

# Resins

## Trenchless Remediation of Deteriorated Sewer and Storm Water Lines

By Kaleel Rahaim

**T**renchless remediation of sewer and storm water lines has been a widely accepted method for repairing aging infrastructure. Three broad categories of continuous plastic structural lining systems are available in the North American market and all of them have been widely used and extremely successful.

At the highest level of classification, these systems can be described as cured-in-place pipe (CIPP), which is a thermoset plastic, and deform/reform and fold-and-form, both made from thermoplastics but with significantly different physical properties. However, like most things, each of these systems has their unique advantages and disadvantages with no single product or system able to claim “silver bullet” status. This presentation will provide an overview of these systems and their respective sub-systems.

The CIPP process uses a custom-sized liner impregnated with a thermoset plastic resin. The liner is sized in diameter and length to fit inside of a specific length of deteriorated pipe. The thickness of the liner is predetermined based on required mechanical properties. The resin-impregnated liner is either inverted or pulled generally from one manhole to another in the deteriorated pipe. This system may be designed to react using hot air, hot water or ultraviolet radiation. The system may also be designed for an ambient cure reaction. Before any of these types of reactions, the liner/resin combination is inflated to conform to the shape of the host pipe. After the liner has been expanded and processed, the thermoset resin reacts and becomes hard.

A CIPP liner may be used to remediate a municipal sewer line, storm water line, culvert, ducting or an industrial line. The limitations for use include the type and concentration of the constituents of the contained fluid, service temperature required and physical property requirements. The site specific considerations also play an important part as to the choice of processes, as well as the type of thermosetting resin used, which will be further discussed below.

The liner material in this process is generally a polyester felt material, but may be a hybrid material composed of felt and some reinforcing material such as fiberglass, aramid fibers or graphite fibers. Liners only made of reinforced fabric also are used. In a felt-only liner, the liner is used as a resin carrier. The felt does not contribute to the physical properties of the finished product. In the hybrid liner, the reinforcing medium may contribute significantly to the finished physical properties. Other considerations to the type of fabric used include fabric integrity, resin wet-out capabilities, strength and stiffness contribution, etc. One side of the liner has either an integral barrier or a removable barrier to provide a layer separating the resin impregnated liner from the inflating and cooking (processing) fluid. Calibration hoses are used in pull-in-place liners to allow a means to inflate the liner. These hoses are inverted inside of the installed pull-in-place liner. Some processes that use all fiberglass liner material have removable barriers.

The resin used in this process is generally a polyester, vinyl ester

or epoxy resin. Other resins that may be used include silicate resins or other thermoset resins. It is required that the resin compound be a workable liquid and be able to easily wet out the liner. The resin must have a predictable catalyzed pot life and must be able to polymerize in the environment of the pipe to be relined. Resin economics are a prime consideration in the choice of polymers. The chemical resistance of the thermoset resin also determines which resin will be used and the resin used determines the predicted longevity of the liner.

### Resin Choices

Resin choices are determined by the contractor and owner to achieve the final product properties desired. ASTM methods define the acceptable criteria for a successful project. Polyester resins are available either filled or unfilled. These resins are the most commonly used resins in municipal sewer or storm water line applications. The chemical resistance of this type of resin is adequate for those environments. Flexural creep of these resin systems is also acceptable for these environments. Polyesters are the most economical in this family of resins. Vinyl ester resins are used in municipal applications that may use more aggressive additives in their sewer systems. Vinyl ester resins are also used in pressure and forcemain applications because of their resilience and fatigue resistance. Vinyl ester resins are also used in many industrial applications where more corrosive environments may be found or where service temperatures are higher.

There are several grades of vinyl ester resins available for different environments and service temperatures. Epoxy resins are currently being used in potable water applications and in applications that have significant water contact with the liner. Epoxy resins are 100 percent solids, exhibit very low shrink properties and have excellent adhesion properties. Epoxy resins also emit no volatile organic compounds (VOCs) into the atmosphere.



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CIPP allows for rehabilitation of pipes with diameters from 4 to 108 in. The economics of the process allow for a competitive reline in those diameter ranges.

The type of CIPP material and resin system will dictate the type of initiator used to activate the thermosetting process once it is in place. In the case of polyester or vinyl ester resins, the initiator may be heat-activated, UV-activated or ambient-cured. The initiated resin is then impregnated into a liner. Care must be taken at this step to prevent the source of initiator activation, whether it is heat, UV light or time from impinging on the liner. Bags with initiated

resin may be chilled or kept in light tight boxes, depending on the initiator system used. The liners are then transported to the project location.

At this point, the liner is removed from the truck and inserted in the host pipe. Prior to this time, the host pipe has been cleaned, inspected and the service connections identified. During the insertion process, pressure on the liner is controlled and continues to be controlled as the liner is inflated to conform to the host pipe configuration.

After the liner is inserted and inflated, the curing process begins. This process will transform the liner from a flexible product to a rigid product with sufficient physical properties to obtain a minimum 50-year service life. When the curing process is complete, the liner is control cooled, ends are cut to evacuate any fluids and service connections are restored. The remediated liner is then inspected and service is restored.

Over the years, this process has proven to be quite successful. Improvements to this process have included newer, stronger fabrics that allow thinner bag design, more stable resin systems, more efficient methods of getting heat to the liner for curing, faster liner processing without sacrificing properties and a wider choice of contractors for installation.

## Future Markets

The future holds promise for continued improvements. The import of new European technology will allow faster, more completely cured liners using UV light. New markets may be opened in industrial applications with the introduction of resins with improved heat capacities and better corrosion resistance. Hot air and steam-cured systems are allowing contractors easier access to more jobsites. Hot air and steam cures also make deep pipe remediation or deep slope remediation more practical.

A new market also awaits the CIPP process. This new market is potable water. The first successful CIPP water line rehabilitation was completed in the United States in the past couple of years. As more resin producers, bag manufacturers and contractors partner, the municipalities will begin to have newer and more efficient opportunities for remediating water lines.

The other lining systems, as noted above, utilize one of two types of thermoplastic resin and do not use a liner material or fabric matrix. Thermoplastic materials may be softened and reformed and cooled and made rigid again over many cycles. In CIPP, the resin is a thermoset so that once the resin is made rigid, it may not be reheated and reformed. The lining system known as U-Liner is a deform/reform system and uses a factory-extruded, high-density polyethylene pipe (HDPE) in the process. Lining systems marketed under the names of Ultraliner, Am-Liner and EX Method all use factory-produced PVC pipe as their liner material and are generally referred to as fold-and-form lining process.

There has been much confusion within the industry regarding what is or isn't fold-and-form and the materials used in each process. Even though the installation process is generally similar with deform/reform and fold-and-form systems, the material properties are significantly different, as are the physical properties of the various PVC liners used in the fold-and-form systems. Therefore, understanding the differences is critical to the evaluation process as each process and pipe material has its respective strengths and limitations.

Deform/reform and fold-and-form lining systems allow for additional products and processes for remediation of sanitary sewer, storm water and, to a limited extent, potable water lines. These materials and processes generally allow rehabilitation of pipe sizes

from 4 to 24 in. The chemical resistance of these thermoplastic resins is excellent. A 50-year minimum service life may be expected with this process. Excellent liner durability may also be expected. As with CIPP, ASTM procedures are a means of setting standards for this industry.

The design of this type of liner uses the same parameters as CIPP liners. Depth of the host pipe, amount of host pipe deterioration, soil loading and soil conditions, hydraulic loading and live loads must be considered in both processes. One advantage of both processes is that the liners are designed to stand-alone. They do not require the host pipe for any mechanical property contribution or longevity. Grouting is not required in either process.

Deform/reform and fold-and-form systems use pipe manufactured to rigorous ASTM, ISO 9000 standards. The pipe material, regardless of type, is extruded and then wound on a reel or spool in a reduced cross-section profile of various lengths. The reduced profile is either made into a "U" shape, "H" shape or is loosely flattened to increase capacity on the reel and for installation ease. These rolls or reels of pipe are delivered to the jobsite along with the installation equipment. The process is generally completed from manhole to manhole. The deformed liner is pre-heated in a steam cabinet where it softens prior to being inserted in the host pipe for the prescribed length. Once in place, the liner is then reheated and inflated under controlled conditions. All phases of the installation process are critical, regardless of the thermoplastic material used. In both CIPP and thermoplastic liner processes, contractor record-keeping and adherence to sound construction practices are important to have a successfully completed project.

In the thermoformed pipe relining process, new technology regarding the bond between pipe sections for some of the thermoplastics is allowing for increased acceptance of this product in longer repairs. This includes both mechanical joining and butt-welding.

In CIPP and thermally reformed pipe, lateral installation is an important part of the process. The traditional method for both processes has consisted of cutting a hole in the liner at the point the lateral intercepts the liner and considering that reinstatement complete. With this process, infiltration and inflow into the mainline, as well as root intrusion, remain a possibility. Newer lateral repair methods allow a sealed joint between the mainline liner and the lateral. Many new processes have become available over the past several years and many more are becoming available.

For almost 30 years, CIPP, deform/reform and fold-and-form have been processes that have successfully remediated hundreds of thousands of feet of sanitary sewer and storm water lines. Ducts and culverts repair have also benefited from these processes. Industrial lines may now be repaired with the tougher, more corrosion resistant resins used in CIPP or the well known attributes of HDPE or PVC and can be used as well, depending on the lining method.

As the industry matures, newer resin systems and improved process methods will allow water lines and pressure lines to be repaired as easily as sanitary sewer lines. Extruded piping materials such as HDPE and PVC already have a hydrostatic design basis and as such can be pressure rated. Depending on the material composition of these pipes, they can also carry a NSF-61 listing for potable water.

Kaleel Rahaim is manager of pipeline remediation polymers with Interplastic Corp., Thermoset Resins Division, which is based in Houston.