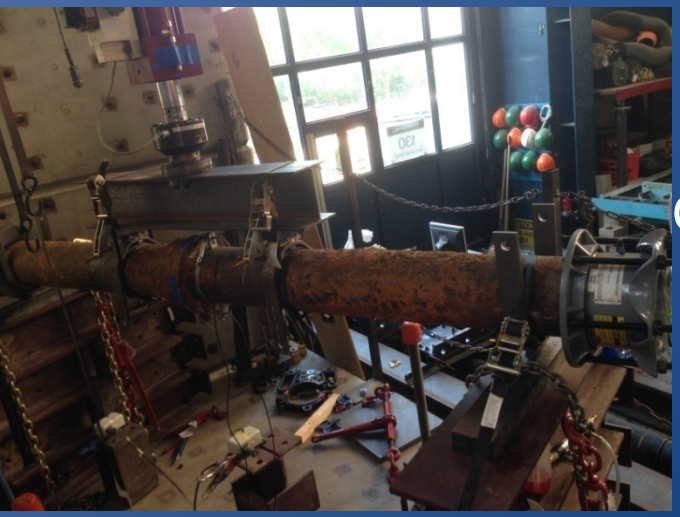
TECHNOLOGY TRANSFER, DEMONSTRATION, & POST-MORTEM TESTING OF CIPL FOR CAST IRON AND STEEL PIPE



CIPL Workshop, Roosevelt Hotel, NYC

August 20, 2015

Presented by: David W. Merte, PE

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Project Objective

- The primary objective of this project is to advance a broad understanding of field aged cured-in-place (CIP) liners as they interact with host steel or cast iron pipe. CIP lined pipe, removed after more than a decade of gas service, will be tested using a foundation of protocols established by Cornell University.

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Project Work Scope

- Conduct a literature search and complete peer reviewed CIPL reports
  - North America and Europe (NYSEARCH)
  - Japan (SwRI)
- To select and extract – (4) jointed & (2) straight in-service CIPL CI lined 8’ segments >10 years field aged
- Cornell University - Conduct cyclic load testing (truck traffic loading, trenching event, freeze/thaw pullout) and liner residual properties testing (tension, lap shear, peel)
- Conduct a live demonstration of CIPL with current standard operating procedures

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Project Status

- Literature search completed in April 2014
- 6” field aged lined CI joint (cement/jute) segments extracted from PSE&G in May 2014
- 12” field aged lined CI (mechanical) joint segments extracted from National Grid in August 2014
- CIPL live demonstration held in October 2014 at Con Edison in Mt. Vernon, N.Y.
- Cornell University testing (mechanical aging & liner residual properties) completed this month

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Literature Search Reports

Cured-in-Place Pipe Lining Literature Compilation Report

Prepared by:

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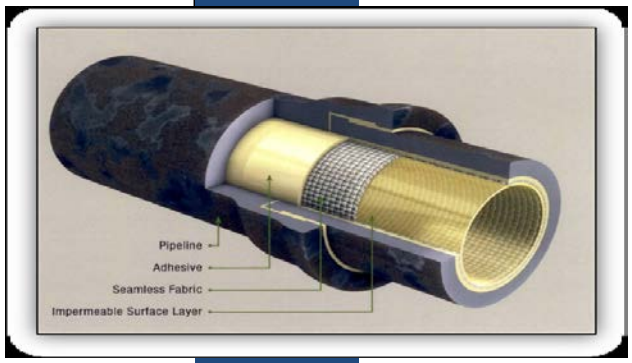
Parsippany, New Jersey 07054

Project Title:
Technology Transfer Demonstrations and Post-Mortem Testing of Cast Iron and Steel Pipe Lined with Cured-In-Place Pipe Liners

NYSEARCH Project #T-770
PHMSA Transaction Agreement #DTPH56-13-000013

Prepared for:
NYSEARCH/Northeast Gas Association
Pipeline Hazardous Material Safety Administration (PHMSA)



April 24, 2014

Cured-in-Place Pipe Lining in Japan

Author

Jay Fisher, Sc.D.

FINAL REPORT
SwRI® Project No. 18.19711

Prepared for

David Merte
Northeast Gas Association
20 Waterview Blvd, 4th Floor
Parsippany, NJ 07054

April 22, 2014

SOUTHWEST RESEARCH INSTITUTE®

Report - Highlights

- North America and Europe Literature
  - GRI, IGT, Battelle, Cornell
  - AMEX, Paltem and Starline®2000 installed (last three decades)
  - Economic benefits (e.g. PSEG, PECO, Con Edison)
  - Reliable functional integrity (e.g.-TPD w/no leak)
  - Cleaning procedures & technologies (optimized liner/pipe adhesive bond)
  - Drilling & tapping (conducted w/o de-bonding)
  - Traffic loading, breaks w/deflection, cyclic loading ≥ 50 yrs. field service equivalence
  - Acceptable technique for cast iron replacement in Germany
    - CIP lined pipe as new PE pipe for leak detection

Japan Report- Highlights

- Japanese Literature/Company Interviews
  - Interviews conducted in Japan by Jay Fisher (SwRI)
  - Early adopters of CIPL technology
    - Osaka Gas (1980's-CI & Steel)
    - Tokyo Gas (44 psi – 145 psi up to 12" diameter)
    - Ashimori Industry Company (PALTEM)
  - 1983 study on durability of earthquake damaged pipe joints

    - Based on joint deformation and breaks after Nihonaki-Chubu earthquake

    - Concluded that CIP liner would not rupture under 1983 Japanese Gas Association (JGA) previous publication for medium pressure gas transmission (5 cm axial deformation)

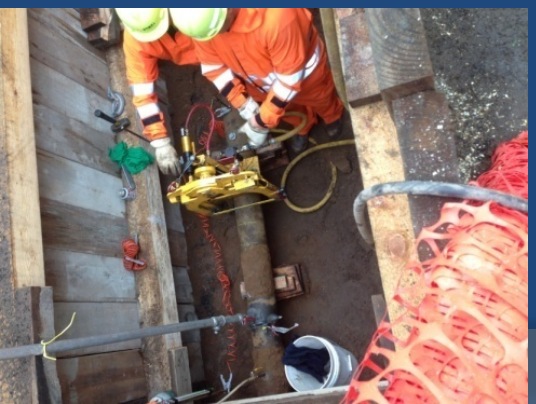
Japan Report- Highlights

- Follow Japan Gas Association voluntary industry guidelines (40-50 year criterion)
- JGA leakage prevention (recommended tests - workability, flexural properties, creep, gas & chemical resistance, thermal acceleration (corrosion & joint), and large deformation (earthquakes))
  - Pre-existing cracks or breakage (CI and steel)
  - Precaution against through-holes that might form (steel)
  - Joints due to sealing degradation (CI and steel)
  - Potential earthquake damage (CI and steel)
- Most CIPL installations by Ashimori Industry Co., (Paltem)

  - 732 miles installed in Japan by 2013 (2”-36” diameter)

FIELD AGED CIPL EXTRACTION – PSE&G

- After a thorough review of funder CIPL in-service pipe segments >10 years old
  - Elmwood Park (Palsa Avenue, N.J.) selected
  - 6” (low pressure) CI installed in 1949
  - Lined with Starline®2000 in 1998
  - Cement/Jute joints (2)
  - 8’ segments removed



FIELD AGED CIPL EXTRACTION – PSE&G

- 16 years of active field service
  - Two 6” CI cement/jute joints

FIELD AGED CIPP EXTRACTION – NATIONAL GRID

- Garden City South, N.Y.
  - Main selected on 5th Place S.
  - 12” (60 psig) CI installed in 1951
  - Lined with Starline®2000 in 2004
  - Mechanical joints (2)
  - 8’ segments removed

FIELD AGED CIPP EXTRACTION – NATIONAL GRID

- 10 years of active field service
  - Two 12” mechanical joints
  - One section w/o joint
  - Crated and shipped to Cornell University

LIVE DEMONSTRATION

- **Conducted on October 21 at Con Edison**
- Access pit & pipe preparation
- Initial pipe inspection
- Surface preparation
- Post cleaning inspection
- Adhesive preparation
- Liner wet-out/adhesive application
- Liner inversion
- Curing & pressure monitoring
- Post Lining Inspection
- 8” and 6” low pressure cast iron

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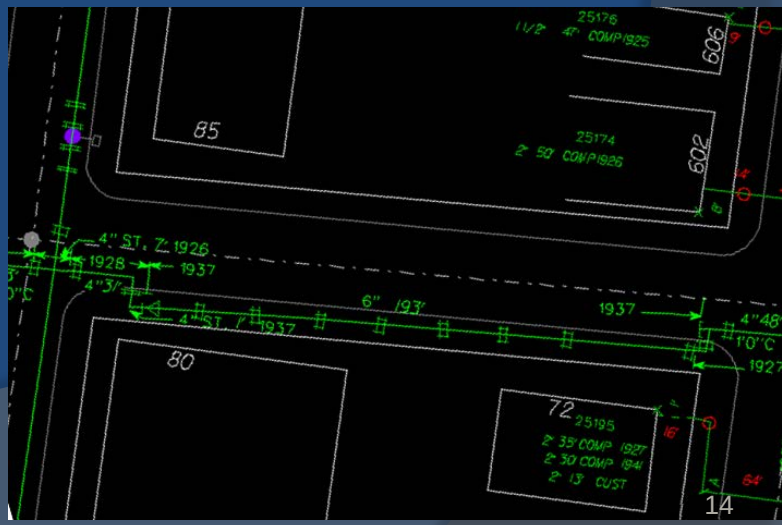
Live Demonstration (cont'd)

- 1st location – E Sidney Av B/T N 3rd Av & Crary Av (Mount Vernon)
- Lining Length – 380 feet
- Material – Cast Iron
- Size – 8 inch
- Pressure – Low
- Misc. – 13 Keyhole Repairs, 2 Clamps, drip

- 2nd location – William St B/T N Terrace Av & Locust St (Mount Vernon)
- Lining Length – 190 feet
- Material – Steel
- Size – 6 inch
- Pressure – Low
- Misc. - Coupled

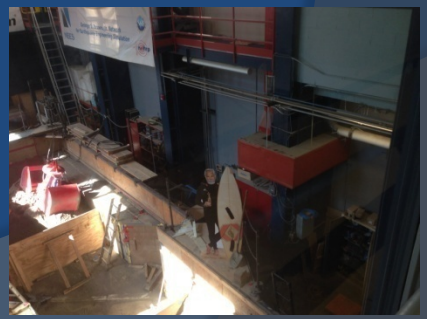


Live Demonstration (cont'd)

- Cut and cleaned both locations prior to day of demonstration
- Inspected, cleaned and prepared for lining
- Lined William St. main prior to day of demonstration and simulated "Day After" camera inspection
- Lined E. Sidney Ave. main on day of demonstration (1 hour and 15 minutes)
- Before & after cleaning- sections displayed

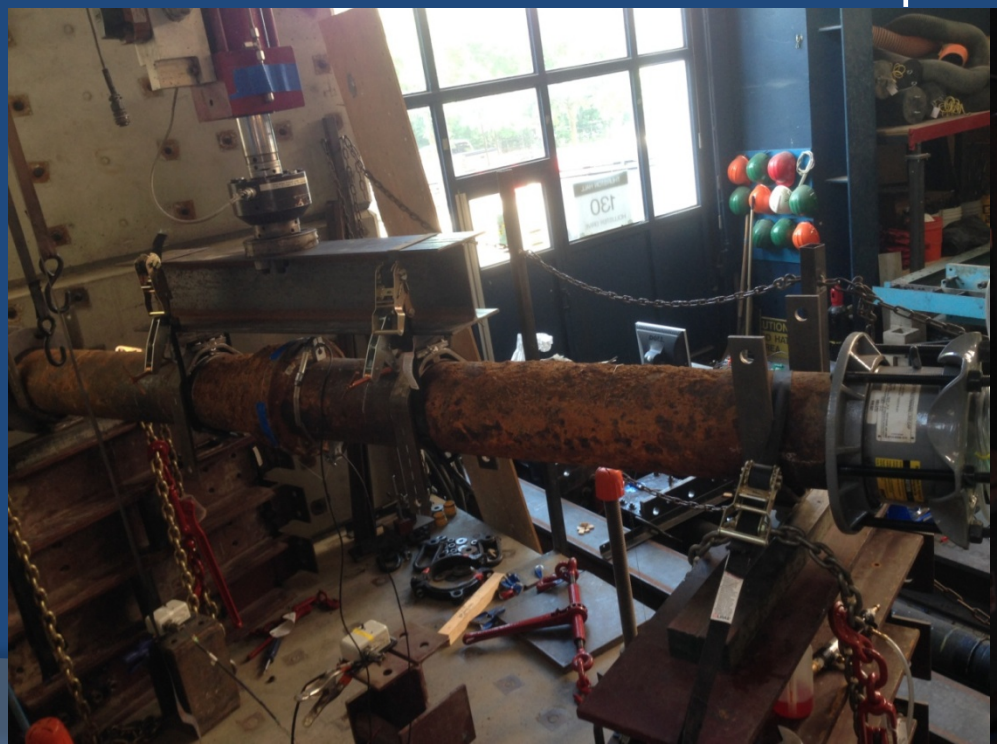
Cornell Mechanical Aging

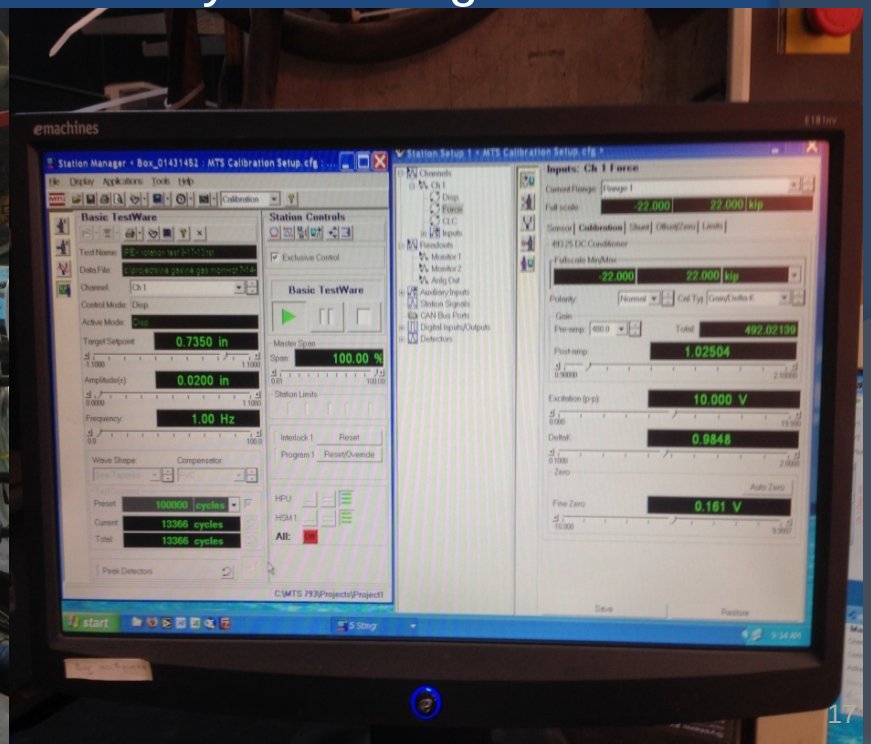
- Traffic cycle loading
  - 1,000,000 cycles (50 years)
  - 100,000 cycles subsequent to undermine/backfill event
  - Thermal push/pull cycles (50 years)
  - Repeat above testing (100 year field service equivalent)



Cornell Mechanical Aging

- Each segment subjected to 2,000,000 traffic load cycles (100 yrs.)
- Each segment to (2) undermine events w/additional 100,000 cycles
- Pull-out testing w/weakened (drilled) cement/jute joints (100 yrs.)
- Tension, peel, and lap shear testing performed on each segment liner after extraction and subsequent to all cyclic testing



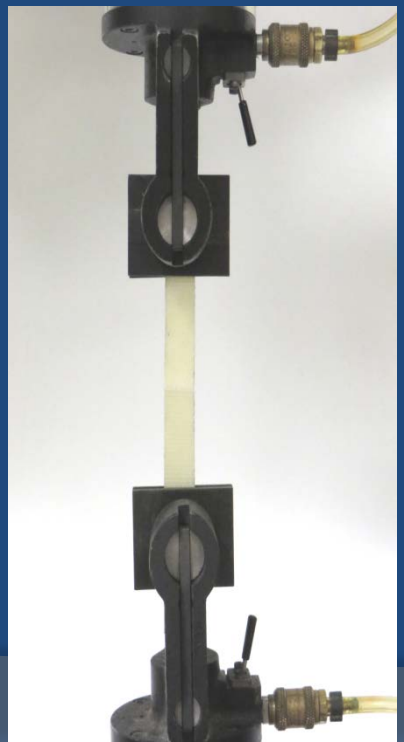
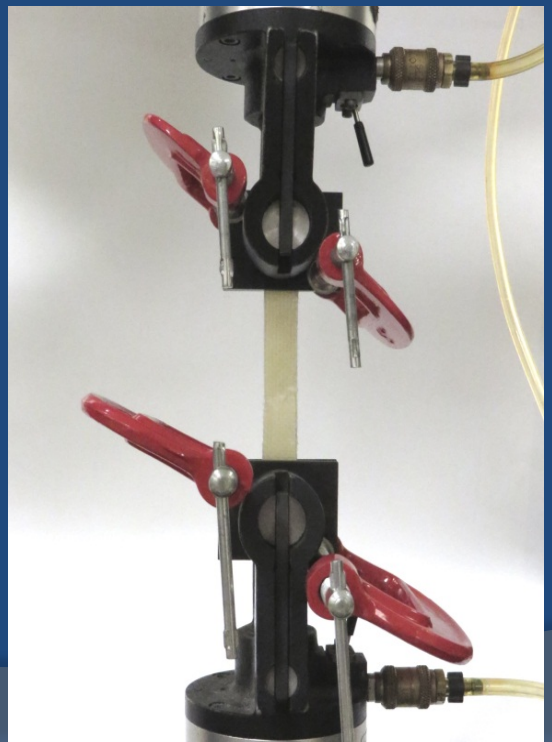


Cornell Liner Testing

- Each segment liner destructively tested after field extraction
- Each segment liner destructively tested in high stress joint area after all heavy traffic, undermine events, and thermal push/pull cycles

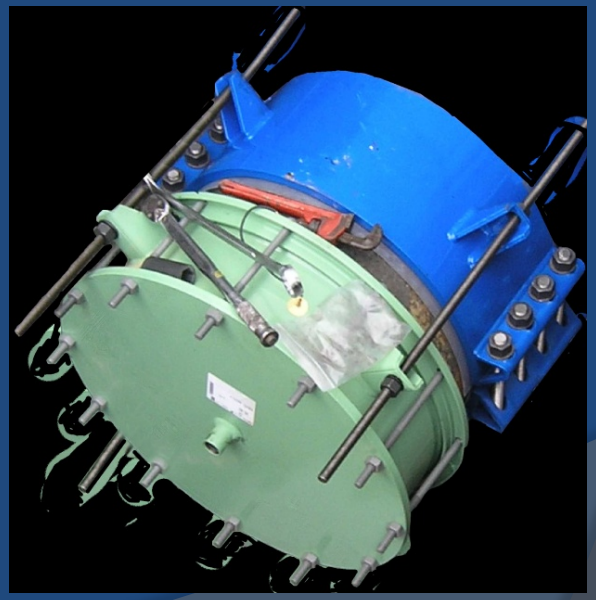
Cornell Liner Testing

- Tension (longitudinal and transverse directions)
  - High stress joint area
  - Bonded and de-bonded
- Lap Shear (primary adhesion test)
- Peel (longitudinal direction – secondary adhesion test)

Cornell Pressure Testing

- Dresser 711 end caps utilized for 6” Low pressure CI (not available for 12”)
- Smith Blair EBR end caps utilized for 12” CI- 60 psig MAOP restraint



- All four segments under pressure during all mechanical aging tests and tested to 90 psig (1.5 X MAOP) after >100 yr. aging

Cornell Pressure Testing

6” Diameter Field Extracted Lined Segments	Specimen			
	6-1a		6-2 a	
	No. Cycles	Internal Pressure (psi)	No. Cycles	Internal Pressure (psi)
Pre-Test Photos	✓		✓	
Vehicle loadings/bending cycles	1,000,000	15 in. water column	1,000,000	15 in. water column
Excavation event	1	15 in. water column	1	15 in. water column
Additional vehicle loadings/bending cycles	100,000	15 in. water column	100,000	15 in. water column
Thermal expansion/contraction cycles	50	15 in. water column	50	15 in. water column
Vehicle loadings/bending cycles	1,000,000	15 in. water column	1,000,000	15 in. water column
Excavation event	1	15 in. water column	1	15 in. water column
Additional vehicle loadings/bending cycles	100,000	15 in. water column	100,000	15 in. water column
Thermal expansion/contraction cycles	50	15 in. water column	50	15 in. water column
Pressurization test	1	150 psi (water)	1	

Cornell Pressure Testing

12” Diameter Field Extracted Lined Segments	Specimen			
	12-1a		12-2 a	
	No. Cycles	Internal Pressure (psi)	No. Cycles	Internal Pressure (psi)
Pre-Test Photos	✓		✓	
Vehicle loadings/bending cycles	1,000,000	15 psi (water)	1,000,000	15 psi (water)
Excavation event	1	15 psi (water)	1	15 psi (water)
Additional vehicle loadings/bending cycles	100,000	15 psi (water)	100,000	15 psi (water)
Thermal expansion/contraction cycles	50	15 psi (water)	1, depressurize and take photos, pressure check to 60 psi (water), pressurize to 15 psi (water), complete 49 cycles	15 psi (water)
Vehicle loadings/bending cycles	1,000,000	15 psi (water)	1,000,000	15 psi (water)
Excavation event	1	15 psi (water)	1	15 psi (water)
Additional vehicle loadings/bending cycles	100,000	15 psi (water)	100,000	15 psi (water)
Thermal expansion/contraction cycles	50	15 psi (water)	50	15 psi (water)
Pressurization test	1	90 psi (nitrogen)	1	90 psi (nitrogen)

Project Overall Status

- All >100 year mechanical aging cyclic testing completed (4 field aged extracted lined segments-heavy traffic, undermine, thermal)
- Initial extracted segment (liner tension, lap shear, and peel testing completed)
- All >100 year equivalent field service destructive liner tension, lap shear, and peel testing at the joints completed
- Results

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