TITLE: CIPP, CFL and Pipe Bursting, When to use this Technologies? Annotations based in Experience.

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1. ABSTRACT

The boom of Trenchless Technologies is imminent and the use or application of these technologies in our cities today, more than an alternative is a necessity. Cities with fast growth, densely populated spaces, roads and mobility increasingly affected by the number of people that are concentrated in the same place, means that the maintenance, replacement and installation methods of services cannot be realized through the traditional methods, excavation and replacement. Trenchless Technologies are the result of minimizing the effect to the populations, the mobility, the trade and clearly the environment. This paper is intended to demonstrate the benefits of trenchless technologies in the environmental and social areas is better defined to identify in which cases one or another technology is better applicable to a certain type of condition Based on experience, it is possible to construct a matrix that indicates the best option when planning the use of TTs.

2. INTRODUCTION

One of the key issues when selecting a Trenchless Technology (TT) projects lies in the selection of which technology applies in each project, which to use, when it is feasible to apply a specific or another technology and what are the restrictions. There are projects for services that are contemplated for the first time, due to population growth and densification of an area and for which it is necessary to install new pipes, of considerable larger diameters and lengths that would take a long time to construct using traditional trenching methods. Likewise, there are projects in areas with the same need, which have existing pipelines installed services, but are already close to reaching their useful life to improve the flow conditions, of these pipelines without being removed and replaced there are trenchless replacement and rehabilitation possibilities. These technologies include CIPP (Cured in Place Pipe), CFL (Close Fit Lining), Slip lining or LFL (Loose Fit Lining), Pipe Bursting, Pipe Eating, Tight Fit Lining, Spray lining, as an example. Based on the experience of the authors a set of basic principles, will be discussed, to establish in which case a TT can be used for rehabilitation or replacement and which will be the most suitable, focusing primarily on CIPP, CFL and Pipe Bursting. While other re-renewal or rehabilitation technologies are available in the market, the authors' focus is on the most installed technologies for that purpose and in turn are usually the most popular.

Based on experience, the authors have determined a series of requirements, advantages and limitations for each of the chosen technologies and based on this information, developed a matrix of choice. This matrix contains data on the site to be developed, the type of material to be renovated or rehabilitated, the length and depth of the host pipe, the space available and required for the location of equipment, changes in direction and diameter lateral pipes, among others. All these are factors as a minimum will affect the engineer's decision making and the applicability of one of these technologies.

With good technology capabilities and other information the engineer can better determine what project requirements must be taken into account when proposing or choosing a TT for replacement or rehabilitation of pipes. What are the advantages of each of the technologies and what are the limitations. . Decision making for trenchless technology projects is an area that requires knowledge of the project goals, the existing pipeline material and the existing conditions in the field. Planning the project with existing condition information is a first step for selecting the best technology and its probable solutions.

3. INDEX

- Trenchless Technologies Classification.
- TTs and its general framework.
- Basic criteria to choose a TTs to renew or rehab pipes.
- TTs Selection Matrix

4. CONTENT

Trenchless Technologies Classification.

The trenchless technologies can be classified into three (3) major groups, those that are for Installation of new pipelines, TTs for Pipeline Replacement and TTs for Rehabilitation.

New pipelines includes Microtunneling Pipe Jacking (MPJ), Horizontal Directional Drilling (HDD), Auger Boring, Pipe Ramming, Mole or Tunnel Liner.

Replacement are the Pipe Bursting, sub divided in Cracking, Splitting and Eating and Reaming. This document summarizes the basic features for Pipe Bursting - Cracking / Splitting.

Rehabilitation includes technologies such as CIPP, CFL, LFL or Slip Lining, Tight Fit Lining and coatings with epoxies or polyurethanes and Spiral Winding. For this case, the most relevant aspects for CIPP and CFL technologies will be explained.

Figure 1 illustrates the different pipeline installation alternatives:

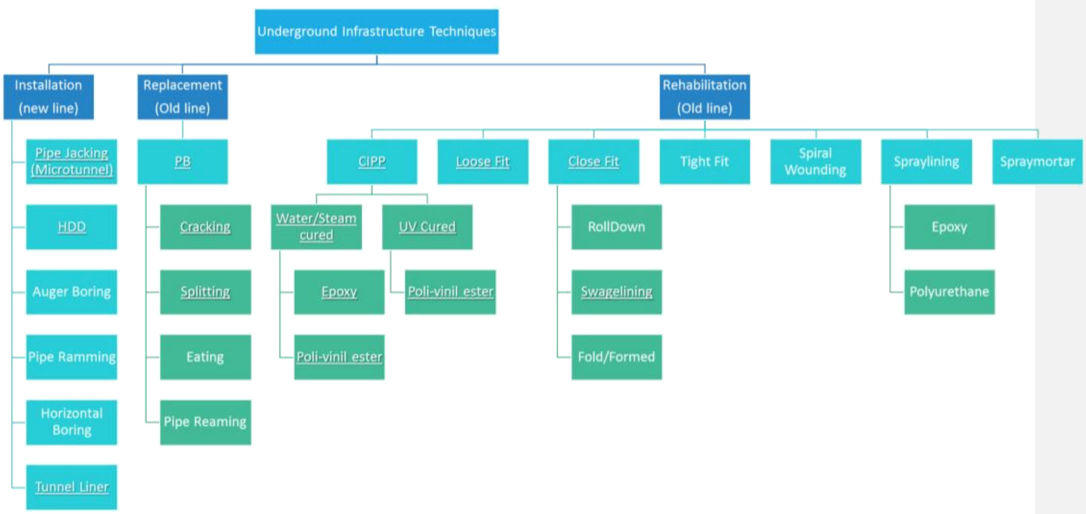

Figure 11. TTs Classification Flowchart

TTs and its general framework.

Pipe Bursting: Taking advantage of the existing route of an existing pipeline that is close to reaching or has reached its useful life and capacity, a technology is selected that can "burst" the existing pipeline and at the same time leave the broken debris in the surrounding soil. Behind the upsizing tool is the pipe that will replace the existing one. It can be used to increase the size of the existing pipeline.

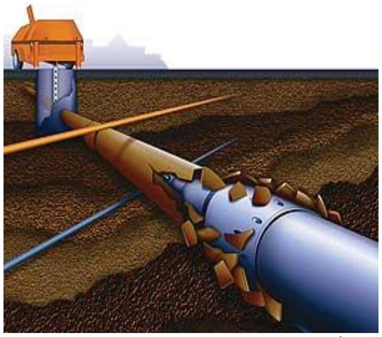

Figure 2. Pipe Bursting - How it works[1]

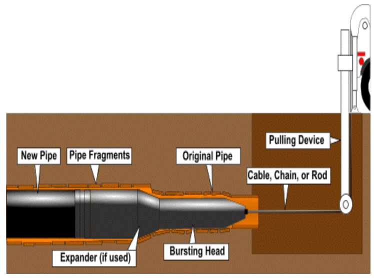

Figure ~~3~~ 2a.- Static Pipe Bursting[2]

Pipe Eating: When an existing pipeline requires to be made larger, but the pipes' surrounding soil cannot be compressed to accommodate the pipe bursting technique then the existing pipe material must be removed and not compressed into the surrounding soil. Following a similar principles as that of Pipe Bursting, an special tool is installed that breaks up and removes the broken remains of the existing pipe. The material is removed by means of a vacuum hose placed just behind the cutting head

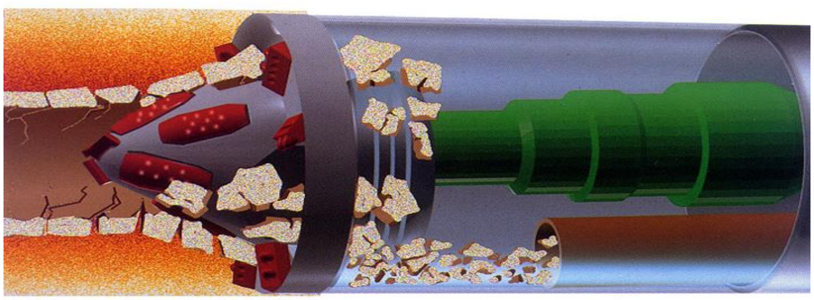

Figure 3. Pipe Eating Close Up[2]

Pipe Reaming – Pipe reaming is similar to pipe eating however, using directional drilling equipment, the old pipeline and the surrounding soil are cut away and the materials form a slurry that is removed from the installation at the downstream end of the pipe, using a vacuum hose. A new pipe is installed immediately behind the reaming operation.

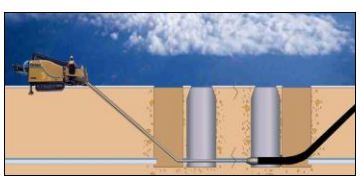

Figure 4. Pipe Reaming

Figure 5 - Typical Reaming Head

[1] http://www.ipbaonline.org/?page_id=99

[2] http://www.unitracc.com/know-how/fachbuecher/rehabilitation-and-maintenance-of-drains-and-sewers/rehabilitation/replacement-en/replacement-by-the-trenchless-method-en/unmanned-techniques-en/pipe-eating-en

CIPP – Cured in Place Pipe: Rehabilitation pipes technique by means of the polymerization of impregnated liquid resin materials in a fabric sleeve that fits the host pipe, shape and form and is subsequently inflated and cured to a harden condition. Applies for cases where the existing pipe is partially damaged but not collapsed. The new CIPP generally uses the host pipe as a mold and will result in a shape identical to the existing pipeline of its condition when being rehabilitated. CIPP can be installed by inversion using either air or water or pulled into place and then expanded using air or water. The liquid resin material can be cured using hot water, steam or Ultra-Violet light. The strength of the new CIPP can be calculated as the resin material in the case of felt material liners and the resin and fiberglass material in the case of fiberglass liners.

Figure 6. Liner Being Installed

Figure 7.- Liner Being Cured with U.V Lights

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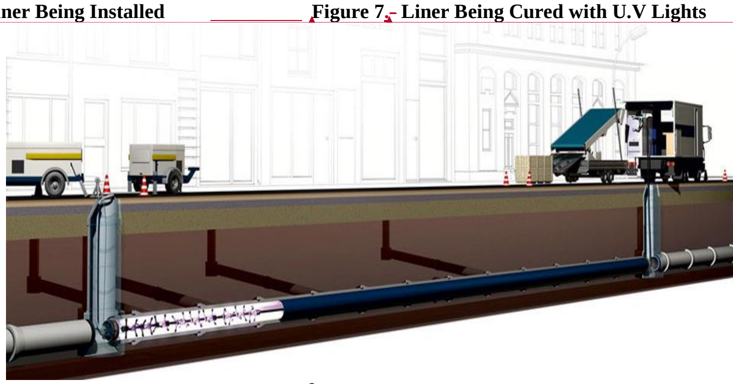

Figure 8. CIPP General Description[3]

Con formato: Sangría: Izquierda: 1,75 cm

CFL – Close Fit Lining: Lining existing pipelines by means of deformed PVC and High Density Polyethylene piping either at the time of production or at the time of launch. CFL liners are typically manufactured in a factory under strict quality control requirements, are then shipped to the project site, installed and then processed, using heat and pressure, to fit tight within the existing pipeline.

[3] http://i-group.uk.com/services-overview/envirocipp-services/

Figure 9. Different Types of Lining[4]

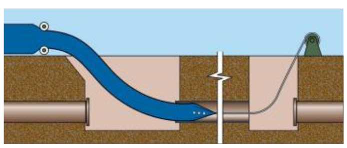

Figure 10. Folded Pipe **Figure 11.— Swagelining** **Figure 12.— Rolldown**

Loose Fit or Sliplining: It was one of the first trenchless technologies, arising in the oil, gas industry and water and sewer, to install pipelines with sizes that are considerably smaller than the internal diameter of existing pipelines, , which are pulled inside the host pipe by means of pulling equipment. This technology can be installed with some existing flow conditions and laterals, (side pipe connections) must be excavated and reconnected to the new smaller pipe.

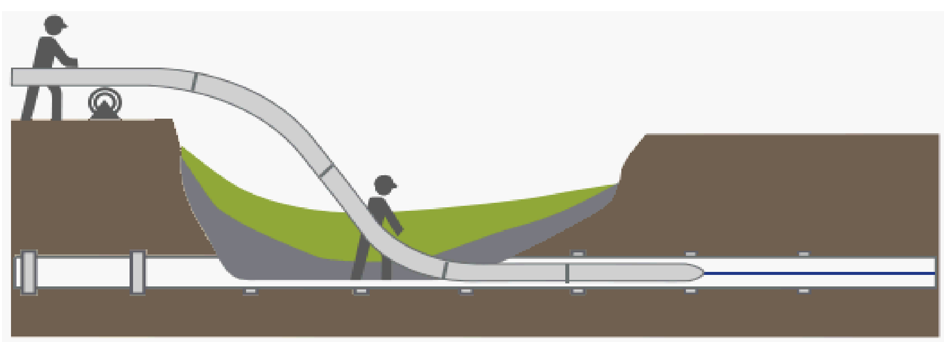

Figure 13. Slip lining General Scheme[5]

[4] http://www.sinzatec.es/

[5] http://infra-sa.pl/de/dienstleistungen/renovation/continuous-pipe-sliplining.html

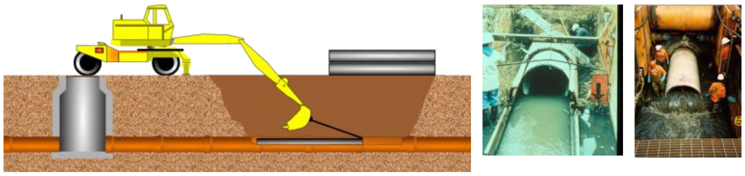

Figure 14. – Segmental pipe sections are installed with the existing flow in the existing pipe

Tight Fit: The development of new materials allow day to day adaptation techniques to improve the technologies without a trench, the Tight Fit Lining is an example. Following the similar requirements as the Close Fit - Fold and Formed Lining, a hose made of Kevlar, Fiberglass and HDPE layers is pulled into a host pipeline and then inflated by means of pressurized air and cured so that the liner fits tightly inside the existing pipe. The product has limited capacity for external static loading and therefore this technique is ideal for systems that work at high pressure.

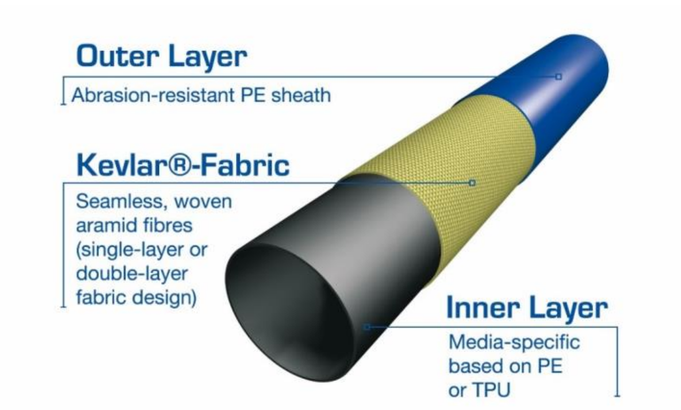

Figure 15. Tight Fit Hose Configuration[6]

Spiral Winding: The liner is installed in situ in the existing pipe through a manhole or insertion pit. Profiles made of PVC, PVC reinforced with steel or HDPE placed on reels on the ground are fed to a winding machine. The winding machine rotates by causing the edges of the profiled strips to interlace into an airtight coating. The rotating action advances the coating through the host pipe.

[6] http://ukstt.org.uk/82-news/912-primus-line-rehabilitation-of-water-mains-using-the-kevlar-reinforced-primus-line-system

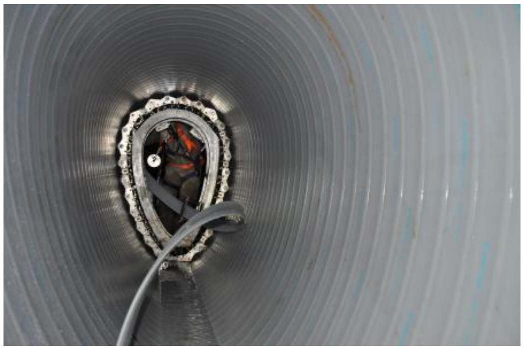

Figure 16. Spiral Winding

Spray Lining -The host pipe is cleaned to remove any accumulated debris and contaminates. The host tube is inspected to confirm that it is clean and suitable for the coating. The spray head is positioned from the launch pit opposite the spray equipment in a controlled manner to ensure a consistent thickness of the coating. The software and hardware systems monitor and control the installation process with measured parameters.

Figure 17. Spray Lining Before and After[7]

Basic criteria to choose a TTs to replace or rehab pipes.

The use of TTs must take into account the technical, logistical, social and environmental conditions of the proposed project and should be evaluated. Trenchless technologies offer a very cost effective approach for extending the service life of an existing pipeline. One technology however does not fit all project requirements
The first approach to these basic criteria for CIPP, CFL and Pipe Bursting technologies can be seen below:

[7] http://www.mswmag.com/editorial/2014/04/manhole_equipment_and_rehabilitation

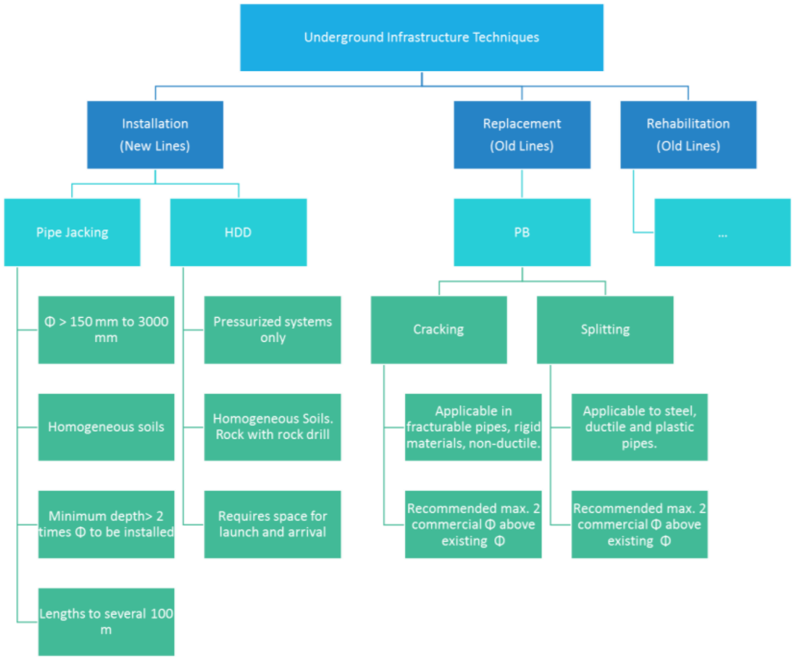

Figure 18. Basic Criteria for TTs

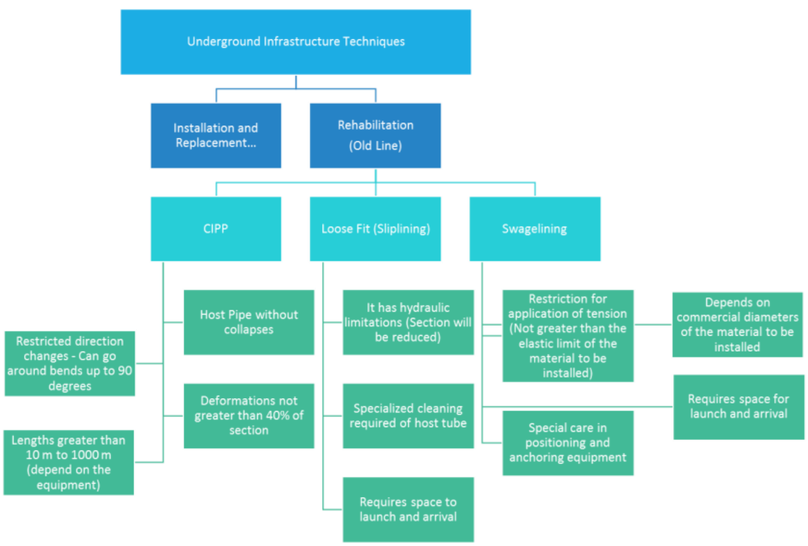

Figure 19. TTs Basic Criteria

TTs Selection Matrix

Once the basic criteria for each TTs have been determined, it is necessary to determine which technology best suits the installation condition. Does the host pipe need to be replaced or can it be rehabilitated. The physical condition of the surface, the space available, the type of soil, the size of the pipe to be replaced or rehabilitated, are just some of the variables to be taken into account to determine the use of TTs and which one applies best for each particular case.

The construction of this matrix was based on the analysis of each of the variables that affect the execution of the TTs, specifically in terms of space, physical and logistic characteristics and existing condition of the pipe to be replaced or rehabilitated. It is also important to keep in mind the limitations of each technology and this is where the field installation experience and knowledge of the technology's capabilities, plays an important role.

A general matrix is shown in Figure 20

TECNOLOGY	TIPE OF PROJECT Replace or Rehabilitate	DIAM. (mm)	DEPTH (m)	SOIL	SECTION LENGTH. (m)	INTERMEDIATE SHAFTS	SPACE FOR SHAFTS	SPACE FOR DITCH	SPACE FOR EQUIPMENT	DIRECTION CHANGES	HYDRAULIC RESTRICTION (Section Reduction)	LIMITATIONS
ALL	Replace or Rehabilitate	50 to 3000	to 25.0+	GW-GP-GM-GC-SW-SC-ML-CL-OL-MH-CH-OH-Pt-R	to 1000	Require or Not	Available or Not	Available or Not	Available or Not	There are not, less than 30°, between 30° and 60° and greater than 60° up to 90°	Can or cannot reduce the existing diameter.	INSUFFICIENT SURFACE SPACE; TRENCH LENGH GREATER THAN 5 m; CHANGE OF DIAMETER; NEED FOR DIAMETER INCREASE IN MORE THAN 2 NOMINAL DIAMETERS; NO EXISTING DIAMETER CAN BE REDUCED; CHANGES OF EXISTING MATERIAL; PARTIAL COLLAPSE; TOTAL COLLAPSE; INCRUSTATIONS AND DEPOSITS THAT CAN NOT BE REMOVED; CHANGE OF TYPE OF SOIL ; VERY LONG LENGTHS THAT DO NOT ALLOW FOR INTERMEDIATE SHAFTS
CIPP	Rehabilitate	50 to 3000	to 8.0	N/A	to 1000	N/A	N/A	N/A	Yes	No greater tan 90°	Yes, depend on the Hydraulic Model, Hydraulic restriction limited due to lower friction factors for CIPP lined pipe.	TOTAL COLLAPSE; MINOR DIAMETER REDUCTION
CFL	Rehabilitate	200 to 1600	0.4 to 2.0	N/A	20 to 1000	Not to lengths of 200 m, for lengths greater than 200 m intermediate stations are recommended.	N/A	Installation trench may be required	Yes	>30°	Yes, depend on the Hydraulic Model, Hydraulic restriction limited due to lower friction factors for CFL lined pipe.	INSUFFICIENT SURFACE SPACE; NICHES of more than 5 m LONG; CHANGES IN DIAMETER; EXISTING DIAMETER CANNOT BE REDUCED; TOTAL COLLAPSE; INCRUSTATIONS AND DEPOSITS THAT CAN NOT BE REMOVED
Pipe Bursting	Replace	200 to 850	to 5.0	Soil Information Required	10 to 100	N/A	N/A	Yes, the greater the depth of the network, the greater should be the length of the pit to achieve pipe insertion curvature	No	>30°	No	PIT OF LENGTH GREATER TO 5 m; CHANGE OF DIAMETER; NEED FOR DIAMETER INCREASE IN MORE THAN 2 NOMINAL DIAMETERS; CHANGES OF EXISTING MATERIAL; TOTAL COLLAPSE; the depth depends on the diameter, the greater diameter, the greater depth required to not affect the surface.

Figure 20. Technology Matrix

Con formato: Fuente: Negrita