Trenchless Piping Technology

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I. Introduction

The conventional approach to pipeline installation is to dig an open trench, place the pipeline and then bury it. Although this method does not pose much of a problem in rural or sparsely populated areas where vehicle traffic is light, it can create havoc in busy urban areas, industrial complexes, when crossing waterways or in environmentally sensitive areas. Prolonged pipe replacement projects can cause major disruptions and economic impacts for industry and other activities affected by excavation and construction. In a sensitive wetland environment such as a river crossing, wildlife habitats would be destroyed and extensive mitigation efforts would be required. As a result, trenchless or "no-dig" technology has been used extensively in Europe, Japan and other parts of the world, but is a recently applied technology in the United States to minimize the disruptive effect of open trench pipeline construction.

The 1972 passage of the Clean Water Act (CWA) highlighted sewer rehabilitation as a way to reduce hydraulic loads on pipelines, pumping stations and treatment plants. Later in 1987, the CWA was expanded to include certain industrial storm-water discharges. Then in 1995, the EPA further expanded their rules to include discharges from commercial and light industrial facilities. Typically the permitting of storm-water discharge requires the identification of areas that may contribute to pollution in a discharge. For example, older bulk petroleum, chemical or other liquid storage terminals may experience infiltration into the existing sewer system making it difficult to meet permitted storm-water discharge quality levels. As a result, sewer renovation or replacement may be necessary. Trenchless methods are likely to be less disruptive and more cost-effective in those areas where excavation may impact other aboveground or underground structures.

II. Scope

Trenchless construction technology methods include the new construction (or replacement) of piping and the renewal (i.e., renovation or rehabilitation) of existing piping. Following is a discussion that describes the difference between installing or renewing pipe underground without digging a trench.

New or replacement piping requires new construction at or near the existing pipeline or at a location along a new alignment. One commonly used method is the directional boring of small diameter horizontal holes up to six inches in diameter to bury underground utility pipe and cable. However, the focus of this paper is on the installation of large diameter fluid carrying pipe in sizes ranging from 6 inches up to 108 inches (9 feet).

Renewal of existing piping involves one of two following methods that may be determined after conducting an assessment of the structural condition and degree of inflow/infiltration exposure.

1. **Renovation** is the first option if the existing piping is found to be structurally sound. Then the objective is to reduce inflow/infiltration by injection or sealing techniques to repair limited damage. However, often the host pipe has structurally deteriorated (i.e., missing pieces/cracked joints in masonry piping, hydrogen sulfide corrosion of concrete piping or corrosion of steel piping) and "rehabilitation" is necessary.
2. **Rehabilitation** measures restore the pipeline's structural condition while still operating the original "host" pipe. Construction techniques may include slip lining with a new pipe; interior lining with cements or installing cured in-place liners and others. This paper is limited to trenchless pipe replacement using slip lining and pipe jacking methods.

III. Trenchless Technology Methods

Following are a number of trenchless technology methods that are described in ascending order, with small diameter methods listed first:

A. New Pipeline Construction or Replacement

a. **Auger Boring:** This is a trenchless construction method used to install a casing by hydraulically pushing the pipe through the ground and removing the spoil through the pipe using an auger. This method is limited to amenable soil conditions, relatively short distances and relatively small diameter piping (e. g., 24 inches).

b. **Direction Drilling:** This is a trenchless construction method that employs a directional drill to bore a horizontal tunnel (e. g., 2,200 feet in length and up to 36 inches in diameter). The tunnel is then reamed to remove the spoil and may be filled with bentonite slurry to maintain tunnel stability. The pipeline is assembled aboveground, pulled or pushed into the tunnel and anchored.

c. **Micro Tunneling and Pipe Jacking:** This is a trenchless piping construction method that pushes the pipe into place (i.e., pipe jacking) behind a micro tunnel boring machine that is remotely controlled. The boring machine is connected to the head of the pipe that follows the slightly oversized tunnel as it is drilled. The minimum diameter is 12 inches, which is limited by the available machines. The practical maximum internal diameter is 84 inches.

d. **Utility Tunneling and Carrier Pipe:** This construction method involves excavating the ground at the leading edge of a shield or boring machine and erecting a lining system from within the excavated space. The minimum size is approximately 48 inches in diameter, which is the size required to allow personnel access to erect a liner from inside the opening. The lined tunnel acts as a host for the installation of the carrier pipe system which is grouted in place.

B. Pipeline Renewal Technologies

a. **Slip lining:** This is a construction method used for pipeline installation inside an existing host pipeline. Although slip lining reduces the inside diameter of the pipe, the reduced inflow and infiltration combined with the smooth interior of plastic or fiberglass slip lining materials increase the hydraulic flow. A typical construction method involves digging insertion pits (e. g., 10 feet wide and up to 25 feet long) over the existing pipeline at approximately 600 to over 1,200 foot intervals. Workers enter the pits and remove the top of the existing pipe. After cleaning buckets are pulled through the line, sections of the slip liner are lowered and either pulled or pushed into place. Final installation may include pumping a grout between the host pipe and slip liner if the structural integrity of the host pipe is in question.

b. **Pipe Bursting:** Pipe bursting tools are used in slip lining to provide access in collapsed or narrow sections of the host pipe and if the pipe diameter is being increased.

IV. Typical Applications

Following are typical applications for new, replacement or rehabilitation of 2 through 102-inch diameter piping systems:

- Storm-water
- Industrial Effluents
- Sewer Interceptors
- Sewer Lines
- Force Mains
- Water Supply
- Salt Water Lines

V. Fiberglass Trenchless Piping Benefits

A. Directional Drilling

Flexibility permits the adhesive bonding of up to 16 inch diameter pipe aboveground and then pulling or pushing lengths exceeding 2,000 feet through a normal size insertion trench and through the drilled tunnel.

B. Micro Tunneling and Pipe Jacking

a. **Outside (OD) Dimensional Consistency and Smooth Exterior Surface:** The computer controlled production process achieves dimensional consistency and smooth exterior surfaces. Both of these qualities minimize friction forces created when jacking the pipe and cutter head forward through the soil to create the tunnel. Minimizing friction when pipe jacking has two advantages:

b. **Smaller versus larger capacity jacking equipment** (i.e., hydraulic capacity and framing size) needed to push heavier pipe materials (e. g., concrete or steel) with large outside diameter tolerance ranges.

c. **Longer drives** up to 800 to 1,000 feet with small diameter piping e. g., an average of 500 feet pushing 36-inch diameter pipe through stiff clays and silt-clays.

d. **High strength to weight ratio** fiberglass has a higher compressive strength than other large diameter piping materials. For example, fiberglass pipe weighs six to eight times less than a similar strength concrete in 72-inch diameter pipe.

e. **Smaller lifting equipment** required off-loading and positioning pipe in the insertion pits.

C. Slip Lining

a. **High compressive strength** of 2.5 times greater than typical concrete permits equal pipe strength with a thinner pipe wall. The thinner wall results in a larger inside diameter and minimizes any flow reductions from the original pipe design capacity.

b. **Smooth inside diameter wall** reduces friction and typically improves flow rate of the original piping system.
c. **Gasket sealed joints** are optional and permit the deflection of pipe couplings such that existing piping curves may be negotiated without special mitered or beveled fittings.
d. **In-service installation** when by-pass pumping is not feasible or allowed. Sewage or other wastewater flow may continue through the insertion pits while the pipe is being inserted into the host pipe. This is a significant advantage over re-routing the outflow and developing an Environmental Impact Report.

D. All Applications

a. **Long life** corrosion resistance externally to an underground environment and, internally to acids and caustics.
b. **Leak-free joints** by using adhesive bonded or rubber-ring seal bell-spigot joints for leak free service.
c. **Easy joining** methods by using push-together joints for simple and quick assembly without welding or grouting.
d. **Standard fittings** that are compatible with traditional ductile iron dimensions.

VI. Summary

While fiberglass is widely used in direct burial piping applications, it is uniquely suited to micro tunneling/pipe jacking for new construction and slip lining into existing host piping systems. As a result, some one-third of the fiberglass pipe footage has been installed using trenchless methods.

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