Internally Restrained Socket-and-Spigot PVC Pipe Used For Horizontal Directional Drilling.

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Abstract

HDD (Horizontal Directional Drilling) Technology originated in the oil fields of the western United States in the 1970's. HDD technology was developed by merging the installation know-how of a water utility with that of a water well drilling company. Now HDD is a common installation method in the USA, Europe, and other developed countries. HDD has revolutionized the way piping systems are installed in congested urban environments. It allows the pipe to be installed with minimum surface disruption, in less time, and at lower cost. However, this technology is not static. The industry is constantly improving the equipment, the drilling mud, and the piping systems. One such improvement is a patented, internally restrained, push-together PVC pipe system. The new product allows the HDD contractor to assemble the pipe string more quickly and with less effort. The high-strength restrained joint has proven to be ideal for the demanding HDD environment. This paper explains the benefits of this installation method, this pipe system, and how this technology could be implemented.

Introduction

Directional boring, commonly called horizontal directional drilling or HDD, is a steerable trenchless method of installing underground pipes, conduits and cables in a shallow arc along a prescribed path by using a surface launched drilling rig. HDD has minimum impact on the surrounding area. It is suitable for a variety of soils conditions and is often the preferred installation method when the pipeline alignment crosses roads, highways, landscaped areas, rivers, large bodies of water, or environmentally sensitive areas. There have been HDD installations up to 6,500 feet (2,000m) in length and with pipe diameters up to 56 inches (1,400mm). Normally, larger pipe diameters tend to have shorter pulls lengths.

HDD is used for installing infrastructure such as telecommunications and power cable conduits, water lines, sewer lines, gas lines, oil lines, and product pipelines. The benefits of HDD include lower cost, less traffic disruption, deeper and/or longer installations, and fewer safety hazards because there are no open ditches. By reducing the installation time and using less equipment, the environmental impact tends to be much less with HDD compared to open cut.

Other benefits of a well-executed HDD installation include:

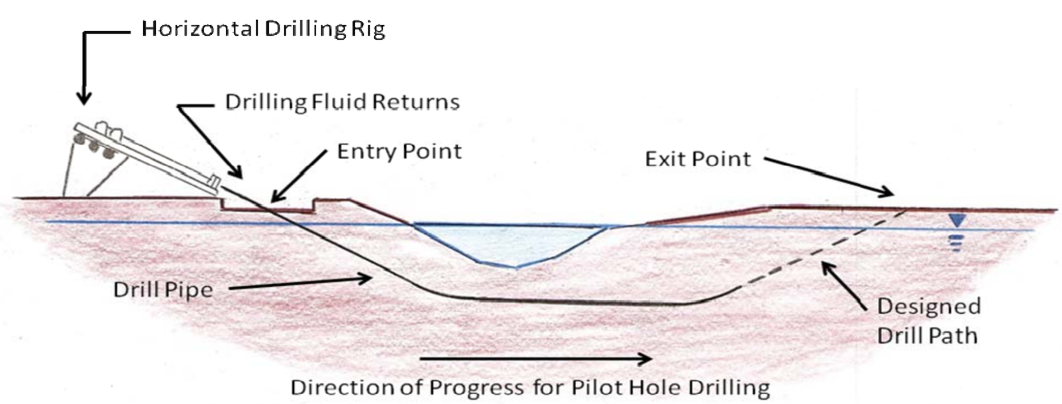
- Continuation of normal operation of the surface activities;
- Avoidance of identified subsurface infrastructure;

- Maintenance of the integrity of roadways, buildings, and natural surroundings;
- Little or no disturbance to wetlands or natural conservation areas; and
- Minimum site restoration.

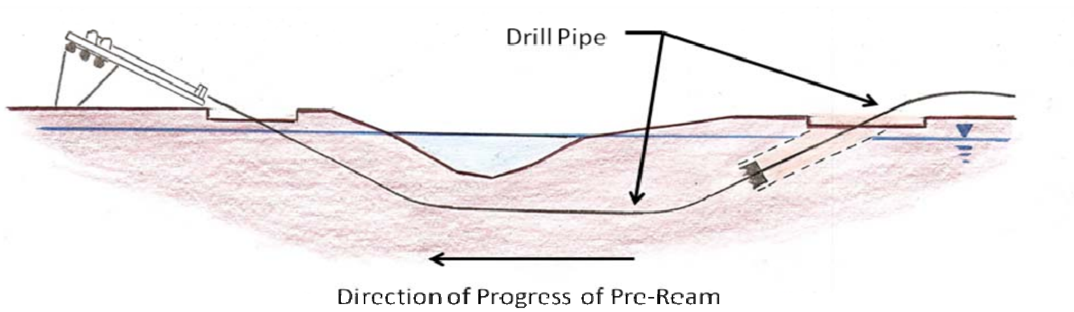
HDD Basics

Before getting to far into the technical details, it may be useful to review the basic steps of an HDD installation for those readers who are not familiar with it.

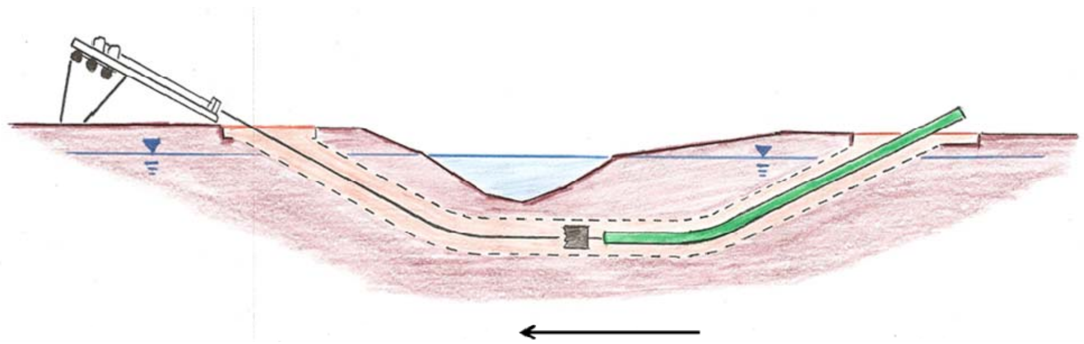
- **ONE:** Drill a pilot hole along the drill path. The drill head is tracked, and its course is continuously corrected (remotely) to keep it on the design path.



- **TWO:** Ream the pilot hole to the diameter needed for the pipeline. While the hole is reamed, drilling mud is pumped into the hole to keep it open and stable.



- **THREE:** Pull the pipeline into the bored hole. This is called the pullback operation.



Direction of PVC Pipe String Progress During Pullback

General HDD Design Considerations

HDD is used extensively in urban areas for installing subsurface utilities and avoiding the expenses related to open cut trenches. Its use, however, necessitates that the operator have complete information about existing utilities so that he can plan the drill path alignment to avoid damaging those utilities. Since uncontrolled drilling can lead to other pipelines being damaged, the different "right of way" owners (agencies, government authorities, or utilities) have formed their rules for safe work.

Since every site is unique, the rules of thumb tend to be very general. Moreover, the installation method selected should draw on the experience of the engineer and contractor. It should also address the needs of the clients and deal with the characteristics of the site. With these caveats, the following rules of thumb have been noted:

- A setback is needed for entrance and exit points and must be included in the length of the borehole. Setbacks range from 3 to 5 feet (1 to 2m) for each foot (0.3m) below grade of the installation. For example, for placement 6 feet (2m) below grade, add a setback of 18 to 30 feet (6 to 10m) of boring on each side of the installation.

- Accuracy of monitoring and placement of bore holes less than 30 feet (10m) below grade is measured in inches (centimeters).

- Mobilization and set up usually take less than an hour.

Of key importance to the infrastructure owner is longevity and durability. If the installation benefits of HDD were to impair the pipeline's long-term durability, the installation method would not have become so widely adopted. Those owners have found that the life expectancy of HDD installed lines have are similar to that of trenched lines and superior to that of exposed lines.

Longevity and Durability of PVC

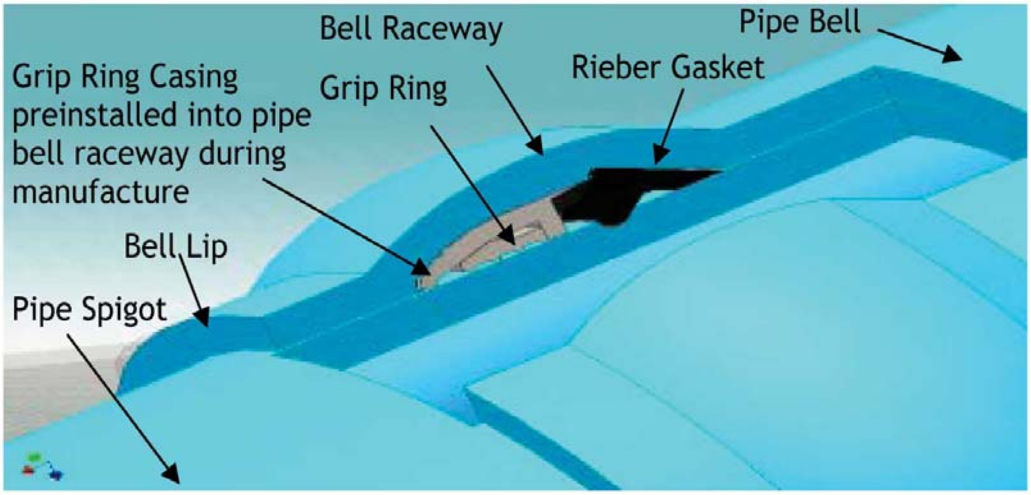
As the previous section noted, longevity and durability is the key criteria for a utility when it is deciding which pipe material is best for its system. For buried water and sewer systems, most utilities in North America have selected PVC as their pipe material of choice. Survey after survey documents that PVC's longevity and durability is the main reason utilities continue to install the product.

For non-PVC users, one method for demonstrating the material's longevity is through research projects that locate old PVC pipe, arrange for it to be exhumed, and then test that pipe to the performance standards for new pipe. This has been done in the USA and elsewhere on both the water side [(Eckstein, 1998); (Gons, 1995); (Hűlsmann, 2004);(Seargeant, 2007)] and the sanitary sewer side [(Alferink, 1995); (Bauer, 1990); (Whittle, 2004)]. In these studies, the old pipe tests out like new. The most impressive of these research projects was the one conducted in Germany on 1930s vintage PVC -- some of the earliest PVC pipe manufactured. (Hűlsmann, 2004)

PVC for HDD

Given the overwhelming preference of PVC by utilities, the natural question by utilities to PVC pipe manufacturers was, "Can you supply PVC pressure pipe that can be installed by HDD?" Not only did the utilities want PVC pressure pipe for HDD, but they desired a product that was as easy to install as the PVC used for their open cut installations. With the development of the Bulldog Restraint System ™, PVC pipe manufacturers were able to satisfy their customer's requests.

The current version of this product is designed for integration into PVC pipe and fittings in diameters 4-inch (100mm) through 12-inch (300mm). The Bulldog hardware consists of a metal casing that sits adjacent to the Rieber gasket in the bell; and the casing is molded into the "raceway" of the bell during pipe belling. A C-shaped grip-ring with several rows of uni-directional serrations is manually inserted into the casing at the manufacturing facility. Both the casing and the grip ring are made of ductile iron that has been coated using an electro-coating process that achieves a uniform thickness and provides superior corrosion resistance. When the pipe arrives at a jobsite, the bell already contains the casing with the grip ring inserted in it, and no additional hardware is needed to provide a restrained joint.

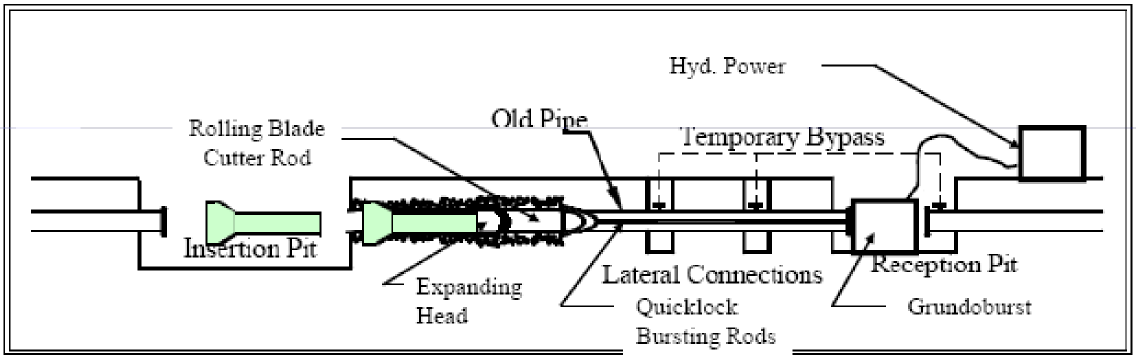


By providing an internally restrained joint, the Bulldog made PVC pressure pipe available for installation by HDD.

PVC pipe using the Bulldog Restraint System can be installed by HDD using the "Assembly-Line Method" if there are no right-of-way restrictions and there is room to lay out the pipe string prior to installation. In the installation pictured below, approximately 400 feet of 12-inch (300mm) DR 18 (PN16) socket-and-spigot PVC pipe was off loaded, assembled, and pulled in roughly 3.5 hours. If fusible thermoplastic had been used, it would have taken around 30-45 minutes per joint to assemble the pipe prior to the pull. Simply put, internally restrained PVC pressure pipe saved this utility over 10 hours of labor. Moreover, it saved on equipment and training costs because no expensive fusion equipment was needed, nor the specially trained crews to operate it.

This project in central Iowa shows how quick-and-easy internally restrained PVC pressure pipe can be installed by HDD.

If there are space limitations at the entrance side, the "cartridge method" is available with a segmental product like the Bulldog. The restrained joint pipe one section at a time. In the sketch below, the Bulldog is being installed one joint at a time for a static pipe bursting project.



Pipe materials installed by HDD must be flexible enough to navigate the tight bends of the typical drill path, but they must also be strong enough to withstand the pull loads from the HDD rig during the pullback operation. The Bulldog Restraint System™ offers this necessary combination of strength and flexibility.

But what about longevity? How can that be demonstrated by a product that has only been in service for three years? In the USA, an aggressive battery of tests is used as a predictor of long-term performance. If the product passes the requirements of ASTM F1674 (ASTM, 2005), it is believed that the restraint mechanism has not impaired the pipe's longevity. The standard requires three tests: a quick-burst test, a 1,000 hour pressure test, and a million-cycle surge test. Of the three, the million-cycle is the most difficult one to pass. It also is the test that best guarantees long-term performance in a demanding environment.

Internally restrained PVC pipe undergoing the million-cycle test

The tests required for DR18 (PN16) will illustrate the severity of the testing required.

- Quick Burst: Pressure at burst must exceed 755 psi (52 bar). Pressure is increased at a rate so that failure occurs between 60 and 70 seconds.

- 1,000 Hour Hydrostatic Test: The restrained specimen must endure 500 psi (34.5 bar) for one thousand hours without failing.

- Million Cycle Test: The specimen must endure one million cycles without failure. The pressure is cycled from a low of 94 psi (6.5 bar) to a high of 188 psi (13.0 bar).

Summary

Internally restrained PVC pipe offers the following advantages:

1. Installing pipe by HDD takes much less time than using the traditional open trench method.
2. There are no traffic disruptions or diversions when pipe is installed by HDD because the installation is bored under the road instead of trenching through the road.
3. HDD requires less labor for pipe installation.
4. PVC pipe is flexible enough to navigate the bends and turns of the bored HDD path, and the internally restrained joint is strong enough to handle the pulling loads from an HDD rig.
5. The metal casing that sits inside the joint comes with a special rust-proof coating.
6. The joining of the internally restrained PVC pipe is as simple and easy as joining conventional socket-and-spigot PVC pipe.
7. The total system is corrosion-free and hence chlorination of water is not an issue.
8. The restrained joint meets the performance requirements of the international standard ASTM F1674. The gasket in the joint complies with ANSI/NSF-61, and the assembled joint has passed the performance requirements of ASTM D3139.

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