Seeing the Light: Practical Approaches to UV-Cured & Reinforced CIPP Lining Design

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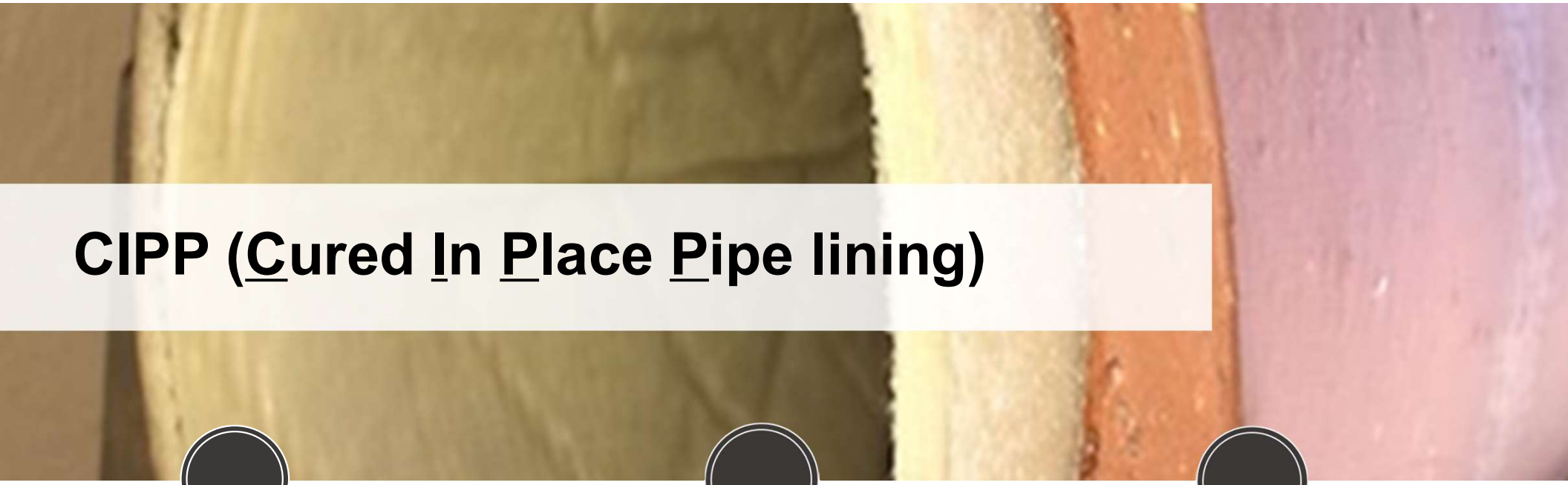
CIPP lining is one of the most common and reliable trenchless pipe rehabilitation methodologies



CIPP (Cured In Place Pipe lining)

Lining of different pipe types, configurations and alignments are possible

Diameter range of 6” to 120”+ for mainline pipes and can be used for gravity and pressure applications

Installation lengths up to 1,000 LF+ can be achieved and can provide fully structural pipe rehabilitation

CIPP Lining – A reliable & highly versatile trenchless rehabilitation technology!

- Needle Felt or Glass Reinforced
- Thermoset resin (polyester, vinyl ester, epoxy)
- Steam & hot water cure is typical for felt lining
- UV-light curing is typical for Glass Reinforced
- Typical flex modulus for felt = 250,000 psi
- Typical flex modulus for UV = 1,000,000+ psi
- Sewer, storm, raw water and potable water applications
- Fully structural design or partially deteriorated design
- Factory or in-field wet out options available

CIPP Lining – Curing & Installation Method Differences

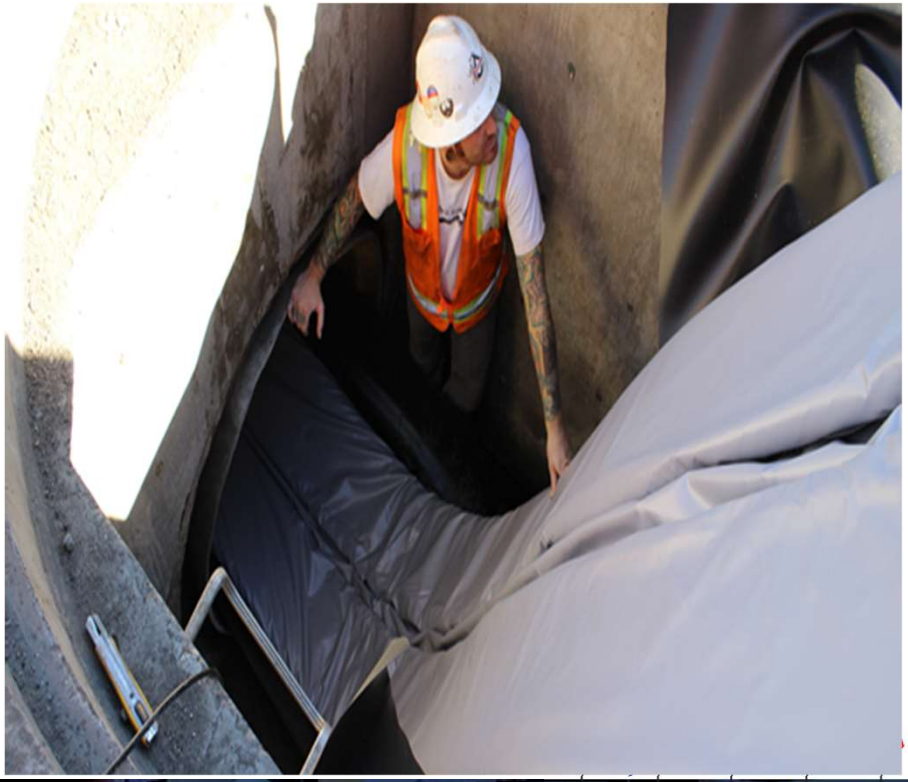
Inversion

Thermal curing is most common

- Hot water (slowest)
- Steam (faster)
  Typically used for unreinforced felt liners
- Liner is inverted into place within host pipe

CIPP Lining – Curing & Installation Method Differences

Pull-in-place



UV-light curing is becoming more common

- UV light methods (fastest)
  - *Typically used for fiberglass reinforced liners*
  - *Steam can be used for glass reinforced too*
- Liners are pulled or winched into place

CIPP Manufacturing and Resin Impregnation:

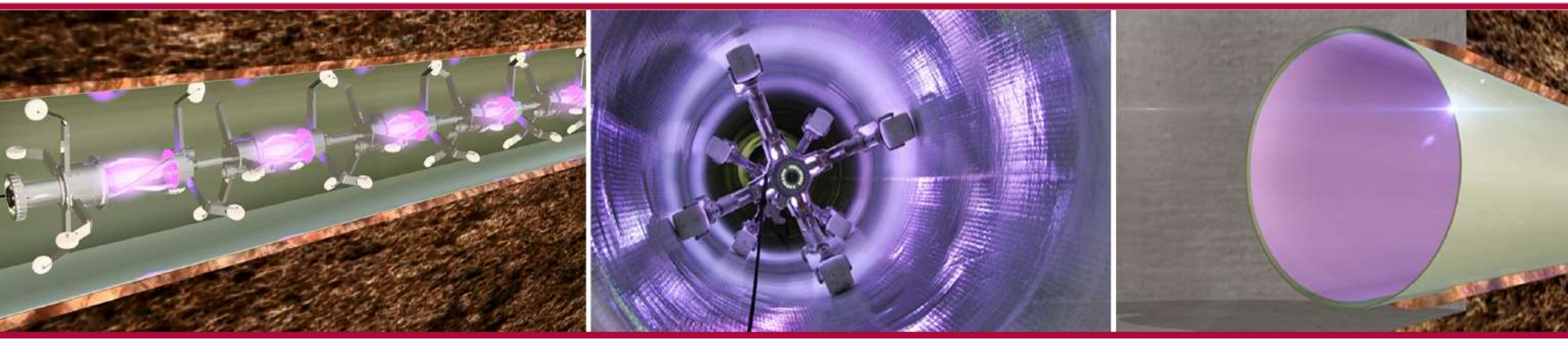
- **Polyester resins**
  (most common & lowest cost – good for most applications)
- **Vinylester resin for more aggressive environments**
- **Styrene-free epoxy formulations**
- **NSF-61 certified resins for potable water applications**

Wet out method often driven by shipping weight and diameter restrictions. Large diameter, longer CIPP liners need to sometimes be wet out in the field

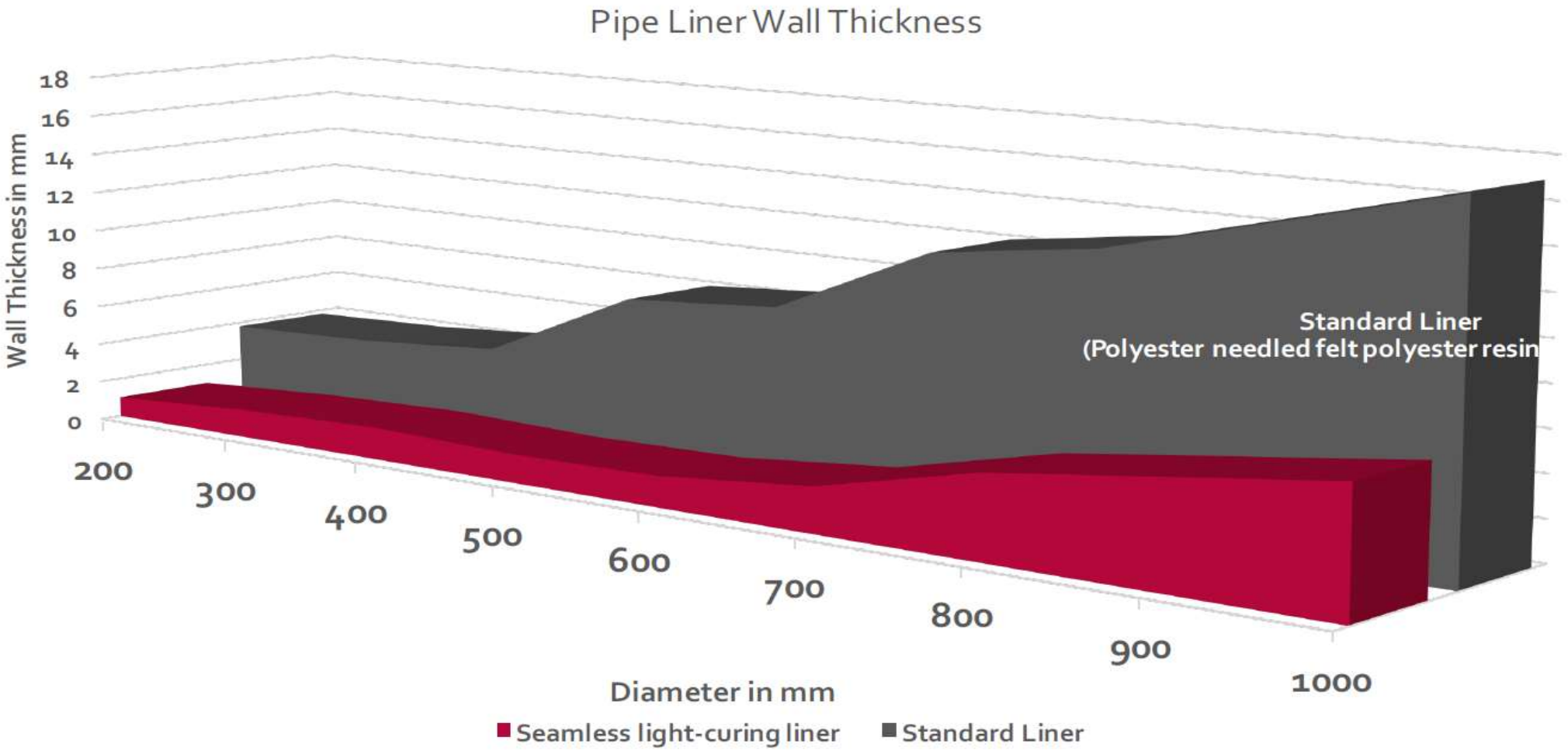
Specify ISO-9001 Quality Control Requirements

UV-Cured Glass-Reinforced CIPP Lining Advantages

- Excellent performance in wet pipe and infiltration conditions
- Outer protective bladder prevents exposure to UV-light and helps contain styrene
- Computer controlled curing process
- Thinner liner design; higher strength material properties
- Pre-inspection capabilities, extra CCTV inspection, smaller installation footprint
- Long shelf life and extended storage advantages



UV-cured & Glass-Reinforced CIPP vs Standard Felt CIPP: Liner Thickness Comparison



CIPP Project Planning – Key Steps Prior to Installation

1.
Initial cleaning of the pipe to be lined

2.
Perform a CCTV inspection of the pipe to be lined

3.
Take good measurements within the pipe & on the surface (inverts, diameters)

4.
Liner selection and design thickness calculations, prepare installation plan

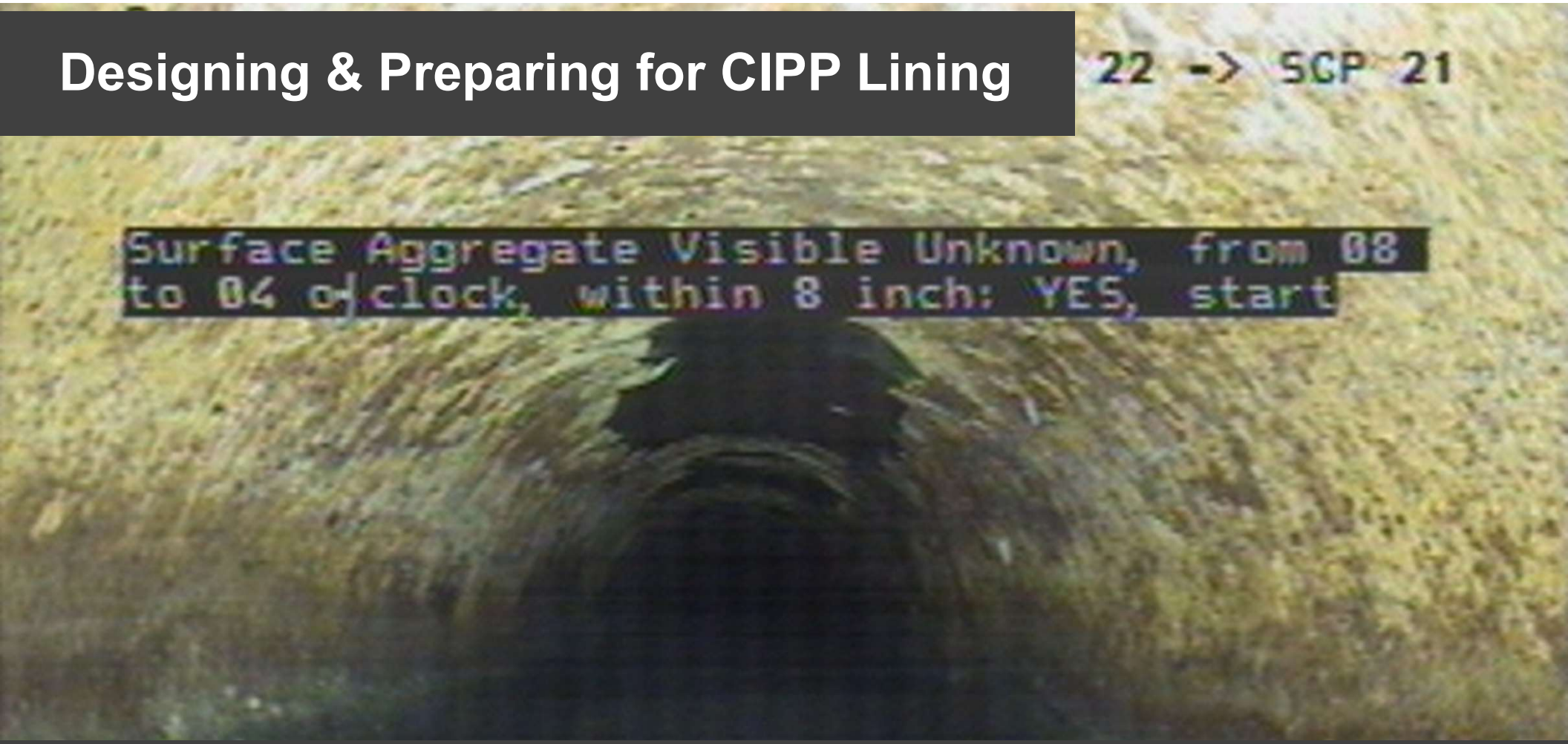
5.
Liner order is placed. For UV-CIPP, all liners for project can be ordered at once (6 month+ shelf life)

6.
Site considerations: Prepare traffic control plan, bypass plan, notification plan & site access plan

7.
Liner delivered to site. Remove protrusions, debris and perform final cleaning, pre-installation CCTV before lining

8.
Inspect liner, establish bypass, setup equipment, and begin lining installation process

Designing & Preparing for CIPP Lining

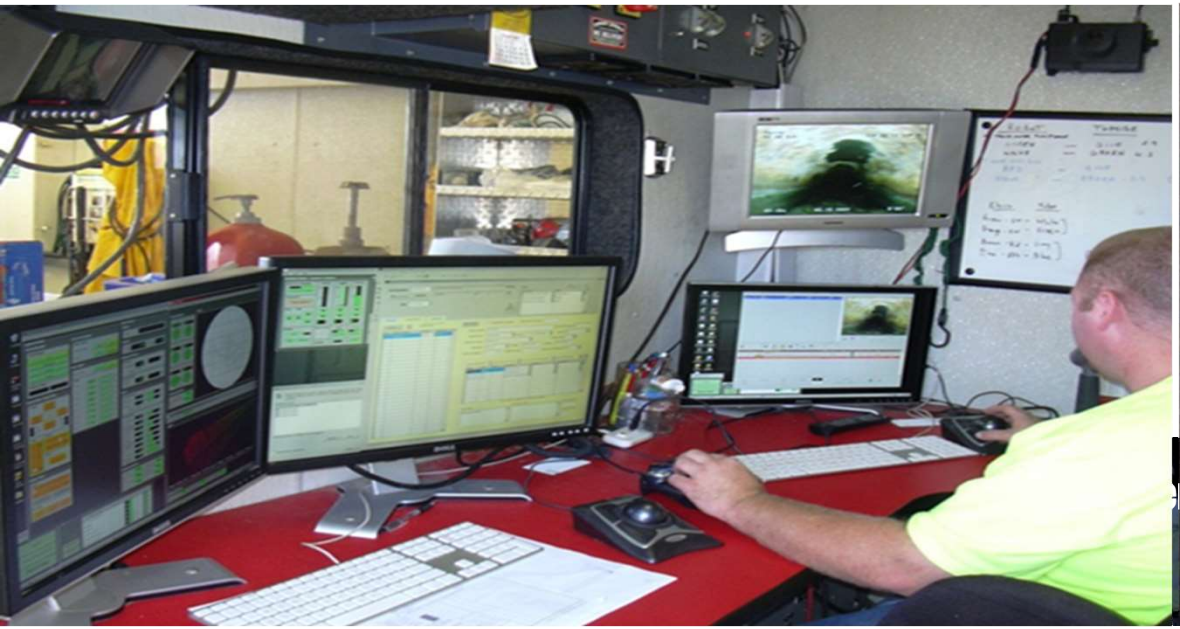


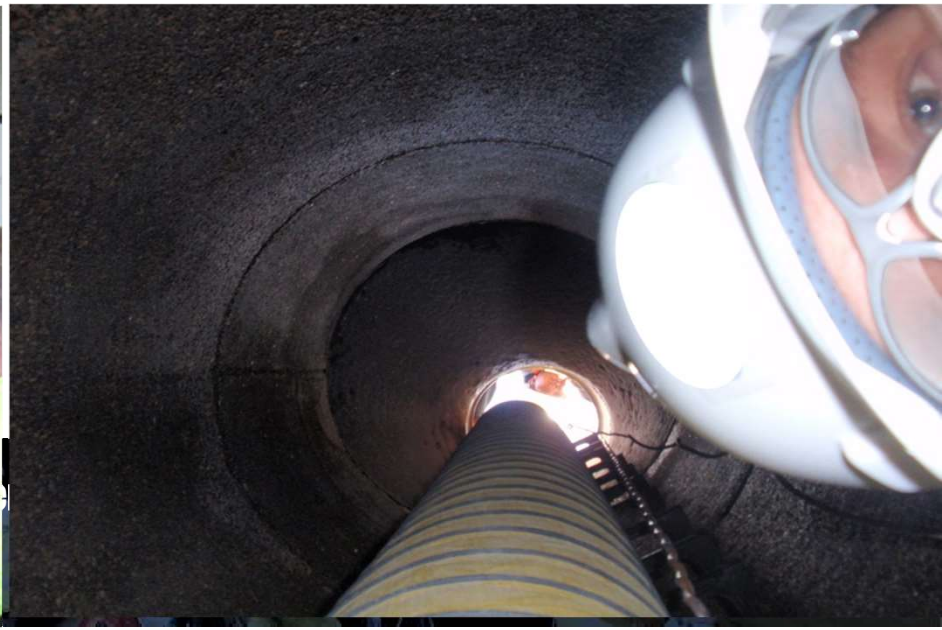
CCTV inspection is an integral part of the CIPP lining & design process.

Work with Good Inspection Information

Inspection and condition assessment information is only as good as the expertise of the people doing the actual inspection work and subsequent data assessment.

Proper training, experience & safety is essential!





CIPP Lining – Design Considerations

Stand alone lining system design can resist hydrostatic loading, traffic loads, soil loads and other live loading conditions

Structural design assumptions for host pipe.

- Fully deteriorated condition
- Partially deteriorated condition

Typically designed with 2x safety factor

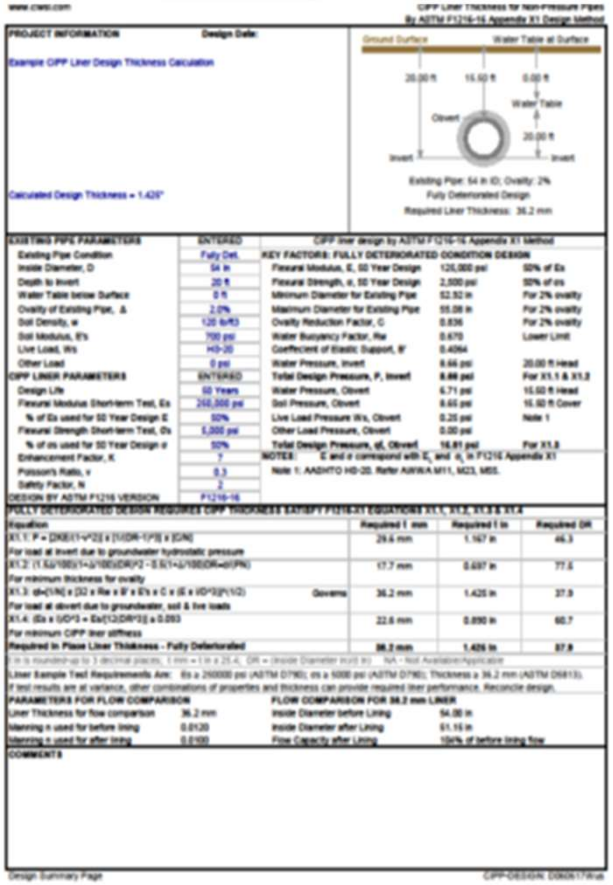
Tight fit. Does not rely on bond to host pipe

- CIPP reduces, but typically doesn't eliminate infiltration issues on its own

CIPP liner design basics

ASTM F1216 is the most familiar CIPP design method used to determine minimum liner thickness

- Flexural modulus (per ASTM D790) = Main driver in design thickness
  - 250,000 psi min for felt liners
  - 1,000,000+ psi min for reinforced liners (UV)
  - Make sure flexural strength is at least 5,000 psi
- ASTM D2990 reduction factor of 50% typical for felt lining design. Often too conservative for reinforced CIPP liners
- Ground water table level, partial vs fully deteriorated conditions, ovality & traffic loads are critical considerations
- ASTM F1216 Appendix X1.1 – X1.4
- Require design to be stamped by PE



Reinforced CIPP liner design methodologies

- ASTM F2019 specified for UV cured CIPP liners
- ASTM F1743 specified for pull-in-place CIPP liners
- ASCE MOP 145 and Modified Glock Equation Design Method for gravity pipes
  - *Now referenced in ASTM F2019*
- ASCE method can be better suited to account for differences in reinforced liners and results in a less overly conservative design & non-circular shapes
- ASTM F1216 can have DR=100 restriction built into it. OK for felt liners, often too conservative for reinforced liners.
- Do not use ASTM F1216 for non-circular designs

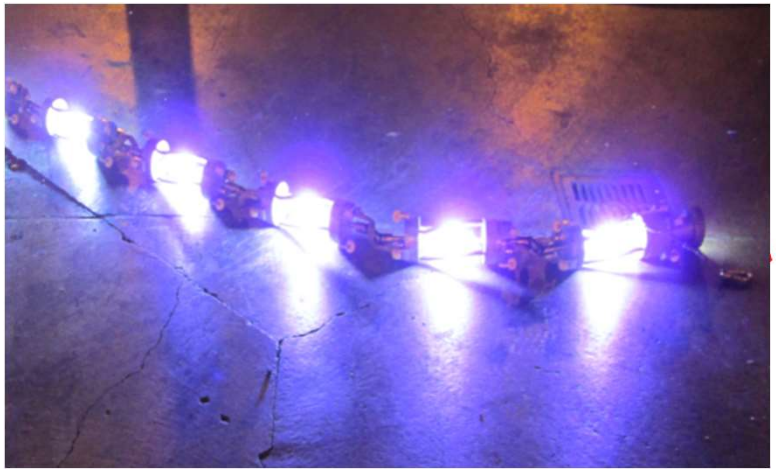
Typical UV-cured & Reinforced CIPP Material Properties

UV Liner Product Example #1:

- 2,300,000 PSI Modulus of Elasticity Short Term
- 30,000 PSI Tensile Strength Short Term
- 6”-64” pipe diameter
- Thicknesses range from 3 mm to 13 mm

UV Liner Product Example #2:

- 1,015,000 PSI Modulus of Elasticity Short Term
- 15,000 PSI Tensile Strength Short Term
- 6”-15” pipe diameter
- Thicknesses range from 3 mm to 5 mm



Remember! Modulus of Elasticity is a primary driver in liner wall thickness design. Compared to unreinforced felt CIPP, reinforced CIPP liners are significantly thinner.

Do's and Don'ts of UV & Reinforced CIPP Design

More conservative is not better! The right design is better

- Do use a reasonable creep reduction factor as recommended by manufacturer
- Do use realistic ground water levels, live-loading, safety factors, soil conditions

- Do Not use an overly conservative reduction factor
- Use ASTM F2019 and/or ASCE MOP 145 for UV and reinforced liner design. ASTM F1216, although easy to use, is overly conservative and should not be used for odd shaped pipes
- Do Not use prescribed CIPP liner thicknesses

More Do's & Don'ts for UV & Reinforced CIPP Lining

- Do allow for pre-liners, slip sheets and over-expansion sleeves
- Do use CIPP, chemical grout & lateral rehab materials together as a ***system*** to stop infiltration – holistic rehabilitation approach
- Do make sure the correct UV-light curing equipment is going to be used
    - UV wavelength and light strength matters. Must be compatible with CIPP liner. UV light must be able to fully penetrate liner to cure correctly
- Do use appropriate design criteria for project site & correct measured liner properties
- Do use real-time cure monitoring wires for all CIPP installations
- Do require ISO-9001 certification for CIPP liner manufacturers
- Do Not forget to specify minimum installer experience requirements

What about styrene issues?

Resin is contained within the reinforced UV-cured CIPP lining matrix because of outer bladder and inner film, which keeps styrene mostly confined to within the liner

Styrene is a frequent source of odor complaints

Studies to determine effects on human health are being conducted (NIOSH, NASSCO, etc)

Complete curing of liner and good contractor housekeeping during installation is important

Potentially hazardous to aquatic life and treatment plant processes in larger concentrations (heat?)

Outside bladder also prevents resin emulsification

What about CIPP Pressure Pipe Applications?

- Fast-growing segment
- Notable advances, but small market share vs. gravity lining
- Reinforced liners; must be able to resist internal loading
- More technically challenging & more expensive
- Design methods evolving for pressure lining; not as clear or defined as for gravity CIPP applications
- AWWA M28 liner structural classifications reference

Utilize UV-cured & reinforced CIPP liner manufacturer pre-design services whenever possible

CIPP Lining Final Inspection: What to look out for…

Post-installation CCTV inspection

Potential defects include:

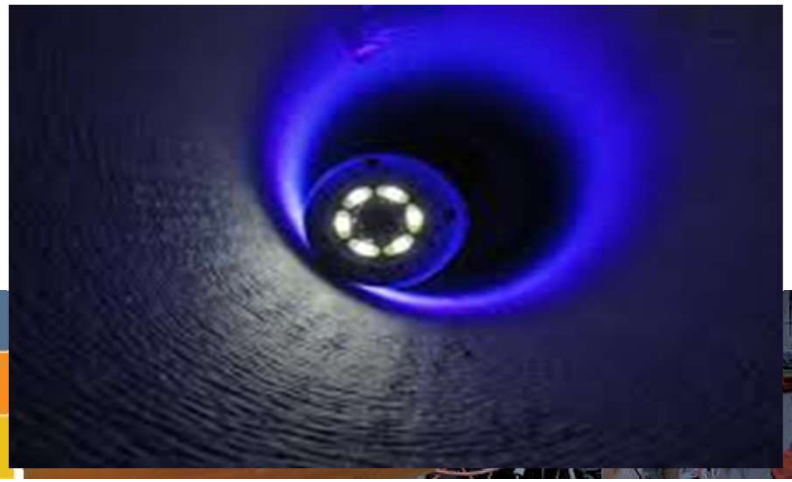
- Wrinkles and fins
- Dry spots
- Buckling
- Alignment issues
- Resin slugs
- Signs of incomplete curing
- Proper connection reinstatement (min 95%)
- Termination issues

QA/QC Testing Critical for Every CIPP Lining Application

- Laboratory testing of actual liner samples
- Test & verify flexural modulus and flexural strength properties (ASTM D790)
- Installed liner thickness verification
- Back-check of liner design calculations
- CIPP submittal review – everything installed per specification requirements?

UV-Cured CIPP Liner Final Product – Looking Good!

CIPP & Other Trenchless Pipe Rehabilitation Technologies will Continue to Rapidly Advance



- Additional breakthroughs are expected
- Systems and contractors will become more readily available and more capable
- Advancement of design methodologies
- CIPP will continue to provide a best value trenchless rehabilitation solution
- Trenchless industry outlook is bright

Questions?

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