INTERNATIONAL SOCIETY FOR TRENCHLESS TECHNOLOGY	**TRENCHLESS TECHNOLOGIES INFORMATION CENTRE**	
	TRENCHLESS TECHNOLOGY GUIDELINES	SECOND EDITION
	INSITU APPLIED COATINGS	NEW VERSION AUGUST 2005

1. OVERVIEW

This Section covers spray lining systems for small diameter (non-man-entry) pressure pipelines. Spray lining techniques for man-entry pipes and chambers are covered elsewhere. The technologies involve the application of a thin cementitious or Thermoset resin coating, either epoxy or Polyurethane (PU), to the inner surface of metallic or asbestos cement pipelines. The function of the coating is to separate the flow stream from the pipe wall and hence eliminate or significantly reduce corrosion and/or flow stream contamination. The cement-based systems create a highly alkaline environment at the coating/pipe interface which passivates the pipe wall and inhibits corrosion. The polymer-based systems create a thin, impermeable protection barrier.

When used on installed pipelines all of these technologies depend on thorough cleaning to restore the original bore by removing accumulated corrosion products (Tuberculation). This also creates a surface to which the lining material can bond, a key factor in the future performance of the lining.

All three systems are presumed to have minimal effect on the structural integrity of the host pipe or leakage although the developers of the PU based systems claim the potential for thicker more structural coatings. The cement-based systems were first used in the 1920's as a factory applied protective coating for new cast and ductile iron and steel pipes. According to W Walsh a cement-lining contractor in the USA the extension of this technique to the in-situ lining of buried pipes was accomplished in 1933 by one Carl Perkins, a founder of the company. However there are other claimants to this accolade.

CML (Cement Mortar Lining) has been widely used to rehabilitate water mains in the UK, N America, and parts of Europe. However in the UK concerns over the performance of CML in soft water and the reduction in flow capacity in pipes of 4in (100 mm) diameter and less prompted the search for an alternative and epoxy lining was born. The end result was the complete replacement of cement mortar lining by epoxy in the UK but not in the USA and other countries where CML still thrives in spite of the availability of epoxy. In the UK Epoxy lining is now being replaced by Polyurethane on the basis of its rapid cure capability, which allows the possibility of returning a water main to service within 12 hours. Supporters of this process also claim it offers easier application in larger diameter pipes.

Development work has been carried out on spray lining techniques for non-man-entry sewers, but so far no such method has achieved commercial prominence. This may be partly because of the different requirements of sewer renovation, where the aim is usually to increase the pipe's resistance to external loading rather than to prevent corrosion, and partly because of the practical difficulties of ensuring that inflow to the sewer is completely stopped while the material is being applied and cured. A practical spray-lining system for sewers would avoid the problem of lateral reconnection inherent with most other renovation techniques.

Spray lining is seldom used in gas mains, although in some countries it is used extensively in gas service pipes. This Section concentrates on the application of spray lining to potable water mains, which is the most common worldwide use of the technique.

2. PREPARATION

Since spray lining is usually intended as a protective coating which may rely on a bond with the existing substrate, thorough preparation of the host pipe is important. Old water mains, particularly those made of cast iron, often have heavy internal deposits of corrosion and scale, which in some cases may reduce the effective bore to a fraction of the original size.

Cleaning techniques include high-pressure water jetting, scraping, pigging, rack-feed borers and mechanically-driven devices such as cutters and chain flails. There is often a balance to be drawn between removing all traces of corrosion and avoiding damage to the pipe wall, and some of the more aggressive techniques should be used with caution.

Pipe scrapers are designed to remove hard deposits and nodules when winched through a pipe, and consist of a number of spring steel blades mounted on a central shaft. A towing eye is fitted to each end of the shaft, allowing the tool to be pulled back if necessary.

Wire brush pigs comprise two circular wire brushes on a central shaft with a towing eye at each end, and are used to remove loose deposits and dust prior to lining. They may also be used to remove debris loosened by a pipe scraper.

Cleaning pigs are available in a wide range of types, and are usually molded from hard resin with an abrasive outer layer. Some have carbide studs around the barrel to remove hard deposits. They are normally driven through the main by water pressure, and can travel distances of several kilometers in continuous pipelines. In a heavily encrusted pipe, pigging is carried out in stages using pigs of increasing size.

Foam pigs are generally pushed through a pipeline by air or water pressure, but versions are available that can be pulled through with a towing rope. They are generally used to remove dust or fluids from pipes of any material, and are also suitable for line drying.

Some models have transmitter housings for pipeline location and tracing. Foam pigs are often bi-directional and sufficiently flexible to pass through fittings such as bends,

valves and branch connections. They may also negotiate reduced pipe diameters and partial obstructions.

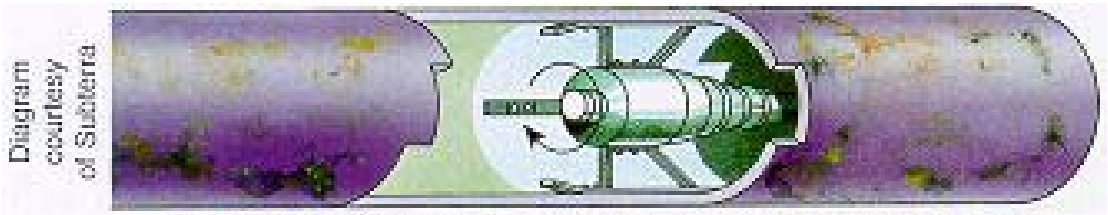
'Pull-through' (also known as 'squeegees') removes fine material and fluids from pipes. They consist of two thick rubber discs fitted to a central shaft, which has a towing eye at each end. Foam pigs or pull-throughs are often used as the final stage of the preparation process, to produce a clean, dry surface to which the spray lining material can be applied.

3. CEMENT MOTAR LINING

The application of a cement mortar lining is a common and relatively inexpensive method of water main renovation. The cement mortar serves two main functions - the alkalinity of the cement inhibits corrosion of iron pipe, and the relatively smooth internal surface reduces hydraulic roughness and improves flow characteristics. It should be noted that cement mortar lining is also applied to many new cast iron and ductile iron pipes, also to inhibit corrosion.

The lining does not fulfill a structural function other than to reduce the rate at which the host pipe will deteriorate, so the technique is not appropriate for pipes which leak, or where corrosion has reduce the wall thickness significantly.

As stated above, thorough preparation of the existing pipe is essential. It is also important to apply sufficient thickness of mortar in order to create the alkaline environment at the mortar/iron interface. As with steel reinforcement in concrete structures, inadequate cover to the metal will allow the onset of corrosion, which will cause the mortar to crack and spall.



Application of cement mortar by a rotating-head spray machine

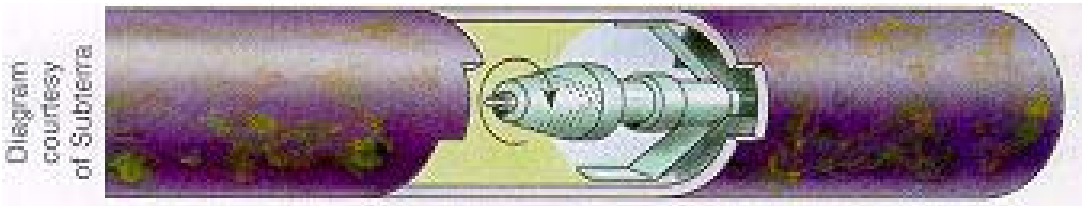
Application is generally carried out by a spraying machine which is either fed through hoses from the surface, or, particularly in larger pipes, may have its own hopper containing pre-mixed mortar. Forward speed control of the machine is important to produce a consistent thickness of mortar. Spray application is followed by trowelling. This may be carried out by rotating spatulas fitted to the spraying machine, or sometimes by a simple tubular shield of the required internal diameter, which is pulled through behind the machine. Whatever system is used, it is essential to centralize the equipment within the host pipe so that the coating is of constant thickness around the whole perimeter.

4. EPOXY AND POLYURETHANE LINING

Epoxy and Polyurethane lining may be seen as alternatives to cement mortar lining, with similar function - to provide corrosion protection and a smooth bore.

The objective is for the resin to bond with the prepared internal surface of the pipe, forming a coating which prevents water penetration and corrosion. The coatings are generally much thinner than cement mortar linings, and therefore do not cause significant bore reduction. They also cure more quickly than cement-based materials. However, any defect in the coating may allow corrosion to start and, unlike cement mortar, there is then no alkalinity to inhibit deterioration chemically. The resins are also relatively expensive compared with cementitious materials.

Resins which have been approved for the lining of water mains by the relevant National Authority do not impair the quality of the conveyed water, provided they are mixed properly in the correct ratio and cured correctly. Resin should not be used for lining water pipes unless the particular formulation has been officially accredited for this purpose. National approval bodies are those such as DWI in the UK and NSF in the USA. In the UK these technologies can only be used by approved contractors operating in accordance with published guidelines



Application of epoxy resin

The resin is applied by a spraying machine, which usually has a rotating nozzle. The thickness of the coating is controlled by the flow rate and the forward speed of the machine. In most systems, the resin base and hardener are fed through separate hoses and are combined by a static mixer just behind the spray nozzle. Ideally, the cure time should be as short as possible to minimize the period during which the main is out of service, and also to reduce the risk of contamination of the resin prior to cure. However, too rapid a cure carries the risk of blocking the static mixer or the nozzle. Unlike with cement mortar lining, the resin is not smoothed or trowelled after spraying, and the surface quality depends on the application technique and the properties of the material.

Epoxy lining spray-head

Various resin formulations are available, including high-build, thixotropic materials that resist sagging. Some water utilities have a preferred material or an approved list of materials for particular applications, and details will be included in the contract specification.

5. SUMMARY

1. Thorough preparation of the existing pipe is important, particularly with spray lining systems, and a variety of techniques is available for descaling, cleaning and swabbing.
2. Spray lining techniques for small to medium diameter pipelines are aimed principally at the renovation of potable water mains. All materials must be approved by the relevant regulatory bodies.
3. Cement mortar lining is relatively inexpensive, offers chemical protection against corrosion of the host pipe, and provides a smooth bore. However, the required thickness of material may produce a significant reduction in bore, and the life expectancy of the lining may be less than for many other renovation techniques.
4. The application and curing of epoxy lining is generally quicker than cement mortar lining and causes minimal bore reduction, but careful quality control during application and curing is essential to avoid any defects in the lining that would allow corrosion to restart.
5. Neither cement mortar lining nor epoxy spray lining are suitable for pipelines that have structural defects or leaks.
6. The cost of spray lining compared with other renovation techniques should be weighed against the relative durability, structural capability and longevity of the alternative systems.

APPENDIX 1

INSITU APPLIED COATINGS – THIN NON STRUCTURAL

Additional Information

1) ISTT conference papers
2) Other conference papers
3) Standards/guidelines
4) List of ISTT member contractors
5) Other contractors

The following table summarises the main features of each technology and provides links to more detailed information

	CEMENT MORTAR LINING	EPOXY SPRAY LINING	POLYURETHANE SPRAY LINING
PRINCIPLE	Thin layer of cement mortar passivates ferrous pipes and prevents corrosion	1mm barrier layer of two part solvent free epoxy resin mixed at spray head	Similar to epoxy but uses polyurethane resin
TYPES OF PIPE	CI,DI,STEEL, A/C		
DIAM RANGE	100-2000	75-600	75-1600
ACCESS	Entry/Exit Pits Every 200m And At Valves		
PREPARATION	Aggressive cleaning using drag scrape ,water jet ,borer		
MAX LENGTH	200M		
CONNECTIONS	No effect		
FITTINGS	Remove all		
OUT OF SERVICE	48hrs min	16 hrs min	2 hrs min
TRACK RECORD	Extensive		
CURRENT USAGE	Mainly use		
ADVANTAGES			
DISADVS			
SELECTION INDICATORS	Pipes >3oomm		
links	LINK A	LINK B	LINK C

APPENDIX 2

IN SITU APLIED COATINGS – THICK SEMI OR FULLY STRUCTURAL

POLYMER BASED

Epoxy and polyurethane based coatings are widely used for the rehabilitation and corrosion protection of man entry pipes, tunnels, manholes and other water and wastewater structures. The materials in two-part, 100% solids, solvent free formulations are hand or spray applied in thicknesses up to 5mm. Careful surface preparation is needed to ensure good adhesion between the coating and the substrate.

Some manufacturers of polyurethane based coatings are claiming that they can now apply thicker coatings inside small diameter pipes and that these behave in a semi or even fully structural manner.

CEMENT BASED

Concrete can be spraying applied in man entry tunnels and pipes using techniques such as Shot Crete and Gunite.

Reinforcement can be incorporated in the sprayed layer either by use of polymer or steel fibres incorporated in the mix or by positioning layers of reinforcing fabric on the pipe wall prior to application of the concrete. This allows the layer to act as a semi or fully structural lining.

Ferro cement is a variant of these technologies in which very fine steel mesh in incorporated in the sprayed layer giving excellent crack control. This material has been widely used in developing countries to manufacturer the wide range of objects. The material has also been used as a structural lining in pipes and tunnels used for both gravity and pressure applications.

For more information on these technologies use the links below:

1. Thick Polymer Coatings D
2. Concrete Coatings E
3. Ferro Cement F