	TRENCHLESS TECHNOLOGIES INFORMATION CENTRE	
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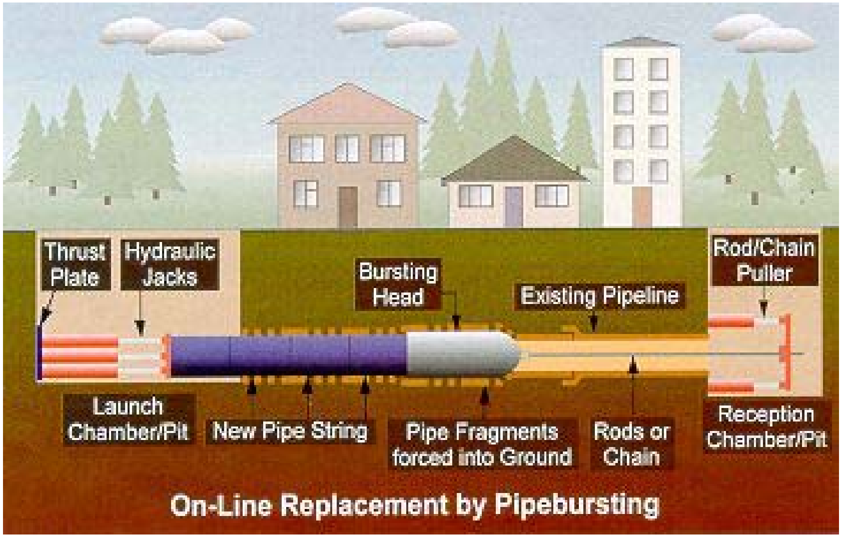
	PIPE BURSTING AND SPLITTING	NEW VERSION JUNE 2005

1. OVERVIEW

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 is referred to in certain countries as 'pipe cracking'. In its earliest forms pipebursting comprised the use of percussive tool (usually a modified impact mole) or a hydraulic expander to break out the existing pipe with a new pipe being pulled or jacked in behind. Using the correct equipment the original pipe size can be increased to a certain extent for increasing the capacity of the new system. More recently however there has been a significant shift away from these systems towards those that rely entirely on axial jacking or pulling forces acting on a tapered bursting head. This system tends to be referred to as Hydraulic Rod Bursting.



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Sewer bursting operations are typically in the diameter range 150 to 375 mm, but pipes of 800 and 900 mm diameter have been replaced by this method, and a 1,200 mm diameter burster has been achieved.

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.

2. PERCUSSIVE PIPEBURSTING

Pneumatic moles, otherwise known as ‘ground-piercing’ or ‘earth-piercing tools’, are described elsewhere. 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.

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.

A range of pneumatic bursters. Picture coutesy of Earth Tool Inc Hammerhead Mole.

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 un-reinforced 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.

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.

3. HYDRAULIC PIPEBURSTING

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.

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.

A hydraulic 'expansion' bursting head. Picture courtesy of PERCO Engineering Ltd.

A variation is to use a very powerful hydraulic pushing and pulling machine that 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.

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.

4. HYDRAULIC ROD BURSTING

Hydraulic Rod Bursting utilises a hydraulically powered rod pushing unit which initially pushes rods through the pipe being replaced from one access point to another. The guide rod used at the front end of the rod chain during insertion is then replaced with the bursting head (either a bladed head for brittle pipes or a cutting head for splitting non-brittle pipe); an expansion head, to push aside the broken shards of the burst pipe or to open out the cut pipe; and the new pipe which is pulled in behind the burster/expander assembly. In the burster/expander assembly the expander shell can also be of a size greater than that of the original pipe in order to upsize the old pipe to a new diameter. As the bursting head is pulled back through the old pipe it is burst or split, pushed to one side into the surrounding ground and the new pipe is pulled into place into the new opening created. Once pulled through to the start pit the bursting equipment is removed leaving the new pipe in place ready to connect to the remainder of the existing system.

A hydraulic rod bursting unit. Picture courtesy of Earth Tool Inc/U Mole Ltd.

One company has extended the more common threaded end rod-based system by replacing solid round section rods with an interlocking ladder or lattice rod design. This is designed to make rod changing easier and quicker so making the operation as a whole very efficient.

5. SMALL FOOTPRINT BURSTERS

There has also been the development of a system that is small enough yet powerful enough to fit into an existing manhole so further eliminating the need for access excavations. With increasing requirement for pipebursting application in the street to property sector of the market several manufacturers have redesigned the basic hydraulic rod burster to use a smaller footprint so giving similar power capability in a unit that has easier access to limited space conditions. As well as the rod based systems some manufacturers have also re-developed the cable based pulling units to give very small footprint units that can be utilized in an access pit as small as 619 mm x 760 mm and to replace pipe s from a little as 50 mm diameter. Production rates are also impressive at up to 3.5 m per minute.

A small footprint pipe bursting unit. Picture courtesy of Earth Tool Inc/U Mole Ltd

6. 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. One aspect of these splitting heads that has made them very popular for both brittle and ductile pipebursting operations is that they have the capacity to ‘cut’ through repair fittings, so increasingly they are used for most bursting operations as the pipe being replaced more often than not will carry several such repair collars. This allows operations to proceed without the need to dig down at repair points or to drag collars through the soil to the reception pit, a circumstance that places increased pressure on the pulling system. Before these heads were available repair collars regularly brought replacement operation to a halt.

7. SPECIALIST PIPES

Whilst the improvements and developments in the bursting equipment itself has been significant over the past decade or so, one of the most pressing problems with pipe bursting has only been answered in more recent times. One regular occurrence when pipebursting in it's the early years was the damage caused to the new pipe during insertion by sharp edges of burst pipe cutting into its surface. To overcome this problem several clients required that thicker wall pipe be used in pipebursting works so that, even with surface damage, the remaining wall thickness was sufficient to do the job required. A rule of thumb for these installations has been that damage depth should not be more than 10% of the pipe wall thickness.

In an attempt to overcome this problem some pipe manufacturers have developed a new pipe system that uses a sacrificial skin around the main body of the pipe. The skin is generally of a harder plastic than the main PE body and so will withstand scouring to a much higher degree. The pipe design also ensures that the main pipe is of the standard required for the installation. Therefore, even if the sacrificial skin pipe is scoured completely through, the main pipe is not affected.

8. OTHER DEVELOPMENTS

As well as the new pipe design, there have been certain other pipe system developments that have aided the growth in the pipe bursting market. One significant one has been the development of pipe coil trailers, which enable pre-determined long lengths of pipe to be transported to site so eliminating the need for pipe welding on site. This reduces the number of operations required on site and also the working area need to complete an operation as the footprint of the trailer-mounted pipe systems is much less then that required when stick pipe is welded on site. Both this and the sacrificial skin pipe development can also applied to HDD operations see elsewhere.

9. SUMMARY

1. Pipe Bursting and Splitting 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 (expander, rod or cable based) or microtunnelling systems 'pipe eating' (see separate section).
2. Correctly applied and with the right accessories the various techniques can replace brittle and ductile materials including pipe materials such as cast iron, clayware and un-reinforced concrete and steel.
3. 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.
4. 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.
5. 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.