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OVERVIEW

This section is dedicated to the techniques and systems needed prior to the commencement of trenchless applications and operations. As with all buried service operations, even open cut, knowing what circumstances you are going to meet once in the ground is as important as knowing what you are ultimately going to be putting in the ground. This is not however about techniques for assessing the condition of existing services with a view to renovation or replacement. This section is about techniques that will assist the implementation of the techniques already chosen for the job. Topics such as site investigation for tracing and mapping the precise location of an existing service, the position of which is believed to be known from utility drawings or surface indicators; Pre- and Post-operation CCTV survey to establish lateral positions, obstacles and the current state of a service and the final as built survey of any rehabilitation system installed; Service cleaning techniques which ensure the ‘host’ service is fit for renovation, empty of debris and will not inflict damage on the renovation system or materials; and Bypass systems for the over-pumping of flows in situations where repair operations cannot interrupt the main line flows for any significant time. There will also be a section on some of the Safety aspects of operations

As with most construction techniques preparation is as much a part of the success of a project as is the final installation because in many cases one cannot be achieved without the other.

SITE SURVEY

It is quite simple; you cannot mend or replace what you cannot find. One of the most common complaints across the industry and across the globe at the moment and over the past several years is that utility plans, for whichever service you can name, are simply not up to date. They may be close, they may not be, but until an accurate map of existing services is available to a contractor or utility installation or repair team there is always the danger of damage to or loss of services or even worse personnel.

The starting point for any site survey has to be the existing plans from all buried utility operating companies. These will show expected manhole/access positions that can be confirmed or modified by viewing on the ground. These can then be used as starting points for a more detailed confirmation of services corridors prior to the start of the main works.

Trial Holes

One of the most common methods of buried service confirmation is the trial hole or pothole. This method comprises the sinking of a small inspection hole over the top of what is believed to be an existing service position in the hope that the trial hole will intersect the service sought. If it does the information just at that point is correct. If it does not the information is incorrect. A series of these holes will spot check the currently plotted route of the service if it lies on the path indicated on current plans. This is all very well if the majority of the potholes find their target. If they do not another avenue has to be used. The disadvantage to this technique is that is it only ‘spot’ checks the service route with intervening positions being guessed as correct if the trial holes intersect a target. It also requires that the operator inflict damage to the existing ground surface which would have to be repaired and in many cases could cause disruption to traffic, businesses and residences in most built-up areas.

Whereas for many years the only way to trial hole was to excavate with a shovel or backhoe, recent developments have seen the introduction of vacuum excavation systems, which use a combination of a high pressure water jet or air stream to cut the ground. The spoil produced is then vacuumed away from the excavation point by a suction tube into a collection tank for later disposal or treatment and replacement as backfill into the test hole.

The advantages of these new systems is that they can excavate very quickly, make precisely sized holes and can intersect the buried services sought without fear of external damage to the service, unlike the older backhoe and shovel techniques which have often broken services lines, cut power or opened sewers.

Vacuum Excavation techniques assist in trial holing for utility tracing with minimum disruption to the ground surface and the continuation of everyday life. (Picture courtesy of U Mole Ltd.)

Using an EM system to trace buried services. Picture courtesy of Radiodetection Ltd.

Tracing and Mapping

There are a variety of Tracing and Mapping techniques and systems available that enable the survey of buried plant without excavation. These systems, in the main, comprise the use of electromagnetic-based equipment to locate a buried service remotely.

The main Electromagnetic or EM systems utilise walk-over systems that trace either the natural signal generated in a power carrying cable laying in the Earth’s magnetic field or in the case of non-power carrying plant, e.g. metal pipes, the use of a signal generator which pushes a traceable signal through the pipe material. A multi-frequency antenna system is use by an operator on surface to pinpoint the peak signal generated by the service, which is taken as lying directly above the service in question. Many systems also offer the facility to use the signal to indicate the service depth below surface.

Where non-metallic pipes need to be traced and mapped, two systems are available that can be used. In the first a transmitter sonde can be pushed on a rod through the pipe from a known starting point, provided access can be obtained without interrupting the service. The signal from this can then be traced using the tracing antenna as above.

Ground Probing radar

If EM Tracing cannot be achieved the second option is the use of Ground Probing Radar (GPR). This technique utilises a signal generating antenna which pulses radio waves into the ground, much as aircraft radar plotting systems do in the air. The reflected signal is picked up by the same antenna system and highly sophisticated computer software plots out the response signal, which can then be interpreted by experienced surveyors into a useful plot of buried services.

A single channel Ground Probing Radar unit. Picture courtesy of Pipehawk Ltd.

Early systems required a lot of expertise and relied heavily on individual interpretation of results. Over the past few years however, advances in software have meant that much of the interpretation is now completed by the machine and its on-board computer.

GPR systems come in a variety of forms from small single channel units to multi-channel ones that claim to be able to give a much higher degree of resolution to the survey. Depending on the circumstances in which they are to be used, each has its advantages and disadvantages. One of the main advantages of any GPR system is the ability to locate and map non-metallic, non-conducting materials such as plastic pipes and concrete or clay ware sewers. As with EM systems, the use of GPR also enables the depth of the utility below surface to be determined, so it position is known in 3 dimensions, not just in plan position.

The different GPR systems have different approaches to data interpretation from onsite, immediately displayed results to data storage with office-based interpretation and results plotting over a number of days.

Each system relies on software set up that gathers, stores and process the data in order to generate the required results. One of the latest developments in this area of work has been the ability to plot results directly on to GIS survey systems or utility maps if required.

INVESTIGATION

Depending on the circumstances of any particular project there is normally a requirement to undertake a pre-project inspection of the work site to ensure that the technique to be used will not be adversely effected by prevailing conditions. In man-entry sized pipelines this can be done by simple walk through or crawl through inspection. In non-man-entry sizes this needs to be done in the main using CCTV cameras.

Although CCTV and internal pipeline inspection is most often thought of as an asset management tool in terms of assessing the state of a pipeline with a view to future work on it, it is also used as a contracting tool in association with many renovation technologies. In these terms it has a role to play in ascertaining pipe condition to ensure that pipelines are clean, free from obstructions which may have occurred since the assessment survey was completed or which have existed as part of the pipe line function for some time (for example intruding laterals, root intrusions, out of line brick work etc) which have to be removed in order to effect a complete renovation, and to establish the position and size of lateral connections that, in most cases, have to be reconnected to the main pipeline after the completion of a renovation operation.

This type of survey will supply the renovation contractor with enough information to establish the level of pre-renovation cleaning required, the number of obstructions, if any, that will need removing prior to the main renovation works and the number and therefore time element/equipment required in reopening laterals.

In many cases, CCTV now has a Post-works role to play as well as increasing numbers of clients demand a post installation survey to show the final product in the ground as part of the 'as built' report to the client. This is advantageous to both client and contractor in that should a claim arise due to failure or underperformance of a renovated system, the condition of the pipeline immediately post renovation can be seen and so where necessary any 'fault' can be established.

CLEANING

Pipeline cleaning is probably one of the most important areas of a renovation project. It may even be classed as a renovation technique in itself provided that the pipe being cleaned is basically in good working order apart from the need for cleaning.

However, as most renovation systems rely on there being some form of bond between the deteriorated host pipe and the new lining/repair, whether through grout injection into an annulus or the use of a close fit lining or for access of robots designed to make localised repairs cleaning is often the first step in the works process. If a pipe is not sufficiently clean before work starts there is an increased possibility that the lining/repair technique will fail sooner than its design lifespan allows for. There are several techniques that allow cleaning to be done correctly, in man-entry size pipes this of course starts with manual cleaning using pressure hoses and scrubbing brushes. This also allows larger obstacles to be removed prior to any renovation work starting. Where man-entry is not possible or not desirable other cleaning methods must be employed.

Jetting/Flushing

Jetting/Flushing is a commonly used technique. The technique employs high-pressure water, which is passed through a specially designed jetting head attached to a pressure hose fed from a surface pump, to be passed through a pipe at any speed desired. The pressure head is designed so that the water sprays out of it to hit the inner wall of the pipeline dislodging any material stuck to it, so cleaning the pipe. The debris created by this water is then pushed back through the pipe either by the pressure water as the head is pulled through the pipe or by the flushing action of the used water as it flows out of the pipe. In some cases the pressure of the water in the jets can be sufficient to cut through some root intrusions.

Where roots are a particular problem and standard jetting equipment is unable to remove the root mass there are specially designed remote controlled robots available that use very high pressure, low volume water jets or rotating cutter blades for the cutting process.

Scraping

Where pipes are much scaled or suffer from tuberculation, as is the case with many water mains, a technique of a more aggressive nature is sometimes required. Scraping is such a technique.

There are various forms of this technology but generally the operation relies on a pipeline being open sufficiently to pass a winch wire through it. Once in place a scraper head, normally a circular rubber or metal device, in the form of a wire brush or metal sheet or rubber shape that may or may not have some form of serration on the cutting edge, is attached to the wire and pulled through the pipe. The scraper

A selection scraper devices for pipeline cleaning. Picture courtesy of Pipe Equipment Ltd.

dislodges any build-up of material and, as it normally designed to the internal diameter of the pipe, it pulls the debris to end of the pipeline into the winching access pit.
Another form of scraping is where a flail in attached to a rotating push rod, which is again pulled through the pipe. The flail dislodges any unwanted material and it falls into the invert of the pipe. Jetting or flushing may then be used to remove the debris.
A major disadvantage of scraping as a cleaning technique is that it can cause severe damage to the pipe under renovation. It has, at times, been known to cause so much damage that the renovation technique employed has had to be changed because the original choice becomes unsuitable for the new problems created.

Pigging
Where the main cleaning work has been successful, sometimes a pipe requires a final inner wall surface clean. To achieve this a pipe 'pig' can be employed. A pig is often a foam or plastic cylindrical plug that fit tightly, but not too tightly, in the internal diameter of a pipeline. The pig is pushed through the pipe, using compressed air or water pressure; to remove any remain fine silts or particles that may interfere with a renovation process.
On some pipeline 'pigging' can be used as the main cleaning technique and is regularly used in the cleaning of plastic pipelines.
Pigs used for the main cleaning action can have smooth outer skins or can be manufactured with a variety of external designs for removing debris from the pipe wall and transporting it out of the pipe.

A selection of foam pigs. Picture courtesy of Pipeline Pigging Products Inc.

MAINTAINING SERVICE AVAILABILITY
In many circumstances, even with the use of Trenchless Technology, there is a requirement to take sections of a service offline during the course of the replacement or rehabilitation work.
In the case of sewers this often means that, unless the storage capacity upstream of the worksite is sufficient, a flow Bypass/over pumping system has to be established to ensure continuing sewer services to customers.
In terms of water or gas supply, unless the work downtime is very short, there would be need to establish a temporary supply service to customers.
Power and telecommunications cables are not generally affected by this type of interruption. It is normal to install a new cable before the supply switch occurs, a move that is normally planned to be of short duration.
In both the sewer bypass and the temporary service supply scenarios, the requirement and the cost of providing temporary services may have a significant impact on the selection of the replacement or renovation technique that will be used, in that shorter run techniques that may at first glance appear less cost effective but it may the long run be more so due solely to the cost of providing a long term service bypass or temporary supply. The cost of such a service provision must be taken fully into account when costing a project at the earliest opportunity in the planning/costing cycle.

Sewer Bypass
Sewer Bypass/over pumping systems are generally required where the work is likely to take longer than the storage capacity of the pipeline remaining in service can handle. More often than not the bypass set up for any particular job works on the adage that the bigger the sewer, the bigger the operation and therefore the bigger the likely need for over pumping.

Flow monitoring undertaken during the investigation and analysis of a pipeline will indicate the levels of flow likely to be encountered and therefore the level of over pumping capacity required. If this information was not obtained at the during the condition assessment of the pipeline it will need to be established accurately before any system can be adequately designed.

The general layout of a bypass system requires the section to be renovated/replaced to be isolated from the remainder of the system, which will continue to operate normally. This would be achieved with adequate sealing techniques or stoppers in the pipelines at either side of the work site, probably at least one manhole further upstream and downstream of the work site.

A typical large-capacity bypass pumping system working from an existing manhole. Picture courtesy of Hampton Roads Sanitation District, Virginia, USA.

An adequate pumping system is then installed at the final operating manhole on the upstream side of the site to raise the flows out of the manhole and pass them to the first available operating manhole on the downstream side of the work site via the bypass pipeline.

Adequate supervision and maintenance, fuel/power supplies, noise regulation, site access, traffic control and disruption to the local area of such a pumping system are all aspects of the temporary system that are vital to control correctly during the operation as it is likely to have to work 24 hours per day for as long as the work site is open. Positioning the pumping system and its pipelines correctly will not only make life easier for the contractor but also reduce the likelihood of complaints for local residences and businesses.

Where expected flows are relatively small the bypass pipe may be able to be placed in the open across the work site with some form of protection shield to prevent damage/leakage. If the system is to operate for a significant length of time or where the over pumping main crosses working highways there may be a need to find a way/route along which it could run to ensure continued uninterrupted operation.

If the sewer under renovation or replacement has significant inflow into it under the normal course of operation which is outside of the storage capacity of the lateral connections, bypass arrangements for these lateral connections may also have to be put into place during the course of the main works. This may involve one or more smaller pumping systems taking flows from laterals and feeding to a downstream manhole.

Maintenance of Service Supply

Where supply main replacement or renovation is being undertaken there is often a need to establish a temporary supply, which may cover either water or gas supplies, in order to keep the customers effected by the works 'on line'.

With temporary supply pipelines, more often than not a connection is made at a convenient position either side of the work site. As the service is normally pressurised, connection to a surface laid temporary pipe that is directly connected to the customer's service pipe will allow continued supplies to be maintained. The main disadvantage to this of course is that the service pipes have to be exposed to allow this connection to be made and unmade at the beginning and at the end of the main work programme. The temporary supply pipe is also often found running along surface in the street. Covers prevent damage and therefore the potential for leakage but often this also makes for poor pavement surfaces, which can limit access to many, particularly the less able. Therefore routing of these services has to be carefully planned and executed.

SITE SAFETY AND ACCESS

General site safety is always a concern to buried service operators and the specifics of site safety arrangements guidelines and regulations differ from country to country and so are far too numerous to cover in detail here. Although it should be stressed that safety is of the utmost importance wherever you may be in the world and that local regulations should be adhered to stringently for the safety of all.

One of the main arguments for the use of trenchless technology for the past 30 years has been its ability to reduce disruption to local communities and businesses. More often than not this has been achieved in one of two ways. First the work sites tend to be there for less time so reducing the impact of the works in terms of time and second the technologies tend to utilise much smaller footprints in terms of operating space. This latter 'advantage' does carry with it some provisos however.

Confined space access requires the correct equipment and training. Picture courtesy of CAS Ltd,

With generally smaller openings and accesses trenchless technologies do offer a smaller 'vision' target so it is very important that signing and fencing are of a high standard, wherever they may be. This in turn leads to the argument that positioning of access pits, shafts, working areas must be taken into account in laying out a project, not just in terms of public and workforce safety but also in terms of vehicle access since most trenchless systems require significant vehicular access, for everything from continual delivery and removal equipment (pipe delivery to a micro tunnel for example where storage space in minimal) to through active participation of equipment in the trenchless process (boilers for water-based CIPP lining for example) to the limitations these access will place on others such as business residential access (if placed close to industrial site gates etc).

As well as positioning, the access to the shafts/pits etc should be made as difficult as possible out of working hours, and even during working hours where open pits may be left for some time unattended, with not only sufficient fencing but also top covers where necessary. Signing and lighting may also be required.

As well as preventing access to unauthorised personnel there is a general requirement for safe working practice according to national regulations, which should be rigorously adhered to. In specific circumstances with certain trenchless technologies where chemical or other hazardous potential exists, personnel should be issued with the relevant safety clothing and equipment and the training necessary to use this equipment correctly.

Where man-entry is required into confined spaces, the relevant nationally recognised Training should have been completed by all necessary personnel and Certification achieved as required. This should include not only the use of access equipment but also site ventilation, breathing apparatus, communications and monitoring systems, such as gas detectors, and rescue systems where necessary.

SUMMARY

1. Site survey and investigation pre- and post trenchless operation is as important in many instances as the work itself.
2. Various techniques are available to achieve a successful site investigation for most given circumstances including Trial Holes, CCTV and GPR.

3. Cleaning can also be as important a part of the operation as the trenchless process itself, with a variety of tools to aid the contractor being available.
4. Maintenance of services around the work programme can play a significant role in the success of a project not least by way of maintaining public support. Bypass and temporary service installations should be planned in advance and positioned with a view to least disruption to everyday traffic and life
5. Safety is paramount in all situations not just for the protection of the workforce but also the general public which will come into contact with projects operating in their locality.
6. Access should be designed to limit the possibility of public entry whilst maintaining the facility to get equipment and materials in and out with the minimum of disruption.

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