

CIPP for Large Diameter Pressure Pipes

Water Research Foundation
Large Diameter Pipe Rehabilitation Seminar

20 January 2016

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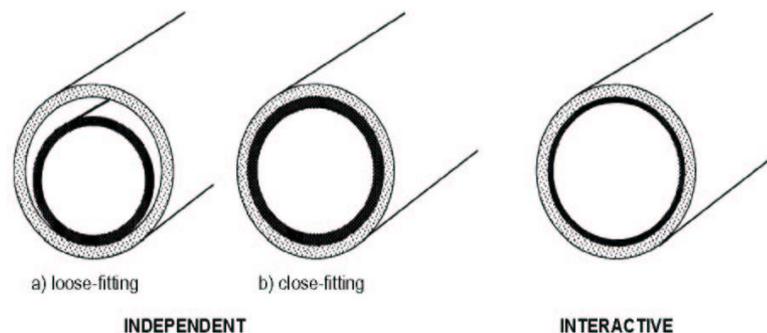
Pressure Pipe Lining – What Does it Mean? What is It?

- No logical global definition of what constitutes a fully structural liner
- AWWA M28
 - Long-term burst must be greater than Maximum Allowable Operating Pressure
 - Liner must survive loads of sudden failure of host pipe due to internal loads
 - Equivalent to new pipe, but may not be designed to meet same requirements for external buckling or longitudinal bending
- ASTM F1216
 - Developed for felt based gravity systems
 - Doesn't recognize superior performance achieved by glass or carbon fiber materials
 - Doesn't consider transient pressure or vacuum
- Standards are sometimes used to conveniently demonstrate compliance

Pressure Pipe Liner Basics – Structural Classification

- Non-structural repairs
 - Repairs that arrest the deterioration process
- Semi-structural repairs
 - Interactive liners with the host pipe
- Structural repairs
 - Independent liners

LINER CHARACTERISTICS	NON-STRUCTURAL	SEMI-STRUCTURAL		FULLY STRUCTURAL
	CLASS I	CLASS II	CLASS III	CLASS IV
INTERNAL CORROSION BARRIER	YES	YES	YES	YES
BRIDGES HOLES/GAPS AT PIPE OPERATING PRESSURE	NO	YES	YES	YES
INHERENT RING STIFFNESS	NO (depends on adhesion)	NO (depends on adhesion)	YES*	YES*
LONG-TERM INDEPENDENT PRESSURE RATING \geq PIPE OPERATING PRESSURE	NO	NO	NO	YES
SURVIVES "BURST" FAILURE OF HOST PIPE	NO	NO	NO	YES



ASTM F1216 – the Current Design Process or Bible

- First introduced in 1989
- With provision for gravity and pressure pipe loading applications, it provides a design approach for un-bonded close fit liners with checks for:
 - Non-pressure
 - Buckling due to hydrostatic loads limited by stiffness
 - Hydrostatic loads limited by flexural strength
 - Buckling loads due to earth/live loads
 - Pressure
 - Hole spanning (interactive design)
 - Full hoop stress (independent design)
 - Standard has a minimum stiffness requirement

Comparing ASTM F1216 with other Design Standards

<i>Design Assumption</i>	<i>ASTM F1216</i>	<i>ASME PCC-2</i>	<i>ASME N-589</i>	<i>ASME B31.1</i>	<i>AWWA PCCP Draft</i>
<i>Hoop Design</i>					
-Working Pressure	X	X		X	X
-Transient Pressure		X	X	X	X
-Vacuum Pressure		X	X	X	X
-Traffic Loads	X	X	X	X	X
-Soil Loads	X	X	X	X	X
-Ovality	X		X	X	X
-Deflection Limits				X	X
-Combined Loading				X	X
<i>Longitudinal Design</i>					
-Poisson's Effect			X	X	X
-Temperature Effect		X	X	X	X
-Thrust Effect		X		X	X
<i>Design</i>	ASD	ASD	ASD	ASD	LFRD

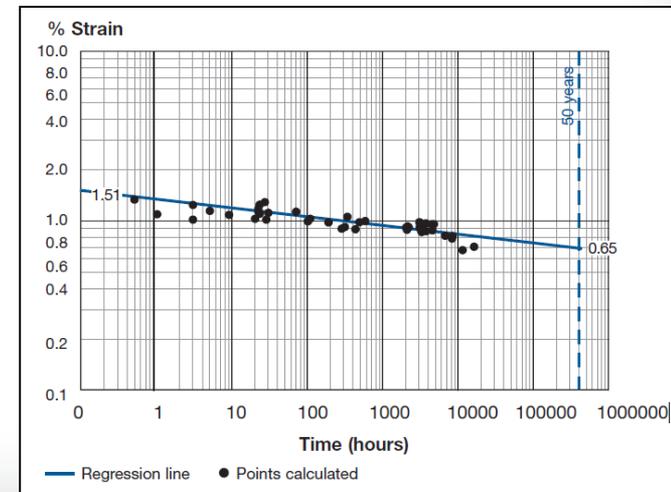
Some of the design considerations omitted in F1216 are added in comprehensive specs

What Do We Expect from a Fully Structural Pressure Pipe Liner?

- Pressure capability to meet Maximum Allowable Operating Pressure (MAOP)
 - With reasonable Factor of Safety, based on material properties and burst strength
 - For glass fiber reinforcing with epoxy resins, 50% properties retention is common
 - Typical municipal distribution system specifications require 150 psi design pressure
 - Transmission applications may require higher pressure
 - Project specifications often require consideration of surge and vacuum
- Survive failure of the host pipe from internal or externally induced loads
- Carry external loads
- Minimize thickness, lessen impact on flow capacity

Validating Pressure Pipe Liners

- AWWA Subcommittee proposing guidelines, focus on smaller diameter
- Potential Options:
 - Short term unrestrained burst test results to ASTM D1599 –Short-Time Unrestrained Hydraulic Pressure
 - with 4 x SF to establish MAOP
 - Long term testing to
 - ASTM D2992 – HDB/Pressure Class for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and fittings, or
 - ASTM D2837 – HDB for Thermoplastic Pipe Products



Large Diameter Pipes – How Can We Confirm Capability?

- Pressure testing liners to burst is costly and dangerous
 - Restrained samples not like buried pipes
 - Specialty apparatus for sample testing
 - In the field a whole new configuration
 - 24" pressure pipe with expected burst pressure = 1000 psi
 - Over 45,000 pounds force on end flange
 - Blind flange = 3" thick
- Burst can be calculated using empirical methods
 - Must be supported by sufficient testing on smaller diameters
- CLEARLY DEFINE design and operating requirements
- Logical QA system to ensure design objectives are achieved

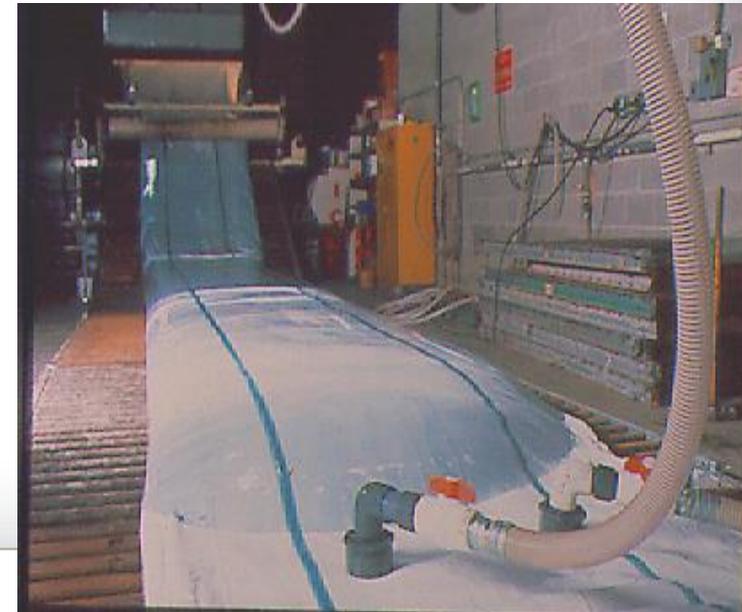


Large Diameter CIPP Pressure Pipe Liners are not New

- Small diameter systems have been in use for nearly 20 years
 - Similar materials and installation employed on large diameter
- Semi Structural, Class III
 - Mid 1990s - 60" pressure pipe at nuclear plant
 - Transfers pressure load to host pipe
 - Designed to span holes and gaps
- Fully structural, Class IV
 - 2014 - 2015
 - Daytona Beach - 8,500 ft. of 30" and 36"
 - 50 psi operating pressure, 100 psi hydrostatic test
 - Newport Beach - 16,000 ft. of 24", 30" and 36"
 - 50 psi operating pressure, 100 psi hydrostatic test
 - 2012
 - 125 ft of 72", 30 psi operating pressure
 - 400 ft. of 36", 15 psi operating pressure, converting gravity sewer to forcemain

What's Inside a CIPP Pressure Pipe Liner

- Manufacturing similar to gravity
 - 6" – 96" (+?)
 - Coating on interior of finished liner
 - Add reinforcing materials
 - Fiberglass
 - Kevlar
 - Carbon fibre
- Wetout at existing facilities
 - Resins
 - NSF/ANSI 61 certified resin for potable water applications
 - Vinyl ester for sewer forcemains



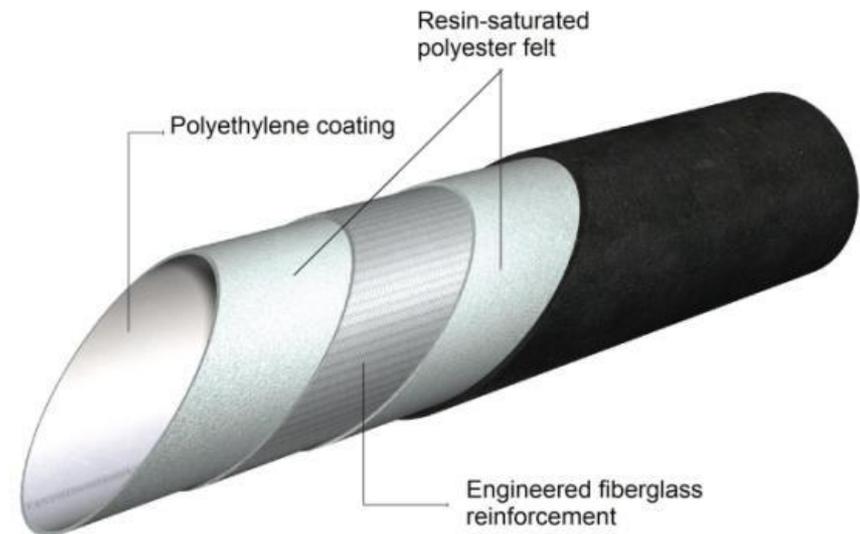
Transporting and Handling Large Diameter Liners

- Two issues in dealing with large diameter liners
- The weight of tube and resin becomes a concern
 - Ice is required to keep the liner cool, retard reaction
 - Up to 2 lb. of ice per lb. of resin
 - Transportation regulations
- Physically maneuvering tube



Historical Capabilities

- For several years MAOP of 150 psi has been available in fully structural CIPP liners
 - Pressure capability is a function of reinforcing material in laminate
 - Typically pressure rating decreases with diameter
 - 6" – 20" up to 150 psi
 - Previously 80 psi for 36"
 - Increased pressures possible with added reinforcement



Where Do We Go From Here?

- Pressure Capability
 - Revisions to reinforcing, resin and coating in 2016 expand envelope
 - 1100 psi burst test of 24" sample, with multiple layers of fiberglass
 - Offers significant increase in operating pressure rating depending on selected design principles and factor of safety
 - 320 psi burst projected for 72"
 - Number of layers of glass will determine pressure rating
- Resin
 - Systems in place that deliver physical properties
 - R&D will provide better manageability and certifications

Installation

- Small diameter approaching 1000 ft.
 - Typically up to 500 ft.
 - Water inversion or air inversion/steam cure
- Large Diameter
 - Risk assessment required – resin, transport and environment
 - Expect 300 – 500 ft. typical
 - Daytona Beach
 - 500 – 600 ft. lengths of 30”, maximum 850 ft.
 - Newport Beach
 - 700 – 900 ft. lengths of 30” and 36”, maximum 1050 ft.



Installation Considerations



Restraint at connection and corrosion protection wrap



Hydrostatic test support for 36" pipe



500 hp boiler curing 750 ft. of 30"

HDPE Rolldown for Large Diameter Pressure Pipes

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HDPE Modified Sliplining – Rolldown and Folding Systems

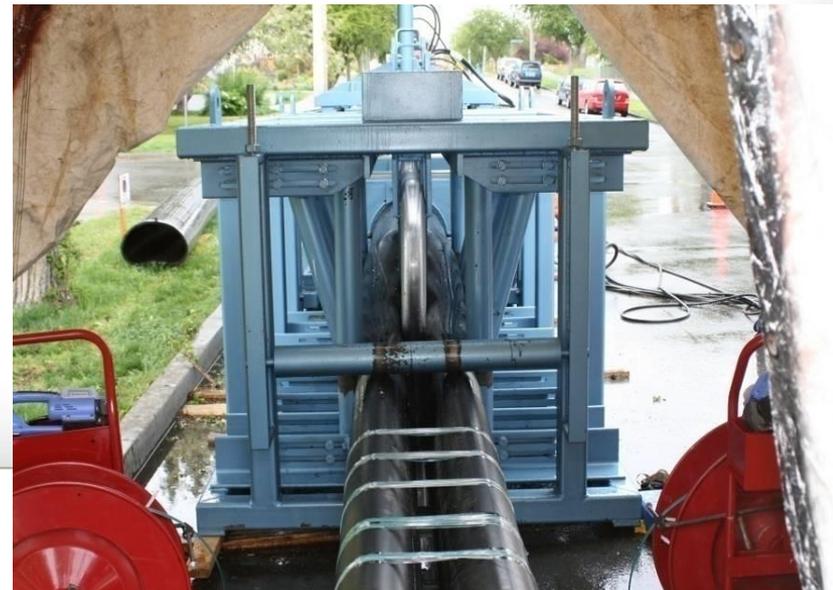
Rolldown

- Roller boxes and winch to keep tension on
- Information obtained indicates:
- Roll down systems are focused on 20” and smaller
- Can provide fully structural
- Primarily used in oil and gas industry
 - Often provide interactive liner for corrosion protection
 - Sometimes use Safety Liner, to collect
- Used in mining applications for abrasion protection
- United Pipelines has installed 52”, thin wall; as well as DR17 on 26” slurry line



Folded Pipe Systems

- Semi-structural solutions
 - Transfer pressure load to host pipe
 - Host pipe carries external loads
 - Span holes and gaps under specified pressures
 - 48" DR 50 – 10,000 ft.
 - 20" DR 26 – 26,250 ft. operating pressure 140 – 160 psi



Questions?

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