Northeast GAS ASSOCIATION
NYSEARCH

Technology Brief

Cured In Place Liner (CIPL) Durability and Longevity Testing

Description: **A testing program to provide experimental data on the expected durability and longevity of the CIPL system when used in cast iron (CI) and steel pipes.**

Status: **The testing for CIPL longevity and durability for up to 100 years is complete. Residual follow-on testing of liner tensile and adhesion properties is expected to be completed in 2022.**

BENEFITS

CIPL technology is a viable pipeline renewal and replacement methodology that provides trenchless rehabilitation for leak prone CI and steel distribution pipes. Also, CIPL serves to significantly reduce methane emissions from aging pipe.

BACKGROUND

CIPL's have been installed on CI and steel pipes in natural gas distribution systems in Europe, Japan and North America over the last few decades. Historically, CIPL have been used because of their rehabilitative and renewal qualities in contrast to the higher costs, construction risks, and public inconvenience associated with conventional pipeline replacement methods, particularly in congested and difficult to access areas such as river and road crossings or urban areas. Natural gas industry operators have demonstrated significant safety benefits with CIPL installations, compared to conventional replacement, in addition to reliable and safe operating histories. In addition, reduction of leak prone pipe serves to reduce methane emissions.

CIPL is a three-component system, referred to as an elastomer-fabric-adhesive structure. The synthetic fabric jacket provides the strength characteristics for resistance to internal and external pressure, soil movement, and radial expansion. The elastomer skin provides the impermeable barrier that prevents the escape of gas. The adhesive is a two-part resin that bonds to form the composite and adheres the fabric jacket to the pipe wall. Tubes of woven polyester fabric, like a hose, saturated with thermosetting resin are inserted, pressurized to expand them, and allowed to cure in existing pipelines.

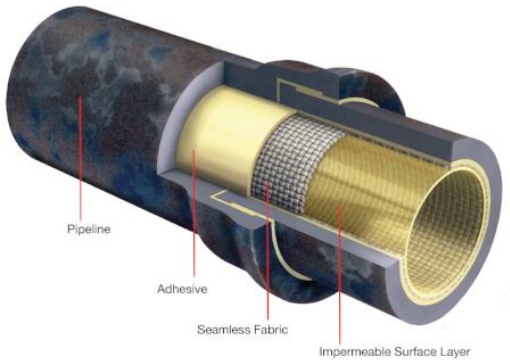

Figure 1: Cured in Place Liner System

TECHNICAL APPROACH

NYSEARCH has conducted extensive testing at Cornell University which have provided measurement data to underpin the experimental verification of the durability of CIPL system for CI and steel pipe repair, rehabilitation, and replacement. For these tests, specimens of 6-inch and 12-inch CI or steel pipe with Starline® 2000 liners were extracted from field service. Typically, these pipes had been installed at least 50 years prior and lined at least 12 years prior to the extraction. In some cases, as needed, a newly lined steel pipe was also utilized.

In 2015, NYSEARCH completed a series of tests on one set of specimens where they were subjected to 100 years of mechanical aging which included

flexure testing to simulate vehicular traffic, bending due to undermining/backfill event, and thermal contraction/expansion cycling to simulate the effects of seasonal variation in temperature. In these tests, the liner was subjected to loading at either a bell and spigot joint or at pipe joints with mechanical clamps natively present in the retrieved lined host pipe. The vehicular traffic simulations were equivalent to 2,000,000 cycles of 180-kN tandem axel load with an impact factor of 1.5, and thermal aging was performed by simulating the expected contraction/expansion of round crack in CI pipe due to a 40°F seasonal temperature (typical for the northeastern US) variation in the ground at typical pipe depths. The results of these tests noted that no leakage was detected throughout all phases of the mechanical aging tests. Pressure testing following the mechanical aging work. Again, results of these tests showed no leaks and all pipe sections maintained pressure.

Additionally, material property tests were performed to characterize the residual tensile properties of the composite liner system to assess the effects of field and mechanical aging on the liner system, as well as the residual liner/CI pipe adhesion strength to assess the durability of the bond strength using lap shear and peel tests. The results of the aged liner material properties were compared to unaged liner system properties (effectively 12 years in service + 100 years mechanically-aged) and confirmed that liner strengths were comparable between the field-aged and the mechanically aged liner specimens and that there is no evidence of significant reduction in either lap or peel strength due to the combined field and mechanical aging.

A notable finding found after visual inspection of all specimens tested in 2015 was that there was CIPL debonding discovered at the separation between the joints and the liner system. The debonding was confined to a small distance either side of the separation (less than 1 pipe diameter). This allowed the CIPL liner to stretch without experiencing excessive strain. However, in one specimen, substantial liner debonding accompanied by minor liner damage were observed. This outlier condition did not prevent the liner from maintaining the pressure boundary or leak in pressure testing. Experimental observations indicated that this distress occurred during the initial thermal loading cycle and was an artifact of the experimental setup.

In 2019, NYSEARCH completed a second study to further examine the outlier condition to ensure that thermal movements (expansion/contraction) are representative of real-world conditions. Like the original study, three lined CI pipe specimens were again excavated and tested via thermal aging. The liner was directly subjected to loading via the host pipe bearing a circumferential crack and loads applied to the pipe and liner system at that location. After the thermal cycling testing was completed, it was noted that all specimens maintained pressure and no leaks were detected. Additionally, visual inspection confirmed that liner debonding was minimal and no fiber damaged occurred. Using the field aged pipe, extracted from the 2019 study, mechanical and chemical properties were tested in Cornell's Department of Fiber Science.

PROGRAM STATUS

The testing for CIPL longevity and durability for up to 100 years is complete. Testing of liner tensile and adhesion properties over (36) months at 70°C was completed in July 2022. The results from the final work prove that even field extracted cured in place lined pipe have a life of over (96) years at 20°C (room temperature). If the gas pipes were to be exposed to lower temperatures, the life would be >100 years.

Highlights

- Strong experimental measurement data provides confidence that CIPL systems used in CI and steel pipe renewal are assured 100 years of life under real world environmental conditions.
- Through a combination of work in the 1990s, 2000s, the 2015 and 2019-2022 studies, NYSEARCH's body of work provides extensive verification of the longevity and durability of CIPL liners for CI and steel pipe repair, rehabilitation, and replacement.

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