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| INTERNATIONAL SOCIETY FOR TRENCHLESS TECHNOLOGY | **TRENCHLESS TECHNOLOGIES RESOURCE CENTRE** | |
| | TRENCHLESS TECHNOLOGY GUIDELINES | SECOND EDITION |
| | SLIPLINING | NEW VERSION JUNE 2005 |

## 1. OVERVIEW

Possibly the simplest technique for renovating non-man-entry pipelines, sliplining basically entails pushing or pulling a new pipeline into the old one. The concept of using the 'hole in the ground' by installing a new pipe within the old is long established, and there are reports of clayware pipes being winched into old sewers and culverts many decades ago.

The availability of polymeric pipes, particularly fusion-jointed polyethylene, increased the popularity of sliplining techniques. Short section polymeric pipes may be formed into slipliners by fusion welding or with mechanical, collarless joints. They are also used extensively with on-line replacement techniques such as pipe bursting (see Section 5).

Although, in theory, any material can be used for the new pipe, in practice polyethylene (PE) is the most common choice. Not only is this material well established in the potable water and gas industries, it is also abrasion resistant and sufficiently flexible to negotiate minor bends during installation. It can be butt-fused into a very long continuous length prior to being winched into the host pipe.

Annulus grouting may be necessary after the insertion of the liner, so that the structure of the existing pipe provides some restraint and increases ring stiffness. In practice, the grouting operation can be the most difficult part of the job. The loss of cross-sectional area may also be significant, particularly if the liner size is governed by the diameters of commercially available extruded pipes, or where the size must be further reduced to negotiate deformation or displaced joints in the host pipe. As a result of these limitations, plain sliplining has become less common than close-fit lining (covered elsewhere), but may still be the best choice in certain cases.

**2. APPLICATIONS**

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| Sewers | ? | (see note A) |
| Gas Pipelines | Yes | |
| Potable water pipelines | Yes | (see note B) |
| Chemical / industrial pipelines | Yes | (see note C) |
| Straight pipelines | Yes | |
| Pipelines with bends | Yes | (see note D) |
| Circular pipes | Yes | |
| Non-circular pipes | ? | (see note E) |
| Pipelines with varying cross section | ? | (see note F) |
| Pipelines with lateral connections | ? | (see note G) |
| Pipelines with deformations | ? | (see note F) |
| Pressure pipelines | Yes | |
| Man-entry pipelines | ? | (see note H) |

A. Sliplining can be used to renovate sewers, but is not usually the first choice system for gravity pipelines because of the reduction in bore.
B. Approval of there relevant regulatory body is needed for all materials in contact with potable water.
C. Subject to the pipe material being compatible with the chemicals.
D. Severe bends cannot usually be negotiated, especially at larger diameters. All bends add to the friction between the old and new pipes during installation, and so reduce the length of liner that can be pulled in without overstressing the pipe.
E. PE pipes are available for non-circular sections, although they are relatively uncommon.
F. The liner must be sized to the minimum dimensions of the host pipe, unless tapers are incorporated.
G. It is usually necessary to excavate to connections and disconnect them prior to liner installation, and certainly prior to grouting. Internal reconnection may be possible, although the process is more complicated than with close-fit lining.
H. Because of the weight of material, it is unusual to pull a new pipeline into a man-entry pipe as a continuous string. Man-entry renovation techniques are covered elsewhere.

## 3. DESIGN REQUIREMENTS

Pipes used for sliplining are generally, but not always, stand-alone pipes of similar type and specification to those used for new installations. PE pipes are usually aimed at applications where internal pressure is the main criterion, and the design of PE slipliners in pressure pipes should follow the same principles as for new pipes. Thin-walled (nonstructural) liners may occasionally be used, provided that the existing pipe is known to offer sufficient restraint, and that complete grout filling of the annulus can be achieved so that no part of the liner is unsupported. This is often difficult to guarantee, and thin-walled liners are therefore not favoured for basic sliplining, although they are frequently used in modified (close-fit) sliplining described elsewhere.

Annulus grouting may not be required when lining pressure pipes, but is usually necessary for gravity pipelines in order to increase the ring stiffness of the liner. Slipliners in sewers are usually designed to be restrained by the host pipe and the annulus grout, but do not form a bond with the existing pipe wall. In such cases, the grout acts only as a filler, and does not require high structural strength. Systems which rely on the host pipe for some measure of structural support are sometimes known as 'interactive lining' techniques.

Because of the relatively low flexural modulus of PE, thick-walled pipes may be needed to withstand high external loading. This may be a significant factor with gravity pipes, which are laid at considerable depths or are subjected to high vehicle loading. In such cases it may be more economical to design the PE liner as a permanent former for high strength grout, rather than to increase the wall thickness of the liner itself. In this type of lining system the grout is the main structural element.

In all cases, the liner must be designed to withstand not only the internal and external forces in service, but also the loads during installation - particularly winching forces and grout pressure.

## 4. LINER PIPES

As indicated above, sliplining pipes are most commonly made from polyethylene, but may be of any material that can be inserted into the host pipe. The main criterion is that, in order to minimise the bore reduction, joints or sockets should not protrude beyond the pipe barrel.

Clearly, if a pipe string is to be winched in, the joints must not pull apart. Butt-fused PE is often used, the fusion taking place either on the surface or within the insertion pit.

Subject to constraints of space, fusion on the surface allows the preparation of long pipe strings, which can be pulled in quickly to minimize the interruption to service. However, due to the curvature limitations of the pipe, this method of installation can require long starter trenches, especially with pipes that are deep or of large diameter. In-trench fusion allows a shorter excavation, but installation can proceed only as quickly as the joints can be welded and cooled.

*Butt-fusion jointing of a PE slipliner*

The normal procedures and precautions for butt-fused joints in new installations apply equally to sliplining pipes, and the recommendations of the pipe and fusion equipment manufacturers should be followed closely.

A recent development in the USA is the butt fusion welding of uPVC pipes. This enables standard uPVC pressure pipe to be used in a similar manner to polyethylene in applications which involve insertion by pulling. The butt fusion welding process requires careful control of resin formulation and fusion conditions.

There are two common alternatives to fused joints - screw joints and snap-fit joints. The former may be used in pipe materials such as polypropylene, and can give a reliable and quickly assembled joint at the expense of higher manufacturing cost. Pipe joints which snap together may be unable to withstand high tensile forces, and are often pushed in from the insertion pit by hydraulic rams. This is a similar technique to that used in some forms of on-line replacement described elsewhere.

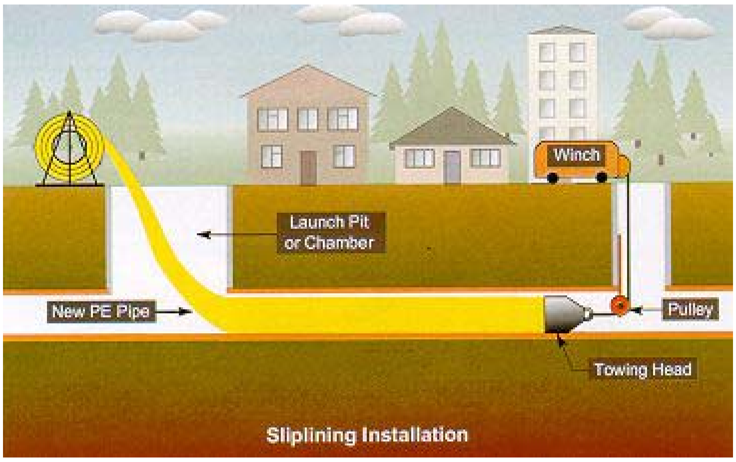
Mechanically jointed pipes are available in lengths to suit the space available for insertion, and can be installed from existing chambers. The machining of the joints may, however, represent a large proportion of manufacturing cost, so short-length pipes often have a relatively high unit cost.

**5. INSERTION**

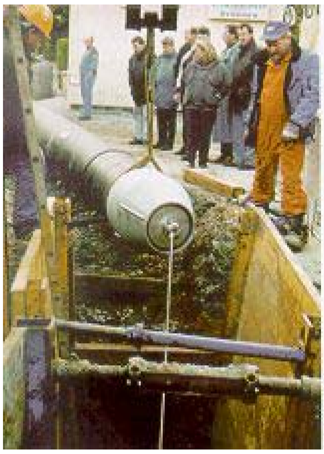
As discussed above, slipliners may be pulled in, pushed in or spirally wound. If pulled in, an important component is the towing head, which grips the new pipe and transmits the force from the winch cable. The towing head should provide a secure connection without imposing high, localized stresses. Some designs also seal the end of the pipe to prevent soil or debris from entering, this being particularly desirable for potable water applications.

Small diameter slipliners are often pulled in using ‘towing socks’. These are tubes made from diamond-shaped mesh, which tend to reduce in diameter and grip the liner as a pull is exerted.

To avoid over stressing the liner, a breakaway connector may be fitted between the winch cable and the towing head. These connectors have a series of interchangeable pins that determine the load at which the two halves of the unit will part company. Although undesirable, breakage of the connector is usually preferable to pipe damage and subsequent failure, and the presence of a breakaway connector also concentrates the minds of the operatives on avoiding excessive winch forces.




Small liners may be pulled in manually, but most need a winch. The winch should apply a steady, progressive pull, without snatching or uncontrolled variations in force. Careful consideration should be given to the positioning of the winch and the routing of the cable, and it is often necessary to fit additional pulleys within the manhole or reception pit, to ensure that the cable has an unobstructed path and does not abrade on any part of the chamber.



*Preparing to pull in a 500 mm diameter PE slipliner*

There are numerous designs of pipe pushing machines, either manually or hydraulically powered. Some types are designed to operate from within the insertion pit, whilst others are located on the surface just behind the insertion pit. The pushing machine grips the liner pipe and pushes it forward into the host pipe. The gripping mechanism is then released and returns to the starting position, and the process is repeated.

**6. SPIRALLY WOUND LINERS**

In the original ISTT Guidelines the earliest form of spirally wound liners which involved an annulus between the host pipe and liner were described in this section. In the revised ISTT Guidelines all of the spiral winding processes are considered together in Section.

## 7. GROUTING

Lining systems in which the liner bonds to, and acts in composite with, the existing pipe, and systems in which the liner tube acts simply as a permanent former for the annulus grout, require structural grouts with a compressive strength generally between 10 and 20 kPa.

Liners which are restrained by the host pipe, but do not need to bond to it, require only a filler which can transmit loads between the two elements. Some of the grouts used for this purpose have a strength similar to that of stiff clay - around 1kPa - although there is no harm in using higher strength materials.

General purpose Ordinary Portland Cement and Pulverised Fuel Ash (OPC/PFA) grouts are commonly used, although a variety of special formulations are available. One of these is a very low viscosity grout that flows through the annulus under gravity or minimal pressure, but sets in about 20 minutes. An advantage of quick-gelling grouts is that they allow stage grouting to proceed more quickly than with conventional materials.

The forces on a liner during grouting are sometimes higher than anything encountered during normal service, and failures due to grout pressure and flotation forces must be avoided. Flotation forces are sometimes underestimated, especially in larger liners, and it should be remembered that the force is related to the weight of grout displaced by the liner (i.e. the volume of the liner multiplied by the grout density) rather than the weight of grout in the annulus.

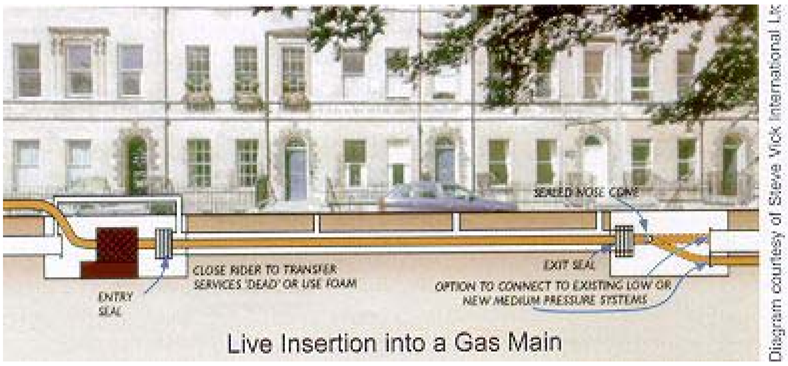
It is common practice to fill the liner with water during grouting, which helps to counteract the flotation force and to resist external pressure. Even so, since most grouts have a specific gravity greater than 1.0, it may still be necessary to grout in stages, especially with larger gravity pipelines where the gradient is critical and flotation could not be accepted.

## 8. LIVE INSERTION AND SERVICE PIPE RENOVATION

Several techniques have been developed to allow the insertion of a new polyethylene pipeline into an existing gas main or service without interrupting the supply. These methods generally rely on gas flowing through the annular space between the old and new pipelines during installation, and so entail a reduction in pipe bore. This may be acceptable in the case of old mains originally designed for gas of lower calorific value, or distributed at pressures lower than those currently available.

It is outside the scope of this document to describe the many proprietary systems for live insertion. For obvious safety reasons, strict and detailed procedures are laid down for installation, and the following is intended only as a general guide to the basic principles. Systems are available for low and medium pressure mains.

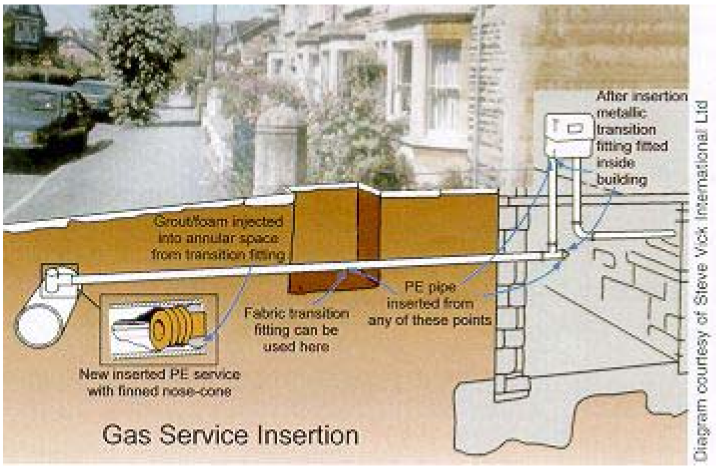
The first stage is to isolate the section of main to be renovated, keeping it supplied with gas via a bypass at one or both ends of the isolated section. The new polyethylene pipe is then fed through gland seals attached to the old main at the entry excavation, and is pushed using pneumatic or hydraulic machines through the entire length of main to be renovated. Typical insertion lengths are between 100 and 500 metres.



Live Insertion into a Gas Main

There are many variations on the technique, but in the simplest version the new PE pipe is passed through gland seals in the exit excavation, and can then be connected either to the existing pipe or to a new, generally higher pressure, network. In all variations, the annular space between the old and new pipes is used to maintain supplies to consumers during installation. To facilitate the transfer of services to the new PE pipe, polyurethane foam is injected into the annular space to stop the flow of gas, allowing the old main to be cut away and the new connection made. Gas mains from 75 mm to 450 mm diameter can be relined using this method.

For the renovation of gas service pipes, a technique is available that allows the existing gas meter position to be maintained by enabling the insertion of PE pipe through a 90$^{o}$ elbow, around a tee, or through a number of long-radius bends. After removal of the meter and the main stopcock, the line-blowing assembly is fitted to the service connection at the meter position. Air is blown through the old service pipe to remove any loose rust. The pipe receiver, bend and standpipe are fitted to the service, and air is allowed quickly into the pipe to blow a line through to the far end. This is then used to pull back the winch cable, and the winch is fitted to the top of the pipe receiver. A short length of PE pipe is winched through to remove any further rust or encrustation. The full length pipe is installed by using the winch in combination with a pushing force applied manually from the other end, and a test is applied after a brief period to allow the pipe to recover from any stretching. The technique can be adapted for the renewal of water services.



Gas Service Insertion

A method of live insertion for gas service pipes has been developed in which a new PE pipe is pushed into an old steel service through a gland sealing system attached to the old pipe, either inside the consumer’s premises or by means of a small excavation outside the building. No excavation is necessary at the service connection with the gas main in the highway. The annular space between the old and new pipes is filled with a permanent sealant, which is prevented from entering the mains system by a type of nosecone fitted to the leading end of the PE pipe. The system is available for steel services from 20 to 50 mm diameter, operating at pressures up to 50 millibar. Adaptations to enable the use of the technique at higher pressures and in water networks are under development.

## 9. LATERALS AND BRANCH CONNECTIONS

The reconnection of laterals and branches in conjunction with sliplining of gravity pipelines usually necessitates excavation. It may be possible to cut an opening in the liner prior to grouting, and to insert an inflatable bag up the lateral to seal between the branch and the liner and prevent grout from entering either. However, the complexity of this operation is justified only if external access is very difficult or impossible, and the procedure can be used only in larger pipes.

Excavation must take place, and the branch must be disconnected, before grouting is carried out. Electrofusion is commonly used to fit branches to PE liners, in the same way as for new installations. Special couplings are available to reconnect the new junction to the existing branch.

## 10. SUMMARY

1. Sliplining is a conceptually simple technique, which can be applied to either pressure or gravity pipelines.
2. Virtually any type of durable liner material can be used, although polyethylene is the most common.
3. Standard pipes and fittings, as used for new installations, can also be used for sliplining, except that joints should not protrude beyond the pipe barrel.
4. Liners may be pulled in or pushed in, depending on the liner material and the joint design.
5. A pipeline as good as new may result, but the bore reduction may be significant.
6. Grouting is generally required, at least in gravity pipelines, to increase resistance to external loads.
7. Techniques are available for the insertion of liners into live gas mains.
8. Laterals must usually be reconnected by excavation.