Emerging Trenchless Renewal Technologies for Pressure Pipe

Brad Conder, P.E. – Regional Sales Manager
Agenda

- AWWA Structural Classifications

- Emerging Pressure Pipe Renewal Applications
  - InsituMain® Cured-In-Place Pipe (CIPP)
    - Mechanical end fittings
    - Mechanical service connections
  - Thermopipe® Liner

- Selecting appropriate pressure pipe renewal technology
Pressure Pipe Renewal Applications

- Potable Water
- Raw Water
- Reclaimed Water
- Sanitary Water
- Industrial (Fire & Process Water)
Common Trenchless Technologies

- **Slip lining**: Installation of a smaller “carrier pipe” into a larger host pipe.

- **Coatings**: Utilizing spray applied materials to renew the surface of the existing pipe.

- **Pipe bursting**: A method of fracturing the host pipe and pulling in a new pipe that is equal to or greater in size.

- **Directional Drilling**: Installation of new pipe through a bored hole under an obstacle.
Emerging Trenchless Technologies

- **Slip lining**
  Installation of a smaller “carrier pipe” into a larger host pipe

- **Coatings**
  Utilizing spray applied materials to renew the surface of the existing pipe

- **Cured-in-place Pipe (CIPP)**
  A jointless, seamless resin saturated tube that is installed in the existing host pipe and cured

- **Pipe bursting**
  A method of fracturing the host pipe and pulling in a new pipe that is equal to or greater in size

- **Directional Drilling**
  Installation of new pipe through a bored hole under an obstacle

- **Hose Lining**
  A modified type of sliplining that involves installing a high-pressure hose product inside a larger host pipe
AWWA Structural Classification of Pressure Pipe Linings
What does this publication provide?

- Problem definitions
- Trenchless technology overviews
- Planning and delivery considerations
- Common approaches to pipe preparation for lining technologies
- Matching problems to technology
- No standards for design
- Qualitative not Quantitative overview of structural lining
Qualitative Classification

Table 1: General Structural Classifications Objectives

<table>
<thead>
<tr>
<th>Lining System Characteristic</th>
<th>Non-Structural</th>
<th>Semi-Structural (Interactive)</th>
<th>Fully Structural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal coating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hole span</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hole span + ring stiffness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural resistance for all specified loads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(internal &amp; external)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class I</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Class II</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Class III</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Class IV</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Internal corrosion protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term adhesion to the host pipe</td>
<td>See Note 1 Below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hole span at MAOP</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Inherent ring stiffness (hydrostatic pressure)</td>
<td>See Note 1 Below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pressure or vacuum loads only</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Water tightness (positive connection to service taps</td>
<td>See Note 1 Below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and sealed at termination points or other discontinuities)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Inherent ring stiffness (all static and dynamic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>external, hydrostatic, and vacuum loads)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Pressure rating of lining &gt; MAOP of host pipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lining survives anticipated host pipe failures</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 The owner/engineer must specify whether vacuum loads exist. This is addressed through reliable adhesion to the host pipe, which is a characteristic of all Class II and some Class I linings, or inherent ring stiffness.

2 For Class III and IV linings, adhesion is not required to develop ring stiffness. However, it may be necessary to achieve a watertight seal (for example, at services and lining terminations). There are also situations where adhesion is not desirable, such as applications with broad temperature swings and in Class IV linings where the host pipe is anticipated to experience brittle failure modes.

Qualitative concept is based on:

- Intended function of the lining technology
- Degree of interaction of lining technology with the host pipe
- Type of loads the lining was intended to resist
Structural Classification of Pressure Pipe Linings

What does this publication provide?

- Takes qualitative concepts to a quantitative format
- Guidance on design and product selection for all lining products.
- Aligns product considerations to design objectives
- Initial thoughts on recommended quality assurance processes during construction
- Discussion on necessary evolution of design for technologies with a proven track record
- Provides illustrative examples of sound engineering judgement to go beyond current design code
Quantitative Classification - Type Testing

Table 2: Type Testing

<table>
<thead>
<tr>
<th>Property</th>
<th>Technology</th>
<th>Test Method(s)</th>
<th>Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potable Water Certification</td>
<td>All</td>
<td>NSF/ANSI 61</td>
<td>(potable water)</td>
</tr>
<tr>
<td>Material Properties</td>
<td>CML</td>
<td>ASTM C143</td>
<td>(ductile test)</td>
</tr>
<tr>
<td>Liner Thickness</td>
<td>All</td>
<td>Per manufacturer’s guidelines</td>
<td></td>
</tr>
<tr>
<td>System Hydraulics</td>
<td>All</td>
<td>Minimum C value</td>
<td></td>
</tr>
<tr>
<td>Adhesion</td>
<td>Some Classes</td>
<td>ASTM D4548 (initial interface)</td>
<td>Demonstration test: Full strength, negative pressure, thermal stress test, shear stress or stress, as required, per the manufacturer’s specifications</td>
</tr>
<tr>
<td>Adhesion</td>
<td>All Classes</td>
<td>Per Class 1 as required</td>
<td></td>
</tr>
<tr>
<td>High Span GB</td>
<td>All Class IV</td>
<td>Any or all of ASTM D790, ISO 178 / ISO 1161-A, EN ISO 12984, EN 1928-2, EN 1928-6, AASHTO C 64 (forced creep)</td>
<td>Test values = short-term flaxural properties, for anisotropic materials, flaxural properties should be obtained in the hoop and axial directions</td>
</tr>
<tr>
<td>Water Tightness</td>
<td>All Class IV</td>
<td>Assisting test data from end test, welds, manufacturers, as applicable</td>
<td>Demonstration test(s) by the manufacturer, as directed by the owner/authority</td>
</tr>
<tr>
<td>Hydrostatic Integrity</td>
<td>All Class IV</td>
<td>Demonstration test(s) by the manufacturer, as directed by the owner/authority</td>
<td></td>
</tr>
</tbody>
</table>

**Type Testing:**

- How we measure that products meet quantifiable measures of short and long term mechanical/chemical resistance properties
## Table 3: Acceptance Testing

<table>
<thead>
<tr>
<th>Property</th>
<th>Technology</th>
<th>Test Method(s)</th>
<th>Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking Water System Components-Health Effects</td>
<td>All</td>
<td>Bacteriological testing</td>
<td>As required</td>
</tr>
<tr>
<td>Material Properties</td>
<td>CML, PL</td>
<td>Compressive strength</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>CML, ANWAR C602, Section 8.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CML, ASTM F3182, Section 8.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lining Thickness</td>
<td>CML, PL</td>
<td>Physical</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>CML, ANWAR C602, Table 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASTM F3182, Section 8.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class I Adhesion</td>
<td>Some Class I</td>
<td>Surface preparation and dryness</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>Visual and CCTV inspection</td>
<td></td>
<td>As required</td>
</tr>
<tr>
<td>Class IV Aggregation Class IV</td>
<td>Per Class IV</td>
<td>Per Class IV</td>
<td>As required</td>
</tr>
</tbody>
</table>

## Acceptance Testing:

- How we measure in the field that the product meets the design objectives
Emerging Trenchless Renewal Technologies for Pressure Pipe
Infrastructure Solutions

- Water & wastewater pipeline rehabilitation
- Structural strengthening

Corrosion Protection

- Pipeline corrosion prevention
- Oil, gas and mining

Energy Services

- Facility maintenance services
Aegion’s Pressure Pipe Products

- Pressure Rated Cured-in-Place Pipe (CIPP)
- Tight-fit HDPE Lining Systems
- Carbon/Glass Fiber (FRP) Systems
- Fusible PVC®
- Thermopipe® Liner
InsituMain® Cured-In-Place Pipe (CIPP)
What is Cured-in-Place Pipe (CIPP)?

- Resin impregnated tube with:
- Glass reinforced felt
- Inversion or Pull-in installation methods
- Hot water, steam, or UV curing methods
- Tight fitting = greater flow maximization
- Joint less, pipe-within-a-pipe that protects against corrosion, build-up, and leakage

<table>
<thead>
<tr>
<th>Diameter Range</th>
<th>6” to 96”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effluent Temperature</td>
<td>Up to 130°F</td>
</tr>
<tr>
<td>Internal Pressure Capability</td>
<td>Up to 250 psi (safety factor of 4)</td>
</tr>
<tr>
<td>Bends</td>
<td>Up to 45°</td>
</tr>
<tr>
<td>Host Pipe Material</td>
<td>All materials</td>
</tr>
<tr>
<td>Mechanical Properties</td>
<td>Exceeds ASTM F1216 &amp; ASTM F1743</td>
</tr>
<tr>
<td>Typical Install Lengths</td>
<td>500 to 1,000 feet</td>
</tr>
</tbody>
</table>
CIPP Design Parameters

- ASTM F1216 / AWWA M28
- Internal design:
  - Operating, transient and vacuum pressures
- External design:
  - Soil, groundwater, traffic, and other live loads
- Other factors:
  - Ovality, end fittings, bends and services
  - Unrestrained burst testing
  - Validates safety factors
InsituMain® Glass Composite Structure

**Epoxy/polyester felt structure**
- Provides for external load capacity
- Layer thickness can be varied depending on loading conditions
- Utilizes epoxy resin system instead of polyester resin (drinking water safe)

**PP/TPU coating**
- Water contact surface
- Coating also provides water barrier for installation processes & handling

**Hazen-Williams Coefficient**
- C=140

**Epoxy/fiberglass structure**
- Provides high tensile/hoop strength
- Number of layers varies depending on diameter and internal pressure
EndConnect® Mechanical Closure

Fiber Reinforced Polymer (FRP) Coupling Piece

- Eliminates need to connect back to the host pipe
- Promotes the use of standard mechanical joint fittings

Host Pipe

Closure Spool Piece

Mechanical Joint with MEGALUG
EndConnect® Mechanical Closure
EndConnect® Mechanical Closure
EndConnect® Mechanical Closure
Service Connections – Adhesive vs. Mechanical

- Step 1 – Cleaning to prepare pipe surface for resin
- Step 2 – Plugging of existing service connection (prior to lining)
- Step 3 – Locating of the existing service (after lining)
- Step 4 – Drilling of the existing service (most CIPP product manufacturers/contractors stop at this step – plug and drill)
- Step 5 – Reinstatement of the existing service (via installation of the mechanical fitting)

* The mechanical reinstatement process does not rely on the integrity of the host pipe (long term) in order to maintain water tightness
Direct Tap Mechanical Reinstatement Equipment

• One unit accommodates multiple functions:
  • Measurement of service connection diameters
  • Guidance using axial and hoop direction lasers
  • Installation of service plugs
  • Autonomous options for service plug location and drilling using magnetic sensors and cameras
  • Installation of service reconnection hardware
Installed Mechanical Fitting

Direct Tap Service
- Reduces or eliminates need for costly excavations
- ½”, ¾” and 1” diameter reinstatement options
- Pipe diameters from 6” to 12”

Saddled Tap Service
Project Description

- Owner: West Palm Beach, FL
- Pipe Material: PCCP
- Diameter: 48-inch
- Length: 5,700 LF
- Pressure: 25 psi
- Type: Sewer Force Main
- Project Value: $1,418,373

Problem Statement

- Located near canal, county club and high-end residential homes
- High social costs
- Difficult site access
- Deteriorated pipe with pre-stressed wire breaks
Renewal Technology Selection

- Fully Structural (AWWA Class IV)
- Full sewer bypass
- Long installation lengths (Averaged 1,000 LF)
- Minimal internal diameter loss

*INSITUMAIN® CIPP LINING*
Project Description

- Owner: Salt Lake City, UT
- Pipe Material: PCCP
- Diameter: 48-inch
- Length: 560 LF
- Pressure: 60 psi
- Type: Potable water
- Project Value: $810,000

Problem Statement

- Gravity pipe required jointless, pressure-rated rehabilitation product
- Leakage at intermediate manhole
- High social costs to open cut pipe
- Short construction window
CIPP Lining – Scenic Drive Upper Conduit, UT

Renewal Technology Selection

- Fully Structural (AWWA Class IV)
- Span holes/joints in host pipe
- Minimal internal diameter loss
- NSF/ANSI 61 Standard
- Minimal site footprint

INSITUMAIN® CIPP LINING
Thermopipe® Hose construction

Polyester Woven Core

- TPU coated (through the weave) polyester woven hose
- Stops leakage by bridging and sealing holes and faulty joints

Polyurethane Inner Coating

- Hazen-Williams = 150
- Class III Solution (relies on host pipe condition)
- NSF 61 Certified

Polyurethane Outer Coating
End Connection

- Epoxy Coated Steel
- Ease of Reconnection
- Plain End Connection
Installation steps

Step 1
Set up Reel on site for unwinding.

Step 2
Attach pull head, connect to cable and use winch for pull in.

Step 3
Inflate liner with compressed air to expand hose and break tape.

Step 4
Simple mechanical end connections and reconnect with standard waterworks fittings.

- Diameter Range 4-12”
- Pressure Rating 200 psi
- Maximum Install Lengths 3,000’+
- Maximum Temperature Rating 150F
Project Description
- Owner: Fairway Village
- Pipe Material: PVC
- Diameter: 6-inch
- Length: 300 LF
- Pressure: 140 psi
- Type: Irrigation water
- Project Value: >$80,000

Problem Statement
- Fully structural host pipe
- Leaking pipeline
- Difficult site access
- High social costs
Renewal Technology Selection

- Semi-Structural (Class III)
- Water tightness
- Small construction footprint

*THERMOPIPE® HOSE LINING*
Selecting Appropriate Pressure
Pipe Renewal Technology
Which Technology Should I Consider?

CIPP

- Spray Applied
- Slip Lining (conventional)

FRP

- Pipe Bursting
- Slip Lining (modified)

Hose Lining
What type of problems is the pipeline system experiencing?
- Structural or non-structural?
- How much longer do I need this asset?
  - Product/Process type as well as designs can be modified accordingly
- Do I need additional capacity in this pipeline?
  - Future commercial or residential expansion
  - Originally under designed
- Can I accept less capacity in this pipeline?
- Are there multiple services and/or bends present in the pipeline?
- Can pipeline access be created easily and cost effectively?
- What is the size of the existing pipeline?

We Have to Ask the Proper Questions
So What Now?

- Not a one-size fits all
- Comparative analysis: scope, schedule, and budget across different technologies
  - As compared to traditional dig & replace
- Each technology will have its pros & cons

Next Steps...
- Initial Project Review – Feasible Options
- Plan & Spec Reviews
- Preliminary Pricing* (aka ROM)
- Budgetary Pricing* (Program Level Funding)

*Includes schedule information
Any Questions?

Thank you!

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