Handbook of Pipe Bursting Practice

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Contents

Pipe Bursting - the Breakthrough in Pipe Renewal

It's wise to choose the pipe bursting replacement method in cases of damaged pipes. With the Grundoburst system (5 models) old pipes can be replaced with new pipes of smaller, equal or larger diameter - up to ND 1000. Why Grundoburst? Because even ductile and grey cast iron, steel, plastic and many other pipes can be replaced with PVC/HD-PE coiled or short pipes. The patented QuickLock® bursting rods are not screwed but simply clicked together giving huge time savings plus increased productivity of up to 200 m and more per day. Grundoburst is also suitable for applying the Tight-In-Pipe (TIP) method. All in all MORE than you expect.

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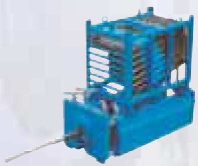
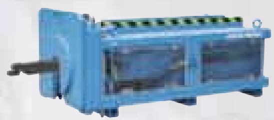
Grundoburst 400 G



Grundoburst 800 G



Grundoburst 1250 G

Grundoburst 2500 G

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1. Introduction

1.1 Definition of “pipe bursting”

Pipe bursting is a eco-friendly trenchless method which replaces existing host pipes by displacing their fragments into the surrounding soil while simultaneously pulling in new protection or utility pipe of the same or larger diameter into the void created. The installation of new, industrially produced and tested pipes of same or larger size is typical for this technology whereby all types of pressure or non-pressure pipes as well as protection pipes can be replaced and installed. New long and short pipe sections are equally suitable. Pipe bursting can be applied from pit to pit, pit to manhole and manhole to manhole.

Caliber pipe bursting of sewage pipes is the installation of new pipes into the host pipe with the new pipes of slightly smaller outside diameter compared to the internal diameter of the existing host pipe. ***Force*** is only transmitted into the host pipe *at damaged pipe sections where the internal diameter is smaller than the expander’s outside diameter,* e.g. pipe deformations or protruding cracks.

The expression “Berstlining” or “Burst lining” is common mainly in Germany, and is rarely used in other countries. Therefore, this technology is known in English-speaking areas as “Pipe Bursting”, “Pipe Cracking” and “Pipe Splitting”. The expression “Pipe Bursting” is the general term for this technology, but also refers to the replacement of brittle material host pipes like cast iron, clay or concrete using the static method with rods. The dynamic / pneumatic replacement of brittle material host pipes is called “Pipe Cracking”. The term “Pipe Splitting” refers to ductile material host pipes like steel, plastic or ductile iron. The terms used in English are more exact, because they do not refer to a “Lining-Process” but to the actual replacement process of “bursting”.

1.2 History of pipe bursting technology

Pipe Bursting has a long tradition, but would never have been so successful or even imaginable without piercing tool / impact moling technology and horizontal steel pipe ramming. The first idea to replace pipes by bursting was elaborated by British Gas and UK´s DJ Ryan engineering company, who on a large scale already applied soil displacement hammers (impact moles) and horizontal ramming machines for trenchless installations of pipes and cables in the early 1980s. Also some contractors with self

Fig. 1.1: Layout of a modern pipe bursting process

Fig. 1.2:
Ryan pipe bursting system in the early 1980s

made equipment had been using the process as far back as 1975. The term pipe bursting was not used at this time however contractors were performing this process in some locations, including within the USA and Germany.

Since 1981, British Gas and DJ Ryan applied for the first basic method and equipment patents in the UK. More patents followed in Europe, USA, Japan and South America.

The reason for further developments in the UK was the so-called "King Report", according to which there was an urgent need for action in replacing thousands of miles of defective cast iron gas pipes installed many years earlier. These replacement programmes were put into practice in the early 1980s and have been carried out ever since.

During the first years, the wider application of pipe bursting outside the UK firstly progressed quite slowly. This was caused by the fact that this technology was patented by British Gas and DJ Ryan, and British Gas who required technical transfer licence fees from manufacturers and royalties for each installed metre which used this technology. Only a few manufacturers with an eye to the future were willing to commit and to sign licence agreements, which, under these circumstances, sometimes caused significant additional operating costs.

As pipe bursting process began to develop in the USA, the market that took hold was the replacement of sanitary sewer piping. The long term neglect of sewer system assets in the US prompted the US EPA to require some major US cities to embark on long term sewer replacement/rehabilitation projects. The City of Houston, Texas is a prime example of this scenario.

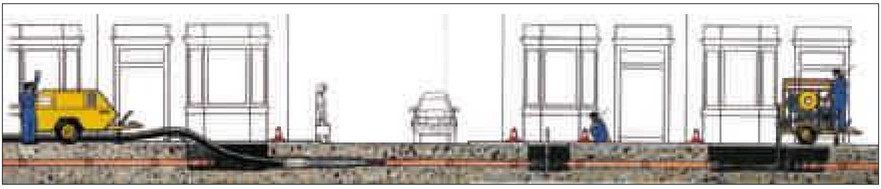


Fig. 1.3: "PIM method" (pneumatic / hydraulic)

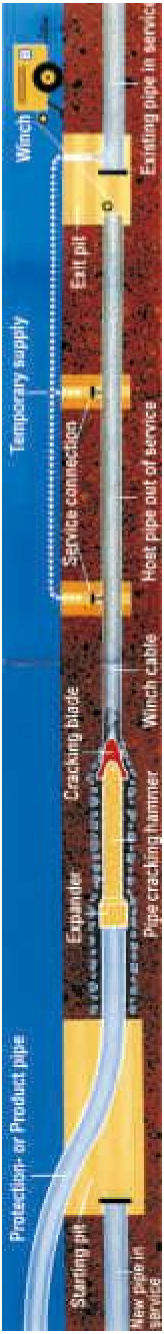


Fig. 1.4: Brochier pipe cracking method with Grundocrack at the end of the 1980s in Germany

The first German companies to apply pipe bursting technology since about 1983 were DIGA in Essen and Brochier in Nuremberg. Tracto-Technik (TT Group) took on pilot function among machine manufacturers. Australia (1985) and the Scandinavian countries Finland (1989), Sweden (1986), Norway (1988) and Denmark (1987) were among the countries in which the benefits of pipe bursting were clearly seen from the very beginning. Russia followed around 1990 with Ireland, France, Argentina, Chile and Brazil following afterwards in approximately 1995.

With the British Gas patents having expired (Europe 2001, USA 2005) and the method having reached a high technological level, pipe bursting has really boomed world-wide. Spain (2000), South Africa (2003) and China (2003) as well as recently Singapore, Malaysia, Indonesia and India and other countries are now replacing their pipe networks by mainly applying pipe bursting. Even in Cuba, this method has been used since 2001.

Pneumatically and hydraulically driven pipe bursting systems were already known from the very beginning of the technology development. Pneumatic machines had been originally known as “PIM machines” (PIM = Pipe Insertion Method).

[1.1] describe the PIM method as follows:

“The PIM machine is characterized by the following components:

- construction as cone for the creation of channels with diameter of a protection pipe to be installed,
- compressed air driven,
- head cone with moveable blades to be activated externally via hydraulic system to burst obstacles like pipe fittings and repair collars
- rear part with direct towing attachment for the protection pipe as an integral part of the machine.

A further characteristic component of this technology is a winch to guide the PIM machine and to assist the bursting process.”

At that time, individual pipeline sections to be replaced with the PIM machine were already up to 100 m (330 ft) in length, whereas, dependent on soil conditions, a bursting process up to 0.5 m/min (1.6 ft/min) could be achieved. It was already possible to replace cast iron pipes up to ND 150 mm (6”).

The development of a purely pneumatic Grundocrack bursting hammer considerably improved the efficiency of the PIM machines. This technology became known as “Pipe Cracking.”

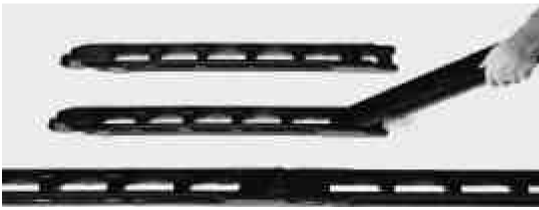
Fig. 1.5:
Grundocrack bursting blade destroying a pipe joint

Grundocrack pipe bursting hammers are based on the principle of horizontal ramming machines. These hammers had a slotted head upon which a bursting blade was attached. This tool configuration was successfully used for replacement of cast iron pipes. The winch assists the bursting hammer by pulling it, with constant tension, against the host pipe. This enabled a direct force transmission of the percussive piston into the host pipe and therefore led to greater efficiency, even when bursting joints and pipe repair clamps. Since then, it was also possible to replace pipelines up to 150 m (490 ft) and up to ND 300 (12”) with bursting times of 1–2 m/min (3–6 ft/min). Grundocrack pipe cracking hammers are successfully used world-wide to this very day.

The first hydraulic pipe bursting machines were equipped with hydraulically expandable and contractible heads in order to displace the host pipe into the surrounding soil. They were already called “static pipe bursting machines” at that time. Currently, this term has to be reviewed: These machines actually were “static pipe bursting machines *without* bursting rods”. Since they relied on pipe material, they could only be applied

Fig. 1.6:
“KM Bursting Robot“

Fig. 1.7:
OEMmie Award for QuickLock quick connection bursting rods



in sewage pipes. Among others, these machines were known as “Clearline Expandit”, “KM Pipe Bursting” or “exPress Pipe Bursting”. In the USA, Xpandit was used in Clay pipe, Cast Iron and Concrete by the Miller Pipeline Corp. This pipe expansion method did not gain much acceptance in practice. Due to its operation in sequences, it could not keep up with the efficiency of the dynamic / pneumatic pipe cracking method or the modern static pipe bursting method with quick connect bursting rods. Also, debris from the broken host pipe and trench bedding often fell behind the interlocking segments of the bursting head caused jamming of the bursting tool in the full open position and consequently operational failures.

While the first applications in the UK were limited to cast iron gas pipes, application range (also in other countries) extended very quickly to water and sewage pipes. Already then, polyethylene pipes had been used as replacement host pipes. However, they were often installed into PVC-protection pipes. For the replacement of supply pipes in shallow depths, the bursting systems could be launched and retrieved from small pits. The winch was positioned at the exit pit. The PE-pipes were welded to a pipe string and pulled into the protection pipes after the bursting had been completed.

Sewer lines at greater depths are being increasingly replaced by pipe bursting as soon as the new equipment technology allowed much smaller and less costly pits, or even made pits obsolete. With increasing requirements, the pipe bursting technology made enormous progress. For example, in order to save manholes in sewage networks, a technology combining pneumatics and hydraulics was developed which, adapted to these conditions and thus allowed short pipes to be gradually installed into the damaged pipeline.

Fig. 1.8: Grundoburst 2500G

In the 1990s the pipe bursting technology range was enriched by a modern variation, the static pipe bursting method with bursting rods. In the beginning, the technology was applied with standard round screw threaded bursting rods, e.g. Clearline Maxiburst or TT UK´s Grundoburst TX. Shortly thereafter, TT Group developed a ladder shaped bursting rod with a quick connection which could be connected by a simple click instead of being screwed together. These so-called “QuickLock” bursting rods offer many technical and economic advantages which will be explained in detail in the following chapters.

During the static pipe bursting process with QuickLock rods, a hydraulically driven bursting rig firstly pushes the rods through the existing host pipe. After arriving in the exit pit, bursting tool, expander and new pipe are connected to the QuickLock rods. The bursting process and pipe installation is started by pulling back the rods. Rigs developing a pulling force up to 2500 kN (275 US tons) are available. In 2004, Grundoburst 2500G (pulling force of 2500 kN / 275 US tons for installing pipes up to 1200 mm / 47”) received the Top 100 Award in the USA. This is an annual award for innovative products in the range of construction machines and accessories. It especially honours products from manufacturers who heavily invest in research and development.

Nowadays, pipe bursting is mainly applied from ND 50 (2”) to ND 800 (31”) for gas and water pipes as well as from ND 50 (2”) to ND 1000 (39”) for sewage pipes.

The number of pipelines to be repaired is ever increasing worldwide – e.g. in Germany, important pipeline rehabilitation projects are not carried out due to the devastating financial situation of the municipalities.

As much of the US underground infrastructure has reached the end of its design life, many cities are aware that they have a major problem lurking under their streets. Some of these cities have been compelled to take action. Many others are not doing much until there is no other alternative. Raising revenue for these massive projects can actually be done fairly easily, by small water rate increases. Unfortunately however, these water rate increases become political fodder for local officials who do not want to be seen as the one who raised everybody’s water bill. On the other hand there are some cities that realize their single largest investment is the piping owned by the city. Keeping these pipelines modern and sized properly is a good investment for the future of a forward thinking community.

Although these problems cannot be resolved completely, economical technologies can contribute toward repairing at least the worst damages.

Pipe bursting is such a technology. According to estimates from Advantica, the pipe bursting method has become the most widely applied trenchless pipe replacement method with more than 50,000 km (31,000 Miles) worldwide.

In general, it has to be decided whether repair, renovation or pipe renewal (replacement) is required. A pipe replacement is necessary:

- when repair or renovation is technically or economically inappropriate
- when the hydraulic capacity needs to be improved by an increased pipe diameter
- when repair or renovation offers only a short term solution with a pipe replacement being inevitable
- when there is request for a long lasting pipe durability and or a higher product life span
- when the static loading capacity of the defective pipe would be otherwise negatively affected

Pipe replacement by open trenching involves traffic impairment, noise- and emission pollution when breaking open the surface. Also there is a risk of surrounding underground pipe damage, soil and groundwater intervention and higher storage, transport and soil removal costs. These drawbacks can be almost completely avoided by replacing pipes using trenchless technology.

With the pipe bursting method, the defective or under dimensioned pipe is cracked with a burst head and then displaced into the surrounding soil. This creates space for the new pipe directly proceeding, of same or greater diameter. The pipe bursting technique allows the replacement of defective pipelines in the same path without any substantial influences on soil and groundwater. Open trenching which requires the breaking up and repairing of valuable surfaces is thereby almost entirely eliminated. In addition, this eco-friendly technique helps to cut down costs considerably. However, like any technology, pipe bursting also has its limitations:

- at this time, the application range is limited to circular existing pipes,
- if necessary, the host pipe has to be taken out of service during the bursting process (not necessary e.g. for mains, drainage pipe replacement, etc.),
- the course of the host pipe must be usable for the new pipeline (e.g. inclination). Heavily encrusted pipes must be cleaned so that bursting rods can be pushed through (static bursting) or respectively the winch rope can be pulled in when (dynamic / pneumatic) pipe cracking,
- the soil surrounding the host pipe must be displaceable,
- house connections have to be installed using pits. This, however, guarantees a professional and safe integration,
- sharp bends, flanged joints of steel and ductile iron pipes, etc., depending on selection of bursting tools require intermediate pits,
- pipe slumps (sags) cannot be removed, however, may be reduced,

- a minimum distance has to be kept away from existing parallel or crossing pipes as well as an adequate cover depth.

However, the application of pipe bursting also offers all **advantages** of a modern, trenchless installation method:

- pipe bursting is the installation of **new**, industrially produced pipes, which may be compromised when installed by open cut methods,
- pipe bursting gives a considerable reduction in excavation and road works (almost no traffic disturbance, no annoyance of the public or noise and dust pollution, reduced construction time and the reduction of indirect costs),
- high daily output up to 150 m (490 ft) gives a cost-effective replacement and considerable cost-savings compared to open cut,
- almost any pipe material available for trenchless installation methods can be installed by pipe bursting, e.g. plastic, ductile iron (DIP), steel, fibre glass reinforced plastic (GRP) and even vitrified clay (VCP) and polymer-concrete pipes (PCP). However, new plastic and ductile iron pipes are most commonly installed with pipe bursting,
- pipe bursting allows the replacement of almost any host pipe material (some with limitations),
- pipe bursting can be applied for any kind of pipe damage as long as the bursting rods can be pushed in (static bursting) or the winch rope can be pulled in (dynamic / pneumatic pipe cracking),
- no reduction of pipe diameter, up-size of pipe diameter is possible,
- preparation of the host pipe, like high-pressure cleaning, removal of debris and blockages are not necessary (but may possibly be necessary for other reasons),
- considerably less danger of unintended ground settlement compared to open cut,
- applicable for pipes in sloped areas and areas with trees, shrubbery and the like,
- installing short pipes, bursting is possible from manhole to manhole (manhole diameter min. 1000 mm / 39”),
- pipe bursting can also be used for the replacement of laterals,
- pipe bursting is controlled and described by worldwide standards, norms and regulations.

1.3 Pipe bursting methods

Modern pipe bursting systems are mainly distinguished by the kind of force transmission. Beside that, methods are also distinguished by their type of propulsion.

1.3.1 Dynamic / pneumatic pipe cracking

Dynamic cracking (also referred to as pneumatic pipe cracking) is assisted by a portable hydraulic winch. A dynamic / pneumatic cracking hammer based on a piercing tool / impact mole or horizontal ramming hammer is used to break and displace the host pipe. The bursting tools are arranged at the front or rear end (depending on job) of the bursting hammer and transmit the ramming energy into the host pipe and crack it. The following expander displaces the burst fragments of the host pipe into the surrounding soil and enlarges the void so that a new pipe of the same or larger diameter can be pulled in, simultaneously.

Fig. 1.9:
Dynamic / pneumatic pipe cracking

The procedure starts, however, with pulling the winch rope into the host pipe using a flexible glass fibre rod. The new pipes are joined outside the pit (e.g. butt-fused polyethylene pipe string). After the new pipe is attached to the cracking hammer and the hammer itself is connected to the air compressor, it is pulled against the host pipe by the winch.

The bursting process commences by starting the compressor. The pulling force of the winch assists the forward movement and directional stability of the cracking hammer. When the cracking hammer arrives in the exit pit, it can either be removed there or pulled back through the new pipe into the launch pit in case of lack of exit pit space.

Dynamic / pneumatic pipe cracking machines are available in various size classes and designs for different applications, in the extreme case even host pipes up to ND 1000 (39”). The dynamic / pneumatic impact ramming energy for the replacement of a water pipe ND 100 (4”), for example, causes less soil displacement or vibration than a vibratory compaction plate.

1.3.2 Static pipe bursting

Special QuickLock, ladder-shape bursting rods support the bursting, displacing and pipe pulling procedure of the static or also called hydraulic pipe bursting.

At first, a hydraulically driven bursting rig is positioned inside the exit pit. A flexible guide rod ensures smooth installation of the bursting rods through the host pipe. The bursting rods are quickly connected by clicking them together. QuickLock bursting rods are easily and securely linked together, not screwed together like traditional drill rods or other conventional static systems. The QuickLock system speeds the installation process as well as the connection procedure. The rods can be quickly added one at a time at the exit pit as the rods are pushed up the old host pipe. Once at the launch pit, the guide rod is replaced by a bursting tool (e.g. bladed bursting head, roller blade cutters), expander and new pipe.

The entire configuration is then pulled back by the hydraulic bursting rig through the host pipe towards the exit pit. While pulling back the bursting rods into the direction of

Fig. 1.10:
Static Pipe Bursting

the exit pit, the bursting tool fragments the host pipe. The expander following the bursting tool displaces the fragmented host pipe radially into the surrounding soil so that a new pipe of the same or larger diameter can be pulled in, simultaneously.

To save manholes or in case there is lack of space on the surface when bursting sewage pipes, it is possible to use special mini-bursting rigs that even fit into manholes of 1000 mm (39”) diameter or larger. If, in addition, short-pipes are used, launch and exit pits are completely unnecessary. Laterals, however, have to be re-connected with minimal digging methods e.g. Suction Excavation.

1.3.3 Calibre pipe bursting

Caliber pipe bursting is an alternative to cured-in-place or lining methods when the hydraulic capacity of the host pipe allows this small reduction in the replacement pipe diameter. Bursting of the host pipe only occurs (dynamically or statically) where individual, localised damages exist. This method is applied, for example, when damages like local deformations, cracks or partial collapses occur, whereas the remaining part of the pipeline shows no or only minimal damages. Moreover, the host pipe should have sufficient hydraulic capacity, that a reduction of diameter by installing a new, slightly smaller pipe can be accepted from the hydraulic point of view.

Progress of work is much better, because the cracking hammer / bursting tool is only activated at the actual damaged pipe areas, while the new pipe is installed into the remaining section like in a lining process.

Fig. 1.11: PE-pipe installed with caliber bursting

Restrictions of calibre pipe bursting:

- application range limited to circular pipes larger than ND 150 / 6” (short-pipe larger than ND 200 / 8”),
- using short-pipes requires a relatively straight and level host pipe length,
- using long pipes requires an installation and machine pit for setting up and removing the bursting rig as well as for the installation of the new pipe (size dependent on bending radius of new pipe),
- Pipe slumps (sags) cannot be removed but may be reduced,
- in case partial or total collapse pushing-in of bursting rods respectively pulling-in of winch cable is critical.

Caliber pipe bursting also offers many advantages:

- total restoration of structural load capacity,
- minimal reduction of diameter in case appropriate pipe materials with special sizes are chosen,
- applicable for damages like deformations, cracks, fractures, breakages, partial collapses, total collapses, slab-outs, etc.,
- new pipe with improved hydraulic capacity and reshaping the circular pipe profile in case of deformations and collapses,
- when operating from manhole to manhole respectively pit to manhole reduction of excavation works is kept to a minimum,
- trenchless installation of house connections possible,
- short set-up times reduce construction and labour costs.

1.3.4 Method variants

In addition to the two classic methods dynamic / pneumatic and static pipe bursting as well as caliber pipe bursting, further variations have been developed over the years. Some of these will be introduced in chapter 8.

References

[1.1] Hoeper, G, Jonas, K.: Rohrnetzsanierung in Essen, Germany 3R International Edition January / February 1986