ON-LINE REPLACEMENT

OVERVIEW

A pipeline with inadequate capacity or whose structural condition is too poor for relining can often be replaced without excavation using an 'in-situ' or 'on-line' pipe replacement system.

The most commonly used method of on-line replacement is pipebursting, in which a percussive tool (usually a modified impact mole) or a hydraulic expander breaks out the existing pipe, and a new pipe is pulled or jacked in behind. Pipebursting is referred to in certain countries as 'pipe cracking'. Some systems do not use a mole, but rely entirely on axial jacking or pulling force acting on a tapered bursting head.

Pipebursting technology was developed in the early 1980s, originally for the replacement of old cast iron gas mains. Following widespread use also in the UK water industry for the replacement of small diameter cast iron potable water systems, pipebursting now has an increasing market worldwide.

Pipebursting systems use a pneumatic or hydraulic bursting head to break out the old pipe, while simultaneously drawing in a new pipe string

In addition to gas and water main renewal, pipebursting is becoming one of the leading no-dig technologies for the replacement of old and undersized sewers. Significant increases in size have been achieved, such as the installation of a 600 mm diameter plastic main through an old 375 mm concrete sewer. Sewer bursting operations are typically in the diameter range 150 to 375 mm, but pipes of 800 and 900 mm diameter have been replaced by this method, and a 1200 mm diameter burster has recently become available.

Another method of trenchless replacement is 'pipe-eating', a variation of microtunnelling in which the old pipe is consumed by the tunnelling machine as the replacement pipe is jacked in. This technique is particularly suited to larger diameters and to situations in which the heave caused by expansive upsizing could risk damage at the surface or to adjacent services.

A recent introduction is a pipe replacement system designed as an adaptation to larger directional drilling machines, using a special reamer to grind up the existing pipe.

Because of the outward expansion of the old pipe, it is necessary to disconnect laterals and service pipes before using pipebursting and most other on-line replacement techniques. Although remote disconnection techniques have been developed, the most common method is by means of a small excavation from which the lateral or service pipe can subsequently be reconnected to the new main. The number and frequency of laterals or service connections can be a determining factor when assessing the economics of trenchless replacement against traditional open-cut methods.

PERCUSSIVE PIPEBURSTING

Pneumatic moles, otherwise known as 'ground-piercing' or 'earth-piercing tools', are described in the Impact Moling and Ramming Section. They comprise a steel cylinder within which a pneumatically driven hammer repeatedly strikes an anvil at the nose of the tool, causing the cylinder to be driven forward. Numerous configurations are available with various designs of nose cone and internal mechanism.

In operation, the bursting head is first expanded to crack the old pipe, and is then retracted. Hydraulic jacks acting on the new pipe string are then used to push the string forward, while tension is applied to the nose of the burster by a chain or hydraulic rod system to maintain directional stability. The process is then repeated, adding further pipes to the end of the string as work progresses. The leading end of the pipe string sits inside a shield connected to the back of the bursting head.

Photo courtesy of Clearline Services Ltd

Hydraulic mole emerging at reception chamber

A variation is to use a very powerful hydraulic pushing and pulling machine which acts on high tensile steel rods connected to a bursting head pulled through the existing pipeline. The new pipeline is drawn or jacked in behind the head. The typical pulling capacity is from 20 to 230 tonnes, depending on pipe diameter and length, and this method relies on the power of the pulling machine rather than the hydraulic expansion of the head itself.

Photo courtesy of Clearline Services Ltd

Bursting head and hydraulically powered rod pulling machine

Although welded PE pipes can be used in conjunction with hydraulic pipebursting, the new pipes are commonly polyethylene with joints that snap together, in short lengths suitable for installation from existing chambers. Clayware pipes designed for hydraulic pipebursting applications have been introduced recently, allowing sewers to be replaced or upsized using a traditional material. The clayware pipes have stainless steel collars to provide enhanced shear strength at joints, and in appearance are similar to those used with microtunnelling systems, though with a thinner pipe wall. Clayware pipes can withstand higher jacking forces than most polymeric materials, although they are heavier and may require powered systems for lifting and handling on site.

PIPE-SPLITTING

Non-brittle pipe materials such as stainless steel collars, ductile iron saddle clamps or polyethylene repair sections may present problems to some pipebursting systems. If such materials are encountered, the burster may continue to operate without making forward progress.

Whilst high rates of success in dealing with non-brittle materials are claimed for certain pipebursting techniques, an alternative approach is a system which uses a cutting and expanding head with the ability to cut through the wall of a ductile pipe or fitting. The head is pulled through the pipeline by a hydraulic rod system, and slices open the old pipe while pulling in a new pipe string behind it. The technique can be used in pipes made from steel, ductile iron, repaired cast iron, asbestos-cement, PVC and polyethylene, and has been used to install diameters of up to 305 mm under suitable conditions. Rates of progress of up to two metres per minute have been achieved.

PIPE-EATING & REPLACING

Microtunnelling equipment, described in the Pipejacking and Microtunnelling Section, can be used for the trenchless replacement of undersized or damaged sewers, as well as for new installation. The 'pipe-eating' process is suitable for the replacement of clayware, concrete, asbestos cement, GRP and even reinforced concrete pipes, with the new pipe being jacked in behind the microtunnelling machine.

Microtunnelling machines can excavate an existing pipe, whilst a new pipeline is simultaneously jacked in behind. The machine crushes the existing pipe with its eccentric-motion cone crusher, and the process also permits realignment and upsizing of the sewer. Systems exist which allow on-line pipe replacement without flow diversion. During installation, the sewage flow is pumped through the shield separately from the pumped spoil slurry circuit, and no over-pumping is required.

Photo courtesy of Iseki Poly-Tech Inc

Pipe eating and replacing system with flow-through facility

A further adaptation uses specially designed teeth within the cone crusher to cut the reinforcement in a concrete pipe, allowing the excavation of all conventional pipe materials in addition to concrete. Some machines have a pilot head fitted to the cutting wheel, which guides the machine within the existing sewer, together with pneumatic hammer action which assists the cutting head to crush the old pipeline.

PIPE-REAMING WITH A DIRECTIONAL DRILLING MACHINE

A recently introduced technique allows on-line replacement using a directional drilling machine with a pullback capacity of at least 10 tonne. The system employs specialised reaming tools to grind up the old pipe, whilst the new pipe string is drawn in behind. The fragments are suspended in the drilling fluid and pass through the existing pipe to a manhole or recovery pit.

LEAD PIPE EXTRACTION & REPLACEMENT

Lead water pipes can represent a significant health risk through the absorption of lead into drinking water. Lead water mains can be lined or replaced by techniques discussed elsewhere in these Guidelines. However, the major problem of lead contamination arises in small-bore service pipes (typically 12 to 25 mm diameter) for which most systems aimed at larger pipes are inappropriate. The lining of lead service pipes with a thin-wall, folded PE liner is covered in the Close-Fit Section.

A method of extraction and replacement has been developed in which the existing lead pipe is pulled out of the ground and replaced by a new PE service. The key element of the technique is a steel cable fitted with cones which expand to grip the internal wall of the lead pipe. A winching force is applied to the cable, and a pushing device is used on the rear of the pipe. As the old pipe is extracted and wound onto a drum, a new PE pipe is pulled in simultaneously by the same cable.

The technique has a high success rate with fairly straight service pipes, but local excavation will normally be required if the pipe has a sharp bend, is surrounded in concrete or has been fitted with flanged couplings.

SUMMARY

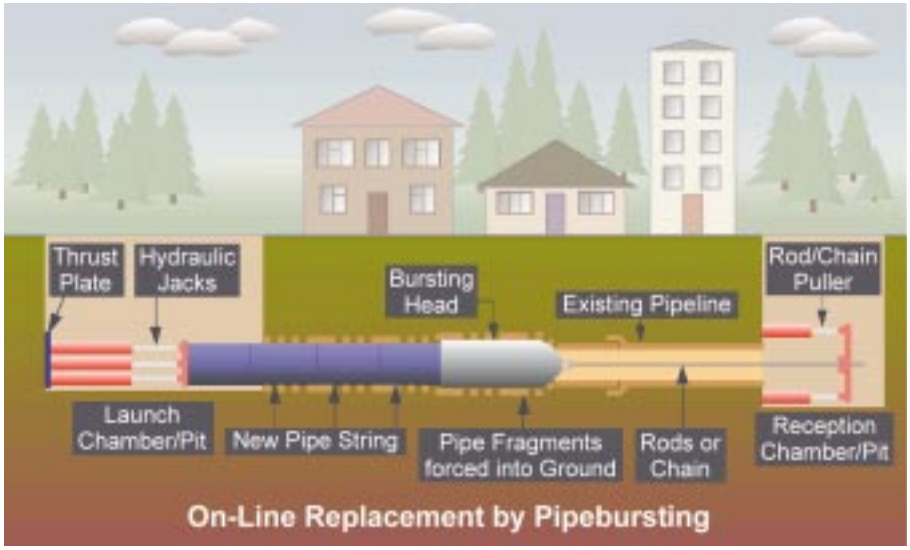
- On-line replacement offers a means of replacing or upsizing existing pressure or gravity pipelines economically and with minimal or no excavation. A wide range of techniques is available, based on pneumatic, hydraulic or microtunnelling systems.
- Most techniques are limited to the replacement of brittle pipe materials such as cast iron, clayware and unreinforced concrete, but some are designed deal with ductile materials including steel.
- In all cases, the success of the operation will depend on having accurate information about the original construction materials and the condition of the existing pipeline, including, for example, whether there have been any localised repairs, and whether sections of the pipeline have been surrounded in concrete.
- Laterals and service pipes must be disconnected prior to the on-line replacement of the main, and then subsequently reconnected to the new pipeline. This is usually carried out from a small excavation. The number and frequency of connections may influence the economic viability of the technique.
- Techniques have been developed for the extraction and replacement of lead service pipes for potable water.
- On-line replacement is one of trenchless technology's major growth areas, and it is likely that new developments will continue to extend the capabilities of on-line replacement systems, whilst also adding to their economic benefits.

Many types of pneumatic mole can also be used for pipebursting, in which the mole travels up an existing pipe, breaks it out and forces the fragments into the surrounding ground. A new pipe is simultaneously drawn in behind the mole, and a cable or rods attached to the nose augment the percussive force whilst also helping to keep the mole on the correct line.

Pipebursting using a pneumatic mole relies on a percussive fracture mechanism, and is therefore aimed at brittle materials such as cast iron, spun iron, clayware and unreinforced concrete. The technique is by far the most popular method for the size-for-size replacement and upsizing of pressure pipes, and has been used in diameters from less than 100 mm to over 500 mm.

The original systems comprised a pneumatic hammer which was pulled through the old pipe by a steel cable attached to a winch. The nose of the burster was fitted with fins to assist in bursting the pipe and collar. Improvements to the technique came with the introduction of hydraulically powered rod systems to pull the burster through the pipeline. Most pipe bursting systems today use rods rather than a cable, and this method offers better control of power, greater safety for operators and the facility for increased pulling power and larger diameters.

The new pipe, usually polyethylene pre-welded to the required length, is drawn in immediately behind the burster unit. In some cases an intermediate jacking force may be applied to the pipe string, rather than relying entirely on the pull from the bursting head at the front or the jacking force from the rear.



HYDRAULIC PIPEBURSTING

On-Line Replacement

One of the factors to consider with pneumatic pipebursting is the effect of the percussion on adjacent pipes, services, foundations and paved surfaces. An alternative is hydraulic bursting, using an expanding head with 'petals' that open and close under hydraulic pressure. Hydraulic bursters are often shorter than their pneumatic counterparts, allowing size-for-size replacement or upsizing from existing chambers without the need to excavate launch and reception pits. To date, hydraulic bursting has been used primarily for the on-line replacement of sewers and gravity pipelines, more than for pressure pipelines. Pipelines up to one metre in diameter have been installed by this method. A portable hydraulic pipebursting system is also available, designed to replace pipes up to 150 mm diameter and using equipment which is sufficiently compact for use in gardens, in or under buildings and in other locations with limited access.