Structural Lining for Water Mains

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2015 PA-AWWA Annual Conference
Thursday, April 23rd, 2015

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Agenda

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6. Cured-in-Place Pipe Liners
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Introduction

- Aging infrastructure
- Alternate to open-cut methodology
  - Trenchless technology
- Limited resources and capital
- Structural Lining
  - Less intrusive
  - Potentially less Cost
- Two primary types:
  - Spray-on
  - Cured-in-place pipe (CIPP)

Image provided by NY Times

Purpose of Lining

- Objectives of Lining may include:
  - Improve water quality
  - Stop water loss/leaks
  - Structurally renew existing pipeline
  - Improve hydraulic characteristics
  - Extend service life of pipeline
  - Reduce cost

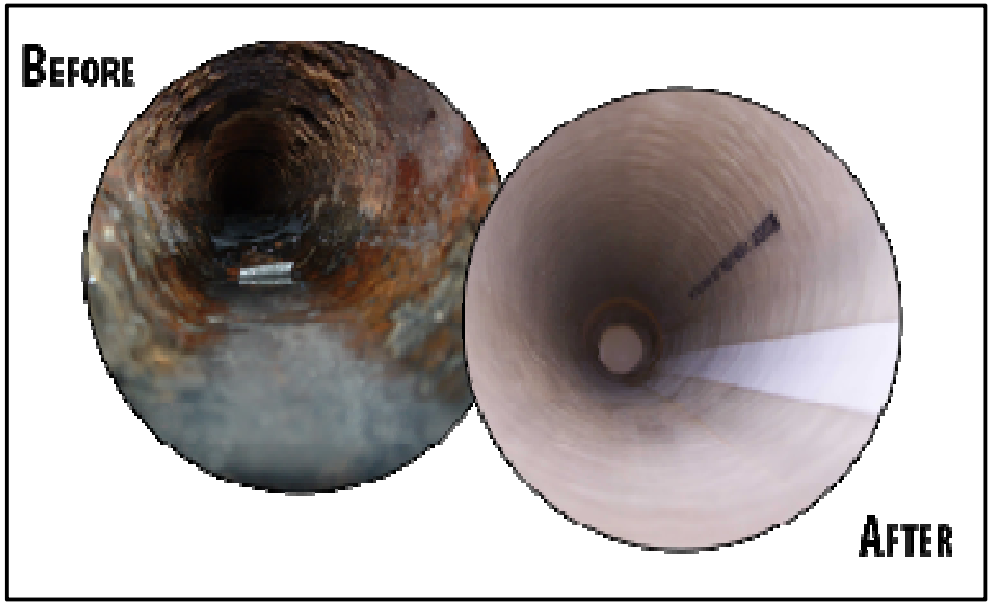


Image courtesy of Ellingson Companies

Lining History – Spray-on

- Cement Mortar Lining
  - First used in 1830s[1]
  - Non-structural
- Structural Lining
  - Epoxy implemented in UK in 1985
  - US approval in 2008 via ANSI/AWWA C620-07 Standard (Spray-applied in-situ epoxy lining)

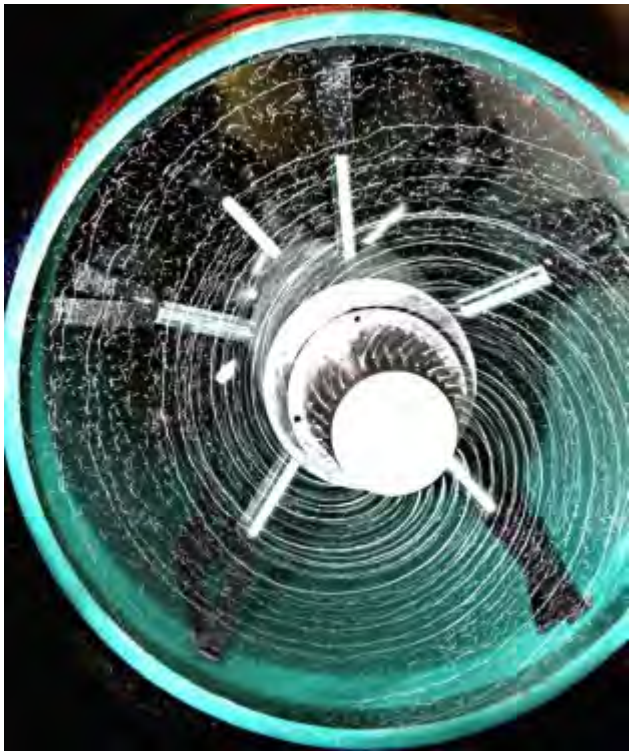


Image courtesy of Thortex® (epoxy coating application)

[1]According to Water Research Foundation (WRF)

Lining History – CIPP

- CIPP[1]
  - Pipe within a pipe
  - First implemented in 1971 in London, named insit u form (Latin for “form in place”)
  - Originally felt tube saturated with resin
  - Patent issued 1977 and commercialized by Insituform® Technologies
  - Patent expired in 1994

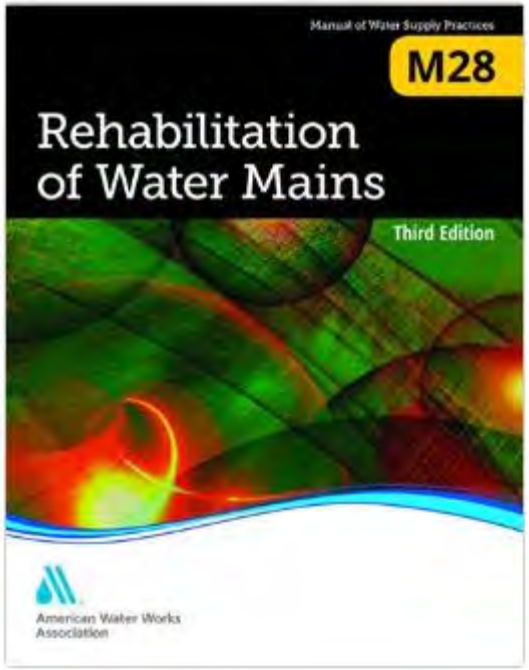
Image courtesy of GML Coatings, LLC

[1]Artice: Evolution of Cured-in-Place Pipe Allows Structural Renewal of Drinking Water Pipe, David Kozman, PE

Classifications of Liners

- AWWA developed classification system to describe and differentiate among linings
  - Class 1
    - Non-structural
    - Coating/corrosion protection
  - Class 2
    - Semi-structural – pressure transferred to host pipe
    - Requires adhesion to host pipe
  - Class 3
    - Semi-structural – pressure transferred to host pipe
    - Does not require adhesion to host pipe
  - Class 4
    - Fully-structural
    - Independent of host pipe
    - Pipe within a pipe

American Water Works Association



Spray-On Structural Liners

Spray-on Structural Liners

- Process Overview
  - Pre-inspection
  - Isolate segment
  - Requires two access points
  - Application rig pushed into position and winched backwards while nozzle head applies material to pipe
  - Post-inspection

Image courtesy of trenchless-pipelining

Spray-on Structural Liners

- Advantages
  - Minimal effort to re-establish service connections
  - Minimize disruptions to community due to minimal access pits compared to open-cut
  - Typical maintenance/repair methods can be applied to completed pipelines
- Limitations
  - Voids and blisters may form if pipe is not properly prepared
  - Potential for uneven liner due to rig issues
  - Material can slump on invert of pipe

Image courtesy of Municipal Sewer and Water Magazine®

Spray-on Structural Liners – Example Manufacturers

- Quest Inspar PipeArmor®
  - Installation sizes: 6 – 174 Inches (any pipe material)
  - Material
    - 100% Polyurea
  - Installed by Quest Inspar
  - >0.020 inch thickness
  - Design standards: ASTM D-192
  - AWWA class IV designation (fully structural)
  - Product Certifications: NSF/ANSI 61 Standard
  - Service Connections: Service connections are not blocked during the lining process.
  - Maximum lining distance: 900 LF in each direction (upstream/downstream) at one time

Image courtesy of Quest Inspar®

Spray-on Structural Liners – Example Manufacturers

- 3M Skotchkote ™ Renewal Liner 2400
  - Installation sizes: 4 – 24 Inches (DI and CI)
  - Material
    - 100% Polyurea
  - Requires authorized applicator contractor
  - 0.05 inch to 0.3 inch thickness
  - Design Standards: ASTM F 1216-09, D638-08, D2990-08, and D1599-99
    - Non-designated fully structural lining (designed to operational pressure and external loads and conforming to above-referenced standards)
  - Product Certifications: NSF/ANSI 61 Standard
  - Service Connections: Service connections are not typically blocked during the lining process. If they are, a mechanical robot can reinstate them.
  - Maximum lining distance: 600 LF at one time

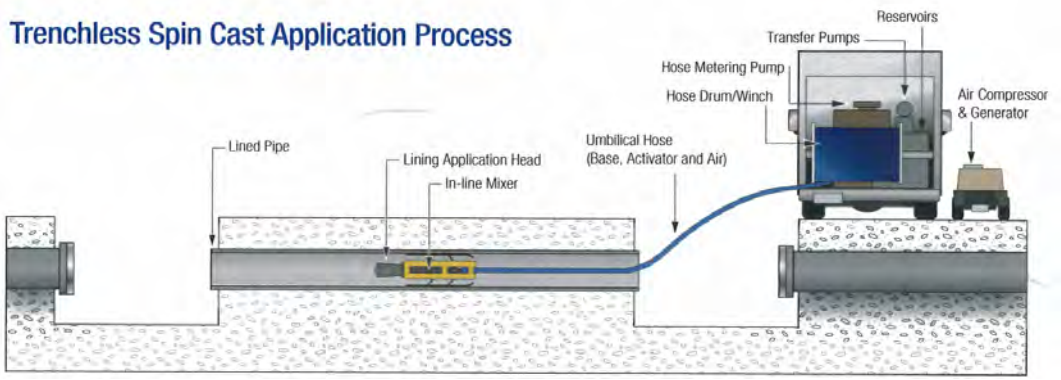


Image courtesy of 3M®

CIPP Structural Liners

CIPP Structural Liners

- Process Overview
  - Liner tube “wetted-out” with resin before inserted into host pipe
  - Cured utilizing hot water, steam, or UV
- Advantages
  - Minimum disturbance to community
  - Line through bends and non-circular shapes (oval, elliptical, etc.)
  - VOC free
- Disadvantages
  - Like spray-on, bypass or isolation of line required
  - Requires temperature monitoring of materials prior to installation
  - Typically requires certified installers

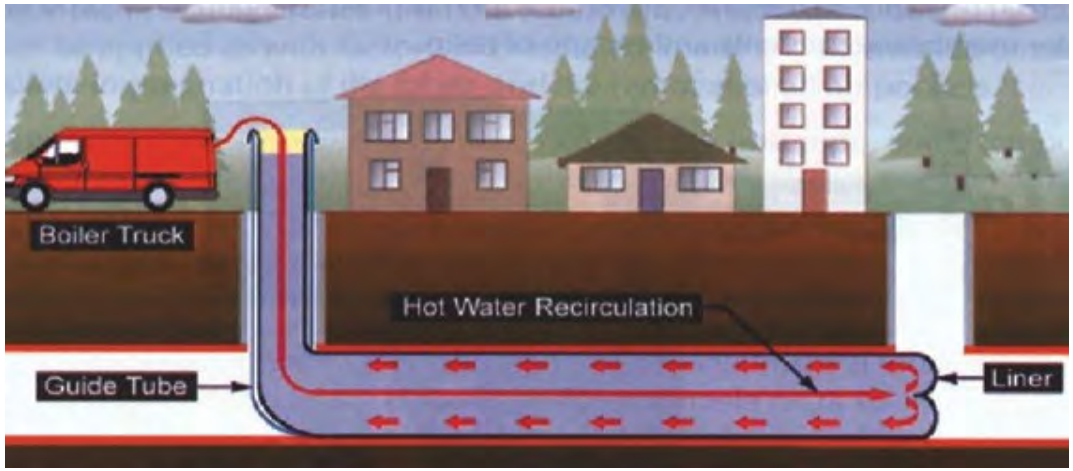


Image courtesy of Trenchless International®

CIPP Liner – Example Manufacturers

- Aqua Pipe®
  - Installation sizes: 6 – 24 Inches (CI, Steel, or DI)
  - Materials, 3 layers:
    - Outer Layer: Semi-Porous synthetic woven polyester (proprietary)
    - Propriety resin
    - Inside: Thermal Polyurethane Membrane
  - Requires licensed installers. Licensing includes rigorous training and equipment purchase.
  - Design Standards: ASTM F1216 and ASTM 1743
  - AWWA Class IV Designation
  - Product Certifications: NSF/ANSI Standard 61, UL, NQ 3660-950, and WRAS[11] Approved Material

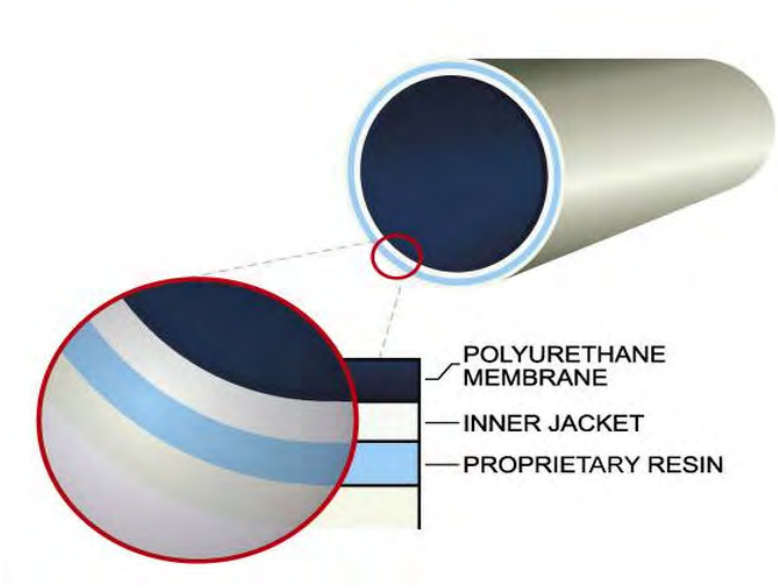


Image courtesy of Aqua Pipe®

[1] Water Regulations Advisory Scheme

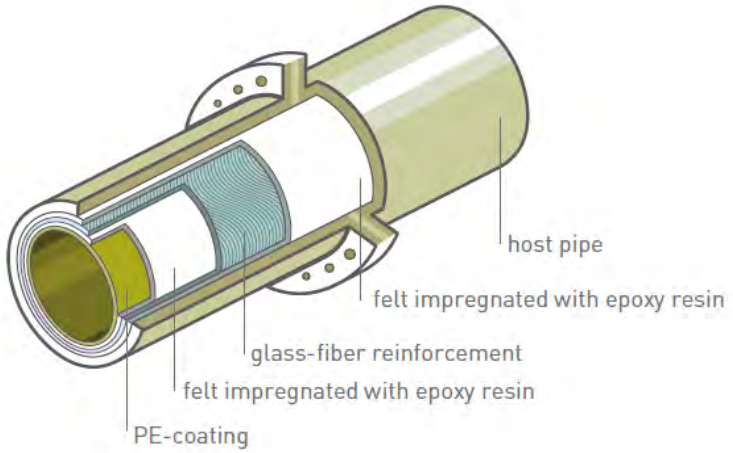
CIPP Liner – Example Manufacturers

- Aqua Pipe®
  - Installation:
    1. The woven synthetic polyester jackets are impregnated on site,
    2. The jacket is pulled in place through the host pipe.
    3. Because the outer layer of the liner is semi-porous, the resin seems through it, allowing adhesion to the host pipe.
    4. The final step includes circulating hot water through the pipe for curing purposes.
  - Service Connections: Following installation a mechanical robot reinstates service laterals.
  - Maximum Installation Length: 1,000 LF at one time

Images courtesy of Aqua Pipe®

CIPP Liner – Example Manufacturers

- SEKISUI NordiPipe™
  - Installation sizes: 6 – 48 Inches
  - Materials, 4 layers:
    - PE Coating
    - Needled Felt
    - Glass Fiber
    - Epoxy Resin
  - Requires licensed installers. Licensing includes rigorous training and equipment purchase.
  - Design Standards: ASTM D638, D790
  - AWWA Class IV Designation
  - Product Certifications: NSF/ANSI 61 Standard



NORDIPIPE™ with a single or two glass-fiber reinforcement layer(s)

Image courtesy of SEKISUI®

CIPP Liner – Example Manufacturers

- SEKISUI NordiPipe™
  - Installation:
    - The liner is impregnated on site, in a climate controlled environment, with an epoxy resin. Once prepared, the liner is inverted into place and cured with steam or heated water.
  - Service Connections: Following installation a mechanical robot reinstates service laterals.
  - Maximum installation length: 500 LF at one time

Images courtesy of SEKISUI®

CIPP Liner – Example Manufacturers

- Insituform InsituMain®
  - Installation sizes: 6 – 60 Inches (CI, DI, Steel, Cement, RCP, Plastic)
  - Materials, 3 layers:
    - Polyester Fiber
    - Fiberglass
    - Epoxy Resin
  - Design Standards: ASTM F1216 and ASTM F1743
  - AWWA Class IV Designation
  - Product Certifications: NSF/ANSI 61 Standard

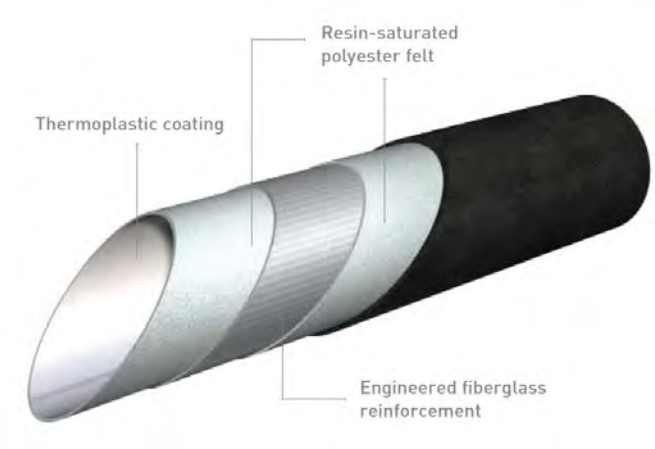


Image courtesy of Insituform®

CIPP Liner – Example Manufacturers

- Insituform InsituMain®
  - Installation:
    - The composite material is impreganated on or off-site with an epoxy resin. The pipe is installed into the pipe with either an inverted or pull-in method (either direction). To cure the material, steam or heated water is circulated through the pipe.
  - Service Connections: Following installation a mechanical robot reinstates service laterals.
  - Maximum installation length: 1,500 LF at one time

Image courtesy of Insituform®

Conclusion and Summary Table

Lining Method	Example Manufacturer	Pipe Size (in.)	Approximate Cost (Per LF)*	Materials	Benefits	Disadvantages
CIPP Lining	SEKISUI Nordipipe® (Class IV)	6 – 48	$100-$125	Woven polyester and polyurethane	• Fast installation • Minimum surface disruption • Minimum annular space between host pipe and liner (no grouting required) • Increased Hazen-Williams C-factor • VOC free • Cost-effective	• Certified installers not available in every area • Internal pressure rating limitations • Materials need to be monitored for temperature • Bend limitations
	Aqua-Pipe® (Class IV)	6 – 24	$105-$125	Needled felt, glass fiber, epoxy resin		
	Insituform InsituMain™ (Class IV)	6 – 60	$120-$140	Polyester fiber, fiberglass, epoxy resin		
Spray-on Lining	3m Skotchtite™ (Class III)	4 – 24	$125-$140	Polyurea	• Quick cure-time • Little to no effort required for service connection re-establishment • Minimal surface disturbance • Cost-effective • Typical maintenance/repair applicable following installation	• Limited number of installers/manufacturers • Potential defects of liner due to applicator issues • Material may slump in invert of pipe
	Quest Inspar Pipe Armor® (Class IV)	6 – 174	$120 – 135	Polyurea		

* Approximate installed costs for 6-inch pipe designed to a structural level. Costs can vary greatly depending upon specific site location, total length of pipe, condition of host pipe, installer, amount of bends and fittings and water service connections.

Questions?