MAKING A BETTER CIPP LINER INSTALLATION FOR AGING PRESSURE PIPES USING TARGETED ADHESION

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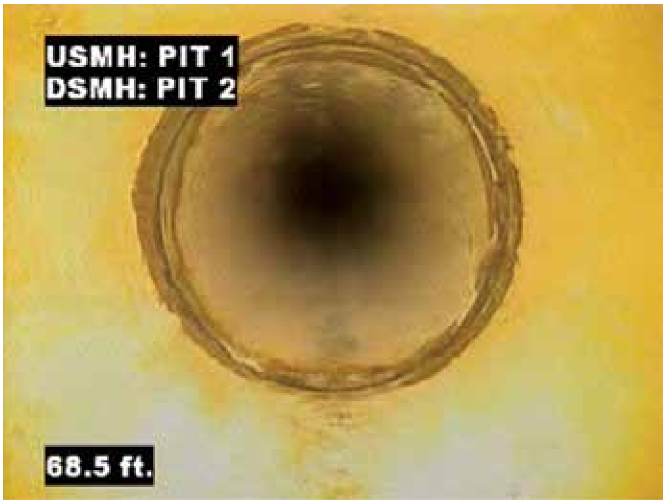
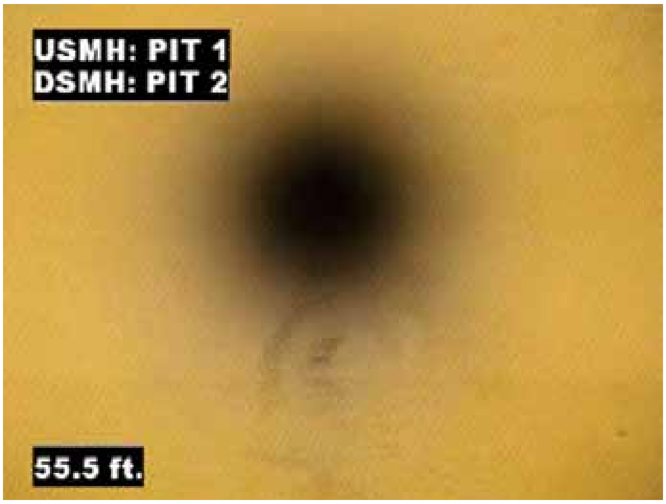
When we consider pressure pipe design for new buried pipes, standard practice in the design for any new installation includes restraint of movement. Restraint must be considered at direction changes, valves and appurtenances to address the pressure forces associated with fluid flow. For mechanically-jointed pipe like ductile iron, thrust restraint is a particularly important design consideration.

For plastic pipe (Plastic Pipe Institute, PPI) fused HDPE fittings are considered to be self-restraining at bends; however, for (material) transition fittings (e.g. plastic to metallic), restraint must be factored into any design due to Poisson-effect pipe shortening. When ductile pipe materials (thermoplastics and thermosets, e.g. CIPP) are pressurized, they expand slightly on diameter, and the length decreases in accordance with the Poisson ratio of the material. (This ratio is approximately 0.4 for HDPE and 0.3 for CIPP). To prevent Poisson pull-out disjoining in the transition area, external restraint must be achieved by installing in-line anchors, or by providing external joint restraints for unrestrained metallic pipe (bell and spigot joints).

For plastic pipe liners (CIPP and HDPE) inserted into metallic hosts, with the intention of providing a fully structural design, there can be no reliance on long-term



Left photo shows 12-inch CML-lined, corroded cast iron pipe under rail line. Right photo shows a pipe joint and prepared CML coating after removal of corrosion products with airborne stone.



Left photo shows 12-inch CML-lined cast iron pipe post-cleaning, preparation and pipe drying with airborne stone. Right photo shows the pipe (at the same location) after CIPP lining.

restraint from merely designing a "tight fit with the host pipe". Given that the AWWA definition of Class IV structural pipe design requires that "all loads are transferred to the host pipe", the host pipe has effectively "disappeared" in terms of design. Restraint of all plastic pipe liners (e.g. CIPP, HDPE) at all material transitions must be a "consideration" for any AWWA Class IV liner design.

Mechanical clamping or bonding of the liner to the host pipe (or what remains of it) is a prudent, first step in providing liner restraint. A second step is to insist on the quantification of this restraint through field-level testing, which is not currently required in AWWA Class IV liner design.

In addition to consideration of Poisson pull-out forces for pressure pipe liners, engineers must also consider tensile strain within the liner. An open-ended liner pipe subjected to internal pressure expands both circumferentially and longitudinally. When circumferential movement is resisted by whatever remains of the host pipe and the surrounding soil, a tensile strain ("stretch") is induced in the liner, which is independent of the length of the liner. Adhesion to the host pipe helps resist this tensile strain.

Beyond Poisson-effect pull-out and pressure induced axial strain, a liner may also experience axial shear loads dues to recurring pressure fluctuations and transient surge pressures. Pressure fluctuations will create axial shear waves that can exceed 2.5 – 3.0 times operating pressure in severe cases. Pressure fluctuations can also create tensile/compression forces on the liner at service connections, whereby the liner may be cyclically pushed and pulled at the service connection (radially) with recurring or transient surge pressure fluctuations.

If tension is about pulling and compression is about pushing, then axial shear is about sliding – the tendency for a liner that is in contact with the pipe wall to literally slide along the host pipe. Surge pressures provide the source for these shear forces, and again, these pressure waves can be of sizable magnitude over and above operating line pressure.

Shearing is what happens when you jerk the rug out from underneath someone's feet. However, if the carpet is bonded to the floor, this provides assurance that adhesion will ensure the person walking on it does not take a tumble. If a quantitative adhesive seal can be achieved at the transition points for liners (from CIPP liner to metallic host pipe), the shearing effects of pressure waves can be mitigated for as long as the host pipe continues to exist. Proper adhesion will keep the CIPP liner installation leak-free at key points like CIPP end seals and CIPP service connections. Poor adhesion can result in liner movement and potential leakage along the interstitial space between the liner and host pipe at end seals and service connections. It is important to note that the logic surrounding the benefits of quantitative adhesion applies to all classes of pipe liners – AWWA Class I through IV.

In order to obtain a quantitative adhesive seal that can help liners resist Poisson pull-out, axial strain and the shearing effects forces of surge pressures, engineers can now have access to a technology that goes beyond simply cleaning the corrosion and sediment from aging pipes. This technology also prepares and dries the host pipe surfaces for long-term liner adhesion. Surface preparation is key for providing a surface profile with increased surface area for better resin adhesion. While the CIPP resin remains the bonding agent for the liner to the host pipe, a dry host pipe (substrate) with enhanced surface area (profile) for adhesion provides maximum resin contact and a high probability for enhanced leak-tight connection. These levels of surface preparation and dryness cannot be achieved using older cleaning methods like rack-feed boring and scraping.

A cleaned, prepared surface profile that meets the National Association of Corrosion Engineers level 3 standard (NACE 3) is now possible. The Tomahawk system uses various calibers of bacteria-free stone in a low-pressure airstream (vacuum truck) to remove old coatings and corrosion products from the inside of the aging host pipes. The stone is accelerated axially down the pipe, scraping the corrosion products from the host pipe surface, while the airflow then dries the pipe. Smaller caliber stone is subsequently metered into the airstream and deflected radially at targeted points like services, joints and end seals. This deflection process is monitored in real time to ensure effective targeting of the stone cleaning and surface preparation operation, which ensures there is no damage to the pipe or service connections. The process typically takes two hours to complete for 300 – 400 feet of pipe, and CIPP lining can start immediately thereafter.

The Tomahawk process was recently used for a CIPP installation under a high-speed rail line in New York City. Approximately 80 feet of 12-inch, mortar-lined cast iron pipe was leaking and had been shut down pending structural repairs. The cleaning objective was to remove corrosion product accumulation at pipe joints and along the pipe wall while providing an enhanced bonding surface for CIPP, to enable rapid lining and quick return to service. The pipeline had been previously shut down due to leakage, and adhesion was desired to provide leak-free insurance against the future potential for water tracking between the host pipe and the CIPP liner.

The cleaning process for this installation took less than one hour, and the CIPP installation process proceeded immediately after final inspection. The customer was completely satisfied with the installation, and Tomahawk is now preparing for cleaning 200 feet of 12-inch diameter cast iron pipe under a major highway crossing in New York City this fall. A further installation is also planned under a major six-lane highway in New York City. While the outcomes for this CIPP installation were largely based upon CCTV inspections as opposed to quantified adhesion testing, such tests are planned for future installations. The speed of cleaning and drying process and the visual evidence (CCTV inspection) of a dry, surface profile provided confidence for the customer that the objective had been achieved. The cleaning and CIPP lining process was executed within 24 hours.

The use of airborne stone has a promising future in providing targeted, dry bonding surfaces that meet national standards (NACE 3) and can provide the adhesion needed to keep CIPP liners restrained, shear resistant, and leak-tight over the long-term.

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Randall Cooper P.Eng. *is a professional engineer with 23 years of experience in pipeline inspection, cleaning, condition assessment, and lining at large US industrial plants. He holds an honours MBA, and is a retired senior military officer with 14 years of service. He is a current member of ASCE, AWWA, ASTM, CATT and NASTT, serving on committees and preparing technical papers for the advancement of trenchless technology for the pipeline industry.*