraulic pump. The general steps that are followed to create a tap with a tapping machine and tapping sleeve are provided below. Always follow the explicit instructions of the tap sleeve and tap machine manufacturers:

1. Install the tap sleeve on the pipe to be tapped per the manufacturer’s instructions. The tap sleeve is normally a two-piece assembly with a ring gasket at the tap outlet providing the seal to the
Section 5
Tapping Fusible PVC® Pipe

The tap sleeve is made to fit tightly around the pipe, but is not a fully supporting device like the tap saddle. It is extremely important to torque the mounting bolts to manufacturer’s requirements. Over-tightened bolts can induce additional stress on the pipe being tapped and cause a pipe failure.

2. Connect the tap valve to the tap sleeve. The tap valve is normally a specialty valve with a gasket-flanged connection to the tap outlet and a mechanical joint-type connection to the tap machine side. Flange adapters are made to connect the tap machine should a flanged valve arrangement be used.

3. Support the tap sleeve and valve independently from the pipe. Supports should be left in place after tapping.

4. Install the required PVC cutter bit and support hardware, which may include a pilot cutter bit, pilot adapter, and other pieces.

5. Attach the tapping machine to the tap valve or adapter.

6. Install temporary supports under the tap machine to support it independently from the pipe, sleeve, and valve.

7. Open the tapping valve.

8. Advance the cutter to the surface of the pipe being tapped.

9. Engage the cutter bit and cut the tap hole. On power operated tap machines, the advance rate and the cutting rate are to be set per manufacturer’s recommendations. The travel distance is also to be set to prevent the cutter bit from going through the pipe and cutting into the opposite side pipe wall. If using a hand-operated model, ensure the proper advance rate, cutter rate, and travel distance are observed.

10. Continue the tapping operation until the tap is complete. Do not stop and extract the cutter until the tapping operation has been successfully completed.

11. At completion of the tap, retract the cutter bit and close the tap valve.

12. Remove the tap machine.

13. Attach the new pipeline to the tap and fitting location.

5.2.8 Tap Results

The tap coupon created by the tapping operation should have a smooth, straight sidewall when removed from the tap machine. A rough sidewall and/or the presence of striations, the formation of molded cutting material in the flutes, or ‘mushrooming’ or signs of push-through are all indications of a poor tap.
Section 5
Tapping Fusible PVC® Pipe

Figure 5.9. Pictorial representation of a poorly made tap and properly made tap by examination of the tap coupon.\(^{(2)}\)

![Wrong vs Right Taps](image)

- Wrong: Rough striations indicate a dull cutter or too rapid feed.
- Right: Clean edge means good cutting action.

Figure 5.10. Photograph of a tap coupon showing signs of a poorly made tap.

- Location of excessive 'push-through' and mushrooming
- Re-melting and 'wadding' of cuttings in the cutter flutes
Section 5
Tapping Fusible PVC® Pipe

Figure 5.11. Photograph of a tap coupon showing signs of an appropriately made tap.

5.3 Tapping Fusible PVC® Non-Pressure Pipe

Most non-pressure pipe systems are assembled with connections, laterals, and tie-ins using dedicated fittings. Maintenance and future connections to an existing line may require an additional connection to the pipeline. Removing a portion of the pipeline to add the connection through the use of fittings is generally workable since the line is non-pressurized. From time to time, the requirement to ‘tap’ a non-pressure line will occur. This could be after a pipeline is rehabilitated with a trenchless technology such as pipe bursting, or it could be advantageous in terms of required bypass flow for shutting down a pipeline for a specified period of time.

Tapping of non-pressure PVC pipelines tends to be less regulated than tapping pressurized PVC pipe, often utilizing hole-saws or other bits designed for wood or other materials. When tapping non-pressurized Fusible PVC® pipe, however, you must follow the same recommendations and requirements for tapping Fusible PVC® pressure pipe. Follow recommendations for specific tap sizes based on the nominal diameter of the pipe, per section 5.4.

5.4 Recommended Tapping Procedures for Specific Tap Sizes and Pipe Diameters

Fusible PVC® pipe is a fully-restrained pipe material that transmits axial stress along its length, both during the installation phase and the long-term use of the product. For this primary reason, tapping of Fusible PVC® pipe may be performed using industry standard means and methods. There is, however, a limit to the size of tap that may be introduced into a given pipe diameter unless further precautions are taken to limit the impact of the tap on the long-term axial stress-transmitting capability of the pipeline. Although larger tap sizes are possible, certain precautions must be taken to ensure that the tap does not adversely impact the ability of the pipe’s cross section to transmit longitudinal or axial stress through the area of the tap without jeopardizing the integrity of the pipe. Table 5.6 includes information on the recommended procedure for each tap size based on the nominal diameter of the pipe being tapped. This table applies to both pressure and non-pressure piping applications.
**Section 5  
Tapping Fusible PVC® Pipe**

![Logo]

**Table 5.6. Recommended tapping procedures based on the size of the tap and the nominal pipe diameter size. Note that while the tap size may be a nominal size, the actual hole that is cut in the pipe is generally smaller. For tap sizes that are not shown, or are larger than those shown, please contact your Underground Solutions, Inc. representative.**

<table>
<thead>
<tr>
<th>Nominal Pipe Size (in.)</th>
<th>¾</th>
<th>1</th>
<th>1 ½</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>NTP</td>
<td>RH</td>
<td>RH</td>
<td>RH</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>NTP</td>
<td>NTP</td>
<td>RH</td>
<td>RH</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>NTP</td>
<td>NTP</td>
<td>RH</td>
<td>RH</td>
<td>RTS</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>NTP</td>
<td>NTP</td>
<td>RH</td>
<td>RH</td>
<td>RTS</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>NTP</td>
<td>NTP</td>
<td>RH</td>
<td>RH</td>
<td>RTS</td>
<td>RTS</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>14</td>
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<td>RH</td>
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<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>16</td>
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<td>NTP</td>
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<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>18</td>
<td>NTP</td>
<td>NTP</td>
<td>NTP</td>
<td>NTP</td>
<td>RTS</td>
<td>RTS</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>20</td>
<td>NTP</td>
<td>NTP</td>
<td>NTP</td>
<td>NTP</td>
<td>RTS</td>
<td>RTS</td>
<td>RTS</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>24</td>
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<td>NTP</td>
<td>RTS</td>
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<td>30</td>
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<td>NTP</td>
<td>NTP</td>
<td>NTP</td>
<td>NTP</td>
<td>RTS</td>
</tr>
</tbody>
</table>

**NTP**  
Normal tapping procedures as described in this installation guidance document may be used.

**RH**  
A restraining harness should be used to transfer axial stress. See Section 5.4.1

**RTS**  
A restrained tapping sleeve should be used to transfer axial stress. See Section 5.4.2

**X**  
Tapping is not recommended, see Section 5.5 for alternate connection methods.

---

**5.4.1 Utilizing a Restraining Harness to Transfer Axial Stress**

A restraining harness can be used to transfer the axial stress-loading around a tap location (see Figure 5.12). The tap size that can be accommodated in this manner is limited by the space between connecting rods to ensure there is enough room to install the saddle and perform the tap. For pressure applications, the tap saddle is first installed per these guidelines and the saddle manufacturer’s instructions, then the restraining harness is placed around the tap area and tightened. The tap is then performed after axial load is transferred to the harness (see Figure 5.13). A split-restraint harness is used on each side so that it can be placed around the pipe after the pipe has been installed. The tap is then performed per the guidance in this document.
Figure 5.12 – Use of a restraint harness around a standard saddle tap can be used to transmit axial stress around a tap location. Note that split ring style harnesses must be used so that they can be attached to the pipe after the pipe has been installed.

Figure 5.13 – Use of a restraint harness around a standard saddle tap is one method to transmit potential axial stress around a tap location on a pressure pipeline.
Section 5  
Tapping Fusible PVC® Pipe

There are several major manufacturers of restraint harnesses available. Assure that the specific model you select is designed for PVC pipe, is the correct size for the outer diameter of the pipe being used, is rated for the pressure class of the pipe, and is installed per the manufacturer’s instructions.

*Whenever considering the use of a restraining harness to transfer axial stress around a tap location on Fusible PVC® pipe, contact your local Underground Solutions, Inc. representative. Your representative will verify the application and any specific installation guidance unique to your application.*

This method will also work for the tapping processes of non-pressure pipe. There are two primary methods of ‘tapping’ a lateral into a non-pressure line. The first is to use a ‘boot’ or other fitting that will cover the area to be tapped, and then cutting a hole or tap within the area covered by the ‘boot’ or other fitting. These applications either use elastomeric material or solvent cement to assure a watertight seal. The second is a fitting that is inserted into a hole that is cut into the pipe. These fittings generally use elastomeric materials to ensure a watertight seal between the pipe and the fitting. If either type of fitting is used, it is critical to verify the fitting will fit within the restraint harness tie rods prior to installing it. This must be done BEFORE the hole is cut in the pipe.

### 5.4.2 Utilizing a Restrained Tapping Sleeve to Transfer Axial Stress

Restrained tapping sleeves function in the same manner as unrestrained tapping sleeves, except that they are capable of transferring axial stress through the sleeve body and around the tap location. They are a split-shell design that surrounds the pipe and are restrained to the pipe using restrainer glands. Split-gland restraint harnesses are required. These restrainer glands are often NOT included with the sleeve itself and must be purchased separately. Be sure to clarify with a supplier what will be included with the purchase of a restrained tapping sleeve and what will need to be procured separately to ensure that the sleeve will function as intended.

Since the restrained tapping sleeve will carry the axial stress loading, larger sized taps are possible. See Figure 5.14 for an example of this type of restrained sleeve. While these restrained sleeves are generally designed for pressure service, they may also be used in the same manner for non-pressure service or application. Care should be used to ensure that the specific pipe outer diameters and sizes are compatible with the required sleeves. Assure that the connection back to the lateral or branch piping is water tight.
Section 5
Tapping Fusible PVC® Pipe

5.5 Alternative Connections Rather than Tapping the Pipe:

An alternative to installing a tap on the pipeline is to utilize a fitting or other connection to the pipe.

One option is to cut the pipe and insert a tee fitting, which is connected to the pipe segments using standard PVC restrained connections. For pressure applications this would include a standard ductile iron or PVC pressure pipe tee that is restrained to the pipe using restrainer glands. If pipe movement is available, the fitting connection can be inserted and connected normally. If pipe movement is not available, a short pup piece of pipe and a solid sleeve may be required to make the connection. Another option could include insertion of a sleeve or other fitting that is pre or post-tapped as required.

For non-pressure applications insertion of a fitting would include a standard PVC tee or wye fitting for lateral connection. For non-pressure applications, restraint of the fitting is still required. This could be done using a solvent cement fitting, sleeve, and short lengths of pipe to tie the assembly together (see Figure 5.16), or it could include using restraint hardware and tie rods to keep the assembly restrained.
Figure 5.16 – Using a pup piece of pipe and couplers to remove axial tensile stress potential. 1) A segment of PVC made to the same size and standard as the primary pipe is inserted into the alignment using two couplers, 2 and 3) this pipe segment is then tapped with the required size tap, 4) a corporation is then used to create the connection point, in this case an Inserta-Tee® is used for this non-pressure application.
Section 5
Tapping Fusible PVC® Pipe

References


6.0 Pulling Parameters of Fusible PVC® Pipe

In most cases, Fusible PVC® pipe is assembled above ground on the project site in long lengths prior to installation. As a result, the pipe must be moved from this layout assembly to the final alignment of the project (see Figure 6.1). This section defines and describes specific aspects of pipe string movement when the pipe is fused together in long lengths.

**The Most Important Items When Pulling Fusible PVC® Pipe:**

1. **DO NOT** bend the pipe beyond the minimum allowable bend radius.
2. **DO NOT** exceed the allowable pull force.
3. **DO NOT** use pulling equipment that will damage the pipe such as wire rope or chains. Use a nylon strap.
4. Use a pull head that is appropriately sized and designed for Fusible PVC® pipe. Follow all instructions for installation and use.
5. **DO NOT USE PERCUSSION HAMMERS OR PNEUMATIC PIPE BURSTING EQUIPMENT WITH FUSIBLE PVC® PIPE.**
6. **Avoid contact with objects or equipment that will gouge, scrape, pierce or otherwise damage the pipe during movement.**

![Illustration of Fusible PVC® pipe being installed along a curved alignment for an HDD insertion. Note both horizontal and vertical curves are being accommodated.](image)

**6.1 Minimum Allowable Bend Radius**

UGS publishes minimum allowable bending radii for all the size configurations of Fusible PVC® pipe. This allowable bend radius is applicable to ALL pipe alignments, including during movement and handling, as well as final positioning and installation. **THERE IS ONLY ONE MINIMUM ALLOWABLE BEND RADIUS VALUE AND IT APPLIES TO ALL**
ALIGNMENTS THAT THE PIPE MAY EXPERIENCE. The minimum allowable bend radius also pertains to all operations and maintenance with the pipe, such as cutting, tapping, and installation by all methods including HDD.

The published values for minimum allowable bend radii represent a geometric radius (see Figure 6.2).

![Figure 6.2. Graphic representation of what the minimum allowable bend radius represents.](image)

If a Fusible PVC® pipe was curved in the smallest possible circle allowed, the radius of that circle would be equal to the minimum allowable bend radius for the pipe section. Tables 6.1 and 6.2 list the minimum allowable bending radii for standard DIPS and IPS pipe diameters available. For minimum bend radii of sizes not listed, visit [www.undergroundsolutions.com](http://www.undergroundsolutions.com), or contact your local Underground Solutions, Inc. representative.

**DIPS Standard Outer Diameters**

<table>
<thead>
<tr>
<th>Nominal Pipe Size (inches)</th>
<th>Minimum Allowable Bend Radius (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>138</td>
</tr>
<tr>
<td>8</td>
<td>189</td>
</tr>
<tr>
<td>10</td>
<td>231</td>
</tr>
<tr>
<td>12</td>
<td>275</td>
</tr>
<tr>
<td>14</td>
<td>319</td>
</tr>
<tr>
<td>16</td>
<td>363</td>
</tr>
<tr>
<td>18</td>
<td>406</td>
</tr>
<tr>
<td>20</td>
<td>450</td>
</tr>
<tr>
<td>24</td>
<td>538</td>
</tr>
<tr>
<td>30</td>
<td>667</td>
</tr>
<tr>
<td>36</td>
<td>798</td>
</tr>
</tbody>
</table>

*Table 6.1. Minimum allowable bend radii for DIPS standard outer diameter pipe sizes. DIPS stands for ‘Ductile Iron Pipe Size.’*

**IPS or Schedule Standard Outer Diameters**

<table>
<thead>
<tr>
<th>Nominal Pipe Size (inches)</th>
<th>Minimum Allowable Bend Radius (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>94</td>
</tr>
<tr>
<td>6</td>
<td>138</td>
</tr>
<tr>
<td>8</td>
<td>180</td>
</tr>
<tr>
<td>10</td>
<td>224</td>
</tr>
<tr>
<td>12</td>
<td>266</td>
</tr>
</tbody>
</table>

*Table 6.2. Minimum allowable bend radii for IPS or Schedule standard outer diameter pipe sizes. IPS stands for ‘Iron Pipe Size.’*
Section 6
Pulling Parameters

Shortening the bend radius below the minimum allowable radius during handling and pipe movement, or bending the pipe to a tighter radius than is prescribed, is the most common cause of handling issues with Fusible PVC® pipe. Careful planning and handling of the assembled pipe length that is being moved – with particular attention paid to bend radius – is the key to assuring successful assembled pipe length movement. Pay particular attention to ways in which the pipe may exceed the minimum allowable bend radius during movement:

- Eliminate the potential for single-point, localized bending around objects, such as trees, utility poles, and embankments.
- Support a required bend, whether horizontal or vertical in nature, with multiple (at least 3) points of contact at recommended spacing. UGS provides different spacing for vertical insertions either in air/on rollers/on ground, open cut installations, pipe bursting pit access, etc. Check with your Underground Solutions, Inc. representative for correct spacing for your particular situation.
- Avoid forcing lateral movement of the pipeline and, if required, use multiple points (at least 3) of contact to eliminate localized bending (see Figure 6.5). Do NOT use the tires of a vehicle or piece of equipment to laterally move the pipe. Careful planning for pipe string assembly and location will minimize the requirement for excessive lateral movement.

Figure 6.3. Examples of adequate support and reference points for assembled pipe lengths that are being moved through a horizontal change in direction.
Section 6
Pulling Parameters

Figure 6.4. Proper support for a vertical curve associated with an HDD insertion. Note the multiple points of support along the curvature.

Figure 6.5. Picture illustrating proper support for movement of a pipe string laterally. Note the multiple points of support and movement along the pipe string.
Section 6
Pulling Parameters

If the assembled pipe length is handled under, or at a shorter radius than the minimum allowable bend radius, a user should expect problems, up to and including pipe fracture and failure at the location of the bend. **Over-bending of the pipe is a safety hazard.** The stress in the pipe wall at a failure location can cause sudden and violent movement of the pipe, including pipe shards that can turn into projectiles that can cause injury or death if a worker is standing near the over bent portion of the pipe.

6.2 Allowable Pull Force

The tensile load that may be safely applied to the pipe is called the allowable pull force. This value is a function of the tensile stress capacity of Fusible PVC® plastic and the cross-sectional area of the Fusible PVC® pipe section being used. Fusible PVC® pipe meets the cell class tensile stress capacity of 7,000 psi when the compound is tested per ASTM D1784. Extruded pipe tensile strength may vary slightly from this. This value is divided by a safety factor of 2.5 to derive an allowable pull stress of 2,800 psi. This allowable pull stress is multiplied by the pipe cross-sectional area to determine the allowable pull force for a given pipe diameter and wall thickness. The pipe cross-sectional area uses the minimum wall thickness as provided by the controlling pipe standard. UGS publishes allowable pull force values for all available configurations of Fusible PVC® pipe; please reference [www.undergroundolutions.com](http://www.undergroundolutions.com), or contact your Underground Solutions, Inc. representative for specific details. Tables 6.3 and 6.4 contain allowable pull force information for most common pipe and wall thickness sizes for the two most popular pipe standard sizing series, ductile iron pipe size (DIPS) and iron pipe size (IPS).
### Table 6.3. Allowable pull forces for DIPS standard pipe sizes, for the most common sizes and wall thicknesses. For other sizes and DR’s, contact your Underground Solutions, Inc. representative.

<table>
<thead>
<tr>
<th>Size (inches)</th>
<th>DR</th>
<th>Allowable Pulling Force (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>14</td>
<td>13,400</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>10,600</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>27,700</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>21,900</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>16,000</td>
</tr>
<tr>
<td>8</td>
<td>14</td>
<td>47,700</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>37,800</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>27,600</td>
</tr>
<tr>
<td>10</td>
<td>14</td>
<td>71,800</td>
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<td></td>
<td>18</td>
<td>56,800</td>
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<td></td>
<td>25</td>
<td>41,600</td>
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<tr>
<td>12</td>
<td>14</td>
<td>101,600</td>
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<tr>
<td></td>
<td>18</td>
<td>80,300</td>
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<tr>
<td></td>
<td>25</td>
<td>58,800</td>
</tr>
<tr>
<td>14</td>
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<td>176,600</td>
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<td>139,700</td>
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<td></td>
<td>21</td>
<td>120,800</td>
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<td>16</td>
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<tr>
<td>36</td>
<td>21</td>
<td>834,600</td>
</tr>
</tbody>
</table>

### Table 6.4. Allowable pull forces for IPS standard pipe sizes, for the most common sizes and wall thicknesses. For other sizes and DR’s, contact your Underground Solutions, Inc. representative.

<table>
<thead>
<tr>
<th>Size (inches)</th>
<th>DR</th>
<th>Allowable Pulling Force (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>17</td>
<td>21,300</td>
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<td>17,500</td>
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<td>79,100</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>64,700</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>52,800</td>
</tr>
</tbody>
</table>
6.3 Temperature Effects on Allowable Pulling Force and Bend Radius

Fusible PVC® pipe properties, like all PVC pipe properties are defined at a standard ambient temperature of 73.4 °F (23 °C). As temperature rises above or drops below 73.4 °F, three pipe properties are affected: tensile strength, pressure capacity, and modulus of elasticity.

The tensile strength of Fusible PVC® pipe decreases as temperature increases. This means that on especially warm days with longer pulls, the ambient temperature at the time of pull-in may lower the allowable pull force for a given pipe size and wall thickness. The temperature impact on allowable pull force is defined in Table 6.5 and is taken from the Handbook of PVC Pipe\(^\text{1}\). To compute the allowable pull force for a particular pipe section that has a temperature above 73.4 °F, use Table 6.5 to find a percentage value based on the actual temperature of the pipe (interpolate between table values as necessary) and apply that percentage to the published allowable pull force value for that pipe section (see Eq. 12.1).

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>% of Recommended Allowable Pull Force (APF(_T))</th>
</tr>
</thead>
<tbody>
<tr>
<td>73.4</td>
<td>100</td>
</tr>
<tr>
<td>80</td>
<td>95</td>
</tr>
<tr>
<td>90</td>
<td>87</td>
</tr>
<tr>
<td>100</td>
<td>78</td>
</tr>
<tr>
<td>120</td>
<td>63</td>
</tr>
<tr>
<td>140</td>
<td>58</td>
</tr>
</tbody>
</table>

Table 6.5 – Ambient temperature impact on allowable pull force for Fusible PVC® pipe.

\[
\text{Allowable Pull Force at Temperatures above 73.4 °F} = \text{Allowable Pull Force} \times \text{APF}_T
\]

Eq. 12.1

The adjustment for temperature applies mainly to the section of pipe above ground. Once the pipe has entered the ground, the temperature will adjust to the in-ground conditions. In nearly all cases the ground temperature will be below 73.4 °F. After an hour or so in the ground the pipe will reach equilibrium with the ground conditions. This means that for an HDD installation as an example, by the end of a pull-in where the higher loads are typically realized, the full allowable pull force of the pipe can be used.

While the modulus of elasticity for PVC pipe decreases with an increase in temperature, there is no recommended change in minimum allowable bend radius recommendations. The published minimum recommended bending radius should be used for temperatures down to 20°F. For installation of Fusible PVC® pipe in temperatures below 20°F, the minimum recommended bending radius should be increased to 120% of the published minimum recommended bending radius (see Eq. 12.2). For more details on cold weather handling practices related to thermal butt fusion of PVC, see Operations Bulletin OB-8-274\(^\text{2}\).

\[
\text{Minimum Allowable Bend Radius at Temperatures less than 20 °F} = \text{Minimum Allowable Bend Radius} \times 1.2
\]

Eq. 12.2
6.4 Use of Percussion Hammers and Pneumatic Pipe Bursting Tools during Pull-in and Pipe Movement

Use of a percussion hammer or a pneumatic pipe bursting tool with Fusible PVC® pipe WILL CAUSE FAILURE OF THE PIPE MATERIAL AT THE MECHANICAL CONNECTIONS. DO NOT USE PERCUSSION HAMMERS OR PNEUMATIC TOOLS WITH FUSIBLE PVC® PIPE.

6.5 Pull Head Connection Frequency

From time to time, the idea of using a single section of Fusible PVC® pipe that has a pull head permanently attached to it and fusing it on to successive pipe strings to move or install them is offered as a way to save time on a project. Underground Solutions, Inc. DOES NOT ALLOW this practice.

ALWAYS MAKE A NEW CONNECTION FOR THE PULL HEAD FOR INSTALLATION OF EACH ASSEMBLED PIPE LENGTH. Never use the same pull head connection for more than one installation. The repeated use of the same pull head connection may carry over hidden damage at the pull head connection from the initial pull-in to subsequent pull-ins, resulting in possible failure of the pull head connection.

6.6 Eliminating Excessive Drag and Pipe Roller Use

Shorter lengths of Fusible PVC® pipe are normally moved by sliding the pipe along the ground surface. Pipe rollers, appropriately sized for the diameter and weight of the assembled pipe length being moved are recommended for longer lengths of Fusible PVC® pipe. In some cases, techniques such as: a) moving rollers or ‘dollies’ that attach to the pipe and move with the pipe, b) moving skids that attach to the pipe and move with the pipe, c) sacrificial dunnage, pipe segments, or racks that are placed under the pipe during movement, and d) floating the pipe on a water surface available and applicable to the pull-in alignment may be appropriate and can be useful for at-grade pipe movement. See Figures 6.6 through 6.9 for examples of these types of friction reducing implements in use.
Section 6
Pulling Parameters

Figure 6.6. Typical pipe roller used to control frictional drag. It is critical to assure that the pipe rollers are sized and rated for the dimension and weight of the pipe being moved. The preferred roller will use pillow block bearings that are properly maintained and lubricated.

Figure 6.7. ‘Dolly-style’ pipe roller (left) and sliding ‘skid-style’ sled (right) used to reduce frictional drag.
Section 6
Pulling Parameters

Support spacing should be evaluated whenever utilizing these methods. Increased spacing beyond Underground Solutions, Inc.’s recommended spacing between the rollers, or other devices will result in excessive sagging of the pipe. This may produce an inefficient washboard-type pulling effect, detrimentally increasing the required pull force needed. Underground Solutions, Inc. recommends support spacing for above ground pipe support and handling through an interactive tool that allows the project conditions to be taken into account. Contact your local Underground Solutions, Inc. representative for more details and for applications involving high temperatures or other unique situations.
Pulling the assembled pipe length in and along a straight alignment is routine. Whenever the pipe must negotiate bends, whether horizontal or vertical in nature, care should be exercised to assure proper support. The assembled pipe length will attempt to move laterally towards the center of any curve that it is pulled through. For vertical curves this is generally easy to deal with by using supports underneath or above the pipe. For horizontal curves, guiding supports provide resistance to this lateral movement. There are several methods for providing this type of support that have been successfully used and are easy to implement in the field. This includes using roller sets, turned on their side and properly supported with equipment or ‘deadmen’ (See Figure 6.1). This also includes using ‘staking’ methods to pin the alignment in a horizontal curve (See Figure 6.1). While standard rollers provide limited side support, in a horizontal curve that approaches the minimum recommended bend radius of the pipe, the side support should follow the same spacing recommendations as the support rollers. Otherwise localized over-bending may result.
Figure 6.12. Use of sleeved drill stem segments as stakes to properly support an assembled pipe length alignment being moved horizontally over the ground.

Whenever moving the assembled pipe length using rollers or other supports, constant monitoring of the assembled pipe length movement and supports is required to ensure that the assembled pipe length does not fall off of the supports and incur damage. Careful monitoring will allow for correction of the assembled pipe length handling before leading to potential damage and delays. If damage does occur from pipe movement, reference section 6.8.

6.7 Pulling Methods

All installation methods, including HDD, pipe bursting, slip lining, and direct bury, must utilize a method to connect the assembled pipe length to the pulling equipment that will safely and effectively transfer the pull force required to move the assembled pipe length. Additionally, handling the assembled pipe length will also require some means of connecting to it.

6.7.1 What NOT to Use

Do not use connection methods or materials that will damage, abrade, or otherwise harm the assembled pipe length for its intended, long term use. This includes wire rope, chains, or other metal devices that will scratch, gouge, or damage the pipe.

Do not screw any connection into the pipe wall. This includes bolts, all-thread, or any other connection method that directly threads into the pipe wall. Do not use a threaded connection against a smooth bored hole in the pipe.

When contemplating connection methods to the pipe that vary from the published guidance, always consult with your local Underground Solutions, Inc. representative.
Section 6
Pulling Parameters

6.7.2 Nylon Strap

A nylon strap is used to pull shorter fused lengths of Fusible PVC® pipe above ground. This applies to pulling the assembled pipe length through the fusion machine during assembly or moving the fused length to the required insertion position. Nylon webbing will not damage the pipe surface and generates enough friction with the pipe surface to make it effective in moving the fused pipe length. Figure 6.13 shows an example of a nylon strap being used to move an assembled length of Fusible PVC® pipe.

If the length of fused pipe is short enough or if friction reducing implements are being employed, the assembled pipe length can usually be pulled with a nylon strap. The tensile capability of the strap must be known to compare it to the pulling force required to move the pipe effectively. To estimate the required pulling force, the weight of the fused pipe length is multiplied by a friction factor. If the assembled pipe length is on rollers, a 0.2 friction factor is recommended. If the assembled pipe length is pulled over the ground, a friction factor of 0.5 may be used. There are many variables that will affect the required pulling force, e.g. wet surfaces typically require less pulling force than dry surfaces, grass is more slippery than native soil, etc., etc.

Figure 6.13. Example of a nylon strap being used to pull a string of Fusible PVC® pipe.

6.7.3 Carriage Bolt with Linkage

When sliplining short assembled pipe lengths, round head carriage bolts can be used to connect a chain or other link internally, to facilitate attachment of a cable for pull-in or pipe movement. The portion of the
Section 6
Pulling Parameters

Carriage bolt, rebar or other material that comes into contact with the pipe wall must be smooth (see Figure 6.14).

![Figure 6.14. Example of carriage bolt type connection used on short sliplining installations.](image)

Care must be taken to ensure the bolted connection is not too close to the end of the pipe. This offset distance from the end of the pipe controls the amount of pipe wall in shear. If the connection is too close to the pipe end, it may pull through the pipe material at the end of the pipe. Table 6.6 provides the minimum offset distance from the end of the pipe for carriage bolt installation.

<table>
<thead>
<tr>
<th>Distance to the End of the Pipe for Carriage Bolt Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Pipe Size (inches)</td>
</tr>
<tr>
<td>4, 6, 8, 10, 12, 14, 16</td>
</tr>
<tr>
<td>18, 20</td>
</tr>
<tr>
<td>24, 27/28, 30, 36</td>
</tr>
</tbody>
</table>

Table 6.6 – Minimum offset distance from the end of the pipe for carriage bolt installation.

This method should only be used for relatively short lengths. Under higher loads in longer assembled pipe length installations, this connection approach may tend to oval the pipe. This also introduces pull out forces on the bolts and stress in the pipe wall that could lead to connection failure. In longer lengths a pull head designed for Fusible PVC® pipe must be used.

If you are unsure whether the method you are contemplating for pulling the pipe is sufficient or acceptable, contact your location Underground Solutions, Inc. representative.

6.7.4 Pull-Head

Underground Solutions, Inc. has designed pull heads for use with all sizes of Fusible PVC® pipe that are rated to specifically provide the full allowable pull force to be applied to the pipe (see Figure 6.15). Appropriately
Section 6
Pulling Parameters

rated pull heads should always be used for installations and movement of larger diameters and longer lengths of Fusible PVC® pipe.

“Grip” type pull heads will not work effectively with Fusible PVC® pipe. Due to the hardness of the PVC material, “grip” type pull heads cannot “bite” into the PVC with enough force to transfer the required pulling force from the pull head to the pipe.

Always use an appropriately sized and rated pull head, made specifically for the size of Fusible PVC® pipe being installed.

Figure 6.15. Example of a properly sized and rated pull head for use with Fusible PVC® pipe.

The pull heads designed for use with Fusible PVC® pipe are typically a three bolt connection design with two high strength steel pull head nuts and a connecting all-thread length between them. These pull heads are designed to accommodate the recommended safe pulling force for each pipe diameter size. The pull head nuts are smooth shank construction to eliminate stress concentrations caused by the edges of a threaded bolt or all-thread. The bolts are countersunk to provide a smooth pulling surface on the outside of the head. The bolt assembly is designed to connect inside the pull head to allow shear loading of the bolt heads at the pipe wall and pull head interface.

External and internal pull heads have been designed and are available for use (see Figure 6.16). The external pull head slides over the pipe end and is through-bolted in place. The internal pull head is installed inside the pipe, to avoid adding additional diameter at the assembly location. The internal pull head also uses through-bolts to connect it to the pipe end. The pipe wall must be beveled at the end to allow the pipe to slide over small obstructions in the pulling alignment prior to use. The internal pull head is primarily used for slipline installations with minimal annular clearance. External pull heads are used for all other applications.
Figure 6.16. An internal and external pull head example are shown for use with Fusible PVC® pipe.

6.7.4.1 Pull Head Installation

Detailed installation instructions for pull heads are included in Underground Solutions Operational Bulletin OB-8-270(3). This document should be referenced and followed to ensure appropriate installation and functionality of the pull head.

6.7.4.2 Pull Head Removal

Pull heads should be removed from the end of the pipe in the reverse order in which they were installed (see Figure 6.17). Remove the bolts and smooth shank nuts and pull the pull head off of the end of the pipe. Pull heads are heavy – ensure there is adequate support and equipment to safely remove the pull head off of the end of the pipe.

If the pipe must be cut prior to the removal of the pull head, ensure that the end of the pipe with the pull head is properly supported so that it does not transfer stress to the area of the cut. If not properly supported, the pipe can fracture and suddenly shift during the cutting procedure if it is under bending stress due to the cantilevered weight of the pull head. Failure to properly support the pull head and pipe during this operation may result in personal injury. Always ensure that...
Section 6
Pulling Parameters

there is a sufficient length of pipe (at least 1 foot) protruding from the pull head so that it may be extracted from the pull head after the pipe has been cut (see Figure 6.18).

Figure 6.17. Remove the pull head in the reverse manner in which it was installed by removing the pull head nuts (left) and sliding the pull head off of the end of the pipe (right).

Figure 6.18. Picture of a properly supported pipe end during the removal of a contractor fabricated pull head by cutting the pipe section. Note that the pipe is cut back with sufficient length to allow for the extraction of the pipe segment still retained within the pull head.

DO NOT CUT THE END OF THE PIPE OFF AT THE EDGE OF THE PULL HEAD! LEAVE AT LEAST 12 INCHES OF PIPE BARREL FOR PIPE EXTRACTION FROM THE PULL HEAD!
Section 6
Pulling Parameters

Since pull heads utilize through-bolt connections, the last several feet of the pipe end will need to be removed prior to any required connections. The total length of pipe assembled and installed should take this small required length into account during the construction planning phase.

6.7.4.3 Pull Head Rental through Underground Solutions, Inc.

Pull-heads are available for rent or purchase from Underground Solutions, Inc. Please contact your Regional Sales person (visit www.undergroundsolutions.com to find the sales contact nearest to your location) or call the main office at 858-679-9551 to inquire about rental rates, purchase prices, availability, or any other aspect of pull heads.

6.8 Pipe Damage

The assembled pipe length should be checked for potential damage after any handling or movement event, however it is especially important to do so prior to the final installation of the product.

The most common forms of pipe damage result from pipe handling and movement. Damage can come from equipment, such as the forks of a front end loader, or from hard metal implements used with the pipe, such as pipe roller stands. Extra caution should be used when working with longer assembled pipe lengths, heavy equipment and pipe supports. Pipe that has sustained damage less than or equal to 10% of the wall thickness of the pipe is still considered fit for its designed use. If a scratch or gouge in the surface of the Fusible PVC® pipe is greater than 10% of the pipe wall thickness, contact the project’s design engineer, or your Underground Solutions, Inc. representative (who will follow up with the design engineer) immediately to determine the next course of action. This may include leaving the pipe as is and de-rating its pressure carrying capacity, or cutting out the damage and re-fusing the pipe string together as determined by the project’s designer.

When cutting PVC pipe that has sustained damage, such as a piece of pipe that has been struck or been dropped resulting in a fracture, it is imperative that the pipe be cut back behind the location of fracture at least two feet. The pipe should be inspected carefully, both internally and externally, to ensure there are no fractures remaining in the section that will be installed. Cracks or micro-cracks that remain in the pipe may cause further performance issues and pipe failures at those locations if they are not removed when the pipe is cut.
Section 6
Pulling Parameters

References


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This document does not purport to address all of the safety concerns, if any, associated with the handling, installation or use of Fusible PVC® pipe or with the various application techniques described herein. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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# Section 7

## Cutting Fusible PVC® Pipe

### 7.0 Cutting Fusible PVC® Pipe

Recommended practices for working with and handling bell and spigot PVC pipe apply to Fusible PVC® pipe. However, lengths of Fusible PVC® pipe, joined by butt-fusion, are subject to additional stresses during installation. These stresses on assembled pipe lengths may occur as a result of bending, internal pressure, external loading, and/or the method of installation. General guidance for cutting PVC pipe can be found in industry resources, such as the Handbook of PVC Pipe,\(^1\) and American Water Works Association documents AWWA C605\(^2\) and AWWA M23.\(^3\) This section reviews the proper cutting procedure for Fusible PVC® pipe as well as some critical items common to cutting most types of PVC pipe.

### The Most Important Items When Cutting Fusible PVC® Pipe:

1. **Follow all safety precautions for lifting and supporting the pipe, operating the cutting equipment, and using personal protection equipment (e.g. safety glasses or face shield, etc.).**
2. **NEVER USE A CHAINSAW.** Use appropriate equipment to cut PVC pipe as detailed in this document.
3. **Properly support the pipe during the cutting process to eliminate bending stresses.**
4. **Always follow Underground Solutions, Inc. recommended cutting procedures.**

### Safety First!

Pipe cutting equipment represents a personal injury hazard due to the sharp nature of the tools among other things. Always follow the requirements and recommendations, as well as the caution and warnings, of the manufacturer of the pipe cutting equipment being used.

Fusible PVC® pipe, both as delivered to the project site and when assembled into long lengths represents a large, heavy material that requires attention during handling, movement, and installation on a project site. Moving lengths of pipe improperly creates a hazard that can result in personal injury or even death. Always follow best practice safety procedures as provided by Underground Solutions, Inc., as well as all entities having jurisdiction for the project.

### 7.1 Cutting Equipment

Serrated bladed saws, such as reciprocating saws are commonly used to cut PVC pipe. Powered ‘cut-off’ or rotating disc-type saws, as long as they are outfitted with a diamond blade or blades made for use with PVC materials are acceptable as well. Be sure that the rotating blade is properly centered and not off-set when using this type of saw. Wire-type cutters have also been used successfully to cut PVC pipe. See Figure 7.1 for examples of applicable and non-applicable cutting tools for use with Fusible PVC® pipe.

**NEVER USE A CHAINSAW TO CUT FUSIBLE PVC® PIPE.** The crude kerf and ripping action of this type of saw can leave small cracks in the cut face of the PVC pipe. This damage may compromise successful installation and long term performance.
Section 7
Cutting Fusible PVC® Pipe

7.2 Pipe Support

To eliminate bending stresses during cutting, it is important that a straight, properly supported pipe alignment on both sides of the cut is provided. If the adjacent pipe alignment cannot be fully straightened, provide support against the outside of the curved pipe section to offset the tensile stress from bending, on both sides of the cut. The pipe must always be fully supported on both sides of the cut and the pipe should be cut on level ground (see Figure 7.2). When the pipe to be cut is cantilevered, such as the end of a pipe string that is supported from only one side; the cantilevered side must be completely supported using a nylon strap or other acceptable arrangement to remove the weight from the cantilevered end (see Figure 7.2). This is particularly important when the cantilevered end of the pipe also has a pull head installed on it. Underground Solutions, Inc. recommends that pull heads be removed in the reverse manner by which they were installed BEFORE cutting the pipe. See Section 6 – Pulling Parameters for Fusible PVC® Pipe, for more information related to pull heads, and pipe handling.
Section 7
Cutting Fusible PVC® Pipe

7.3 Stress Loading in the Pipe

In addition to the steps taken to relieve the bending stresses, some residual stress may still remain in the Fusible PVC® pipe string at the proposed cut location. When the pipe is cut perpendicular to the axial centerline of the pipeline, any unrelieved longitudinal or axial stress may pull the pipe apart. This may result in separation of the pipe at the cut location prior to being cut the entire way through. Always properly support the pipe to minimize problems during the cutting procedure. In cases where axial stresses are present in the pipe, the initial cut may be uneven (see Figure 7.3) and will require that another clean, squared-end cut to be made afterward. Always make sure that enough material is left for this clean-up cut per the requirements of the project.

Figure 7.2. Two examples of a properly supported pipe alignment on both sides of the cut to be made.

Figure 7.3. When stress is not relieved in the pipe during the cutting process, the forces in the pipe may cause the cut to be uneven.
Section 7
Cutting Fusible PVC® Pipe

7.4 Cutting Procedures

In order to achieve a controlled, perpendicular cut in PVC pipe, the following cutting procedure is recommended. This procedure should be used for ALL cuts made on Fusible PVC® pipe.

**ALWAYS MAKE SURE THE PIPE TO BE CUT IS NOT INTERNALLY PRESSURIZED. ALL INTERNAL PRESSURE MUST BE RELIEVED.**

**ALWAYS MAKE SURE THE PIPE IS NOT UNDER TENSILE LOAD FROM PULLING EQUIPMENT OR OTHER SOURCES. RELIEVE ALL LOADING ON THE PIPELINE PRIOR TO MAKING A CUT.**

Internal pressure or tensile loading at the location of the cutting operation can cause sudden and violent movement of the pipe, including shards of pipe that may turn into projectiles that could cause injury or death.

1. Mark a circumferential line around the pipe prior to making the cut. Consider using a “Wrap-A-Round” pipe marking tool or other similar device to align the mark perpendicular to the axis of the pipe and around the full circumference of the pipe. The pipe can be marked effectively with a black “Sharpie” or equivalent marker.

2. Consider the size of the cutting equipment that will be used and position the pipe so that the bottom can be cut cleanly. This may require excavation under the pipe.

3. Score the pipe at a maximum of ¼-inch depth increments. **ONLY SCORE THE PIPE, DO NOT COMPLETELY CUT THROUGH THE PIPE.**

**STEP 1:** Start by making the initial scoring cut from the 9 o’clock position of the pipe to the 6 o’clock position – see Figure 7.4.
**STEP 2:** Continue by making another scoring cut from the 3 o’clock position of the pipe to the 6 o’clock position – see Figure 7.5.

![Figure 7.5](image)

**STEP 3:** Continue by making another scoring cut from the 12 o’clock position of the pipe to the 3 o’clock position – see Figure 7.6.

![Figure 7.6](image)
**Section 7**

**Cutting Fusible PVC® Pipe**

**STEP 4:** Complete the first scoring pass by making a final scoring cut from the 12 o’clock position of the pipe to the 9 o’clock position – see Figure 7.7.

![Figure 7.7](image)

**STEP 5:** For smaller diameter (12-inch and less) pipes, make a complete cutting pass for each quarter pipe section in the same order as described in steps 1 through 4 (see Figure 7.8). For larger diameter (14-inch and greater) pipe, continue to make scoring passes, removing approximately ¼-inch increments of the pipe wall for each quarter pipe section in the same order as described in steps 1 through 4. Repeat this scoring cycle until the pipe has been completely cut through (see Figure 7.8).

![Figure 7.8](image)
Section 7
Cutting Fusible PVC® Pipe

Figure 7.9 shows a 30-inch Fusible PVC® pipe that was cut using this method. Note the excavation under the pipe to allow the scoring and then ultimately the cutting of the full pipe section. Also note the full, level, soil support of the pipe on either side of the cut. After the cut has been completed you will note that there is nearly no displacement of the two sections relative to one another, which indicates that the pipe sections were fully supported.

Figure 7.9. Example of pipe sections shown after the cut has been completed. Note the full support of the pipe on both sides of the cut and the excavation just under the location of the cut to allow for access and free movement of the cutting tool to facilitate a proper cut.

7.5 Damaged Pipe Sections

Equipment, such as the forks of a front end loader, the corners of construction equipment, or metal pipe roller stands can cause damage during pipe handling. Caution regarding pipe damage should always be exercised when working with longer pipe strings, heavy equipment, and pipe supports. Pipe that has sustained minor superficial damage, or scratch or gouge depths less than or equal to 10% of the wall thickness of the pipe, is still considered fit for use. If a scratch or gouge in the surface of the Fusible PVC® pipe is deeper than 10% of the pipe wall thickness, contact the project owner or owner’s representative immediately to determine the next course of action. This may include leaving the pipe as-is and de-rating its pressure carrying capacity, or cutting out the damaged section and re-connecting the assembled pipe lengths together. This determination must only be made by a responsible party who possesses complete knowledge of the pipe design and intended use, according to the owner.

When cutting PVC pipe that has been damaged the pipe should be cut back to reach undamaged pipe, behind the location of any evident fracture by at least two feet. The pipe must be inspected carefully, both internally and externally to make sure there are no fractures remaining in the section that will still be used. Fractures or micro-fractures that remain in the pipe may cause issues at these locations if they are not removed when the pipe is cut for repair.
If the undamaged pipe sections are to be joined by thermal butt fusion, reference Section 2 – Thermal Butt Fusion Process and Requirements for Fusible PVC® Pipe for more information. If the undamaged pipe sections are to be joined by conventional couplings or fittings, reference Section 3 – Fusible PVC® Pipe Connections for more information. If other means of joining the pipe sections are being considered, please contact your local Underground Solutions, Inc. representative for more information.

More detailed information about repairing damaged pipe that is installed and in-service can be found in Section 12 – Ongoing Maintenance and Special Installations with Fusible PVC® Pipe.
Section 7
Cutting Fusible PVC® Pipe

References


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8.0 Horizontal Directional Drilling Installation with Fusible PVC® Pipe

Horizontal Directional Drilling (HDD) is a trenchless installation method whereby long pipe lengths can be installed in locations where it will be difficult or impossible to install pipe using conventional trenching methods. This may include locations with large socio-economic impact and cost, such as a major highway crossing, or locations where environmental impacts would be high, such as a river and wetlands crossing. HDD entails creating a bore, or a hole underground, by using a steerable drill. After this hole is created and properly sized, the pipe is pulled back through it, installing the pipe along the desired alignment without having to excavate from the surface.

There are many available resources on HDD installation methodology, planning, pipe design, and best practices available in the industry. Three such resources are David Willoughby’s “Horizontal Directional Drilling: Utility and Pipeline Applications,”(1) the HDD Consortium’s “Horizontal Directional Drilling Good Practices Guidelines,”(2) and the Handbook of PVC Pipe.(3) Underground Solutions, Inc. offers several tools in relation to Fusible PVC® pipe for HDD installations, among them are a sliderule and a Driller Log Book. For information about these resources and questions regarding HDD installation of Fusible PVC® pipe, contact your local Underground Solutions, Inc. representative.

This section covers the basic items to remember when working with Fusible PVC® pipe for HDD installations.

The Most Important Items When Using HDD with Fusible PVC® Pipe:

1. Safety is the first priority. All safety precautions must be followed.
2. Always follow allowable bending and pull force recommendations for installation.
3. When ballasting, fill the pipe to just below the drilling fluid level in the pipe insertion pit.

Safety First!

Horizontal Directional Drilling equipment generates a massive amount of force to create bore holes and install pipe using the HDD method. Always follow the requirements and recommendations, as well as the caution and warnings of the manufacturer of the HDD equipment being used.

Fusible PVC® pipe, both as delivered to the project site and when assembled into long lengths represents a large, heavy material that requires attention during handling, movement, and installation on a project site. Moving lengths of pipe improperly creates a hazard that can result in personal injury or even death. Always follow best practice safety procedures as provided by Underground Solutions, Inc., as well as all entities having jurisdiction for the project.

8.1 HDD Pre-Planning Best Practices

When using HDD installation methods, each project is unique. Geology, underground utilities, site constraints and other aspects of a project will impact how it will be completed. Before work begins on an HDD installation, it is prudent to consider some of the planning aspects of the project. Some of these items are best practice for HDD in general, and others will be helpful specific to Fusible PVC® pipe.
8.1.1 HDD Alignments

HDD alignments are typically a “U” shape in the vertical plane and straight in the horizontal plane (see Figure 8.1 for a typical vertical plane alignment). As an example, if a waterway is to be crossed using HDD methods, the plan alignment would typically be a straight line, perpendicular to the waterway, crossing from one side to the other. Vertically, the profile alignment would angle down from the surface on one side of the alignment, curve to a tangent section that crosses under the waterway at the required depth, and curves back up to an angled alignment that surfaces on the other side of the waterway.

![Figure 8.1. Typical HDD alignment shown schematically.](image)

When using Fusible PVC® pipe, be sure that the final alignment meets the minimum recommended bend radius for the particular pipe size that is being used. The geometric bending radius is published for all sizes of pipe offered.

More complex alignments are possible with HDD methodology, but it increases the difficulty of an installation. Horizontal bends and compound curves, curving both in the horizontal and vertical direction, should be avoided if possible. Reverse curves, or curving the pipe back to grade or back to a set depth of bury on either side of the HDD installation is not recommended (see Figure 8.2). Use an angled or bend fitting to transition from an HDD installation back to standard bury installation on either side.
Drillers, or the HDD installing contractors, may elect to vary bore alignments and installation arrangements based on site geology, project site layouts, and intended equipment.

### 8.1.2 Insertion and Exit Angles

Drill rigs typically operate somewhere between 6 and 18 degrees in terms of the drill rig insertion angle (see Figure 8.3). The actual angle will depend on the site conditions, geometry, and subsurface utilities to name a few. Drill rig and pipe insertion angles in the 10 to 12-degree range are ideal and HIGHLY RECOMMENDED, as they will allow an easy, industry standard fitting transition back to grade using an 11.25 degree angled fitting.

Exit Angles should be verified electronically before pipe is pulled to make sure that the pipe aligns correctly with the Bore Alignment during pullback.
8.3 Alignment Bend Radii

Table 8.1 translates deflections for different rod lengths that correspond to the minimum allowable bending radius for each pipe size. This is the maximum deflection that should be applied over the length of a single rod, either in degrees or percentage. Note that the steering correction should take place OVER THE ENTIRE ROD LENGTH, not just at the beginning or end. These represent smooth curves and should be constructed with gradual adjustments.

Underground Solutions, Inc. makes no recommendation regarding the appropriate rod length or drill rig size for a given pipe size or HDD installation. Appropriate equipment sizing is the responsibility of the drilling contractor, and should be based on the requirements of the project as a whole.
Table 8.1. Maximum allowable deflection adjustments per rod length per minimum allowable bend radius values for each pipe size. Underground Solutions, Inc. makes no recommendation regarding the appropriate rod length or drill rig size for a given pipe size or HDD installation.

Underground Solutions, Inc. recommends transitioning back to the rest of the pipe alignment by using angled bend fittings on either side of the HDD installation. **UGS DOES NOT RECOMMEND REVERSE CURVATURE OF THE DRILL OR THE PIPE ALIGNMENT AFTER THE HDD INSTALLATION TO BRING THE PIPE BACK TO GRADE.** These alignments are typically very difficult to construct and have a high likelihood of over-bending the pipe (see Figure 8.2).

Underground Solutions, Inc. provides a Driller Log Book that contains information regarding slope, angles, rod deflection and more. Contact your local Underground Solutions, Inc. representative for more information and to obtain a Driller Log Book.

### 8.1.4 Bore Hole Sizing

The standard industry recommendation for minimum borehole size is based on the outer diameter (OD) of the pipe that is being installed. Table 8.2 provides details on recommended bore hole sizing based on Fusible PVC® pipe OD.
Table 8.2. Recommended final bore hole diameter sizing based on Fusible PVC® pipe outer diameter.(2)

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Bore Hole Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 8 inches</td>
<td>Pipe Dia. + 4 inches</td>
</tr>
<tr>
<td>8 inches to 24 inches</td>
<td>Pipe Dia. X 1.5</td>
</tr>
<tr>
<td>&gt; 24 inches</td>
<td>Pipe Dia. + 12 inches</td>
</tr>
</tbody>
</table>

For example, if the pipe size being installed is a 12-inch DIPS, with a 13.20-inch OD, then the bore hole size recommendation would be the OD, 13.20 inches, plus 50% of the OD (since 12-inch is between 8-inch and 24-inch), 6.60-inches, for a total size of (13.20 + 6.60) 19.80 inches. Further, if the pipe size being installed was a 30-inch DIPS, with a 32-inch OD, then the bore hole size recommendation would be OD, 32 inches, plus 12 inches (since 30-inch is greater than 24-inch), for a total size of (32 + 12) 44 inches. For product pipe that is less than 8-inches, it is common practice in the industry to add 4-inches to the OD to size the final bore hole diameter.

Bore hole sizing will depend on the geology encountered along the borehole, among other factors related to the HDD process. The final bore size required should be selected based on these factors and the driller’s experience. Underground Solutions, Inc. recommends, however, that the industry standard minimum bore hole sizing described be followed.

8.1.5 Connections on Either Side of HDD Installation

Standard mechanical fittings are recommended for the connections on either side of an HDD installation. These fittings should be restrained to assure that any pipe movement or settling of the pipe alignment in the HDD bore hole over time will not result in any issues at the fitting connections (see Figure 8.4). Assure that there is enough restrained pipe on the pipe alignment leading into and out of the HDD section that pipe joint pull-out will not occur on subsequent joints away from the fitting connections on either side of the HDD alignment and connections.
Section 8
Horizontal Directional Drilling

8.1.6 Installation Loads for HDD

As part of a pipeline design, the required wall thickness of the Fusible PVC® pipe required for the project is determined. The wall thickness needed is set by the operating conditions of the utility or end user. In most cases the wall thickness (or DR) for the Fusible PVC® pipe needed for operation provides more than adequate axial tensile capacity and external load resistance for the HDD installation. While tensile loading, external loading, and possible cyclic operation must be evaluated, in most HDD installations, the operational Fusible PVC® pipe requirements will provide sufficient wall thickness for tensile forces, external loading, and cyclic operation.

HDD installation methods place specific installation-based loads on the pipe as it is pulled back into place. These loads include axial stress from the pulling process, bending stresses, and external loading from the drilling slurry. Changes to the drill plan, alignment, drilling fluid, or any other variable, may impact the loading realized on the pipe during installation.

Always make sure that the HDD rig is calibrated so that hydraulic pressures registered during the installation may provide an estimate of pullback force being applied to the pipe. Verify at all times during the installation that the pullback force being applied by the drill is less than the allowable pulling force (see Section 6 – Pulling Parameters of Fusible PVC® Pipe for more information on allowable pulling forces for Fusible PVC® pipe).

Contact your Underground Solutions, Inc. representative for more information regarding pipe stresses during pullback and to check any aspect of an HDD installation in terms of pipe loading. Underground Solutions, Inc. can explain the nature and orientation of HDD installation loading on Fusible PVC® pipe. Underground Solutions, Inc., does not perform HDD designs and will NOT provide estimates of this loading.
for a project submittal or provide any calculations on behalf of another party. Underground Solutions, Inc. will from time to time estimate this loading – typically very early in the design process of a project – to confirm pipe sizing and wall thicknesses for Fusible PVC® pipe.

8.1.7 Fusion Layout and Pipe Assembly

Ideally, all pipe required for HDD installations will be joined together using thermal butt-fusion joints into a single assembled length which would be in line with the insertion pit and then installed. See Section 2 – Thermal Butt-Fusion Process and Requirements for Fusible PVC® Pipe for information related to thermal butt-fusion of Fusible PVC® pipe.

Thermal butt fusion joining operations should take place as close to the insertion location as practical. If the assembled pipe length needs to be moved to the insertion location, follow the best practices as outlined in Section 6 – Pulling Parameters of Fusible PVC® Pipe. Sometimes, an entire length of assembled pipe, especially for longer installations, cannot be fully assembled prior to the insertion. In these cases, it is possible to assemble thermally butt-fused shorter lengths of pipe and then thermally butt fuse these shorter lengths together as the pipe is inserted (see Figure 8.5). The HDD insertion operation must stop while these intermediate fusion joints are performed. An intermediate fusion joint takes no longer to complete than a production fusion joint if done under the same ambient conditions. From experience, however, additional time will be needed to stage the shorter assembled pipe lengths into alignment with the fusion machine. Upfront planning can minimize the time required for handling these intermediate lengths. After an intermediate fusion joint has been completed, the HDD insertion or pullback may recommence. Section 2 – Thermal Butt-Fusion Process and Requirements for Fusible PVC® Pipe contains information related to intermediate fusion joints. Clean water ballasting and other aspects of the insertion may be adjusted for intermediate fusion joint assembly. Contact your local Underground Solutions, Inc. representative for more details about incorporating intermediate fusion joints into your project.
8.2 Insertion Pit Recommendations

Insertion alignments need to be carefully considered to assure that the pipe is not over-bent and is properly supported as it is inserted. The insertion point is a critical location for the installation. This area should be monitored during the pull-in operation to make sure that the entire insertion operation goes smoothly and to be prepared to make adjustments as necessary during that process. Rollers or other friction reducing implements, if used, must also be monitored closely to make sure that the pipe does not fall off of them. Particular attention should be paid to horizontal alignment bends and the supports used at those locations.

It is recommended that all insertion alignments line up with the horizontal HDD alignments and that horizontal bends going into the insertion are limited to the greatest extent possible. Selection of the appropriate insertion type for HDD will depend on the size of the installation, the size of the pipe, and the site constraints. All insertion alignments are dependent on the ACTUAL DRILL EXIT OR PIPE INSERTION ANGLE that has been constructed. ALWAYS TAKE AN ACTUAL MEASUREMENT OF THE DRILL EXIT OR PIPE INSERTION ANGLE PRIOR TO SIZING AND CONSTRUCTING INSERTION ALIGNMENTS.

The following sections outline three basic insertion methods typically used with HDD installations. Contact your local Underground Solutions, Inc. representative for more information and a tailored detail of insertion for your particular project.
8.2.1 Pipe at Grade Level

For shorter (less than 1,500 LF), smaller diameter drills (less than 16-inches), it is typical to pull the pipe along the ground and into an insertion pit, prior to it entering the bore hole. For these types of insertions, the insertion pit should be appropriately sized to assure that the pipe is not over-bent as it is being inserted (see Figures 8.6 and 8.7).

This type of insertion pit requires the least amount of equipment and is easy to set up (just dig the pit at the end of the HDD alignment), however it uses the most available space, i.e., it will require the largest excavation, and must be carefully constructed to assure that a smooth curve is used to transition the pipe from grade to the HDD insertion angle.

![Diagram of Grade level HDD insertion pit example schematically.](image-url)
Items to be careful of for this type of insertion set up are to actually measure the pit to assure that minimum pit dimensions are met and check for scraping of the pipe at the edge of the pit if it is cut in asphalt or rocky ground.

8.2.2 Pipe on Supports

As installations get longer (1,500 LF and longer) and pipe sizes get larger (16-inches and larger), it is often advantageous to utilize pipe rollers or some other form of friction reducing element at grade as the pipe is pulled into the insertion area. These types of implements will raise the height of the pipe as it is pulled into the pit, thus reducing the required excavation size for the pit (see Figures 8.8 and 8.9).
It is critical that rollers or other devices be in good working order and functioning. Care must also be utilized to assure that pipe does not inadvertently fall off of the rollers during insertion, which can damage the pipe. It is a best practice to ‘tail’ the pipe end as it is pulled in with an excavator and nylon sling (see Figure 8.10). This arrangement can ease the pipe over the rollers and tend the end of the alignment to make sure it doesn’t pull the assembled pipe length off of the rollers. The alignment and supports should be monitored during the ENTIRE installation to assure that no pipe damage is sustained. See Section 6 – Pulling Parameters of Fusible PVC® Pipe for more information regarding supports and friction reducing implements for use with Fusible PVC® pipe. Make sure to use the appropriate ACTUAL height of support to calculate the insertion pit required. If there are not enough supports to support the entire length of pipe for the installation, use what supports that are available at the appropriate spacing, STARTING AT THE INSERTION.
PIT AND WORKING BACK TOWARDS THE END OF THE ALIGNMENT FOR AS FAR AS THERE ARE SUPPORTS AVAILABLE. DO NOT EXTEND SPACING BETWEEN SUPPORTS. Not having enough supports at the appropriate spacing will result in increased pull forces required to move and install the pipe.

Figure 8.10 – ‘Tailing’ the pipe string to make sure that the end does not sustain damage or pull the rest of the pipe alignment off of the rollers.

8.2.3 Aerial Insertion

Aerial insertion is useful for extremely tight insertion pit layouts or excessively steep insertion angles. This method elevates the pipe as it approaches the insertion, so that it can be guided down to the appropriate insertion angle prior to reaching grade (see Figures 8.11 and 8.12).
Section 8
Horizontal Directional Drilling

Figure 8.11 – Aerial insertion pit example schematic.

Figure 8.12 – Project example of an aerial insertion pit.
Section 8
Horizontal Directional Drilling

This type of insertion requires very little excavation at the insertion location; however, it requires specialized pipe handling gear and equipment to position it correctly. The pipe should utilize friction reducing implements along the alignment.

The aerial insertion requires pipe supports that can be elevated to the required height to assure the appropriate insertion angle. These devices are ideally cradle roller or roller sling supports which provide full support to the pipe section and can be positioned with an appropriately sized piece of lifting equipment. It is critical to assure that the equipment used to support the pipe in the required alignment is capable of holding the pipe at the required height and can handle the required pipe weight. Depending on the insertion alignment and requirements other methods may be used. Contact your Underground Solutions, Inc. representative for more information on aerial cradle roller supports.

8.3 Pulling Connections

A pull head, advocated for use by Underground Solutions, Inc. and designed to carry the full allowable pulling force for the pipe section being installed, should ALWAYS BE USED FOR HDD INSTALLATION. The pull head should also be sealed to limit the amount of drilling slurry that is able to make its way into the pipe. For information about pull heads, sealing pull heads, and proper installation of pull heads, reference Section 6 – Pulling Parameters of Fusible PVC® Pipe and Operations Bulletin OB-8-270. [5]

8.4 Ballasting

Internal ballasting is the operation of filling the pipeline, usually with clean water, as it is being installed into an HDD alignment. This technique reduces the buoyancy of the pipe in the bore hole, which in turn reduces frictional drag of the pipe on the top of the bore hole. The pullback force required to install the pipe is then reduced as a result. The hydrostatic head of the ballast water also increases the pipe section’s resistance to external loads by increasing the pressure within the pipe. The most common method of ballasting is called clean water ballasting and uses a clean water source to pump water into the back end of the pipe to a level just below the drilling fluid in the insertion pit as it is being inserted into the bore hole. A far lesser used method, is called self-ballasting, whereby a perforated pulling head is used on the pipe that allows the drilling slurry to enter the pipe as it is being pulled into place. In this manner the pipe ‘self-ballasts’ as it is being installed.

8.4.1 Clean Water Ballasting

The most important element of clean water ballasting is to assure that the water only fills the portion of the pipe that has been inserted into the bore hole below the drilling fluid level, and DOES NOT back-up and fill the portion of the pipe that is above the drilling fluid level. If the water level is above the slurry level, DRAG WILL INCREASE on the pipeline as it is installed. The second element to consider is having enough water available and enough flow to fill the pipeline in a reasonable amount of time compared to the length of time that will be necessary to install the pipe. Figure 8.13 shows schematically, what a typical clean water ballasting operation entails.
A typical clean water ballasting operation will have a water source, such as a fire hydrant as shown in the Figure 8.13, and appropriately sized hose or tubing to get the water delivered to the insertion point (see another example of this in Figure 8.14). The hose or tube should be as long as the pipe being installed, and should be anchored at a known point that assures that the end of the tube where the water will be placed stays fixed a short distance into the borehole alignment (see Figure 8.15) below the drilling slurry level. As the Fusible PVC® pipe is installed into the HDD alignment, the hose or tube will stay fixed and slide out the back of the Fusible PVC® pipe. The water source is metered to accurately track how much water has been placed in the pipe. As the Fusible PVC® pipe is being installed, the calculated volume of the pipe that is going into the ground can be constantly compared to the amount of metered water that has been placed with the ballasting system. This will provide an understanding of how much of the pipe has been filled at any given time for tracking purposes, and will also assure that the pipe is not being overfilled or under filled.

At the end of this Section, Tables 8.3 and 8.4 include ballast volume calculations for the most common Fusible PVC® pipe sizes and wall thicknesses.
Figure 8.14. Example equipment set up for clean water ballasting operation. Water is pulled from storage in the frac-tank by the pump, the flow is recorded and a volume of water is calculated based on the pumping time, and the water is delivered to the pipe as it is being installed.
When clean water ballasting, follow these guidelines:

1. **Make sure to properly seal the end of the pipe at the pull head.** See Section 6 – Pulling Parameters of Fusible PVC® Pipe for details on sealing the pull heads.

2. **Properly test the ballasting set up for flow capability.** Fully assemble the ballasting set up, including the full length of hose or tubing that is to be used and run a flow test to verify how much water it will pump into the pipe. Perform a flow test to assure that the water meter is accurate. These are the only means that will be available to accurately track the amount of water being pumped into the pipe. If it is determined that there is not enough flow to completely fill the pipeline in a reasonable amount of time, make adjustments to the set up as needed. Increase hose size, get a larger pump, or locate another water source, for example.

3. **Always FULLY ballast the line when it is installed.** Do not partially fill the line with water, always fill the Fusible PVC® pipeline as it is installed to a level just below the level of the drilling fluid in the insertion pit.

4. **If the line is not fully ballasted during installation, BE VERY CAREFUL WHEN REMOVING THE PULL HEAD AND SEAL PLUG IF ONE WAS USED.** Vacuum loading may be created between the seal plug and the partially filled pipeline in the rising leg at the end of the installation. If there is significant
Section 8  
Horizontal Directional Drilling

separation between the seal plug and ballast water level due to under-filling, as the pipe rises up to the surface, a vacuum can form in this leg. As a result, the seal plug may be drawn down into the pipe alignment if it is not tethered to the pull head. **USE CARE WHEN REMOVING THE SEAL PLUG.** It is **HIGHLY RECOMMENDED** that a seal plug be used that has a pass through with a valve. The valve should be closed during the installation and ballasting operation, and then should be opened to allow the relief of any vacuum loading behind the plug after installation and prior to attempting to remove the plug.

5. **Watch for signs that the pipe is being overfilled.** Always monitor the insertion side of the pipeline and watch for signs that the pipe is being filled past the drilling fluid level in the insertion pit. Signs of overfilling may include the pipe riding lower in the drilling fluid of the insertion pit, excessive sag between supports at grade, or a rapid increase in pulling force required. Quickly adjust water filling practices should these be observed.

Clean water ballasting may also be performed if intermediate fusion joints are required for installation. One method includes assembled pipe lengths that are staged for joining by intermediate fusion joints which have fill lines pre-installed in them. After a length of pipe has been pulled into the borehole, the fill line is backed out of the pipe, disconnected and removed, and the next length of pre-assembled pipe is staged for intermediate fusion. After the fusion joint is completed, the fill line is reconnected to the pre-installed fill line in the added pipe segment, and installation resumes. When the fill line reaches the appropriate location for filling, ballasting can resume. Figure 8.16 illustrates this particular ballasting process with intermediate fusion joining. Other alternatives are also available for ballasting the pipe while performing intermediate fusion joints on an installation. Contact your Underground Solutions, Inc. representative for more details.
8.4.2 Self-Ballasting

Pipe may be self-ballasted and filled with drilling fluid as it is installed in order to reduce buoyancy loading and reduce critical collapse potential for extremely deep installations. Self-ballasting is performed by using a perforated pull head, which contains holes that allow the drilling fluid that is in the bore hole to fill the pipe as it is being installed. Figure 8.17 shows an examples of this type of pull head.
This type of ballasting is rarely performed for typical water and wastewater HDD installations because some manner of flushing and cleaning of the pipe is then required after the installation is complete. This can be a very difficult and time consuming process. Contamination from the surrounding soils is also a potential issue. If this method is used, a clean borehole is required so that the holes do not get plugged with cuttings, rendering the ballasting operation ineffective. **DO NOT modify Underground Solutions, Inc. supplied pull heads without discussing with your local Underground Solutions, Inc. representative.**
### Section 8
**Horizontal Directional Drilling**

#### Ballast Volumes for Common Fusible PVC® Pipe Sizes 4-12 inch

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*Table 8.3. Ballast volumes for common pipe sizes, 4 inches through 12 inches.*
## Section 8
### Horizontal Directional Drilling

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*Table 8.4. Ballast volumes for common pipe sizes, 14 inches through 36 inches.*
Section 8  
Horizontal Directional Drilling

References


(5) OB-8-270, “Underground Solutions® Pull Head Installation and Use” Underground Solutions, Inc.

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This document does not purport to address all of the safety concerns, if any, associated with the handling, installation or use of Fusible PVC® pipe or with the various application techniques described herein. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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9.0 Sliplining and Casing Installation with Fusible PVC® Pipe

Sliplining is the insertion or ‘slipping’ of a new Fusible PVC® pipe section inside an existing pipe of a larger diameter. Casing installation is similar to sliplining, however, the casing is usually installed prior to the carrier pipe being ‘slipped’ into it, thus the entire installation is new and is not considered rehabilitation work. Sliplining provides a new, factory produced and quality controlled pipeline that by itself is fully “structural.” Unlike other field applied processes that depend on the installation process to define the quality and capability of the end product, sliplining is installing a brand new pipeline – the major difference is that this new pipeline is installed inside an existing pipeline being rehabilitated.

The final flow area of the new sliplined pipe will be less than the original flow area of the existing pipeline. It is important to note, however, that the removal of tuberculation, debris and sediment from the existing pipeline, along with a significantly lower coefficient of friction (or higher “C” value) for the new Fusible PVC® pipe compared to the existing pipeline, often will make up for the loss in flow area, so that pipeline systems will continue to operate at their current flow rate with no increase in head losses.

There are industry sources available that provide more information about sliplining applications. The American Water Works Association (AWWA) includes sliplining for water main rehabilitation in its M28 waterline rehabilitation manual. ASCE has also published Renewal of Potable Water Pipes that contains chapters on sliplining. The PVC Pipe Association provides information in the Handbook of PVC Pipe. General slipline information is available in the text, ‘Trenchless Technology: Pipeline and Utility Design, Construction, and Renewal.’ Contact your local Underground Solutions, Inc. representative to find out if sliplining with Fusible PVC® pipe for a particular project is viable.

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The Most Important Items When Sliplining with Fusible PVC® Pipe:

1. **Safety is the first priority.** All safety precautions of the equipment manufacturers and jurisdictional authorities must be followed.
2. Always follow allowable bending and pull force recommendations for installation.
3. Allow for ~2-inches of clearance between the inner diameter of the existing pipe and the outer diameter of the new pipe.
4. Take into account the potential for movement of the new pipe and secure the new pipe in place with a low density grout. Thrust restraint must be considered for all installations.
5. Video inspect and clean the existing pipeline prior to sliplining to assure no hidden obstructions inhibit a successful installation.

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Safety First!

Pulling equipment used to install Fusible PVC® pipe via sliplining may generate high forces during its operation. Always follow the requirements and recommendations, as well as the caution and warnings of the manufacturer of the equipment being used.
Section 9
Sliplining

Fusible PVC® pipe, both as delivered to the project site and when assembled into long lengths represents a large, heavy material that requires attention during handling, movement, and installation on a project site. Moving lengths of pipe improperly creates a hazard that can result in personal injury or even death. Always follow best practice safety procedures as provided by Underground Solutions, Inc., as well as all entities having jurisdiction for the project.

9.1 Thermal Butt-Fusion Joining of Fusible PVC® Pipe for Sliplining and Casing Insertion Applications

Fusible PVC® pipe that is to be installed using sliplining and casing insertion is joined using thermal butt-fusion. See Section 2 – Thermal Butt-Fusion Process and Requirements for Fusible PVC® Pipe for specific details regarding this joining method for Fusible PVC® pipe. Fusible PVC® pipe must ALWAYS be joined by a qualified fusion technician, trained for the size of new pipe being installed.

The external Fusible PVC® fusion bead should be removed to minimize any interference with the existing pipe or casing. This is done immediately after the thermal butt fusion process and adds no additional time to the fusion process. See Section 2 – Thermal Butt-Fusion Process and Requirements for Fusible PVC® Pipe for more details regarding external de-beading.

9.2 Planning for a Slipline Project with Fusible PVC® Pipe

9.2.1 Existing Pipe Cleaning and Preparation

The existing pipeline should be adequately clean and free from obstructions prior to the slipline installation of the new Fusible PVC® pipe. Tuberculation, sediment build-up, scaling, or any other issues should be mediated (see Figure 9.1). The interior of the existing pipeline may be cleaned by a variety of methods. Water-jetting is typically done to remove loose sediments and mechanical scraping is done to remove tuberculation and scale. Figure 9.2 and 9.3 show examples of several methods/tools for pipe cleaning. The method or methods chosen should be reflective of the type of material being removed.

Figure 9.1. Picture of tuberculated pipe.
Cave-ins, collapsed pipe sections, abandoned valves, fittings, or other material obstructions must be removed or returned to the original inside diameter of the existing pipe. Excavated sections can be left open as installation access points for the new pipe.

It is recommended that a closed circuit television (CCTV) survey be performed to determine if the existing pipeline is free of obstructions (see Figure 9.1), if there are any abandoned or unknown fittings, corporation stops projecting into the pipeline, or internal diameter reductions that will impact the installation, and to assess the condition of the existing pipe. If there are questions regarding pipeline alignment, joint deflections, or potential offsets in the pipeline, it is recommended that a pipeline survey be performed. By surveying the alignment, a more complete understanding of what areas will be able to be sliplined and those sections that will not can be determined.

### 9.2.2 Sliplining through Deflected Pipeline Alignments

Fusible PVC® pipe can be sliplined through a deflected pipeline alignment or an existing pipeline that is not straight. The amount of joint deflection that can be accommodated is based on the existing pipe inner diameter, the new sliplined pipe’s outer diameter, and the minimum allowable bend radius of the new pipe.
Section 9  
Sliplining

The actual deflection angle(s) being negotiated can then be compared to what is allowable to determine if the deflection is within the capability of the new pipe (see Figure 9.4).

![Diagram of a sliplined pipe negotiating a single existing angular deflection in the existing pipe.](image)

*Figure 9.4. Diagram of a sliplined pipe negotiating a single existing angular deflection in the existing pipe. Multiple deflection capability is determined using 50% or less of the lay length.*

Contact your local Underground Solutions, Inc. representative for more information regarding sliplining Fusible PVC® pipe through angled deflections in existing pipe systems.

9.2.3 Location of Fittings and Connections

When preparing for a sliplining installation project the following best practices are offered. The most reliable way to assure a successful slipline is to remove all obstructions and fitting locations in an existing pipe prior to performing any sliplining operation. Utilize the locations of these excavations as insertion and pull pits if possible.

If the fitting location is straight in line, such as with a ‘tee’ fitting or a ‘cross,’ or a straight-through manhole location as part of a sanitary sewer system, the sliplining operation can pass through the location. Any connecting pipes, in the case of fittings, and the manhole in the case of a non-pressure pipeline, should be disassembled or retrofitted to accommodate the operation prior to the sliplining installation (see Figure 9.5).
Figure 9.5. An existing tee location was removed prior to the slipline operation and after completion, a new tee was cut into the sliplined section and the branch pipeline was reconnected.

If the fitting location is a bend fitting, it is usually most efficient to remove the fitting and utilize that location for either a pulling pit (for the installation equipment) or for an insertion pit. If it is desired to ‘pull through’ this alignment variation, the fitting must be removed, enough pipe must be removed on either side of the fitting, and enough excavation must be completed at the location of the fitting to ensure the minimum allowable bend radius for the Fusible PVC® pipe section being used will be maintained (see Figure 9.6). The same will be true of a manhole that has an alignment deflection located in it for non-pressure collection.
Figure 9.6. An angle fitting or bend fitting was removed on the existing steel pipeline and enough trench was removed on either side to allow the sliplined pipe to curve through the location.

Existing connections to the existing pipe, such as sewer laterals or water service line taps and corporation stops, must be excavated and removed prior to the sliplining operation. These locations can be then used to reinstate the service connections after the sliplining operation has been completed. See Section 5 – Tapping Fusible PVC® Pipe for important information about making these types of connections to Fusible PVC® pipe.

9.2.4 Project Access Locations

Consider fused pipe lengths and insertion requirements when laying out a project in terms of segments to be sliplined. Determine that there will be enough room to assemble and stage the pipe segments needed. Determine that there is enough room to align the pipe segments with the insertion location and orientation such that the pipe section’s minimum allowable bend radius is observed.

Allowable lengths for sliplining will be largely dictated by the weight of the new pipe, the cleanliness of the existing pipe, and the location of fittings and connections in the existing system that is being rehabilitated. Consideration should also be given to the current state of the existing system as well as available thermal
but butt fusion assembly, layout, and insertion staging area when deciding the appropriate lengths to attempt for the sliplining insertions.

Verify that the alignment is sufficiently straight for the size of pipe being used and amount of annular space available. Contact your Underground Solutions, Inc. representative for detailed information on sliplining through smaller, existing angled bends or offsets.

### 9.2.5 Annular Space

When sliplining existing pipe systems, it is recommended that there is at least two inches of space between the internal diameter of the existing pipe and the outer diameter of the Fusible PVC® Pipe (see Figure 9.7). This annular space allows for variances in the existing pipeline, such as joint deflections, constricted areas, and joint offsets, among other potential variances. It also provides sufficient room for annular space treatment after the installation is complete.

![Figure 9.7. A minimum of 2-inches of annular space is recommended for sliplining projects.](image)

### 9.2.6 Casing Spacers

UGS generally does not recommend the use of casing spacers. Fusible PVC® does not have an increased diameter at the joints so it will lay in the existing pipe invert and generally be fully supported – this negates the need for spacers.

Long slipline sections are not suited for spacers. The spacers can slide along the pipe barrel resulting in wedged and bunched sections in the host pipe. This leads to discontinuous support, with the pipe potentially sagging over longer than specified support distances. Short sections, like a slipline into a jack
and bore casing, can accommodate spacers if they are required in the specifications. Care needs to be exercised in inspecting the installation to determine if the spacers have remained at the specified spacing.

### 9.3 Planning for a Casing Insertion Project with Fusible PVC® Pipe

#### 9.3.1 Annular Space

When inserting Fusible PVC® pipe into casing installations, it is recommended that there is approximately two inches of space between the internal diameter of the casing pipe and the outer diameter of the Fusible PVC® Pipe.

In certain instances, it is allowable to have a smaller annular space than two inches for casing pipe insertions. Smaller spaces than two inches should consider how straight the alignment is, how clean the casing pipe is, the joining method used for the casing pipe, whether casing spacers are desired to be used, and the overall length required for the installation.

#### 9.3.2 Casing Spacers

Casing spacers, insulators, or skids are primarily used to elevate the carrier pipe from the bottom of a casing pipe to keep the bell joint or mechanical coupling of the carrier pipe from creating stress concentrations due the geometry of the pipe laying on the invert of the casing. Fusible PVC® pipe does not have a bell or mechanical joint, so casing spacers are not needed for use with the product. It can rest on the invert of the casing or existing pipe in a continuous alignment and support.

If casing spacers are used for other reasons, use spacers that are appropriately sized and designed for the pipe diameter and casing pipe inner diameter. Also, use spacers designed specifically for use with PVC pipe (see Figure 9.8).
Section 9
Sliplining

Figure 9.8. Example of casing spacers being used on a casing pipe installation.

9.4 Methods of Pipe Insertion for Sliplining and Casing Installations

There are three methods used to assemble and insert Fusible PVC® pipe for slipline or casing installations. The first method is to assemble and stage the required lengths of Fusible PVC® pipe needed for the insertion process by performing thermal butt fusion and then inserting the entire length into the existing pipe or casing installation through an excavation. This is known as preassembled, grade level insertion. The second method is similar to the first in that the pipe is inserted through an excavation into the existing pipe or casing installation, however it is not preassembled. The Fusible PVC® pipe, rather, is assembled using thermal butt fusion as it is being inserted into the existing pipe or casing installation, one pipe length at a time. This method is known as grade level, fuse and pull insertion. Finally, the third method utilizes an excavation adjacent to the end of the existing pipe or casing installation where the pipe is assembled as it is inserted. The Fusible PVC® pipe is assembled using thermal butt fusion in the excavation immediately prior to insertion. This method is known as in-pit, fuse and pull insertion.

Details for these three methods in relation to the thermal butt fusion process can be found in Section 2 – Thermal Butt Fusion Process and Requirements for Fusible PVC® Pipe. The following sections review the insertion process specifically for slipline and casing pipe insertion processes.

9.4.1 Assembled Pipe Lengths Inserted from Grade or Fuse and Pull Inserted from Grade

Pre-assembled pipe lengths inserted in a continuous movement from grade limit installation time – if there is ample room to assemble and stage the required pipe lengths prior to installation. If there is not enough room to stage fully assembled lengths of pipe, another option is to perform a fuse and pull operation with a standard insertion pit. This reduces the amount of space required, but allows for thermal butt-fusion to
be performed at grade level. When performing insertions from grade level regardless of whether fuse and pull is used, pay particular attention to the following items:

1. The tail ditch will not require manned access and does not need to be much wider than the diameter of the pipe. Assure that the tail ditch does not bind or pinch the pipe and allows it to move freely into the alignment.

2. Assure that the sharp edges of the insertion pit, which may potentially damage the pipe, are mitigated. This would include the beginning of the tail ditch if it is located in asphalt or rocky ground; the edges of the existing host pipe at both cut locations at both ends of the pit; and critically, the inside lip of the host pipe at the insertion point (see Figure 9.9 for an example end treatment).

3. Monitor the pipe insertion at all times, paying particular attention to potential pipe damage and binding.

4. If the fuse and pull method is to be used, communication is key between the operator pulling the pipe section into the alignment and the fusion technician. Make sure that reliable communication equipment (walkie-talkies, cell phones, etc.) are available so that precise starting and stopping of the insertion can be coordinated with the fusion operations.
Section 9
Sliplining

9.4.2 Assembled Pipe Lengths Inserted Using In-Pit Fuse and Pull Methods

Occasionally, due to limited access or exceptionally deep installations, it will be necessary to perform ‘in pit’ fusion. See Section 2 – Thermal Butt Fusion Process and Requirements for Fusible PVC® Pipe for details and specifics on the fusion process for in-pit fusion.

For sliplined or cased installations there are several critical points to remember when doing in-pit fusion:

1. Set up the fusion machine carefully to ensure that the pipe exiting the fusion machine – and entering the sliplined or cased portion of the insertion – slides in freely and is in general alignment with the host or casing pipe. The sliplined or inserted pipe should NOT bind in the existing pipe or casing pipe.

2. Ensure that the pipe does not get damaged on the edges of the casing or host pipe where the insertion begins for the entire circumference (see Figure 9.9). Use a wear plate, or protective material if needed at this location.

3. Reference Section 6 – Pulling Parameters for Fusible PVC® Pipe and the pulling mechanisms discussion for information on applicable pulling connections for slipline or casing insertions. Cable winches are often used for the shorter, lighter duty installations, and static pipe pulling equipment is often used for longer, heavier duty installations.

4. Communication is key between the operator pulling the pipe section into the alignment and the fusion technician. Make sure that reliable communication equipment (walkie-talkies, cell phones, etc.) are available so that precise starting and stopping of the insertion can be coordinated with the fusion operations.

9.5 Insertion Pit Recommendations

If an insertion pit is going to be used to insert assembled Fusible PVC® pipe into a slipline alignment, the pipe must bend generally in an “S” configuration, with two separate, but equal bending radii. The recommended bend radius for the pipe being inserted (shown as ‘Rb’ in Figures 9.10, 9.12, and 9.14) is the parameter that defines the length of the insertion pit (shown as ‘Overall Pit Length (L)’ in Figures 9.10, 9.12, and 9.14). Underground Solutions, Inc. provides insertion pit recommendations in a handy sliderule format. Contact your local Underground Solutions, Inc. representative for more details. Additionally, an Underground Solutions, Inc. representative will be able to provide an insertion pit layout for any assembled pipe length inserted from grade with minimum requirements (provided or assumed) for the pipe section being used.

Several key things to consider for the insertion pit requirements based on the installation situation for sliplining or casing pipe insertions:
1. If the host pipe or casing pipe is sloped away from the insertion location, a lesser bend could be required, thus a shorter pit may also be allowed.

2. If the host pipe is substantially larger than the Fusible PVC® pipe to be inserted, a portion of the bending could be accomplished inside the host pipe. This also could act to shorten the required insertion pit excavation.

Contact your Underground Solutions, Inc. representative for more details on these specific circumstances and how they will impact insertion pit size requirements.

There are three general types of configurations for sliplining or casing pipe insertions. Each will require a similar Pit Length (PL) to accommodate the bending radius of the pipe into the existing pipe alignment. They differ, however, in the amount of tail ditch required, based on the configuration of the pipe at grade level.

9.5.1 Pipe Inserted from Grade Level

It is common practice to pull the pipe along the ground and into the insertion pit. For these types of insertions, the insertion pit should be appropriately sized to assure that the pipe is not over-bent as it is being inserted (see Figures 9.10 and 9.11).
Figure 9.10. Grade level slipline or casing insertion pit example schematically.

Figure 9.11. Grade level slipline insertion pit example from a project.
Section 9  
Sliplining

Items to be careful of for this type of insertion set up is proper dimensionality of the pit (make sure to use a measuring device to assure that minimum pit dimensions are met), and scraping of the pipe at the edge of the pit if it is cut in asphalt or rocky ground.

9.5.2 Pipe Inserted on Supports

Pipe rollers or another form of friction reducing equipment or material at grade can be used as the pipe is pulled into the insertion pit. See Section 6 – Pulling Parameters for Fusible PVC® Pipe for more details on the use of friction reducing implements. These types of implements will raise the height of the pipe as it is pulled into the pit, thus reducing the required tail ditch length for the pit (see Figures 9.12 and 9.13).

Figure 9.12. Slipline or casing insertion pit using rollers example schematically.
The rollers or other devices must be in good working condition. Care must also be taken to assure that pipe does not fall off of the rollers during insertion, damaging the pipe. The alignment and supports should be monitored during the ENTIRE installation. See Section 6 – Pulling Parameters of Fusible PVC® Pipe for more information regarding supports and friction reducing implements for use with Fusible PVC® pipe. Make sure to use the appropriate ACTUAL height of support to calculate the insertion pit required. If there are not enough supports to support the entire length of pipe for the installation, use what supports that are available at the appropriate spacing, STARTING AT THE INSERTION PIT AND WORKING BACK TOWARDS THE END OF THE ALIGNMENT FOR AS FAR AS THERE ARE SUPPORTS AVAILABLE. DO NOT EXTEND SPACING BETWEEN SUPPORTS. Not having the pipe completely supported on rollers will increase the pull-in resistance resulting in an increased pull force needed. This must be evaluated in each case.

9.5.3 Aerial Insertion

One final method of insertion that is useful for tight insertion pit layouts is an aerial insertion (see Figure 9.14). This method elevates the pipe as it approaches the pit, so that it can eliminate as much of the tail ditch as possible.
Section 9
Sliplining

This type of insertion requires specialized pipe handling gear and equipment to position it correctly. The pipe should utilize friction reducing implements along the alignment. The aerial insertion requires pipe supports that can be elevated to the required height. These devices are ideally cradle roller supports (sling rollers or roller slings) which provide full support to the pipe section and can be positioned with an appropriately sized piece of equipment. The equipment used to support the pipe in the required alignment must be capable of holding the pipe at the required height and must be able to handle the required pipe weight. Contact your Underground Solutions, Inc. representative for more information on cradle roller supports and aerial insertion alignments.

The following items are critical to bear in mind when laying out, constructing and using insertion pits for sliplining or casing insertion installation method:

1. The tail ditch will not require manned access and does not need to be much wider than the diameter of the pipe. Ensure that the tail ditch does not bind or pinch the pipe and allows it to move freely into the alignment.

2. Ensure that the sharp edges of the insertion pit or end of the existing pipe or casing that may potentially damage the pipe are mitigated (see Figure 9.9). This would include the beginning of the tail ditch, if it is located in asphalt or rocky ground.

3. Monitor the pipe insertion at all times, paying particular attention to potential pipe damage and binding.

Figure 9.14. Aerial pipe bursting insertion pit example schematic.
9.6 Best Practices for Sliplined or Cased Installations

9.6.1 Sliplining Pipe Connections for Insertion

Short slipline or casing insertion installations may use a modified pulling connection, including the use of a ‘carriage bolt’ configuration to connect and insert the Fusible PVC® pipe. See Section 6 – Pulling Parameters of Fusible PVC® Pipe or contact Underground Solutions, Inc. for more details on this type of connection. If this method is used make sure that the front edge of the pipe is beveled.

Short slipline or casing insertion installations may also use a ‘pushing’ method to insert the pipe. This can be done one of several ways. A nylon pipe sling may be used to attach to and slide the pipe into the existing pipeline or casing (see Figure 9.15). The sling is then readjusted backwards and the method repeated until the pipe is installed.

![Figure 9.15](image)

Figure 9.15. Using a front loader and sling, backing up (left) to pull or ‘stroke’ the pipe to be sliplined into place (right). The sling is repositioned and pulled again to continue the installation.

Longer installations and insertions should utilize a pull head to install the Fusible PVC® pipe. The pull head should utilize the standard through bolt connection and be rated for the allowable pull force of the pipe section. Specific pull heads have been designed for slipline insertions, which minimize the additional diameter that the pull head adds to the exterior of the pipe. These are known as ‘Internal’ pull heads. See Section 6 – Pulling Parameters of Fusible PVC® Pipe, or contact Underground Solutions, Inc. for information regarding appropriately designed pull heads for the sizes of pipe being used.
When determining the type of connection to be used in installing Fusible PVC® pipe by sliplining or casing insertion, consider the required removal of pull head or connection method, especially in tight spaces, such as an existing manhole. Also consider that some length of pipe from the end where the connection is made will have to be removed due to the through-bolt connections. Always consider this length in the required installed length and reconnection plan.

9.6.2 Axial Stress Mitigation

After a length of pipe is installed, it is best to ‘push back’ on the pipe length until movement is realized at the insertion pit. Use the pull head, a protective end cap, or dunnage on the pipe end to avoid damaging the pipe end when pushing back on the pipe length. This will act to reduce the axial stress that stays in the pipeline from the old pipe/new pipe friction during installation.

9.6.3 Post Installation Cutting

Use care when cutting pipe that has been installed via sliplining or casing insertion. Determine that the pipe is not bound or under load before starting a cut. Also determine that the pipe is not excessively bent at the location of the cut. Use the cutting best practices provided in Section 7 – Cutting Fusible PVC® Pipe for all cutting operations on Fusible PVC® pipe.

9.7 Connection Methods for Fusible PVC® Pipe Installed by Sliplining or Casing Insertion

Typical fittings and connection methods are used to couple pipe that is installed using sliplining or casing insertion methods. Refer to the Section 3 – Fusible PVC® Pipe Connections for more information regarding making connections to Fusible PVC® pipe and existing systems as part of sliplining or casing insertion projects.

Fittings and connections used on either side of a slipline or casing insertion installation that carries internal pressure should be restrained to assure that any potential pipe movement will not result in issues at the fitting connections (see Figure 9.16). Be sure there is enough restrained pipe on the pipe alignment leading into and out of the pipe sliplined or casing insertion section so that pipe joint pull-out will not occur on subsequent unrestrained joints away from the fitting connections on either side. It is good practice to restrain all fittings used for slipline or casing insertion installations. This reduces any risk of pipe movement after the pipeline is put back in service.
Care should be exercised when making connections if the annular space is NOT filled in a slipline or cased installation. Casing spacers DO NOT COUNT as providing any resistance to axial thrust loading and little resistance to lateral movement. If the annular space is not treated there is no pipe to soil friction component to provide resistance to potential thrust forces, such as those developed by unbalanced thrust forces at fittings, thermal changes, and Poisson effect (internal pressure changes). Fittings and connections on either side of a slipline or cased installation should be restrained to assure that any potential pipe movement will not result in excessive movement at the fitting connections. Assure that there is enough restrained pipe on the pipe alignment leading into and out of the sliplined or cased section that pipe joint pull-out will not occur on subsequent unrestrained joints away from the fitting connections on either side.

If future connections are required on a length of pipe that has been installed using sliplining methods, the pipe must first be accessed. Carefully remove the old pipe from around the sliplined pipe at the location of the required connection. Make sure that you do not damage the Fusible PVC® pipe during this removal process. Also clear away any annular space treatment used, again being careful not to damage the Fusible PVC® pipe. Connections can then be made as appropriate per Section 5 – Tapping Fusible PVC® Pipe and Section 3 – Fusible PVC® Pipe Connections.
9.8 Axial Stress’s Impact on Cutting and Tapping Operations

Sliplining and casing insertion installation will place an axial load on the pipe that will provide some amount of residual axial stress in the pipeline after the installation is complete. This can increase by any bending of the pipe in the alignment. Pushing backward on the pipeline after installation can relieve some of this stress but may not relieve all of it.

Best practices and Underground Solutions, Inc. instructions for installing the pipe may leave some axial stress in the pipeline, and the axial stress may reveal itself during cutting by pulling apart. Follow Underground Solutions, Inc.’s cutting procedure to control the amount of pipe that may be affected by this reaction.

When tapping the pipeline, care should be taken to follow the best practices included in Section 5 – Tapping Fusible PVC® Pipe to ensure a successful tap including any need to mitigate axial stress at the location of the tap. Always contact your Underground Solutions, Inc. representative should you have any questions, or if you are unsure about working with Fusible PVC® pipe in a given situation.

9.9 Filling Annular Space After Installation

Underground Solutions, Inc. recommends that the annular space be filled after the sliplined pipe has been installed (see Figure 9.17). Filling the annular space eliminates a major void from around the new utility installation, helps to eliminate nuisance water flow, eliminates settlement or void from the host pipe losing its resistance to external loading, keeps the pipe from moving both laterally and axially, and provides structural support for the pipe section.

![Figure 9.17. Slipline installation of a culvert with the annular space treated with grout.](image)

9.9.1 Grouts
Typical sanded, or structural grouts may be used to fill the annular space. Highly air-entrained, low-density grouts, made specifically for the purposes of filling void spaces, are also available for use. Each must be pumpable for filling longer slipline lengths.

9.9.1.1 Typical Sanded or Structural Grouts

Typical sanded or structural grouts are cementitious mix designs with high compressive strengths. These mix designs can be used to fill voids such as the annular space of a slipline installation; however, they have significantly higher compressive strength (several thousand psi) than needed to replace the surrounding soil (a hundred psi or less), can be difficult to pump long distances, do not usually have desirable flow characteristics, and due to the cement content, tend to produce higher heat of hydration temperatures as they cure.

If sanded or structural grouts are used, close monitoring of the grouting process and filling the new pipe with water will mitigate pipe floatation, provide a heat sink for heat of hydration, and provide additional external grout pumping pressure resistance.

9.9.1.2 Cellular Grouts

Underground Solutions, Inc. advocates the use of low density, low cement content, cellular grout for annular space filling. Low density, cellular grout is highly flowable and highly pumpable; excellent at filling small, irregular shaped voids; lighter weight than standard, sanded grout; has lower heat of hydration temperatures; and it is harder to float the sliplined pipe inside the host pipe when it is used due to its lower density.

Cellular grouts contain an admixture which is a foaming agent. This admixture creates a highly air-entrained grout, which reduces the compressive strength, but greatly increases the ability to pump the grout, as well as the ability for the grout to flow very easily into void spaces.

If grouting is used, the following best practices should be followed:

1. Fill the sliplined pipe with water. The water will act as a heat sink for the heat of hydration generated by the grout as it cures, and it also counterbalances the pipe and aids in preventing it from floating. If the use of high cement content that results in a high heat of hydration is a concern, the water in the pipe can be circulated to maintain pipe temperature.

2. Verify that the grout pressures used to install the grout will not collapse the sliplined pipe. Grout and annular space pressure should be verified by the use of a pressure gauge on the grout fill line. Monitor pressures VERY CLOSELY during the ENTIRE OPERATION. The sliplined pipe can be pressurized if needed to counteract the unconfined buckling pressure of the grout when it is installed. See Table 9.1 for a list of the critical buckling pressures for the most common dimension ratios of Fusible PVC® pipe.
3. Assure that proper fill lines and vent lines are used to distribute the grout and expel all the air from the annular space. Adequate bulkheads at all locations where there is a break in the existing pipe is critical.

<table>
<thead>
<tr>
<th>Dimension Ratio, DR</th>
<th>Long Term Critical Buckling Pressure (psi)</th>
<th>Recommended Maximum Annular Grout Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>426</td>
<td>213</td>
</tr>
<tr>
<td>18</td>
<td>191</td>
<td>85</td>
</tr>
<tr>
<td>21</td>
<td>116</td>
<td>58</td>
</tr>
<tr>
<td>25</td>
<td>68</td>
<td>34</td>
</tr>
</tbody>
</table>

*Table 9.1. Critical buckling capabilities of PVC pipe by dimension ratio (DR), including recommended maximum annular grout pressures, utilizing a safety factor of two. The most common pressure water pipe DR’s are bolded.*

9.9.2 Blown Sand

Sand or fine aggregate can be used to fill the annular space between the casing or host pipe and the new sliplined or inserted pipe. Blown sand is not applicable to longer distances of installation. It also does not guarantee that all void spaces will be filled in the annular space. Proper venting is critical to blown sand installation.
Section 9
Sliplining

References


(2) Najafi, Mohammad, and Perez, Mario, editors, Renewal of Potable Water Pipes. ASCE MOP 132, American Society of Civil Engineers, Reston, VA.


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This document does not purport to address all of the safety concerns, if any, associated with the handling, installation or use of Fusible PVC® pipe or with the various application techniques described herein. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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10.0 Pipe Bursting Installation with Fusible PVC® Pipe

‘Pipe bursting’ describes the rehabilitation of an existing pipe by simultaneously breaking it apart in place, pushing the broken pipe into the surrounding backfill, and pulling in a new Fusible PVC® pipe into the same alignment. Pipe bursting utilizes a conical expander head that is pulled through an existing pipeline alignment utilizing a static bursting unit. The brute force of this head being pulled through the existing pipe fractures and expands the pipe zone to form a temporary void where the existing pipe used to be. Immediately behind the conical expander follows the new, assembled Fusible PVC® pipe, which replaces the existing pipe. Pipe bursting is a trenchless technology that has several key advantages, the biggest one being that a new pipeline of LARGER diameter size may be utilized to replace an existing pipeline. Pipe bursting may be utilized with pressure or non-pressure piping. This section includes information related to pipe bursting with Fusible PVC® pipe.

There are many industry sources available that provide more detail about pipe bursting applications. The North American Society for Trenchless Technologies (NASTT) offers courses and has a Good Practices Guidelines document for pipe bursting. The American Society of Civil Engineers (ASCE) provides a manual of practice (MOP) for pipe bursting projects. The American Water Works Association (AWWA) also includes pipe bursting for water mains in its M28 water line rehabilitation manual. The PVC Pipe Association provides information in the Handbook of PVC Pipe. The International Pipe Bursting Association (IPBA) also publishes information related to pipe bursting. Pipe bursting may or may not be an applicable solution for a particular project. Underground Solutions, Inc. recommends that you consult equipment manufacturers such as TT Technologies, Inc. and Hammerhead Trenchless Equipment for questions about applicability when using their equipment or if you have general questions about pipe bursting.

The Most Important Items When Pipe Bursting with Fusible PVC® Pipe:

1. Safety is the first priority. All equipment manufacturers’ safety precautions MUST be followed.
2. Use ONLY static pipe bursting equipment with Fusible PVC® pipe.
3. Always follow allowable bending and pull force recommendations for installation.
4. Use an expander that moves independently from the pull head and does not transfer compression forces back through the new pipe.
5. Remove the external bead on the fusion joints to minimize any burst path interference.

Safety First!

Pipe bursting equipment generates a massive amount of force to install pipe using the pipe bursting method. Always follow the requirements and recommendations, as well as the caution and warnings of the manufacturer of the pipe bursting equipment being used.
Section 10
Pipe Bursting

Fusible PVC® pipe, both as delivered to the project site and when assembled into long lengths represents a large, heavy material that requires attention during handling, movement, and installation on a project site. Moving lengths of pipe improperly creates a hazard that can result in personal injury or even death. Always follow best practice safety procedures as provided by Underground Solutions, Inc., as well as all entities having jurisdiction for the project.

10.1 Only Static Pipe Bursting is Applicable for Fusible PVC® Pipe

There are two primary types of equipment used for pipe bursting, the first is called ‘static’ equipment. This equipment uses brute force to pull the pipe bursting equipment (cutters and conical head) through the existing pipe. Generally, hydraulic rams are used to generate the force needed to perform the operation. The second type of equipment used for pipe bursting is ‘pneumatic’ or air driven. Pneumatic pipe bursting equipment contains a reciprocating piston driven by compressed air that applies a percussive action to the bursting head in conjunction with a hydraulic winch, much like a “hammer drill” applies a percussive force to a drill bit in conjunction with the pressure being applied to the drill while drilling. This ‘hammering’ action allows the required pulling forces to move the tooling through the existing alignment to be lower than that required by static equipment.

ONLY STATIC PIPE BURSTING EQUIPMENT MAY BE USED WITH FUSIBLE PVC® PIPE. Pneumatic tooling impact will damage the Fusible PVC® pipe at the pull head connection.

Pneumatic bursting equipment has been most commonly used on gravity sewer pipe materials like clay tile or concrete pipe. The air driven hammer works well to break these materials. Pressure water pipes that are replaced by bursting are more typically cast iron, ductile iron, or steel, with metallic repair clamps and other appurtenances that require a cutting and expanding action instead of a fracturing approach as provided by pneumatic bursting equipment. For these materials, static bursting provides the most efficient set up with cutting wheels and expander in tandem for the burst. Additionally, the pneumatic piston exhausts tool oil into the new pipeline during installation. This is not much of a concern for gravity sewer or force main applications, but is an issue for potable water applications.

10.2 Thermal Butt-Fusion Joining of Fusible PVC® Pipe for Pipe Bursting Applications

Fusible PVC® pipe that is to be installed using pipe bursting methodology should be joined using thermal butt-fusion. See Section 2 – Thermal Butt-Fusion Process and Requirements for Fusible PVC® Pipe for specific details regarding this joining method for Fusible PVC® pipe. Fusible PVC® pipe must ALWAYS be joined by a qualified fusion technician, trained specifically for the size of pipe that requires fusion.

To minimize interference of the external fusion bead with the expanded pull-in path it is recommended that the external fusion bead be removed. See Section 2 – Thermal Butt-Fusion Process and Requirements for more details on external deboeading.
Section 10
Pipe Bursting

10.3 Insertion Pit Recommendations

Pipe bursting operations normally require that the entire assembled pipe length be prepared prior to the pipe being installed. Stopping the pipe bursting operation for any period of time can jeopardize the ability to complete the pipe bursting operation or installation.

The assembled pipe length must bend generally in an “S” configuration, with two separate, but equal bending radii. The recommended bend radius for the pipe being inserted (shown as ‘RB’ in Figures 10.1, 10.3, and 10.5) is the parameter that defines the length of the insertion pit (shown as ‘Overall Pit Length (L)’ in Figures 10.1, 10.3, and 10.5). Underground Solutions, Inc. provides insertion pit recommendations in a sliderule format. Contact your local Underground Solutions, Inc. representative for more details. Additionally, an Underground Solutions, Inc. representative will be able to provide an insertion pit layout for any assembled pipe length inserted from grade with minimum requirements for the pipe section being used.

The following items are critical to bear in mind when laying out, constructing and using insertion pits for the pipe bursting installation method:

1. Pipe bursting requires that the insertion alignment of the Fusible PVC® pipe be tangent to the existing pipe alignment at the location of the beginning of the pipe burst. Therefore, no pipe curvature is to be taken up in the existing pipe alignment for the insertion.

2. The tail ditch will not require manned access and does not need to be much wider than the diameter of the pipe. Make sure that the tail ditch does not bind or pinch the pipe and allows it to move freely into the bursting alignment.

3. Make sure that the sharp edges of the insertion pit that could potentially damage the pipe are mitigated. This would mainly include the beginning of the tail ditch, if it is located in asphalt or rocky ground.

4. Monitor the pipe insertion at all times, paying particular attention to potential pipe damage and binding.

There are three general types of insertion configurations for pipe bursting. Each will require a similar Pit Length (PL) to accommodate the bending radius of the pipe into the existing pipe alignment. They differ, however, in the amount of tail ditch required, based on the configuration of the pipe at grade.

10.3.1 Pipe at Grade Level

It is common for most pipe bursting installations to pull the pipe along the ground and into the insertion pit. For these types of insertions, the insertion pit should be appropriately sized to assure that the pipe is not over-bent as it is being inserted (see Figures 10.1 and 10.2).
Section 10
Pipe Bursting

Figure 10.1 – Pipe at grade level pipe bursting insertion pit example
Make sure that the proper dimensionality of the pit (make sure to use a measuring device to assure that minimum pit dimensions are met) is attained, and watch for scraping of the pipe at the edge of the pit if it is cut in asphalt or rocky ground.

### 10.3.2 Pipe on Supports

As installations get longer and pipe sizes get larger, it is often advantageous to utilize pipe rollers or some other form of friction reducing element at grade as the pipe is pulled into the insertion area. These types of insertion aides will raise the height of the pipe as it is pulled into the pit, thus reducing the required tail ditch length for the pit (see Figures 10.3 and 10.4).
Figure 10.3 – Pipe bursting insertion pit using rollers or other friction reducing implements example.
It is critical that rollers or other devices be in good working order and functioning. Care must also be utilized to assure that pipe does not inadvertently fall off of the rollers during insertion, which can damage the pipe. The alignment and supports should be monitored during the ENTIRE installation. See Section 6 – Pulling Parameters for Fusible PVC® Pipe for critical information regarding supports and friction reducing implements for use with Fusible PVC® pipe. Make sure to use the appropriate ACTUAL height of support to calculate the insertion pit required. If there are not enough supports to support the entire length of pipe for the installation, use what supports that are available at the appropriate spacing, STARTING AT THE INSERTION PIT AND WORKING BACK TOWARDS THE END OF THE ALIGNMENT FOR AS FAR AS THERE ARE SUPPORTS AVAILABLE (see Figure 10.4). DO NOT EXTEND SPACING BETWEEN SUPPORTS.

10.3.3 Aerial Insertion

One final method of insertion that is useful for extremely tight insertion pit layouts is an aerial insertion (see Figure 10.5). This method elevates the pipe as it approaches the pit, so that it can eliminate as much of the tail ditch as possible.
Section 10
Pipe Bursting

Figure 10.5 – Aerial pipe bursting insertion pit example.
This type of insertion requires specialized pipe handling gear and equipment to position it correctly. The pipe should utilize friction reducing implements along the alignment. The aerial insertion requires pipe supports that can be elevated to the required height. These devices are ideally cradle roller supports (roller slings) which provide full support to the pipe section and can be positioned with an appropriately sized piece of equipment. It is critical to assure that the equipment used to support the pipe in the required alignment is capable of holding the pipe at the required height and can handle the required pipe weight. See Section 6 – Pulling Parameters for Fusible PVC® Pipe for critical information regarding supports and friction reducing implements for use with Fusible PVC® pipe. Depending on the alignment and specific requirements, other methods may be used. Contact your Underground Solutions, Inc. representative for more information on cradle roller supports and aerial insertion alignments.

10.4 Best Practices for Pipe Bursting Installations – Planning and Layout

10.4.1 Location of Fittings and Connections

When preparing for a pipe bursting project the following best practices are offered as a means to ensure a quality installation and increase efficiency. It is easiest to remove all obstructions and fitting locations in an existing pipe prior to performing any pipe bursting operation. Utilize the locations of these excavations as insertion and pull pits (see Figure 10.6) if possible.

Figure 10.6. This location where a tee needed to be replaced was used as a pulling pit for the pipe bursting equipment. These photos show (left) the location of the pulling equipment in the pit and (right) the replacement tee assembly in the same location.

If the fitting location is straight through, such as with a ‘tee’ fitting or a ‘cross,’ the pipe bursting operation can pass through the fitting location, but the connecting pipelines should be disassembled prior to the pipe bursting operation (see Figure 10.7). The same is true for a manhole in a non-pressure system.
If the fitting location is a bend fitting, it is usually most advantageous to remove the fitting and utilize that location for either a pulling pit (for the pipe bursting equipment) or for an insertion pit. If it is desired to ‘burst through’ this alignment variation, the fitting must be removed, enough pipe must be removed on either side of the fitting, and enough excavation must be completed at the location of the fitting to ensure the minimum allowable bend radius for the Fusible PVC® pipe section being used will not be exceeded (see Figure 10.8).
Section 10  
Pipe Bursting

Connections to the existing pipe, such as sewer laterals or water service line taps and corporation stops, must be excavated and removed prior to the pipe bursting operation. These locations can then be used to reinstate the service connections after the pipe bursting operation has been completed. See Section 5 – Tapping Fusible PVC® Pipe for important information on making these types of reconnections to Fusible PVC® pipe.

10.4.2 Project Access Locations

Consider fused pipe lengths and insertion requirements when laying out a pipe bursting project. Ensure that there will be enough room to assemble and stage the pipe segments needed. Ensure that there is enough room to align the pipe segments with the insertion location and orientation such that the pipe section’s minimum bend radius is observed.

Figure 10.8. An angled bend fitting was removed at this location and the pipe was ‘burst through’ this pit. Note the extensive excavation required to allow the pipe to maintain a bend that meets the minimum allowable bending radius for the pipe section being used.
10.5 Best Practices for Pipe Bursting Installations – Equipment Connections

10.5.1 Pull Head Pipe Connection

The pull head should utilize a standard through bolt connection and be rated for the allowable pull force of the pipe section. See Section 6 – Pulling Parameters of Fusible PVC® Pipe, or contact Underground Solutions, Inc. for information regarding appropriately designed pull heads for the sizes of pipe being used.

An appropriately designed pull head – that is separate from the expander head – should be used to connect the Fusible PVC® pipe to the pipe bursting equipment (see Figure 10.9). The pull head should be separate from the expander head to minimize potential issues with pipe rebound when bursting through fittings, repair clamps and other difficult situations.

![Figure 10.9. Pipe bursting assembly showing the pull head connection separate from the expander head and pipe bursting cutter assembly.](image)

10.5.2 Pull Head to Pipe Bursting Equipment Connection

The pipe bursting expander head should also have a slack, or loose fit connection between the pipe pull head and the expander head (see Figure 10.10). This assures that if the pipe bursting train jerks forward suddenly and then stops, the forward momentum of the pipe and pull head will not create a compression
wave in the pipe. This type of wave action can cause issues with the pull head connections to the assembled pipe length and may even cause fracturing of the pipe at this connection.

Figure 10.10. The expander head link to the pull head should allow for compressive slack between the expander assembly and the Fusible PVC® pipe pull head.

10.6 Best Practices for Pipe Bursting Installations – Post Insertion Considerations

10.6.1 Axial Stress Mitigation

After a length of pipe is installed, it is best to ‘push back’ on the pipe length until movement is realized at the insertion pit. Use a protective end cap or dunnage on the pipe end to avoid damaging the pipe end when pushing back on the pipe length. This will act to reduce the axial stress that stays in the pipeline from the installation loading.

10.6.2 Post Installation Cutting

Use care when cutting pipe that has been installed via pipe bursting. Determine that the pipe is not bound or under load before starting a cut. Also determine that the pipe is not excessively bent at the location of the cut. Use the cutting best practices provided in Section 7 – Cutting Fusible PVC® Pipe for all cutting operations on Fusible PVC® pipe.
10.7 Connection Methods for Fusible PVC® Pipe Installed by Pipe Bursting

Typical fittings and connection methods are used to couple pipe that is installed using pipe bursting methods. Refer to Section 3 – Fusible PVC® Pipe Connections for more information regarding making connections to Fusible PVC® pipe and existing systems as part of pipe bursting projects.

Fittings and connections used on either side of a pipe bursting installation that carries internal pressure should be restrained to assure that any potential pipe movement will not result in any issues at the fitting connections (see Figure 10.11). Be sure there is enough restrained pipe in the pipe alignment leading into and out of the pipe bursting section so that pipe joint pull-out will not occur on subsequent unrestrained joints away from the fitting connections on either end. It is good practice to restrain all fittings used for pipe bursting rehabilitation. This reduces any risk of pipe movement after the pipeline is put back in service.

Figure 10.11. Restrained valve installation, connecting pipe burst section of pipe back to existing pipe system.
10.8 Axial Stress’s Impact on Cutting and Tapping Operations

Pipe bursting installation will impart an axial load on the pipe that will provide some amount of residual axial stress in the pipeline after the installation is complete. This can be compounded by any bending of the pipe in the alignment. Pushing backward on the pipeline after installation can relieve some of this stress but may not relieve all of it.

The best practices and Underground Solutions, Inc. instructions for installing the pipe may leave some axial stress in the pipeline, and it may react to being cut by pulling apart during the cut. Following Underground Solutions, Inc.’s cutting procedure (see Section 7 – Cutting Fusible PVC® Pipe) will help to control the amount of pipe that may be affected by this reaction. It is recommended that extra length be provided for the first cut, so that a second, more precise cut may be done to clean up the pipe end for connection.

When tapping the pipeline, care should be taken to follow the best practices included in Section 5 – Tapping Fusible PVC® Pipe to assure a successful tap including any need to mitigate axial stress at the location of the tap. Always contact your Underground Solutions, Inc. representative should you have any questions, or if you are unsure about working with Fusible PVC® pipe in a given situation.
Section 10
Pipe Bursting

References


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11.0 Direct Bury Applications with Fusible PVC® Pipe

Direct bury method of pipe installation is the oldest and most common form of pipe installation: a trench is excavated to the required depth and alignment, the pipe is placed in the trench, and then the pipe is bedded and backfilled to complete the installation. Fusible PVC® pipe is well suited for this method of installation and is commonly used where monolithic restrained pipe is required. These include elimination of gaskets in difficult-to-access areas, close proximity between sewer and water lines, restrained sections in place of thrust blocks or bell restraints, and areas where hydrocarbon contamination and permeation may be of concern. Fusible PVC® pipe easily connects to ductile iron, bell and spigot PVC and all appurtenances. This section covers the specific aspects of installing Fusible PVC® pipe using the direct bury method.

There are many resources and guides available that provide more detail regarding direct bury installation of PVC pipe. The primary resource for PVC pipe installation is the PVC Pipe Handbook. Other sources include AWWA C605, AWWA M23, ASTM D2774, and ASTM D2321. Underground Solutions, Inc. representatives should also be contacted for information concerning direct bury installation of Fusible PVC® pipe.

The Most Important Items When Installing Fusible PVC® Pipe with Direct Bury Methods:
1. Safety is the first priority. All safety precautions must be followed.
2. Always follow allowable bending and pull force recommendations for installation.

Safety First!

Direct bury installation methodology generally requires heavy construction equipment and machinery. Always follow the requirements and recommendations, as well as the caution and warnings of the manufacturer of all equipment used.

Fusible PVC® pipe, both as delivered to the project site, and when assembled into long lengths, must be handled and installed correctly. Careless or improper handling and installation can result in personal injury or even death. Always follow best practice safety procedures as provided by Underground Solutions, Inc., as well as all entities having jurisdiction for the project.

11.1 Thermal Butt-Fusion Joining of Fusible PVC® Pipe for Direct Bury Applications

Fusible PVC® pipe that is to be installed using direct bury installation methodology is primarily joined using thermal butt-fusion joining technique. See Section 2 – Thermal Butt-Fusion Process and Requirements for Fusible PVC® Pipe for specific details regarding this joining method for Fusible PVC® pipe. Fusible PVC® pipe must ALWAYS be joined by a qualified fusion technician, trained specifically for the size of pipe that requires fusion.
Although generally not required or recommended, the external fusion bead may be removed for pipe installed using direct bury techniques. This can be advantageous when moving the pipe at-grade over varied topography and surfaces. It can also be advantageous in limiting bedding disturbance if the pipe is pulled into place along the trench bottom. External fusion bead removal is done during the thermal butt fusion process. See Section 2 – Thermal Butt-Fusion Process and Requirements for Fusible PVC® Pipe for more details on external de-beading.

### 11.2 Pipe Staging and Installation

The primary difference between Fusible PVC® pipe and segmented pipe for use with direct bury applications is that Fusible PVC® pipe is generally assembled outside of the trench, while segmented pipe is assembled in the trench. There are two basic methods for direct bury installation of Fusible PVC® pipe that has been assembled outside the trench: the ramp insertion method and the placement method.

When installing long lengths of Fusible PVC® pipe in direct bury applications, the trench will need to be excavated for the entire length of pipe being installed, or as a minimum, for a length that allows for the installation method selected. Consider crossing utilities, shoring requirements, depth of bury, types of soils and the amount of trench that may be allowed to be open at one time when planning for installation lengths and project site layout. Trench construction should follow industry standard practice and the requirements for the project. Always follow applicable jurisdictional codes for construction. Standard guidance on trench construction and embedment for PVC pipe is available from AWWA (AWWA C605 and M23), ASTM (ASTM D2774 and ASTM D2321), and the PVC Pipe Association (Handbook of PVC Pipe), among other sources.

#### 11.2.1 Ramp Insertion Installation Method

One direct bury installation method for Fusible PVC® pipe is to pull the assembled pipe length down a ramp into the end of the excavated trench or down a ramp constructed on the side of the excavated trench. The pipe is fused ahead, behind, or to the side of the trench excavation (depending on where the ramp will be located) in approximate alignment with the trench. The insertion ramp provides for a controlled transition from the pipe fusion location on the ground level surface to the trench bottom. Figure 11.1 diagrams an insertion ramp and shows the slope geometry, based on the minimum allowable bending radius for the pipe section being installed.
Figure 11.1. Diagram of an end cut ramp and insertion. This geometry would also be required for a side cut ramp along the trench.

This ramp insertion technique works well when there is not enough room in the trench easements for a fusion and/or staging area next to the trench alignment. In some cases, the spoils from the trench take up available room adjacent to the trench. Figure 11.2 shows an example of an end insertion ramp and Figure 11.3 shows an example of a side insertion ramp being used on a project site.
Figure 11.2. Example of an end ramp being used for a pipe installation for direct bury method. Note how the ramp transitions the pipe alignment from grade level to the trench elevation.
Figure 11.3. Example of a side ramp being used for a pipe installation for direct bury method. Note how the ramp transitions the pipe alignment from grade level to the trench elevation.

This method will also work if a ramp or insertion location is set up alongside an existing trench. If the trench is much longer than the pipe string to be installed, the string can be brought down into the trench at a midpoint location using a ramp cut in from the side. The same slope geometry is required whether the ramp or slope is placed at the end of the trench or along the side of it.

After the pipe is brought to the elevation of the trench bottom through the use of the insertion ramp, it is pulled along the trench length until it is located at the proper final alignment. Make sure that any bedding used under the pipe is in place and not adversely impacted by the pipe movement along the trench bottom during pull-in. If bedding is uneven, fill in all voids to provide uniform pipe support prior to back-filling. Make sure no sharp or uneven rocky ground damages the pipe when using this method.

When pulling the pipe, always follow the guidance in Section 6 – Pulling Parameters of Fusible PVC® Pipe. Be cautious with lateral movement of the pipe. Properly support the pipe without over-bending it by assuring the appropriate number and location of pick points are used per Section 6 – Pulling Parameters of Fusible PVC® Pipe.
Section 11
Direct Bury

11.2.2 Placement Installation Method

The second installation method is to move the pipe from a parallel alignment immediately next to the trench, into the trench and final alignment. There are two ways in which this may be accomplished.

One way to place the pipe is to lift it as a single length of pipe and placed into the trench and final alignment. If this method is used, sufficient equipment must be used to properly support the pipe. See Figure 11.4 for an example of this type of placement installation method. Each location where the equipment handles the pipe is known as a ‘pick point.’

Figure 11.4. Example of a pipe length being placed into the trench using multiple pick points and equipment.

A second way to place the pipe is to utilize the bend radius of the pipe section and place the pipe from one end to the other in a “rolling” fashion. In this case, the bend radius of the pipe is used to determine the location of the pick points required to place the pipe. At least three pieces of equipment must be used to create these continuous pick points (see Figure 11.5).

The first step in the process is to assemble the Fusible PVC® pipe and stage it next to an excavated trench (shown as Step 1 in Figure 11.5). A minimum of three pick points must be used and placed as required by the theoretical offset distance (see Figure 11.6) that exists between the staged alignment location and the final, in-trench alignment. To determine this theoretical distance, the horizontal offset (X) and the trench depth (D) as shown in Figure 11.6 must be known or conservatively approximated. Work with an Underground Solutions, Inc. representative to determine the correct pick point spacing based on the specific layout of the project site.
Figure 11.5. Illustration of the steps required for the ‘rolling’ placement installation method for direct bury of Fusible PVC® pipe.
Three pieces of equipment should be used to begin the placement process. Then, at a minimum, two pieces of equipment should be positioned at the location of the pick points as the pipe continues to be placed (see Figure 11.7). If more equipment is available, it can be positioned on the alignment at locations not greater than the maximum distance (shown as L1 in Step 2 and 3 in Figure 11.5) between equipment placement.

Begin the placement of the pipe by connecting all pieces of equipment to the pipe string. All equipment should work together to move the pipe string at the same time, keeping the curvature of the pipe approximately the same as that shown in Figure 11.5, Step 2. The end of the pipe is lifted and placed in the trench and anchored or held for the initial pipe insertion (shown as Step 2 in Figure 11.5). This can be done using another piece of equipment, or the pipe section can be bedded and partially backfilled to hold it in place. After some additional length is placed in the trench the pipe will no longer need something to fix it from sliding or moving. At this point, there are two options for progressing. The first option is to use the equipment to ‘leap frog’ down the alignment taking positions at the changes in the bend direction, separated by the same required spacing (L1 shown in Step 2 and 3 in Figure 11.5) to move the entire pipe string into the trench. The second option is to use the equipment in a single formation and move along...
the trench. With this method, the equipment holds its relative pick point locations as shown in Step 3 of Figure 11.5, and the connections to the pipe slide along the pipe until the entire pipe string is installed. If this method is used, it is critical to use pipe lift connection mechanisms that enable or allow the pipe to slide easily. Cradle rollers or roller slings are the best connections to use for this purpose.

Figure 11.7. ‘Rolling’ placement method being used on a project site. (top left) The trench is excavated and (top right) pipe length is staged next to trench alignment. (bottom left) The pipe length is placed in the trench after it had been prepared, and (bottom right) pipe after placement exercise is ready for bedding and backfill.

The equipment used to place the pipe should include cradle rollers (see Figure 11.7), nylon straps (see Figure 11.4) or other acceptable implements to lift and move the pipe. Never use chains, wire rope, or other lifting equipment that may damage the pipe. Follow the guidance in Section 6 – Pulling Parameters
Section 11
Direct Bury

of Fusible PVC® Pipe. The equipment should be able to lift the pipe and move it laterally. Assure that the equipment used for this purpose, such as excavators or boom cranes, are capable of handling the weight of the pipe and the boom reach required to place it in the trench.

When using these placement methods, the pipe may also be staged far enough away from the trench excavation activities so that it will not risk being damaged. If this is done, an intermediate movement of the pipe from the original location to a location next to the trench may be completed. This movement should follow the guidance of Section 6 – Pulling Parameters of Fusible PVC® Pipe. The pipe can then be placed with either method variation as described.

Contact your Underground Solutions, Inc. representative for specific information regarding direct bury projects and appropriate installation method(s) for a project.

11.3 Connection Methods for Fusible PVC® Pipe Installed by Direct Bury

Typical fittings and connection methods are used to connect and couple Fusible PVC® pipe that is installed using direct bury methods. Refer to Section 3 – Fusible PVC® Pipe Connections for more information regarding connections to Fusible PVC® pipe.

Long lengths of Fusible PVC® pipe may be installed and then cut into shorter lengths for installation of the required connections and fittings. Or Fusible PVC® pipe may be installed in the required lengths prior to connection. Fusible PVC® pipe may be connected to fittings, to other appurtenances (such as valves), or to the bell end of a commensurately sized and standardized PVC pipe by inserting the plain end of the Fusible PVC® pipe into the bell of another PVC pipe length (see Figure 11.8). Make sure that a field cut bevel is made on the pipe end to be inserted. Take care to assure that the insertion is made in a straight alignment. Also, make sure that the insertion is made to the appropriate depth by measuring out and marking a witness line on the pipe spigot end to be inserted. Always follow the guidance as provided in Section 3 – Fusible PVC® Pipe Connections. Assure that the insertion operation does not inadvertently impact the bedding or foundation support under the pipe. Always make repairs to the bedding if it has been adversely impacted because of joint assembly.

Fusible PVC® pipe can also be provided with bell ends that can be fused onto a Fusible PVC® pipe string. Bells will be made to the same standard as the pipe, and will be compatible with other PVC pipe made to the same standard. The inclusion of bell end Fusible PVC® pipe MUST BE PLANNED PRIOR TO PIPE ORDERING AND MANUFACTURING. Please contact your Underground Solutions, Inc. representative regarding bell sections for a given project, but do so PRIOR TO THE PIPE BEING ORDERED. See Section 3 – Fusible PVC® Pipe Connections for more details.
Figure 11.8. Project example of a length of Fusible PVC® pipe being inserted into the bell of a commensurately sized and standardized PVC pipe.
11.4 Best practices for Direct Bury Applications

The following best practices are encouraged when working with Fusible PVC® pipe for direct bury applications:

1. Plan the layout and construction sequencing of direct bury installation before beginning work. Consider location of fittings and appurtenances when determining pipe string lengths, the location of fusion, and staging layouts.

2. It is best to assemble longer pipe strings close to the location of final placement. If using the placement method of installation, it is ideal to fuse and assemble the pipe strings immediately adjacent to the pipe trench, staging them next to the alignment of the trench.

3. Assure that the specified bedding and trench section is maintained throughout the installation process. Center the pipe in the trench. Be careful to avoid displacement of the foundation bedding under the pipe if the ramp insertion method is used. If bedding displacement occurs, be sure to restore uniform bedding support.

4. Follow the appropriate guidance for all pipe handling and movement (Section 6 – Pulling Parameters for Fusible PVC® Pipe), making connections (Section 3 – Fusible PVC® Pipe Connections), and tapping (Section 5 – Tapping Fusible PVC® Pipe).
Section 11
Direct Bury

References


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Section 12
Special Considerations

12.0 Ongoing Maintenance and Special Installations with Fusible PVC® Pipe

This section covers certain aspects of operation and maintenance as well as special or non-standard installation methods, techniques, and applications for Fusible PVC® pipe.

The Most Important Items Related to Maintenance and Special Installations of Fusible PVC® Pipe:

1. Follow all safety precautions for lifting and supporting the pipe, operating cutting equipment, and using personal protection equipment (e.g. safety glasses or face shield, etc.).
2. Fusible PVC® Pipe may be repaired using industry standard means and methods for PVC pipe. Thermal fusion is not required.
3. Contact Underground Solutions, Inc. if you are considering special or unusual installations or applications.

Safety First!

The use of improper or improperly maintained equipment, or failure to follow recommended procedures relating to operating and maintaining pipelines may represent a personal injury hazard. Always follow the requirements and recommendations, as well as the caution and warnings, of the manufacturer of equipment being used, as well as the procedures for all entities having jurisdiction for the system.

Fusible PVC® pipe, both as delivered to the project site and when assembled, is large and heavy and can be challenging to handle and install. Improper pipe handling, operating, or repairing can result in personal injury or even death. Always follow best practice safety procedures as provided by Underground Solutions, Inc., as well as all entities having jurisdiction for the project.

12.1 Ongoing Maintenance and Operations with Fusible PVC® Pipe

12.1.1 Repairing Fusible PVC® Pipe

If a Fusible PVC® pipe section needs to be repaired, the pipeline must first be taken out of service. Relieve any pressure in the pipeline and drain the pipeline so that it is empty of water.

**ALWAYS ASSURE THE PIPE TO BE CUT IS NOT INTERNALLY PRESSURIZED. ALL INTERNAL PRESSURE MUST BE RELIEVED.**

Internal pressure or tensile loading at the location of the cutting operation can cause sudden and violent movement of the pipe that could cause injury or death.

After the pipeline has been taken out of service, the damaged portion of the pipe must be removed and replaced. When removing sections of damaged pipe, determine where the damage ends based on visual...
confirmation, both inside and outside of the pipe, such as where fracture(s) stop. When cutting out the damaged portion, always cut **AT LEAST 2 FEET** away from any/all visible damage. Follow the guidance in Section 7 – Cutting Fusible PVC® Pipe and Section 3 – Fusible PVC® Pipe Connections when completing these actions.

Repair the pipeline by replacing the damaged segment with a pipe section of the same outer diameter and the same or lower DR (the same or higher pressure classification). Use repair sleeves or couplings that are appropriate for the system being repaired and the requirements of the pipeline. For pressurized systems, repair sleeves, solid sleeves, or other fittings may be used. For non-pressurized systems, unions, couplings, sleeves, or other fittings as appropriate may be used. Always use fittings appropriate for the application and that follow the jurisdictional requirements of the pipeline location and ownership.

The repair should consider that the Fusible PVC® pipe being connected is fully restrained. Therefore, reconnection hardware may need to be restrained depending on location and service.

**IT IS NOT REQUIRED TO UTILIZE THERMAL FUSION OR OTHER SPECIALIZED FUSION EQUIPMENT TO MAKE REPAIRS TO FUSIBLE PVC® PIPE.** The replacement PVC pipe DOES NOT have to be Fusible PVC® pipe. The PVC pipe used to repair the pipeline should meet the same minimum standards as the pipe being repaired.

### 12.1.2 Adding a New Connection to a Previously Installed Fusible PVC® Pipe

Adding connections to an existing Fusible PVC® pipe system should be done with the same standard tools, understanding, and skillset as is required for PVC pipe.

Services, whether it be a potable water service line or a sanitary sewer lateral connection, can be made to installed Fusible PVC® pipe. Make sure that the guidance of Section 5 – Tapping Fusible PVC® Pipe is followed. In particular, determine if an axial restraint is required for the size of service line connection desired.

Fittings are recommended for larger diameter connections. This could include a tee or wye fitting that is appropriately tied back into the system (See Figure 12.1).
12.1.3 Cleaning an Existing Fusible PVC® Pipe

Fusible PVC® pipe may be cleaned in the same manner as other PVC pipe systems. These methods may include flushing, high pressure water jetting, vacuum excavation, or other means and methods. If pigging will be the cleaning method, see subsection 12.1.4. Always follow the cleaning equipment manufacturers’ instructions and recommendations when using pipe cleaning equipment.

Cleaning methods must follow the same requirements for maximum pressures, maximum pressures surges, and other limits as set forth in the pipe standard or pertinent design handbooks and manuals. If there are questions about the acceptability of certain cleaning methods for Fusible PVC® pipe, contact your Underground Solutions, Inc. representative.

12.1.4 Pigging a Fusible PVC® Pipe

Pigs can be used to clean or swab a Fusible PVC® pipe. See Figure 12.2 for an example of a pigging device used to clean out a Fusible PVC® pipe.
When using a pig with Fusible PVC® pipe, make sure that the pig is designed for use with PVC pipe. These are typically low density foam rubber or urethane with a density between 2 pounds per cubic foot (pcf) and 8 pcf. Successful pigging requires a clear plan be developed that includes contingencies in case a non-routine event occurs during the pigging operation. A stuck pig, debris build up, or an unscheduled shutdown of the pumps providing flow are several examples. Always follow the pig manufacturer’s guidance regarding the operating parameters, operation and use of a pigging device. Pig manufacturers provide guidelines for the pressure and flow needed to move the pig through the pipeline. Pig manufacturers recommend that pigging operations occur with water.

ENTRAPPED AIR REPRESENTS A STORED ENERGY SOURCE THAT MAY CREATE AN INHERENT SAFETY HAZARD AND CAN LEAD TO CATASTROPHIC PIPELINE FAILURE, PERSONAL INJURY, OR DEATH DURING A PIGGING OPERATION! USE CAUTION WHEN PIGGING A PIPELINE WHERE AIR MAY BECOME ENTRAPPED AND PRESSURIZED!
12.1.5 General Pipeline Maintenance

Pipelines are assets that require ongoing maintenance to ensure peak performance, much like any other asset. Make sure that pipelines and pipeline appurtenances are maintained per the manufacturer’s recommendations and guidance. Be sure that automatic air-release valves remain functional and are checked regularly for functionality. Blow-offs should be kept free of debris and remain accessible. All specialty equipment such as line valves, emergency shut-offs, pressure sustaining or reducing valves, surge relief equipment, etc. must be functional and maintained per the requirements of the manufacturer.

12.2 Special Installations of Fusible PVC® Pipe

This section covers some of the special installations and aspects of working with Fusible PVC® pipe. Always contact your local Underground Solutions, Inc. representative for further details and information regarding special installation situations.

12.2.1 Above Ground Installations

PVC pipe is generally placed underground. The final alignment may occasionally include installation above ground. General guidance on using PVC pipe above ground can be found in the Handbook of PVC Pipe. Specific items to consider for Fusible PVC® pipe as well as regular PVC pipe for above ground use include:

1. PVC pipe should be shielded from long term exposure to ultraviolet (UV) radiation such as the UV radiation found in sunlight. Utilize an opaque or permanent cover with the pipe, or use a quality latex based paint to protect the pipe from UV radiation (see Figure 12.3).

Figure 12.3. An example of an above ground application of Fusible PVC® pipe for an outfall highlighting the latex based paint coating (gives it the dull gray color) used to protect the pipe from UV damage.
Section 12  
Special Considerations

2. Axial thrust loading should be considered in the design of piping that will be installed above ground, particularly if the pipe will be internally pressurized. All potential thrust components, including thermal variation and Poisson effect resulting from internal pressure changes, must be considered. Fusible PVC® pipe’s fusion joint is a fully restrained joint and can be used to provide a fully restrained system as long as the mechanical connections (fittings and other appurtenances) are also fully restrained.

3. Above ground installation usually includes the use of supports. Refer to the Handbook of PVC Pipe for information regarding proper support spacing (see example in Figure 12.4). Fusible PVC® pipe is fully restrained at the fusion joint locations, therefore spans of greater than 20 feet, which is the typical joint length for bell and spigot are possible for larger sizes. Contact your Underground Solutions, Inc. representative for more information.

Figure 12.4. An example of an above ground application of Fusible PVC Pipe for an outfall highlighting supports and adequate support spacing.

12.2.2 Vacuum Loading

Pipelines can be designed with negative pressures or vacuum loading as in a syphon, for example, and vacuum conditions can sometimes occur in unplanned operations. PVC is resistant to full vacuum up to DR 32.5 where the critical buckling pressure will drop below 14.5 psi. Reference Underground Solutions, Inc.’s Pipe Engineering Data Sheet or contact your local Underground Solutions, Inc. representative for more information.
Section 12
Special Considerations

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