Structural Lining for Water Mains

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1. Introduction
2. Purpose of Lining
3. Lining History
   1. Spray-on
   2. CIPP
4. Classifications of Liners
5. Spray-on Structural Liners
   • Example Manufacturers
6. Cured-in-Place Pipe Liners
   • Example Manufacturers
7. Conclusion
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)
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 1830s¹
  - 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)

¹According to Water Research Foundation (WRF)
Lining History – CIPP

• CIPP¹
  – Pipe within a pipe
  – First implemented in 1971 in London, named insitu form (Latin for “form in place”)
  – Originally felt tube saturated with resin
  – Patent issued 1977 and commercialized by Insituform® Technologies
  – Patent expired in 1994

¹Article: 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
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
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
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)
    • Proprietary 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 WRAS¹ Approved Material

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

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 impregnated 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

<table>
<thead>
<tr>
<th>Lining Method</th>
<th>Example Manufacturer</th>
<th>Pipe Size (in.)</th>
<th>Approximate Cost (Per LF)*</th>
<th>Materials</th>
<th>Benefits</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| **CIPP Lining** | SEKISUI Nordpipe® (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 | | |
| | In situMain™ (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?