Cornell Qualifications

- 40 Years R&D for Gas Distribution & Transmission Systems
  - Cast iron pipelines, railroad/highway crossings, pipeline rehabilitation, aging protocols, reinforced polymer linings, risk reduction, seismic performance

- Cornell Large-Scale Lifelines Testing Facility

- 40 Years R&D, Design, and Construction Experience for Large Geographically Distributed Systems
CORNELL LARGE-SCALE LIFELINES TESTING LABORATORY

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CURED IN PLACE LININGS AND PIPES

AWWA classifies the linings based on their ability to carry loads due to internal pressure and external loads into CIPLs that are semi-structural linings, and CIPPs that are structural.

- The Starline 2000 CIPL is a flexible semi-structural lining with a seamless woven polyester hose and thin interior polyurethane layer. The polyester hose is saturated with a two-part polyurethane that bonds to the inside surface of the pipe.

- A CIPP is composed of woven/unwoven polyester hose or felt impregnated with epoxy resin with and without fiber glass reinforcement.

- Installation is performed by the “inversion method”, in which the lining is inverted into an existing previously cleaned pipe, or the lining is pulled into place.
Repetitive Loading Effects

- Jeon et al. (2004), demonstrate the effectiveness of CIPLs (Paltem-GR and Ammex) for cast iron (CI) pipelines that have full circumferential cracks and weak joints. Jeon et al. (2004) performed large-scale laboratory tests on 6-in. pipe that imposes 2 million cycles of traffic load, 50 cycles of thermal (40°F), undermining excavation, and the effects of 8 in. of maximum settlement induced by parallel trench construction. During those tests, a CIPL-reinforced CI pipeline with a round crack was able to accommodate the excavation-induced soil movements.
CIPP LININGS: STARLINE

- Diameter Range: 4 - 48 in. & services
- Pipe Section Length: 2500 ft maximum
- Bends: YES
- Host Pipe: Cast Iron, Ductile Iron, & Steel
- Thickness: 0.05 - 0.1 in.

Tough, impervious polyurethane membrane

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KEY CIPP RESEARCH FINDING

- Local de-bonding required to accommodate movement at cracks & weak joints
- De-bonding confined to a distance of one diameter from crack
- Installation engineered for local de-bonding
Performance Testing of Field-Aged Cured-in-Place Liners (CIPL) for Cast Iron Piping
Stewart, O’Rourke, Wham, Netravali, et al. 2015

• 2 million cycles of traffic load, 100 cycles of thermal (40°F) deformation, & undermining excavation. No damage to 6-in. CI pipe w/ 16-yr lining and some thread tearing in 12-in. CI pipe w/ 10-yr lining. Polyurethane membrane intact. Pressure testing at 150 psig (6-in. CI pipe) and 90 psig (12-in. CI pipe).

• No tensile strength difference in longitudinal & hoop directions where damage absent, but some reduction where threads damaged.

• No significant difference in lap shear strengths of field, field mechanically aged, and 2000 unaged specimens.

• No difference in 6-in. peel strengths. 12-in. not comparable.
Slow Cooling of Cured-In-Place Liners for CI and Steel Pipelines Stewart, Weinberg, Berger, & Strait, 2019

- Slow cooling in environmental chamber over months ~ 80 days, not rapid thermal deformation
- No leakage or thread damage at 20 psig in 12-in. CI specimens with 18-yr lining life. Specimens intact.
- No leakage or thread damage at 20 psig in 12-in. steel specimens with new lining. Specimens intact.
- Slow cooling eliminates the thread damage associated with rapid thermal deformation
12 in. CI Lined Pipe Joint

Post-Mechanical Aging Tests

De-Bonding

Spigot/Bell

Crown

Some Fiber Damage

Slow Cooling

Cast iron pipe #1
Nom. D = 12 in. (300 mm)
Apr 09, 2019

Debonded zone showing wrinkles after unloading

Approx. location of initial separation

Cast iron pipe #1
Nom. D = 12 in. (300 mm)
Apr 09, 2019

Debonded zone
No damaged fibers.

≈ 4-6 in.
(100-150 mm)

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Earthquake Response of CIPLs

Pinching of CIPL

Crack / Joint Opening (mm)

Pulse Period (s)

0-517 kPa internal pressure range

- Simplified Model
- 250 cm/s
- 200 cm/s
- 150 cm/s
- 100 cm/s
- 50 cm/s

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Intelligent CIPP

- Distance range ≈10-30 km
- Readout resolution = 0.05 m
- Gauge length resolution = 0.2-1 m
- Strain Resolution = 10-30 me

The frequency shift of the Brillouin scattered light is proportional to the strain.

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