TABLE A

	Trenchless Technology - CIPP	
CIPP	Cured In Place Pipe (CIPP) is a form of trenchless technology whereby a rehabilitation lining comprised of a material impregnated with a resin (usually comprised of a 2 part mixture- reactant and co-reactant) is introduced into the host pipe and expanded to fit tightly against the walls. The co-reactant in the resin is activated to start curing (setting and hardening) the resin. The result is a newly rehabilitated segment of "pipe within a pipe". There are three main characteristics of CIPP: Method of Insertion, Materials Used, Cure Method. Each of these 3 main categories contains various sub-categories. We will look at the major sub-categories of these three characteristics below. It is worthwhile to note that the way these sub-categories are combined give rise to the various manufactured brands of lining products and systems.	
INSERTION METHOD	**PROS**	**CONS**
PULL IN PLACE (PIP)	Some PIP technologies offer a No Dig solution (typically for a NO- DIG project you do not even need a shovel on the job.) Other PIP technologies may require varying degrees of excavation but still offer a Trenchless solution.	Need access point(s), usually on either side of the rehabilitated section. These are usually part of standard infrastructure- man holes, clean outs, etc…but they must be present to utilize this technology.
	You can better control the insertion and move it past bends, offsets, and other potential obstacles.	Typically limited in the length of pipe you can rehabilitate per insertion. Can become cumbersome for long run repairs (over 100 feet). May require multiple insertions to do longer jobs.
	Works well for short run and spot repairs (1 foot to 100 feet).	
	Generally able to handle a wide range of diameters: from smaller diameters (2") to larger	
	Moderate capital requirements to acquire a robust system	
PUSH IN PLACE	Good solution for spot (4 to 6 feet or less) repair.	Effective on limited range of diameters.
	Very low capital investment	Unable to effectively handle sharp bends, pipe transitions, offset joints.
		Unless specifically designed otherwise, becomes increasingly impractical for repair lengths 10 feet or longer.
INVERSION	Can offer a No Dig solution. Typically only requires one access point.	May experience significant trouble navigating around 90° elbows or through offset joints.
	Efficient method to rehabilitate unbroken, long run sections of pipe (from two hundred to thousands of feet in main line/manhole to manhole applications)	Overall capital requirement may be significant. Process may require multiple pieces of equipment. Relatively expensive to purchase all equipment necessary to handle full range of situations (i.e., bends, diameters less than 6", diameters greater than 26", jobs less than 100', jobs greater than 100', etc…
	Can handle a wide range of diameters	Expense: smaller and larger diameters may require special equipment (see above).
		May require a pit to be dug to allow for required access
MATERIALS	**PROS**	**CONS**
FIBERGLASS	High quality. Very strong, very durable. Marine repairs are made with fiberglass	Fiberglass quality is more expensive material than lower quality material (felt).
	Can be fabricated in ways to produce a strong rehabilitation liner at relatively thin wall thickness.	
	Can be fabricated in ways to meet the needs of a more complex design engineered rehabilitation project without the need for additional equipment (i.e., series of bends, 90° elbow, pipe transitions, pipe offset, smaller diameter, larger diameter, inverts, missing sections of pipe/voids, etc…)	
FELT	Relatively inexpensive (which in some situations is the key to winning work put out to bid)	Necessary to increase thickness to achieve required strength. In smaller diameter situations, this can reduce the diameter of the finished project to unacceptable levels.
		Relatively flimsy material. Very difficult to use in situations with missing sections of host pipe or large voids.
		Fabrication with traditional felt material in tubular or "sock" form makes it very difficult to rehabilitate sharp bends, offset joints, or size transitions without bunching the liner in the host pipe, thereby creating obstructions.
EPOXY RESIN	No Volatile Organic Compounds (VOC's) to evaporate or leach out	More expensive vs. styrenated resins
	Requires the proper amount of heat to activate the co-reactant and start the curing process. Can utilize techniques to remove heat and delay cure for many hours.	
	Very strong - cured epoxy provides excellent structural support	
	Highly adhesive - cured epoxy promotes a strong bond to a clean host pipe	
	Excellent longevity - cured epoxy greatly prolongs the life of rehabilitated pipe	
STYRENATED RESIN	Relatively inexpensive vs other types of resins	There exists controversy regarding the carcinogenic properties of styrene. The National Toxicology Program of the Department of Health and Human Services reports:
		"…no qualitative differences between humans and experimental animals have been demonstrated that contradict the relevance of cancer studies in rodents for evaluation of human hazard. Detection of styrene-7,8-oxide–DNA adducts at base-pairing sites and chromo- somal aberrations in lymphocytes of styrene-exposed workers supports the potential human cancer hazard from styrene through a genotoxic mode of action." The Coast Guard, Department of Homeland Security, The Department of Transportation (DOT), The Environmental Protection Agency (EPA), The Food and Drug Administration (FDA), and The Occupational Safety and Health Administration (OSHA) all have regulations, requirements, and laws about the handling, use, and transportation of styrenes.[3]
		Some Styrenated resin mixtures are formulated with a co-reactant that immediately begins the curing process. You have minimal time (less than an hour) to position the rehabilitation liner perfectly in place. Any error can result in costly waste and/or remediation steps to remove a "bad" liner.
		Noxious and objectionable (if not toxic), fumes are released when using these resins.
		Will contract or "shrink" as they age. This creates the potential for a styrenated resin rehabilitation liner to pull away from the sides of the host pipe and create annular space, resulting in an infiltration behind the liner. It can also result in the liner actually moving down the host pipe, an occurrence known as "creep".
		Styrenated resins may not exhibit exhibit most optimal tensile and flexural measurements as compared to other types of resins.
	[3] National Toxicology Program, Dept. of Health and Human Services, Report on Carcinogens, Twelfth Edition (2011)	
METHOD OF CURE	**PROS**	**CONS**
DIRECT Hot Water (Commonly called Hot Water Cured) = once the liner is in place hot water is run through it to activate the hardner and cure the resin. The water is in direct contact with the resin impregnated liner.	You can bring the temperature up to a level that will start the cure.	It is difficult to keep the entire liner at constant temperature throughout the cure. Overheating can occur that can degrade the resin causing the liner to become brittle and ineffective in a condition known as styrene boil. Underheating can result in spots not fully cured that could potentially fail.
	You can exert pressure to hold the rehabilitation liner against the wall of the host pipe, creating the opportunity for a strong bond.	Washout - water comes in contact with the resin and can leach out chemical content delivering it downstream upon discharge.
		You have to suspend use of the pipe or create a detour (blocking & pumping) for the duration of the repair.
		Cure times may be longer compared to indirect heat systems. This should be closely researched on an individual basis.
		The expense of a hot water cure system
DIRECT Steam (Commonly called Steam Cured) = once the liner is in place, steam is injected into the liner to activate the hardner and cure the resin. The steam is in direct contact with the resin impregnated liner	You can bring the temperature up to a level that will start the cure.	It is difficult to keep the entire liner at constant temperature throughout the cure. Overheating can occur that can degrade the resin causing the liner to become brittle and ineffective in a condition known as styrene boil. Underheating can result in spots not fully cured that could potentially fail.
	You can exert pressure to hold the rehabilitation liner against the wall of the host pipe, creating the opportunity for a strong bond.	Washout - steam comes in contact with the resin and can leach out chemical content delivering it downstream when discharged.
		You have to suspend use of the pipe or create a detour (blocking & pumping) for the duration of the repair.
		Cure times may be longer compared to indirect heat systems. This should be closely researched on an individual basis.
		The expense of a steam cure system
INDIRECT HEAT - Water or Steam = Hot water or steam is run through a bladder that the resin impregnated liner is wrapped around. The water does not come in direct contact with the resin impregnated liner	You can bring the temperature up to a level that will start the cure.	The expense of a bladder system
	You can better control the temperature and the cure process while eliminating the effects of washout and dewatering.	
	By filling the bladder with water or steam, you can exert optimal pressure that will press the rehabilitation liner against the host pipe, creating the opportunity for a strong bond.	
	Guesswork about cure time and effectiveness is removed.	
	Cure time is greatly reduced	
	Some technologies provide flow through capabilities, eliminating need for detour operations	
AMBIENT CURE - In effect, let the resin "air dry".	Reduce the expense of equipment necessary for the curing process.	You can never be sure the liner is fully cured prior to being placed in service. Once in service an uncured liner will remain soft and can begin to rapidly deteriorate.
		Ambient cures can take up to 36 hours to be fully cured. This greatly extends the project and adds to labor cost.
		You have the LEAST amount of control over your lining project using an ambient cure.
		The cure process starts almost immediately allowing installation crews just 30 or 40 minutes to wet out AND fully position and install the rehabilitation liner. You must work VERY quickly and accurately. If not fully installed, the "bad liner" must be removed — sometimes resulting in a very expensive process.
Ultra Violet (UV)	Guesswork about cure time and effectiveness is removed.	Expense: UV systems require a very large capital investment.
	You can better control the cure process while eliminating the effects of washout and dewatering.	Additional equipment needed to service variety of diameters; requiring extensive collection of expensive equipment.
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