Evolution and Applicability of Pressure Pipe Rehabilitation

November 1, 2017

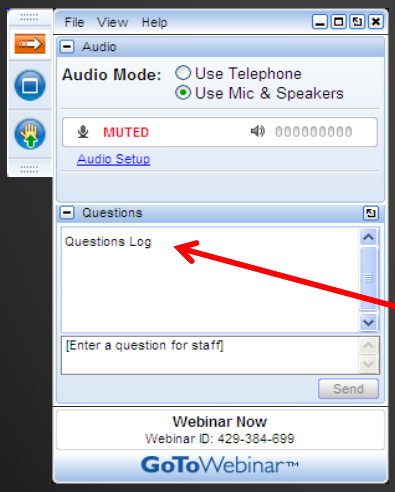
1:00 – 3:00 pm Eastern

Thanks to our webcast sponsor!

NATIONAL ASSOCIATION OF SEWER SERVICE COMPANIES
NASSCO

Water Environment Federation
the water quality people

How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

Water Environment Federation
the water quality people

Today's Moderator

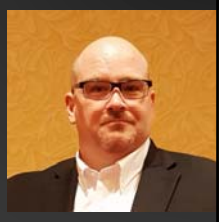
Jennifer Steffens, P.E.,
Senior Project Manager,
Pure Technologies, Inc.

Today's Speakers

John Schroeder, P.E., Vice President at CDM Smith

John Matthews, Ph.D., Director of the Trenchless Technology Center (TTC) at Louisiana Tech University

Ian Lancaster, Senior Director of Pressure Pipe, Aegion



John Moody, Director of Sales-USA, Primus Line Inc.

John P. Schroeder, P.E., BCEE

- National Pipeline Assessment and Rehabilitation Specialist
- 25 Years Experience with CDM Smith
- Columbus, Ohio
- B.S University of Cincinnati, Civil/Environmental Engineering

CDM Smith

Water Environment Federation the water quality people

Pressure Pipe Prioritization and Assessment

What pipe should we inspect ?
How should we inspect ?
When should we inspect ?
What Data do we need?
How much will the data cost?
What do we do with the data?

Water Environment Federation the water quality people

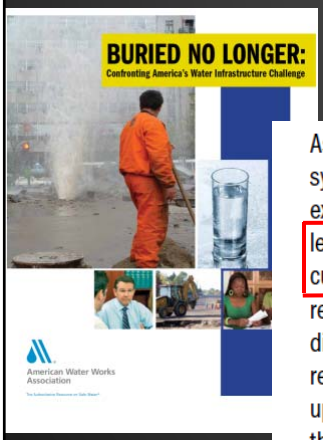
Agenda

1. Why are pipeline inspections Important?
2. RISK = Consequence of Failure x Probability of Failure
3. Failure Trends
4. Components of Condition Assessment Programs

–

Why is This Important?

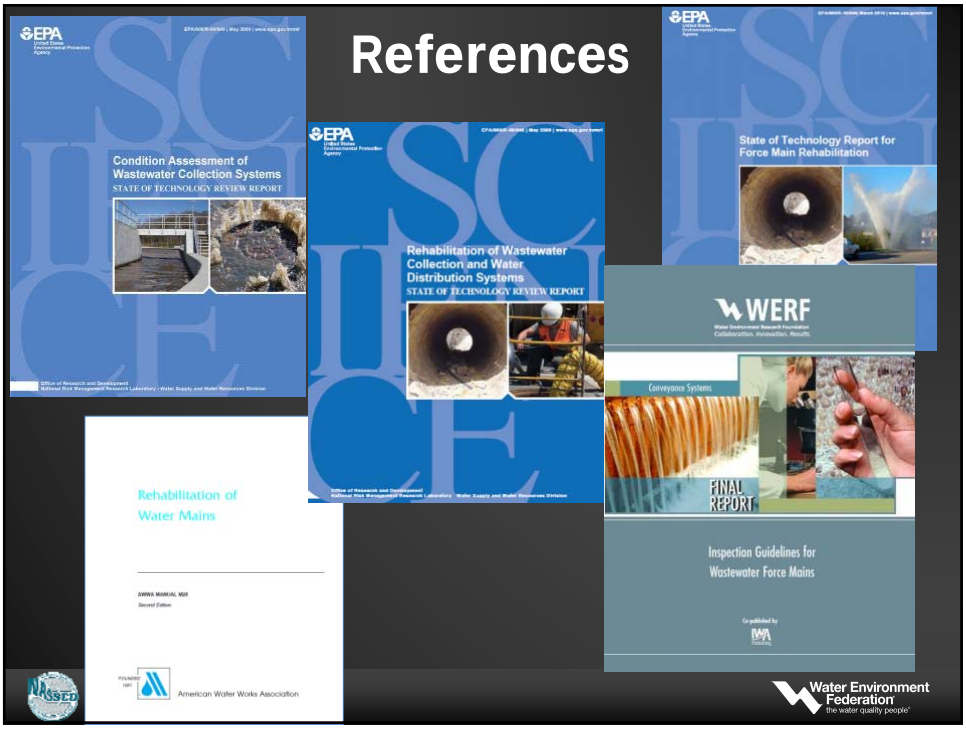
A Wake-Up Call To All Utilities



As documented in this report, restoring existing water systems as they reach the end of their useful lives and expanding them to serve a growing population will cost at least $1 trillion over the next 25 years, if we are to maintain current levels of water service. Delaying the investment can result in degrading water service, increasing water service disruptions, and increasing expenditures for emergency repairs. Ultimately we will have to face the need to "catch up" with past deferred investments, and the more we delay the harder the job will be when the day of reckoning comes.

Water Environment Federation
the water quality people

References

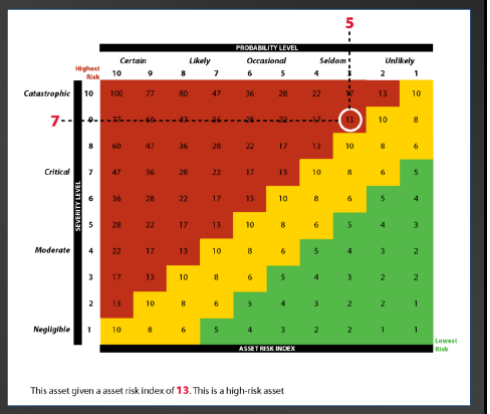


Water Environment Federation
the water quality people

Evaluate Risk of Failure

Risk = Prob. of Failure(POF) x Consequence of Failure (COF)

- Many utilities fixate on probability of failure, but neglect the consequences
- Triple Bottom Line Consequence criteria are important
  - Financial Cost $$$
  - Public
  - Environment



Risk Matrix

Risk Allocation Matrix

Likelihood Score	Consequence Score: < 50	50 - 75	76 - 100
76 - 100	Medium	High	High
50 - 75	Low	Medium	High
< 50	Low	Low	Medium

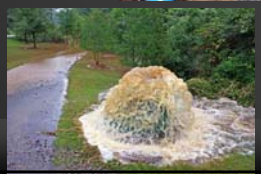
Consequence Pipe Failure/ Triple Bottom Line

PUBLIC
- Traffic Delays
- Health and Safety
- Customer Loss of Service

FINANCIAL
- Emergency Personnel
- Constr. Replacement Costs
- Bypass Pumping
- Commercial Losses
- EPA Fines

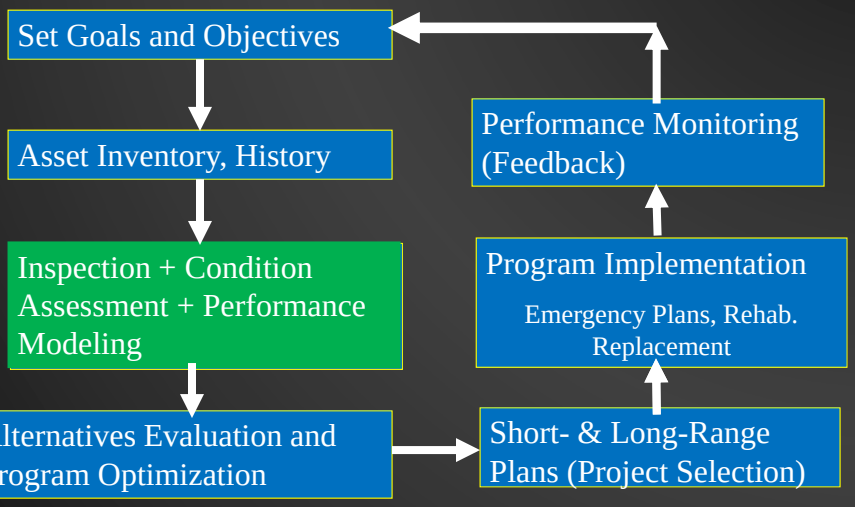
ENVIRONMENTAL
- SSOs, CSOs
- Aquatic Life




Environment eration

Asset Management Continual Life Cycle



Water Environment Federation

14

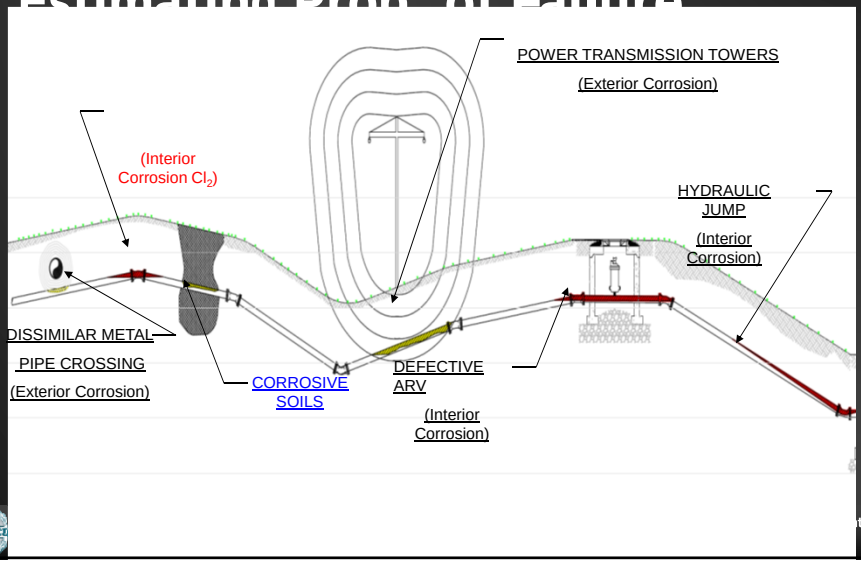
Components of Pipeline Condition Assessment Programs

- Review of Existing Information
- Determine Prominent Failure Points
- Desktop Criticality Analysis
- GIS Tools and Asset Management Integration
- Location/Verification of High Points (for wastewater forcemains)
- Field Work (Excavations, Soils, Water)
  - Pipe Assessment Tools
  - Internal Assessment
  - External Assessment

Information to Review

- As-Builts Drawings
- Maintenance Records
  - Interviews with Maintenance Staff
- Complaint Logs
- History of Breaks, Leaks & Repairs
- Work Order Forms
- Soils Maps
- Topographic Features
- Existing Nearby Metallic Pipelines and CP Systems

Desktop Analysis Considers Prominent Failure Points for Estimating Prob. of Failure



How to establish an inspection prioritization framework?

Risk =

Likelihood of Failure x Consequence of Failure

- Physical Attributes
- Condition Attributes
- Environmental Attributes
- Operational Attributes

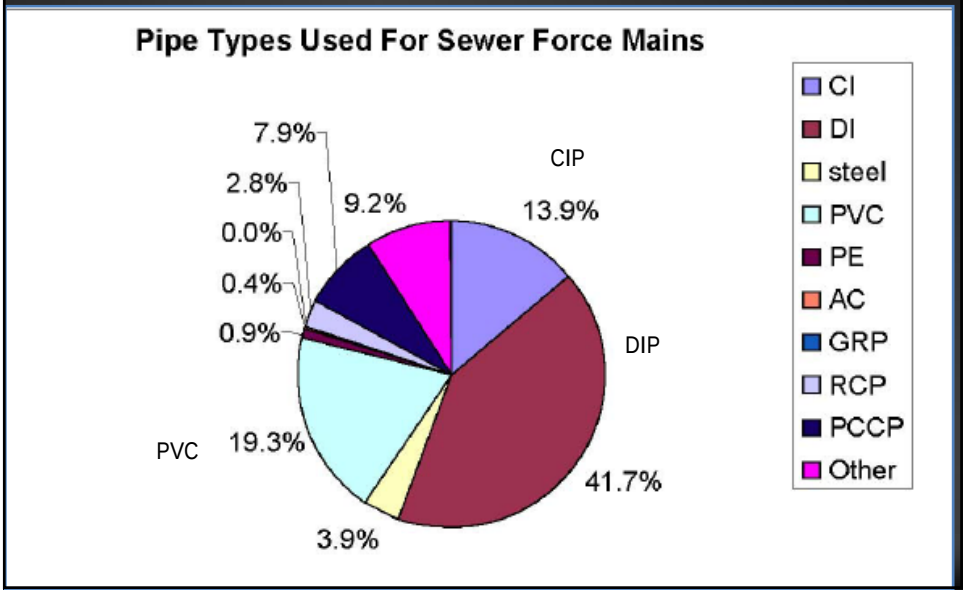
- Critical Customer
- Pipe Size
- Pipe Location
- Redundancy

Likelihood of Failure

- Physical data
  - Age
  - Size
  - Material
- Condition data
  - Pipe condition
  - Joint condition
- Environmental Attributes
  - Soil condition
  - Groundwater table location
- Operational/performance data
  - Pressure
  - Maintenance records
  - Breaks and leaks history

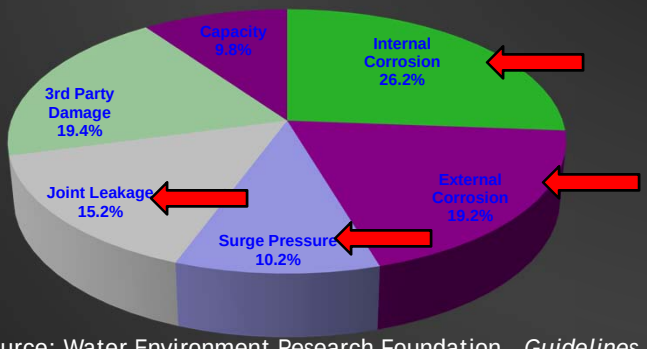
Typical Weighting factors	
Attribute Category	**Weighting Factor**
Physical	0.15
Condition	0.35
Environmental	0.25
Operations & Performance	0.25

Pressure Pipe Materials in the U.S.



Modes of Failure for Ferrous Pipelines

- Failure modes for metallic force mains



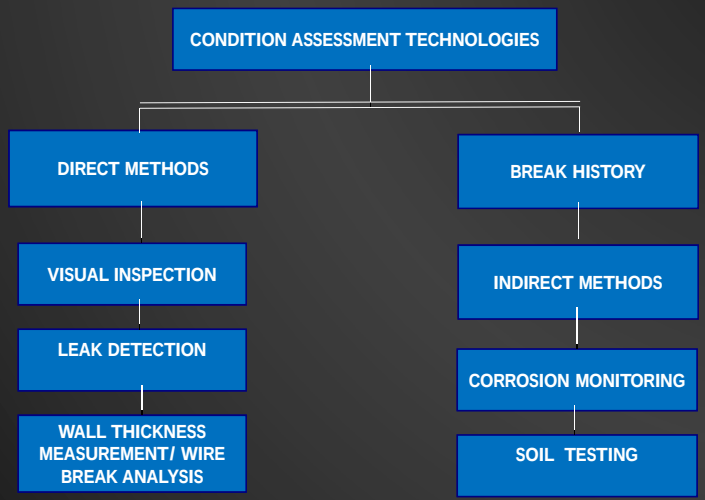
Data source: Water Environment Research Foundation – *Guidelines for the Inspection of Force Mains* (2010)

Consequence of Failure

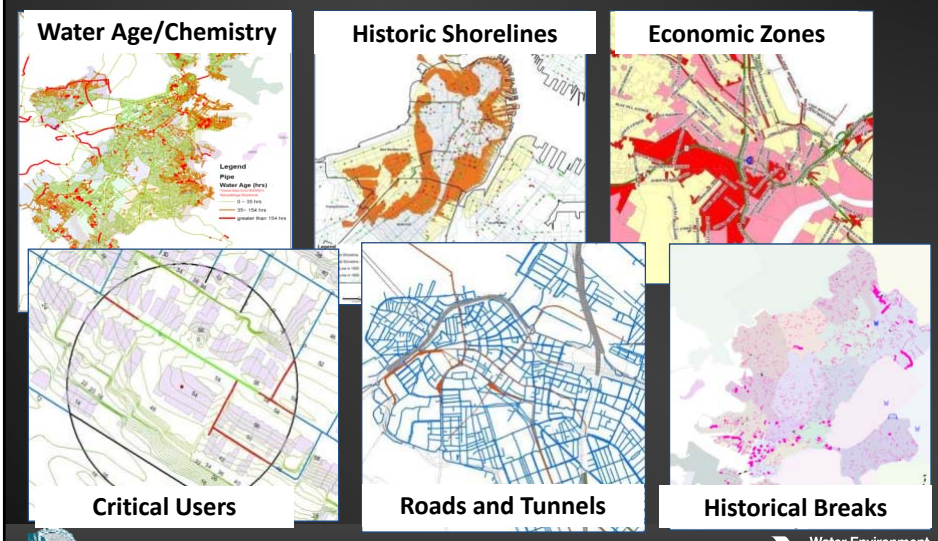
- Number of customers served by the pipe
- Proximity to hospitals
- Proximity to large users
- Serving business districts
- Road Type – Interstate, State, Local
- Environmental impact
- Potential for adverse publicity
- Redundancy
  - Existing parallel pipe or existing loop

22

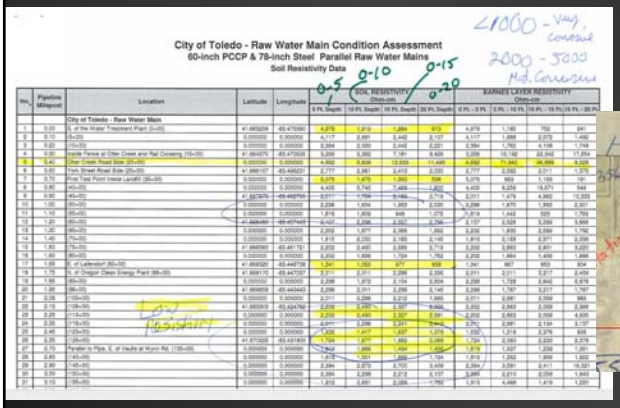
What are some of the available inspection technologies?



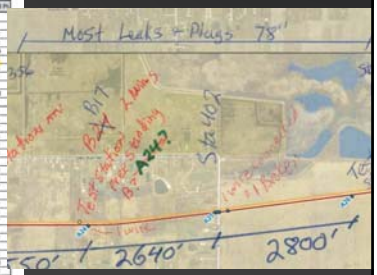
Leverage GIS and Data Inputs



Leverage GIS and Data Inputs


City of Toledo - Raw Water Main Condition Assessment
60-inch PCCP & 78-inch Steel Parallel Raw Water Mains
Soil Resistivity Data

Soil Resistivity (Ohm-cm)



Historical Breaks

Direct Assessment Technologies

DIRECT CONDITION ASSESSMENT TECHNOLOGIES

VISUAL INSPECTION	LEAK DETECTION	Wall Thickness, Wire Breaks, & Pitting
CCTV	LDS1000	ACOUSTIC MONITORING
SWIMMING CAMERA	SAHARA SYSTEM	GUIDED WAVE
BORESCOPE	SMART BALL	ULTRASONIC
LASER PROFILING	ACOUSTIC MONITORING	REMOTE FIELD TECHNOLOGY
EXTERNAL INSPECTION	GPR	BROADBAND ELECTROMAGNETIC
	INFRARED	MAGNETIC FLUX
		COUPON SAMPLING

Pressure Pipe Assessment Matrix

Technology Size Pipe Material In/Out Service Type of Testing / Data

TECHNOLOGY		APPLICABLE SIZE RANGE	PIPE MATERIAL				PIPE STATUS DURING TEST			TEST CONDITIONS	
			Ferrous	Cementitious		Plastic	In-Service	In-Service	Out of Service		
Name	Firms		CI/DI/SS	PCCP	AC/RCP	PVC/HDPE/FRP	No Excavation	Excavation	Excavate, Open	Parameter Tested	
Acoustic/Leak Detection Tools											
Acoustic Leak Detection (tethered)	Pure Sahara	10" and Up					No Exc. if 2" Tap available			Leak detection, air pockets	Hot inserted and retrieved thru air pockets
Acoustics Leak Detection (surface mount)	Echologics RTLeakListener	All Sizes						pothole for accelerometers		Leak detection only	Install accelerometers on exp not validated yet on force ma
Free Swimming Acoustic Leak Detection	PURE SmartBall	8" and up								Leak detection, air pockets	Hot inserted and retrieved thru bonnets and retrieved at main for air pockets
Acoustically Sensitive Fiber Optic	PURE Soundprint AFO	All Sizes					Out of service during installation around valves, fittings			Now - software only for PCCP wire breaks Future - Leak detection, air pockets	Permanent installation
	Echologics LeakMonitor	All Sizes								Leak detection	Expected to be effective
Wall Thickness/Condition Tools											
Acoustic Wall Thickness	Echologics	All Sizes			(AC)			Need to pothole for		Remaining wall thickness in DI, CI and ST	Echologics recently tested in Beach in 2010. Both require accelerometers. Initial results
	Pure Sahara with PWA	10" and up						Need to pothole for		Average Remaining wall thickness	
Broadband Electromagnetic (Internal Pig)	Rock Solid Group allied with several testing firms in US	All Sizes								Remaining wall thickness in CI and DI and ST	Pipe must be drained, expose
Broadband Electromagnetic (External HSK)											Pipe exterior must be expose
Magnetic Flux Leakage (External scanner)	AESL	All Sizes								Wall Thickness testing/profiling	Pipe exterior must be expose
Remote Field Eddy Current/MFL	PICA	4" to 24" (to 36" in future)					If inserted thru pig launcher	If inserted thru pipe opening	If pulled thru on a tether	Internal test for metal wall loss, corrosion in DI, CI and ST	Pipe must be drained, expose
Ultrasonic (External)	NDT Corp, MacTec, others	All Sizes			(AC?)					External test for wall thickness	Local only along pipe wall. N calibrated to material.
Ultrasonic (Internal)	NDT Corp, Rosen, others									Internal test for wall thickness	Developed in Germany for SI pilot in NYCDEP not success
Magnetic Tomography	Transkor-K	All Sizes								External test of wall thickness and active corrosion	Used from the surface
Prestressing Wire Condition Assessment Tools											
Remote Field Eddy Current / Transformer Co	Pure Technologies	Varies by tool					Pipe Diver	Pipe Crawler	Crawler, Walker	Internal test for wire breaks in PCCP	Can hot insert from 24 to 36" and opened
Other/Ancillary CA Program Components											
Closed Interval Potential Survey	PPT	All Sizes								External test of pipe coating failure (soil corrosion)	Requires pipe to be electrical
Soil & GW Corrosion Testing	Many Firms/Local Labs	All Sizes								Take soil & groundwater samples for lab analysis	Indicator only of soil corrosio constantly so data is of only
Pipe Coupons or Sampling	Many Firms/Local Labs	All Sizes								Take coupons or pipe samples for analysis	Take samples from pipe to c strength, flexural strength, m universal indicator for AC

Questions?

Contact Information

John Schroeder

schroederjp@cdmsmith.com

John C. Matthews, Ph.D.

- Director of the Trenchless Technology Center (TTC) at Louisiana Tech University
- 14 Years Experience in Pipeline Condition Assessment & Rehabilitation
- B.S in Construction Engr. Technology, 2004 (LA Tech)
- M.S. in Civil Engr., 2006 (LA Tech)
- Ph.D. in Civil Engr., 2010 (LA Tech)

LOUISIANA TECH UNIVERSITY TTC TRENCHLESS TECHNOLOGY CENTER

Water Environment Federation the water quality people

Overview

- Background on Water Main Rehab
- Available Rehabilitation Methods
  - Applicability
  - Advantages
  - Limitations
- Factors for Selecting Methods

2

Water Environment Federation the water quality people

Background

- Many pipelines are reaching the end of their useful lives
- Failure can cause catastrophic damage and emergency repairs are extremely expensive
- Utilities have limited budgets for asset replacements so one must use asset management principals
- A key part of pipeline asset management is rehabilitation to extend the useful life of an asset (see AWWA M36)

Background

To help utilities gain access to information on pipeline rehabilitation, the EPA published several reports under its Aging Water Infrastructure (AWI) Program

Key reports include:

- A State-of-Technology (SOT) report on Water Main Rehab
- Multiple demonstration projects of innovative rehab technologies
- Multiple reports on innovative condition assessment technology, a key step in the asset management process

Applicable Rehabilitation Methods

- Pipe bursting & eating involve breaking a host pipe in place, while pulling in a new pipe

Applicable Rehabilitation Methods

Sliplining Advantages

- Only trenchless tool capable of upsizing pipe diameter
- Can typically withstand all loads (Class IV)

Sliplining Limitations

- Services require pits for external reinstatements and many bend conditions
- Surface heave possible under some soil circumstances
- Site must be large enough to layout repair pipe for fusing

Applicable Rehabilitation Methods

- Sliplining with either close-fit liners or grouted in place pipes or liners

Applicable Rehabilitation Methods

Sliplining Advantages

- Can line long straight segments at one time (>1,000 ft)
- Can typically withstand all loads (Class IV)

Sliplining Limitations

- Services require pits for external reinstatements
- Largest reduction in diameter typically
- Cannot line through most bend conditions (pits required)
- Cleaning requirements for tight fit liners

Applicable Rehabilitation Methods

- Cured-in-place pipe (CIPP) liners with reinforcing for pressure systems

Applicable Rehabilitation Methods

CIPP Advantages

- Can typically withstand all loads (Class IV)
- Robotic reinstatement of service connections
- Can line through various bend conditions up to 45º
- Hydraulic capacity can potentially increase

CIPP Limitations

- Limited to ~800 ft lining shots
- Excavation required for large bends & damaged services
- Cleaning requirements for tight fit liners

Applicable Rehabilitation Methods

- Carbon fiber reinforced polymer (CFRP) wraps

Applicable Rehabilitation Methods

CFRP Advantages

- Can typically withstand all loads (Class IV)
- Reinstatement of service connections not required
- Can line through any bend conditions
- Hydraulic capacity can potentially increase

CFRP Limitations

- Only applicable to person-entry sized pipes
- Spot repair mostly, though continual lining is possible
- Cleaning requirements for bonded liners

Applicable Rehabilitation Methods

- Joint and spot repair systems and seals for leaks

Applicable Rehabilitation Methods

Joint Seal Advantages

- Sleeves mechanically lock into place and cannot unlock
- Seals leaking joints and pinholes
- Reinstatement of service connections not required

Joint Seal Limitations

- Only applicable to person-entry sized pipes
- Non-structural solution limited to point locations
- Cannot seal around bends

Applicable Rehabilitation Methods

- Spray-on coatings and liners (epoxy, polyurethane, polyurea, cement mortar)

Applicable Rehabilitation Methods

Spray-on Lining Advantages

- Reinstatement of services not typically required
- Spans small corrosion holes and joint gaps
- Cures quickly and maintains or improves flow capacity

Spray-on Lining Limitations

- Cleaning requirements for bonded liners
- Ridging and shadowing common in robotic installations
- Structural claims are unproven for many products

Factors for Selecting Methods

- Structural Requirements
- Service and Branch Connection Reinstatements
- Flow Capacity Needs
- Pipe Accessibility
- Contractor Availability/Timing
- Diameter, Length, Bend Requirements

17

FOR MORE INFORMATION

WEF & NASSCO Pressure Pipe Committee (Update)

EPA Drinking Water & Wastewater Systems Research

- www.epa.gov/water-research/drinking-water-and-wastewater-systems-research

Trenchless Technology Center (TTC)

- www.ttc.latech.edu

North American Society for Trenchless Technology (NASTT)

- www.nastt.org

18

Questions?

Contact:

Dr. John C. Matthews

Director of Trenchless Technology Center (TTC)

Louisiana Tech University

TRENCHLESS TECHNOLOGY CENTER

19

Ian A. Lancaster

- Senior Director of Pressure Pipe
  - Aegion is a worldwide engineering, manufacturing and construction corporation
- 20+ years of underground utility experience

AEGION
Stronger. Safer. Infrastructure.

Structural Rehabilitation of Pressurized Pipelines

Ian A. Lancaster
Sr. Director, Aegion

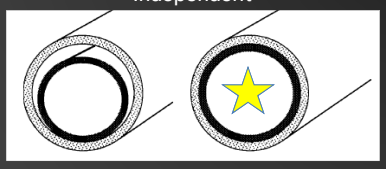
Agenda

- Benefits of structural pressurized pipeline rehabilitation
  - Ideal project characteristics
- Cost considerations
- Design parameters
- Proven products/processes
  - Cured-in-place pipe (CIPP)
  - Fiber reinforced polymer (FRP)
  - Modified HDPE slip lining
- Project Steps
- Example Projects

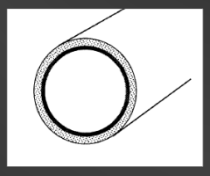
Benefits of Pressure Pipe Rehabilitation

- Rapid installation
- Minimal excavation
- Maintenance of traffic
- Improved flow characteristics
- Structural stability
  - 50-100 year design
- Corrosion resistance
- Cost savings

Independent



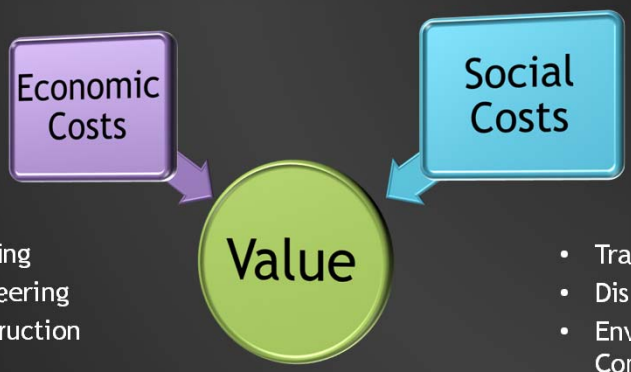
Interactive



Ideal Projects

- Critical locations
  - High-profile areas, railways, etc.
- Major roadways
- Distribution & transmission pipelines
- Busy right-of-way
- Social costs > Direct costs

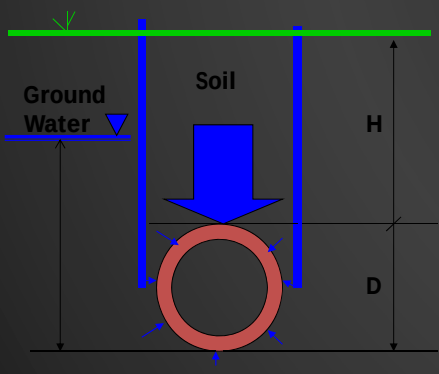
Cost Considerations



- Planning
- Engineering
- Construction

- Traffic
- Disruption
- Environmental Concerns

Design Parameters



- ASTM or AWWA
- Internal design:
  - Operating pressure, transients, vacuum
- External design:
  - Soil, groundwater, traffic, and other live loads
- Other factors:
  - Ovality, bends, services
- Unrestrained burst testing
  - Validates safety factors

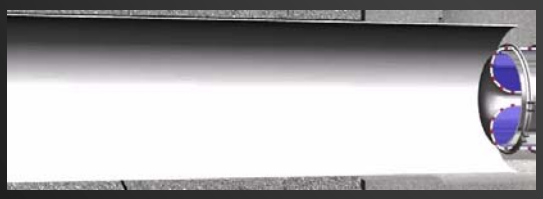
Proven Products/Processes

- Cured-in-place pipe (CIPP)
- Fiber reinforced polymer (FRP)
- Modified HDPE slip lining




Cured-in-place Pipe (CIPP)

- Thermosetting resin impregnated tube with:
  - Glass reinforced felt
  - Woven polyester jacket
- Diameters from 6" - 96"
- Pressures up to 250 psi
- Tight fitting = flow maximization
- Joint less, pipe-within-a-pipe that protects against corrosion, build-up, and leakage

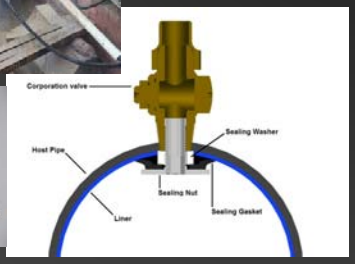



Since 1997, millions of feet of CIPP pressure pipe has been installed successfully worldwide

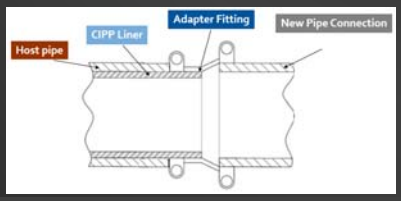
CIPP – Areas of Focus

- Pipeline cleaning
  - High-pressure water
  - Pigging
  - Drag scraping

- Service connection reinstatement
  - Adhesive
  - Mechanical



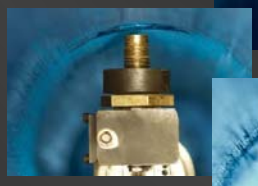
- End terminations
  - Adhesive
  - Mechanical
  - Specialty Adapters
  - FRP



Water Environment Federation
the water quality people

CIPP - Service Reinstatement

- Adhesive or Mechanical
  - Step 1 – cleaning of protruding service
  - Step 2 – plugging of existing service connection
  - Step 3 – locating and drilling of the existing service (after lining)
  - Step 4 – installation of mechanical connection



Water Environment Federation
the water quality people

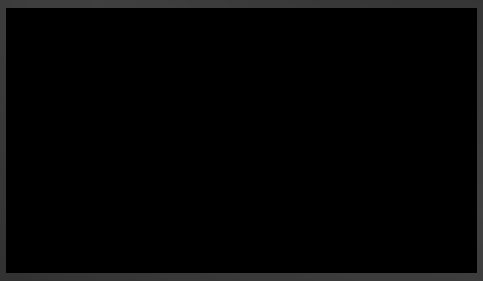
Fiber Reinforced Polymer (FRP)

- Hand applied thermosetting resin saturated fiber:
  - Carbon
  - Glass
- Diameters:
  - Internal – 30” and greater
  - External – any diameter (exposed)
- Pressures exceeding 450 psi
- Small footprint
- Maximizes inside diameter

FRP Application

Modified HDPE Slip Lining

- PE 4710 HDPE material
- Tight-fit or Close-fit
- Custom engineered & manufactured
- Tight fitting = flow maximization
- Installed by compression or deformation
- Diameters from 4” - 66”
- Pressures up to 250 psi



Modified HDPE Slip Lining

Radial compression

- Diameter is temporarily reduced by radial compression
- Timing is important as the liner will begin to grow back once tension is released
- Can be used for structural or non-structural
- Entire liner section is installed in a single and continuous “pull”

Elastic deformation

- Achieves significant cross sectional reduction to facilitate installation
- Wall thickness limitations—maximum of 1”
- Not suitable for structural loading
- “Fuse and fold” method facilitates small worksite footprint
- Only moderate collapse resistance
- Re-rounded after installation

Typical Project Steps

- Bypass (if necessary)
- Access pits
- Pipeline cleaning
- Inspection
- Structural lining installation
- Pressure testing
- Service reinstatement (if necessary)
- Chlorination (if necessary)
- Restore service

Example Projects

- Cured-in-place pipe (CIPP)
  - West Palm Beach, FL – Force Main Rehabilitation
  - 2017 Project of the Year
  - 48” diameter, ~6,000’

- Modified HDPE slip lining
  - Tredyffrin Township, PA - Valley Forge Force Main
  - 2017 Project of the Year, Honorable Mention
  - 30” diameter, ~18,000’

- Carbon fiber reinforced polymer (CFRP)
  - City of Baltimore, MD - (SC) 875, Phase III
  - 2015 Project of the Year, Honorable Mention
  - 78” diameter, ~2,000’

In Summary…

- Less disruption, compared to excavation
- Fully structural materials
- 50-100 year design life
- Proven products/processes (20+ years)
  - Cured-in-place pipe (CIPP)
  - Fiber reinforced polymer (FRP)
  - Modified HDPE slip lining
- Diameters from 4" – 96"
- Pressure ratings exceeding 450 psi

Thank you for your time! Any questions?

Flexible Kevlar woven / PE coated Liner

Presented by John Moody
Director of Sales-USA
Primus Line Inc.

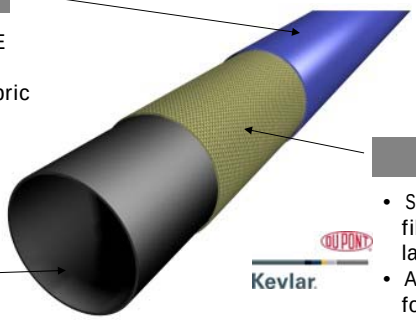
Pros and Cons of flexible Liner

Benefits of Flexible Kevlar P.E. Coated liner	Considerations for installation
No onsite wet out or cure on site. Liner is inflated with air after install.	Pressure test must be done to insure proper installation. Installers must be certified
Very small foot print and minimal disruption to the environment, only requires a winch to pull in material.	Not a tight fit, annular space= reduction of inside diameter
Pipe does not have to be dry or perfectly clean.	CCTV inspection must be completed prior to installation to confirm suitability. Problem for long runs and multiple bends.
Extremely long runs(8,500LF) with multiple bends including 45 degree bends. High pressures are acceptable	Host pipe is only a conduit for the liner all internal pressure and forces are not conveyed to host. Host must be able to bare soil loads.

Composition of Primus Liner

External Layer

- Abrasion-resistant PE sheath
- Protection of the fabric during insertion



Kevlar®

- Seamless, woven aramid fibres (single or double-layered)
- Absorption of the tractive forces during insertion
- Accommodates the operating pressure

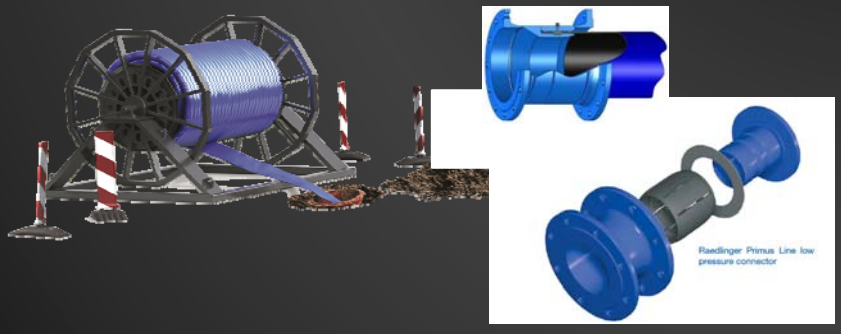
Internal Layer

- Fluid specific
- Based on PE, TPU
- 15 potable water certifications (AS/NZS 4020:2005/NSF61)

Liner system consists of …

Flexible high-pressure composite pipe

…and patented end fittings



Rehabilitation of Twin 12” industrial water lines for Paper Mill under a Highway.

Rand-Whitney Containerboard
Montville CT.

Project Details

Year of rehabilitation – January /2017

Technical Details:

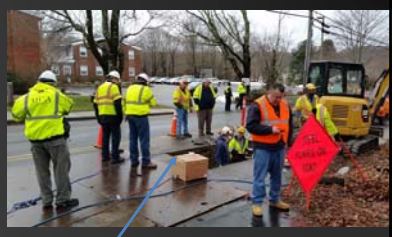
Host Pipe Material:	Ductile iron
Transported Medium:	Industrial water
Host Pipe Diameter:	12 inch
Operating Pressure:	160 psi
Raedlinger Primus Line® System:	12 inch Primus Liner with a nominal design pressure of 363 psi
	4 x 12 inch low pressure connectors with double-sided 12 inch flanges
Total Length:	2 x 980 ft
Number of Construction Sections:	2 installation sections with 980 ft
Installation Time:	3 days for the installation of the Primus Liner and connectors

Water Environment Federation
the water quality people

Water Environment Federation
the water quality people

Conclusion

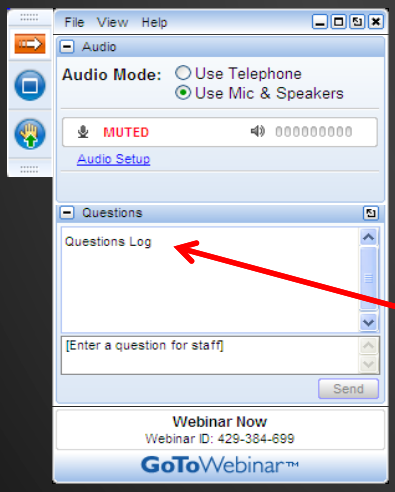
- Project was finished on schedule
- There where no issues during the installation
- Cleaning did take longer then anticipated
- One day for cleaning and prep
- One day for installation
- One day for fittings installed/pressure test
- State/ town officials all satisfied with results
- Pipe owner is planning more rehabilitation with this system
- Installer said it could have been completed in two days. He was being cautious as it was his first installation of this system.



End pit.
Small foot print

Water Environment Federation
the water quality people

Questions?



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

Water Environment Federation
the water quality people


Evolution and Applicability of Pressure Pipe Rehabilitation
November 1, 2017
1:00 – 3:00 pm Eastern
Thanks to our webcast sponsor!
NATIONAL ASSOCIATION OF SEWER SERVICE COMPANIES
NASSCO
Water Environment Federation
the water quality people