Raising the grade

An innovative solution to certifying wastewater infrastructure rehabilitation

A California sewer agency demonstrates the effectiveness of Focused Electrode Leak Location (FELL) to find and measure leaks in cured-in-place pipe liners. Jamie Johnson of Electro Scan Inc. reports.

Every four years, the American Society of Civil Engineers (ASCE) releases its American Infrastructure Report Card based on physical condition and investments needed for improvement. The latest Report Card, released in 2017, shows that America's wastewater infrastructure earned a D+. This comes as no surprise, given the age of many sewer and stormwater systems and the difficulty in funding underground repairs, rehabilitation, and renewal projects, especially as the public cannot readily see the problems or benefits.

With approximately 1.3 million kilometers (km) of public sewers and nearly 805,000 km of private laterals, experiencing 23,000 to 75,000 sanitary sewer overflows (SSOs) each year, and water services receiving *less than* 5 percent of federal government funds directed toward infrastructure, it is increasingly important that spending is used to fix the right pipes, the right way, the first time around.

Historically, the primary method of inspecting sewers has been to use visual inspection methods such as closed-circuit television (CCTV). A mainstay for most utilities to assess the condition of sewer systems, more than 18,000 sewer agencies in the United States (US) have used CCTV to evaluate, prioritize repairs, and certify rehabilitation of these critical sewer infrastructure repairs to allow another 50 to 100 years of service.

While useful for evaluating certain operation and maintenance indicators, such as fats, oils, and grease (FOG) and roots, CCTV is limited in its evaluation of infiltration and its ability to certify newly rehabilitated or installed pipes. This limitation is primarily due to its reliance on visual features – the camera actually needs to see any defects – and operator interpretation.

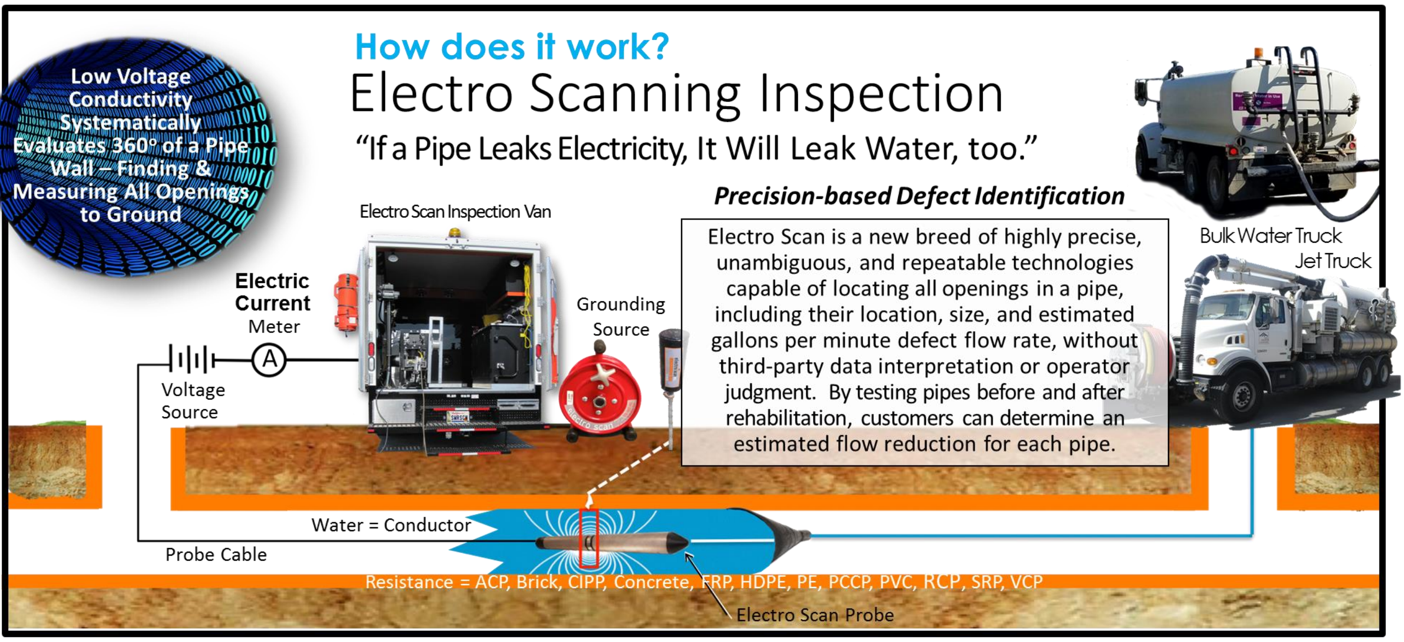
The inability of visual inspection to detect the difference between a superficial crack and a crack that goes through a pipe's wall, or to accurately rate the condition of joints and service connections, has inadvertently caused bad pipes to be missed and good pipes to be unnecessarily repaired. Additionally, in the case of certifying and accepting repairs or relining – using methods such as Cured-In-Place Pipe (CIPP) – these limitations have resulted in the approval of rehabilitation projects that leak.

With a growing population and many communities having wastewater treatment plants already at or near capacity, eliminating infiltration and exfiltration is a pressing concern for many agencies. And with more than US$10 billion being spent annually to repair and replace aging wastewater infrastructure, it's clear that municipalities cannot afford to incorrectly fix non-critical pipes or accept substandard rehabilitation by relying on outdated inspection methods.

Focused Electrode Leak Location

If CCTV is not the right tool to prioritize pipes based on eliminating infiltration or to certify rehabilitated or newly installed liners, then what is? *The Operation and Maintenance of Wastewater Collections Systems Manual,* Volume 1, Seventh Edition (2015) – referenced by the Environmental Protection Agency (EPA) in its Capacity, Management, Operation, & Maintenance (CMOM) Program – is now recommending that Electro Scanning Inspection (ESI) be performed before and after any pipe repairs, replacements, or renewals. The Office of Water Programs at California State University in Sacramento (CSUS) published the manual.

Electro Scanning Inspection – also known as Focused Electrode Leak Location (FELL) and Low Voltage Conductivity (LVC) – locates (within 1 cm or 0.4 inches)



and measures (in gallons per minute or liters per second) each crack, fracture, bad joint, hole, defective service connection, or any other opening to ground, whether visible or not. This process is achieved using a low-voltage, high-frequency AC current to provide a meticulous interrogation of openings in the wall of new and rehabilitated non-metallic pipes (i.e. asbestos cement, brick, fiberglass, vitrified clay, plastic, reinforced concrete, etc.). Anywhere electricity escapes, so will water.

This machine-intelligent technology provides fast, accurate, unbiased, repeatable, and quantitative data on leakage, without requiring any third-party data interpretation, with data accessible on the cloud from any device with an internet connection within minutes.

CIPP pipe lining

Since its inception in 1971, Cured-In-Place Pipe (CIPP) lining has been used to rehabilitate an estimated 121,000 km worldwide. Yet little, if any, testing has been done on fully installed pipelines, with agencies instead relying on CCTV visual inspection or pressure testing to certify their liners.

Unfortunately, in many cases, CIPP liners are not living up to their estimated 50-year useful life. When properly installed, CIPP has the potential to last for decades. Regrettably, this lifespan is often not reached, as many steps can go wrong in the process, from not enough resin to overcooking to wrinkles, just to name a few.

With the introduction of FELL, pipeline owners and operators can correctly certify and accept newly repaired, relined, and renewed pipes by automatically finding and measuring every leak in a liner and determining an estimated liters per second (or gallon per minute) of defect flow.

Projects completed between January 1 and December 31, 2016 using FELL have shown that 69 percent of CIPP liners had defects. While representing an overall improvement compared to previous pipe conditions, results showed that more than 20 percent of lined pipes had the potential to leak at approximately 76 liters per minute (lpm) or more.

A surprise to many that have long relied on trenchless lining to repair, rehabilitate, and renew sewer and water mains and laterals, the 2016 results confirm previous findings by Ken Kerri, PhD, PE, that led him to recommend Electro Scanning Inspection for both pre- and post-rehabilitation, as published in the 7th Edition, Volume 1, *Operation and Maintenance of Wastewater Collection Systems Manual (2015).*

California sewer agency uses FELL inspection method

Unable to consistently or accurately find defects in CIPP lining using existing methods, a California sewer agency was looking for a solution that could provide an unbiased and unambiguous assessment of a contractor's work.

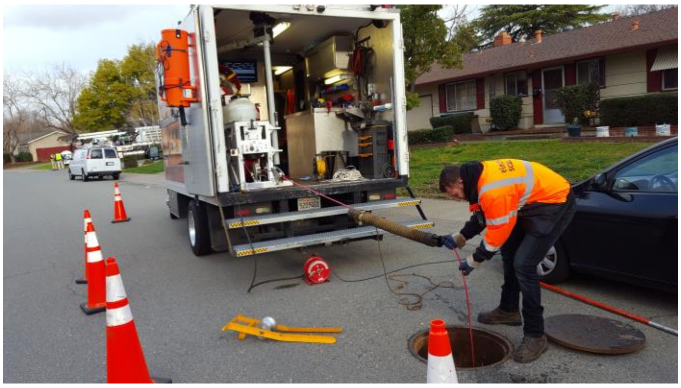
Following field demonstrations in 2016, the agency determined that FELL was best positioned to provide a baseline defect flow rating for its sewers, measured in gallons per minute, so the agency could more easily determine a quantified reduction in flow and more confidently certify and accept rehabilitation by its contractor.

Electro Scan Inc., headquartered in Sacramento, California, USA, was hired to complete the pre- and post-rehabilitation FELL inspections for a pilot project. Taking place over a several-month period, FELL was used to evaluate seven mainlines, or approximately 610 linear meters of pipe, before and after CIPP lining. Only one mainline did not have a pre-rehabilitation inspection, as it was an uncoated ductile iron pipe.

All inspections and reporting were completed in accordance with the *Operation and Maintenance of Wastewater Collection Systems Manual,* Volume 1, 7th Edition (2015) and ASTM F2550, *Standard Practice for Locating Leaks in Sewer Pipes By Measuring the Variation of Electric Current Flow Through the Pipe Wall.* Additionally, all results were made available to the agency immediately following the test completion, through Electro Scan's proprietary cloud-based software, CriticalSewers®.

FELL results showed that post-CIPP work had reduced total individual defect locations from 658 to 35 – a 95-percent reduction in the number of defects – and that estimated defect flow was reduced from 3,452 lpm to 382 lpm – a reduction of 3,070 lpm, or 89 percent.

It was observed that nearly all of the post-CIPP defects were linked to specific lateral service reconnection locations, previously identified as live, i.e. not capped. However, it was also found that not all lateral service reconnections experienced post-CIPP defect flows. The ability to identify which service reinstatements are leak-free and which contain defects is valuable, as it can save agencies money by eliminating lateral lining that may not be required or necessary.



Electro Scanning Inspection locates within 1 cm and measures in water volume per second each crack, fracture, bad joint, hole, defective service connection, or any other opening. Photo by Electro Scan Inc.

Additionally, it was found that two lines experienced larger defect flows after CIPP, in comparison to baseline readings before CIPP. In many cases, mechanical cleaning of pipes, prior to lining, may cause additional damage to already fragile pipes. For instance, the process of cutting and removing roots may further exacerbate or compromise joints, causing larger defects to occur directly before the lining process. Remote tap cutting to reinstate service laterals after lining and curing the pipe may also cause large defects in a pipe that were not present before rehabilitation.

Lessons learned

A variety of lessons were learned from this case study, including:

- CCTV should not be used to certify or approve lining contractor's work. Since CCTV is a visual inspection process, it cannot reliably or consistently detect lining defects, quantify openings to ground, or assess service reinstatements. As has been proven many times, defects in CIPP often do not become visible on camera until a few seasons later, typically after the warranty period has expired.
- CIPP lining of sewer mains does not always reduce defect flows. Post-CIPP defect flows may be higher after lining than before, as remote tap cutters may accidentally create collateral openings to the soil.
- To better manage capital expenditures, lateral connection liners should be a post-CIPP decision, not an across-the-board pre-CIPP specification requirement.
- Since FELL provides a highly precise location and severity for each defect, post-CIPP CCTV should be done after FELL, with cameras stopping at each defect location identified by FELL to pan, tilt, and zoom accordingly. Otherwise, CCTV will likely pass by or miss the defect.
- Agencies should not just measure success on a top-down basis to see area reductions in defect flow; rather, they should assess contractor performance on a pipe-by-pipe basis.
- Since many lateral service reinstatements measured zero defect flows, contractors should have an incentive to achieve more precise remote tap cutting, eliminating the need for costly and unnecessary lateral connection liners. Lateral connection liners should only be recommended for those services that have unacceptable levels of defect flow.
- Future wastewater rehabilitation specifications should consider (1) a contractor performance bonus for every service connection that registers zero defect flow; (2) a requirement to joint grout all service connections where defect flows are found by FELL; and (3) require the installation of a lateral connection liner at the cost to the contractor, where all services show post-CIPP defect flows greater than pre-CIPP levels.

Conclusions

As stated by the ASCE's Infrastructure Report Card, "Our nation's infrastructure problems are solvable if we have leadership and commit to making good ideas a reality. Raising the grades on our infrastructure will require that we seek and adopt a wide range of solutions."

With its ability to accurately locate and quantify defects within a pipe, FELL represents the next generation in leak detection and is the best tool for conducting pre- and post-rehabilitation assessments, making it the solution that many agencies have long been looking for.

Author's Note

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