NJWEA - Winter Tech Transfer 2025 Trenchless Technologies

CIPP & FFRP – Gravity & Pressure Rehabilitation Technologies

NJ AWWA Spring Technology Transfer

By Brian Goad, PE
Regional Director of Pressure Pipe
Insituform

0

Problem

- The utility landscape is becoming increasingly congested, with easement conflicts arising from existing infrastructure and multiple service providers.
  - How can we make the most of the space we have?
- How can we streamline construction timelines to minimize disruptions and ensure timely client reinstatement?
- Is it possible to rethink traditional rehabilitation methods and find alternatives that don't rely on horizontal directional drilling or open-cut excavation?
- It's time to challenge conventional thinking and explore innovative solutions.

1

Trenchless Rehabilitation Alternatives

Coatings (CML/SIPP)
Utilizing spray applied materials to renew the surface of the existing pipe

Sliplining (conventional or modified)
Installation of a "carrier pipe" into a host pipe

FRP Lining
Manned entry for hand applied fiber reinforced polymer

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

Hose Lining
A modified type of slip lining that involves installing a high-pressure hose product inside a larger host pipe

Pipebursting
A method of fracturing the host pipe and pulling in a new pipe that is equal to or greater in size

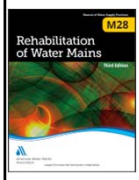
2

AWWA Structural Classification of Pressure Pipe Linings

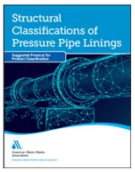
3

AWWA Publications

What does each publication provide?



- Problem definitions
- Trenchless technology overviews
- Matching problems to technology
- *No* standards for design
- *Qualitative* not *Quantitative* overview of structural lining



- Takes qualitative concepts to a quantitative format
- Guidance on design and product selection for all lining products.
- Aligns product considerations to design objectives
- 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

4

Structural Classification of Pressure Pipe Linings

Loose-Fit (Class I/II)

Close-Fit (Class III)
Transfers internal pressure stress to host pipe

Close-Fit (Class III/IV)
Capable of carrying full internal pressure stress

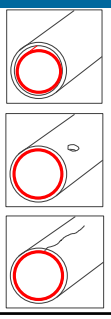


Table 1: *General Structural Classifications Objectives*

Lining System Characteristic	Non-Structural	Semi-Structural (Interactive)		Fully Structural
	Internal coating	Hole span	Hole span + ring stiffness	Structural resistance for all specified loads (internal & external)
	Class I	Class II	Class III	Class IV
Internal corrosion protection	✓	✓	✓	✓
Long-term adhesion to the host pipe	See Note 1 Below	✓	See Note 2 Below	See Note 2 Below
Hole span at MAOP		✓	✓	✓
Inherent ring stiffness (hydrostatic pressure or vacuum loads only)	See Note 1 Below	See Note 1 Below	✓	✓
Water tightness (positive connection to service taps and sealed at termination points or other discontinuities)		✓	✓	✓
Inherent ring stiffness (all static and dynamic external, hydrostatic, and vacuum loads)				✓
Pressure rating of lining ≥ MAOP of host pipe				✓
Lining survives anticipated host pipe failures				✓

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 further failure modes.*

5

Trenchless Methods by Category & Classification

Industry Classification	Non-Structural	Semi-Structural		Fully Structural
AWWA Classification	Class I	Class II	Class III	Class IV
Trenchless Products	Cement Mortar Lining	CIPP	CIPP	CIPP
				Slip Lining
	Epoxy/PU Lining	Modified Epoxy Lining	Modified Slip Lining	Modified Slip Lining
				FRP

6

Insituform's Cured-in-Place Pipe Rehabilitation

CIPP 101

7

What is Cured-in-Place Pipe (CIPP)?

- Developed by Insituform in 1971, cured-in-place pipe (CIPP) is a **trenchless technology**
- The end product is a jointless, seamless, pipe-within-a-pipe that protects against infiltration, breaks and pipeline leakage
- Insituform has installed over 30,000 miles of CIPP and has been the industry leader for nearly 50 years

8

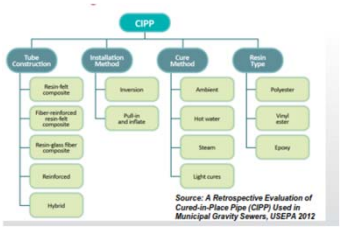
What is Cured-in-Place Pipe (CIPP)?

- Cured-in-place Pipe (CIPP) method to rehabilitate a pipeline that is often called Rehabilitation or Renovation.
  - Stops Deterioration of Host Pipe
  - Can handle groundwater, soil and surface loads.
  - Smooth interior to increase hydraulic
  - New pipe within a pipe

9

What is Cured-in-Place Pipe (CIPP)?

- CIPP is Close Fit Lining
- Flexible tube to sustain resin impregration – "tight fit"

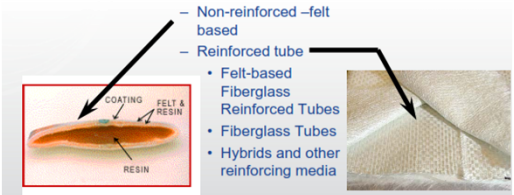


10

What is Cured-in-Place Pipe (CIPP)?

CIPP Product Variations – Tube Construction

- Lining tube variations
  - Non-reinforced –felt based
  - Reinforced tube
    - Felt-based Fiberglass Reinforced Tubes
    - Fiberglass Tubes
    - Hybrids and other reinforcing media



11

Type of Tubes

CIPP Liners are Primarily Comprised of:

1. Felt Tube
2. Thermoset Resin
3. Coating

Gravity Sewer Systems

- Primary Concern: Buckling from External Loading
- Polyester Resin / Standard Felt
- Felt has minimal contribution to cured physical properties

Emphasis on Resin

Pressure Pipe Systems

- Primary Concerns: External Loading AND Internal (Tensile) Stresses
- Epoxy or Vinyl Ester Resins
- Felt Tube Reinforced with Fibers

Emphasis on Resin AND Tube

12

CIPP Benefits

- Eliminate infiltration and exfiltration
- Prevent sinkholes and surface settlement
- Eliminate joints, root intrusion and leaks
- Restore full structural integrity
- Suitable for irregularly shaped pipes and changes in pipe diameter
- Increase flow capacity
- Protect pipes from corrosion
- Minimal traffic disruption
- Affordability vs. Open Cut
- Installation Flexibility

13

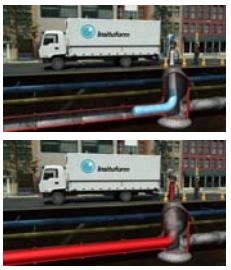
Curied-in Place Pipe – Installation Gravity

CIPP 101

14

Basic Gravity CIPP Installation Overview

- Thermosetting resin is injected into a felt tube (impregnation)
- The tube is inserted into an existing host pipeline by either pull-in or inversion (water/air)
- The tube is inflated to the size of the host pipe
- The CIPP tube is cured using hot water, steam, or UV light
- Ends are cut and the final product is a fully-functional fully-structural pipe-within-a-pipe



15

CIPP Video – Large Diameter Installation (Gravity)

16

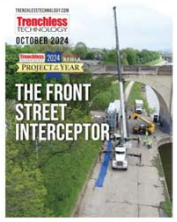
Basic Installation Steps

- Flow Control
- Cleaning & Pre-CCTV
- Liner Installation
- Curing
- Cut ends
- Lateral Reinstatement
- Post-CCTV

17

Case Studies – Front Street Interceptor (HarrisBurg, PA)

- Project: Relining 3 Miles of 113 year old Concrete Box Arch Pipe
- Located: Susquehanna Riverfront Park – 20 MGD
- First project to use a New ASCE standard for non-circular pipe design.
- 28 Wet outs, 1000 LF, 725,000 lbs of rein used. $18 million project



18

Case Studies – Front Street Interceptor (Harrisburg, PA)

- Project Details: Conveys flow for Half of the City. Never Undergone rehabilitation
- Sever Deterioration: Exposed rebar, cracks losses along its 140000 LF alignment.
- Bypass Ran
- In the heart of Harrisburg
- 2024 Trenchless Technology Rehabilitation Project of the Year

19

Insituform CIPP Technical Envelope - Gravity

Diameter Range	6 to 120 inches
pH Range	.5 to 10.5
Effluent Temperature	Up to 140°
Fully Deteriorated Pipe Condition	Yes
Partially Deteriorated Pipe Condition	Yes
Bends	Yes
Offset Joints	Yes
Diameter Changes	Yes, without manhole access
Thickness Changes	Yes, without manhole access
Typical Shot Length	200 ft. to 1,000 ft.
Host Pipe Shape	All Shapes
Host Pipe Material	All Materials

20

Curied-in Place Pipe – Pressure Applications

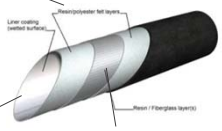
CIPP 101

21

Pressure Pipe CIPP 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)

Hazen-Williams Coefficient
- C=140

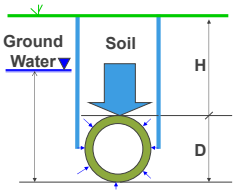


PP/TPU coating
- Water contact surface
- Coating also provides water barrier for installation processes & handling

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

22

CIPP Design Parameters



Custom design for each project, not a one size fits most with closest fit!

- **ASTM F1216 / AWWA M28**
  - Equations in Appendix X
  - Function of …
    1. *External Loading*
       - Soil
       - Groundwater
       - Traffic, Rail, etc.
    2. *Internal Pressure*
       - Operating
       - Transient
    3. *Ovality, Bends, Services*
    4. *Chemical Resistance*

23

InsituMain® CIPP installation



Step 1:
If required, setup a temporary water bypass and excavate pits to provide access to the existing pipeline.

Clean the pipeline and inspect using closed circuit TV (CCTV) in order to ensure the host pipe is free of any potential hazards.

Step 2:
Install the InsituMain® liner into the host pipe using:
- Air (steam cure)
- Water (water cure)
- Pull-in (steam cure)

After curing, the pipe is cooled and the ends are cut.

Following hydrostatic pressure testing, post-installation CCTV inspections are also completed.

Step 3:
Reinstate service connections (if present) and/or reconnect lined sections to the existing system using standard pipe fittings.

Finally, restore excavation pits and remove temporary bypass, if applicable.

24

CIPP terminations and pipeline reconnections utilizing

EndConnect®

25

Liner Terminations – Two Schools of Thought

26

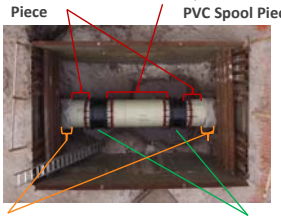
End Termination - Adhesive

1. End prepared prior to lining
   - SSPC-SP7 / NACE 4
2. Resin application
   - Acts as a bonding agent between liner and host pipe
3. CIPP liner installation / curing
4. Liner cut flush with existing pipe
5. Mechanical fittings connected to existing host pipe for closure

** This process relies solely on the integrity of the host pipe (long term) in order to maintain water tightness*


27

EndConnect® Mechanical Termination & Closure



1. Precast Termination Spool composite pipe
   - Interior abraded and primed with bonding agent
   - CIPP inserted through FRP and cured to obtain a watertight bond
2. Eliminates need to connect back to the host pipe
3. Promotes the use of standard mechanical joint fittings

28

EndConnect® Mechanical Closure


29

EndConnect® Mechanical Closure



30

Flexibility with Closure Spool Piece


31

Mechanical Service Reinstatement for Potable Water

Service Connections

32

Service Connections – Three Schools of Thought

Excavated – Involves open-cut excavation and installation of new mechanical connections at each service.

Adhesive – Plug and drill method whereby liner adheres to host pipe and service corporation

Mechanical – Utilizing a robot to mechanically reinstate the service corporation.

33

Service Connections – Adhesive

- **Step 1 –** Intense cleaning to prepare pipe surface for resin
- **Step 2 –** Plugging of existing service connection
- **Step 3 –** Locating of the existing service (after lining)
- **Step 4 –** Reinstatement of the existing service (via drilling)

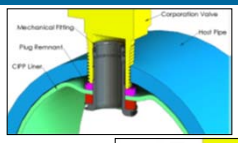
**** This process relies solely on the integrity of the host pipe (long term) in order to maintain water tightness***



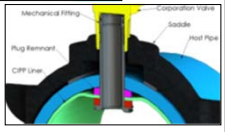
34

Service Connections – 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)



Direct Tap Service



Saddled Tap Service

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

35

Notable Pressure Pipe Rehabilitation

CIPP Case Studies

36

InsituMain® Pressure CIPP Installations




37

Pressure Testing – ASTM F1216

ASTM F1216-16

…recommended pressure and leakage test would be at twice the known working pressure or at the working pressure plus 50 psi, whichever is less.



38

Notable Project List

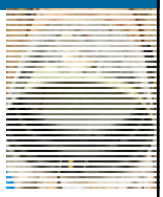
Since 2005,

Over 500,000 LF of pressure rated rehabilitation

- 40,000 LF of medium to large potable CIPP
- 289,000 LF of medium to large non-potable CIPP

Recent Project List

- 1,900 LF of 16" AC Water Main- NJ
- 3,379 LF of 30" DI Water Main- IL
- 500 LF of 48" PCCP, UT
- 1,147 LF of 12" DI Water Main- MD
- 4,000 LF of 8" Water Main- NJ
- 2,861 LF of 10" CI Water Main- Canada




39

CIPP Lining – Scenic Drive Upper Conduit, UT

Project Description

- *Owner:* Salt Lake City, UT
- *Pipe Material:* PCCP
- *Diameter:* 48-inch
- *Length:* 560 LF
- *Pressure:* 60 psi
- *Type:* Potable Water

Problem Statement

- Gravity pipe required jointless, pressure-rated rehabilitation product
- Leakage at intermediate manhole
- High social costs to open cut pipe
- Short construction window




40

Pilot Project – Pleasant Grove, UT

Project Description

- *Owner:* Pleasant Grove City, UT
- *Pipe Material:* Ductile Iron
- *Diameter:* 8-inch
- *Depth of Cover:* 8 feet
- *Length:* 540 LF
- *Pressure:* 120 psi
- *Type:* Potable water
- *Services:* Ten one-inch service connections

Problem Statement

- Historical breaks and leaks
- Pipe sloped downhill to from Pit 1 to Pit 3


41

Pilot Project – Pleasant Grove, UT

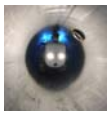
Portable Water Bypass

CIPP Liner Installation

Service Reinstatement

Milling of Direct Tap

Service Plug



Service Reinstatement

42

Case Histories - West Palm Beach Force Main

- Owner: City of West Palm Beach, FL
- Pipe Type: Sanitary Sewer
  - Material/Dia: 48" PCCP
  - Length: 5,700 LF
  - Pressure: 25 psi operating; 55 psi test
  - AWWA Class IV
- Deteriorated force main that ran underneath country club & condo building, and along canal/high end residential properties
- Why CIPP vs. other options?
  - Minimal diameter reduction
    - CIPP Design Thickness of 18mm (or 0.71") x 2 is less than 1.5" diameter loss on 48" host (3% reduction)

Trenchless Technology — Road Worthy Project of the Year

43

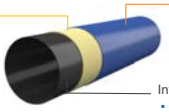
FFRP Lining

44

Added value through a proven and reliable system

The system consists of a flexible high pressure Liner…

Kevlar®
- Seamless, woven aramid fibers
- Absorption of insertion forces
- Accommodates the operating pressure independently of host pipe support



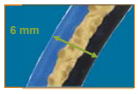
External Layer
- Abrasion resistant PE
- Protection of the fabric during insertion

Internal Layer
- Fluid specific based on PE or TPU
- Seals inner layer against the fluid
- ANSI/NSF 61 approved

Key advantages:

Flexibility and long insertion length:

High fabric strength with small wall thickness:



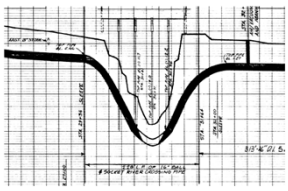
Bendability up to 45 degree (r=1.5xD):

45

Primus Line Applications

- Multiple Bends
- High Thermal Expansion/Contraction
- Utility Conflicts
- Crossings
  - Street
  - Bridge Mounted
  - Aerial
  - Railroad
  - Canals & Rivers (Subaqueous)
- "Weird Stuff"

Addressing:
- Leaking pipelines
- Failing joints



46

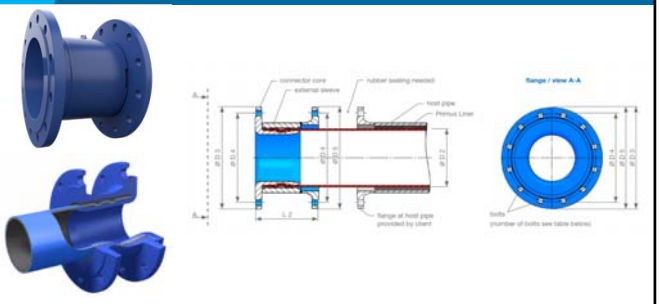
Installation Procedure & Project Layout

- No Pipe Laydown Area
- Line Long Lengths through Multiple Bends
- Simple Slipline Installation Procedure

Typical installs 1,000 – 2,000 LF

47

End Connection Installation Low Pressure



48

Installation Process

49

Final End Connection – High Pressure

50

FFRP Lining – Corteva, Midland, MI

Project Description

- *Pipe Material:* Cast Iron
- *Diameter:* 14-inch
- *Length:* ~2100 LF
- *Pressure:* 40 psi, 80 psi surge
- *Type:* Potable Water

Problem Statement

- Cast iron is structurally sound but joints were leaking.
- Multiple bends - 22s and 45s within each installation.
- Installation in plant and under roadway

51

FFRP Lining – Houston, TX

Project Description

- *Pipe Material:* Ductile Iron
- *Diameter: 6*-inch
- *Length:* ~16,000 LF
- *Pressure: Low to medium Pressure*
- *Type: Force Mains*

Problem Statement

- FM to be rehabilitated multiple 45's and 90's bends.
- Cost savings $1.5 million, several pulls over 4,000 LF and 3,000 Feet

52

FFRP Lining – Kansas City, KS

Project Description

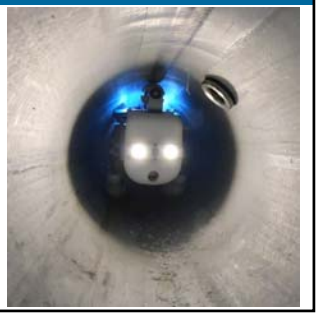
- *Pipe Material:* PCCP
- *Diameter:* 24-inch
- *Length:* ~1890 LF
- *Pressure:* 128 psi (Pressure Test)
- *Type:* Potable Water

Problem Statement

- Lining an Existing PCCP pipe under a new road that was recently paved.
- Multiple bends – 90s and 2-45s
- One Pull over 3 days. Client saved over $1 million dollars

53

Conclusion



54

Conclusion for Pressure CIPP & FFRP

CIPP	FFRP
Wide Range of Options for Rehabilitation	Wide Range of Options for Rehabilitation
If Social Costs could be an excellent fit	If Social Costs could be an excellent fit
Each design is custom for CIPP Pressure	Fast Installation, takes a few Days.
Minimal Disruption, projects take weeks not months	Keeping Existing ROW and can eliminate needs to acquire easements
Keeping Existing ROW and can eliminate needs to acquire easements	Extremely Durable resistantly project for those “weird” rehabilitation projects.

55

Thank you for your time! Any questions?

Brian Goad, PE
Regional Director of Pressure Pipe
Insituform
832-883-3270
bgoad@azuria.com

56