A SUPPLEMENT OF *TRENCHLESS TECHNOLOGY*

2013 PIPE

PIPE RELINING

Trenchless TECHNOLOGY

CONTENTS

PIPE RELINING TAKES CENTER STAGE

JIM RUSH

As the backbone of the trenchless technology industry, pipe relining covers a broad range of techniques and applications, with new innovations continually coming to market. To help showcase the latest developments in this realm, *Trenchless Technology* is publishing this special supplement — the *2013 Pipe Relining Guide*.

Pipe relining covers methods that include cured-in-place pipe (CIPP), close-fit lining (Swagelining, fold-and-form), sliplining, spiral wound, spray lining, panels. Historically pipe relining has been most prevalent in gravity sewer systems, but it is also suitable for pressure pipes, water mains, storm drains and culverts, gas mains and more.

The purpose of this supplement is to offer a glimpse of the available options, as well as showcase successful project stories and products.

We start the editorial with some background and current market conditions then introduce some of the environmental implications and benefits of using pipe relining (see "Pipe Lining: The Green Technology of the 21st Century," beginning on page 12, written by NASSCO Technical Director and longtime trenchless guru Gerry Muenchmeyer).

Next, we address how to select the most appropriate relining method for your particular project in an article written by John Matthews, a principal researcher at Battelle and a former researcher and student at Trenchless Technology Center (TTC) at Louisiana Tech. Choosing the right method from the start gives you the best chance at the successful completion of a project.

Next, we get into some of the specific pipe relining methods and applications by showcasing case histories. Some of the topics include, storm culvert repair, sliplining, spray-on lining, light-cure CIPP, lateral lining and water main rehab.

We close the issue with a special Marketplace section featuring companies most active in the area of pipe relining. We encourage you take a look at this section and contact the companies to learn more about their latest products. These companies are driving the market by introducing new products and services that make pipe relining more efficient and cost effective.

As we look to the future, there continues to be new innovation and refinements to the existing technologies. We contacted NASSCO, one of the oldest trenchless-related organizations in the United States, for some perspective on how the pipe relining market is changing, and here is its response: "There have been several significant developments in the use of CIPP, although the most influential development is the gradual development of industry standards of quality. Other recent developments include new innovations in robotic support equipment and curing monitoring technology. Also, structurally enhancing materials such as fiberglass and carbon fiber, added to the felt liner material, have increased liner strength capabilities and the market opportunities for CIPP rehabilitation of pressure pipelines for sewer, gas, industrial and potable water applications."

Lynn Osborn of Insituform, who has been in the market for nearly three decades, offered this perspective: "New inventions and developments will also lead to new products for the pressure market, which could grow the trenchless share of that huge market. With these developments, we're likely to see a similar education process as we saw with the gravity products, helping to gain market acceptance. It's likely that for the pressure market, the next several years could present challenges similar to what we faced over 25 years ago when the trenchless industry was just beginning."

So while pipe relining in many respects is a mature market, there is a lot of room for growth and new areas ripe for development. It promises to be a dynamic market segment now and for the future.

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THE PIPE RELINING MARKET AT A GLANCE

After Years of Innovations in Multiple Relining Practices, CIPP Continues to Lead the Market as the Ever-Evolving Method of Choice

BY ANDREW FARR

When looking at the rehabilitation side of underground construction, it's hard to imagine where the industry would be without certain practices, certain methods, certain companies — and certain people. Many innovations over the course of many years have taken place on the technological and methodical fronts to drive the industry forward.

Take the pipe relining market. Can you imagine where the market would be if the cured-in-place pipe (CIPP) process was never developed? Before CIPP, grouting and early sliplining methods were used for pipe repair. Little did Insituform founder Eric Wood know that in 1971, when he performed his makeshift rehab process on a pipe in an air duct at a mushroom farm, that it would spawn a global industry and reshape the way cities address failing infrastructure.

But it wasn't just Wood's process some 42 years ago that has revolutionized pipe relining. It's perhaps important to remember that the trenchless industry is still young, and some of the most important innovations and best practices have happened in half that time. For example, when talking about methods for gravity sewer rehab, CIPP has remained dominant. But since the 1990s, the process has been applied significantly in water applications, as well.

What seems to be ever-growing in the CIPP market is that every aspect of the process has been continuously improving — developments in resin technology, new curing methods and the ability to perform large diameter relining are just a few of those areas. Aside from CIPP, sliplining, pipe bursting, cement mortar lining and the use of spray-on linings and epoxy coatings that offer structural rehab and corrosion protection are also gaining traction. Each of these areas will be addressed in detail throughout the *Pipe Relining Guide*.

A recent survey by *Trenchless Technology* showed that a majority of utilities across the United States are routinely using trenchless relining methods. Of the utilities polled, 84 percent claim CIPP as the most common method, and a few industry experts agree there have been several significant developments in CIPP and across the pipe relining market.

CIPP AS THE PREFERRED METHOD

Some of the major innovations in pipe relining have taken place in CIPP work, and according to the *Trenchless Technology* survey, it remains the preferred method. Industry-wide, it is estimated that CIPP has been used to rehabilitate more than 35,000 miles of pipe since the early 1970s.

The biggest changes in CIPP work have been in technological advancements and improved procedures, production and equipment, according to Lynn Osborn, senior applications manager with Insituform.

"At one time, a small diameter CIPP crew was doing well if they installed four shots per week, totaling maybe 1,200 to 1,400 ft at most," said Osborn, who has been with Insitufrom since 1984. "Today, many crews have joined the 'mile' club by installing over one mile of CIPP in one week. Also, the critical path in installing small diameter CIPP is often reopening the house service laterals. With the robots available today, we are able to meet these higher production rates and continuously provide more value and faster solutions for the customer."

Osborn also points to the addition of water main applications and pressure pipes for CIPP as being one of most notable shifts in the CIPP market over the last 20 years.

"We [Insituform] started working on water mains in the early 1990s, so it's not a recent development, but it's certainly more difficult and more technical," he said. "It's a lot easier to do sewer work. The challenge is that water mains are pressurized. You have to dig a lot more to access water mains and you have to keep everything clean, because it's for water. So the new initiative in the industry has really been pressure pipe."

From the time Eric Wood's first successful relining project was completed in London, Insituform controlled the patents to the CIPP process until February 1994, giving the company a 23-year head start on any competition and allowing it to build its brand and solidify its market presence. Expiration of those patents opened the door for other companies to challenge Insituform, as well as expand the flourishing pipe rehabilitation market.

Layne Inliner —previously Reynolds Inliner — has since grown to be one of the largest cured-in-place pipe contractors in the United States with more than 16 million ft of CIPP in the ground. Denise McClanahan, vice president at Layne Inliner, agrees that CIPP work is without a doubt, holding steady as the most extensively used process in rehabilitation options.

"The market is so competitive and there have been so many material

"If you look at trends in the market today, what we're seeing are the larger, more complex, multi-disciplined projects. We are also seeing more annual contracting mechanisms with renewal periods being utilized."

DENISE MCCLANAHAN
LAYNE INLINER

changes like fiberglass additives, carbon fiber additives, changes to resin and the strengths and properties that you're able to give to resins," McClanahan said. "The resin companies have done a really good job of continuing to push resin technology, so applications we couldn't do before — whether they would be high corrosion or high temperature — we can do today because the resins advanced to that."

McClanahan also pointed to enhancements in the curing process and the expansion of curing options to allow alternate curing methods for different applications. "When cured-in-place pipe started, it was all hot water cured," she said. "Today, you can do hot water, you can do stream, and now, ultraviolet light is coming on."

Ultraviolet (UV) light as a curing process is still relatively new to the United States in the last five years. Instead of having thermal reactive initiators in resin, there are now UV light initiators. The process is essentially the same, only once the CIPP lining tube is inserted into the pipe, an ultraviolet light bulb is used to cure the liner rather than the traditional heat or steam technology.

"I think the biggest thing some [municipalities] are still relatively unfamiliar with is the curing methodologies and knowing when they should use water, when they should use steam, when they should specify UV and when they should leave it entirely up to the contractor," said McClanahan. "I think that's one thing the industry is still trying to wrap their arms around, and asking, 'What are the benefits of each method and how can they best apply them to their applications?'"

MARKET TRENDS

In spite of the economic downturn of 2007-2008, the pipe relining market has remained steady even as industry concerns still linger. The American Society of Civil Engineers' 2013 report card gave wastewater a 'D' grade in 2013, and according to the report, U.S. utilities will need to spend approximately $300 billion over the next 20 years in wastewater infrastructure, with pipeline rehab representing the majority of that work. On the drinking water side, a report conducted earlier in the year by the U.S. EPA estimated that $384 billion will be needed to ensure safe drinking water through 2013.

In many instances, cities in the United States are mandated to upgrade their water and sewer systems. While funding for these projects will likely continue to be a question mark, the work itself remains competitive.

"The rehabilitation market is extremely competitive and there is growth in certain areas," said McClanahan. "[The] biggest problem customers have is how to meet the budgetary demands of fixing aging infrastructure. If you look at trends in the market today, what we're seeing are the larger, more complex, multi-disciplined projects. We are also seeing more annual contracting mechanisms with renewal periods being utilized.

"If you look at the wet-outs today, and the installation equipment, [it's] totally different than when the technology first came to the U.S.," McClanahan added. "I think all of us are continuing to develop new installation units so we can install larger diameter and longer installs. Those kinds of changes really keep cured-in-place a flexible, preferred method of rehab in the industry today. If we looked like we did in 1991 today, we wouldn't exist."

As trenchless methods become more known to the construction industry as efficient and cost-effective, there has perhaps been a renewed focus on education. The communication of ideas and practices that have influenced project successes — and failures — has helped the industry become more knowledgeable.

This trend is evidenced by the establishment of academic institutions like the Trenchless Technology Center at Louisiana Tech University and other schools that have adopted trenchless engineering programs, such as the Center for Underground Infrastructure Research and Education (CUIRE) at the University of Texas-Arlington.

"The biggest developments have been in the areas of asset management, inventory, inspection, quality of service, and more availability and options for renewal and rehabilitation methods and materials, which have resulted in cost reductions," said Dr. Mo Najafi, professor and director of CUIRE.

"With aging pipelines and availability of technical specifications, design guidelines, educational materials and books, and awareness of public in social costs of open-cut, engineers and owners are more comfortable with using relining methods. Therefore, the market for relining methods is certainly increasing."

McClanahan agrees this communication is benefiting the industry and that it is creating a dialogue between contractors, engineers and their clients where the goal is to gain a better understanding of the capabilities of products and techniques.

"Probably the trend that's most encouraging is we're seeing that the industry is on a quest for knowledge," she said. "We have more engineers and more owners and more clients call us today than we ever had before. They don't just want specifications on our products, but they want to understand the strengths of it, the weaknesses and whether it is the right application for what they want.

"They're really letting us help define some of the things that are going into rehab projects up front. There's a concerted effort to communicate those areas instead of a specification coming out that we have to adhere to. I think that's probably the most positive trend we're seeing today."

Andrew Farr is assistant editor of *Trenchless Technology*.

SURVEY

PIPE RELINING MARKET STRONG IN NORTH AMERICA

BY JIM RUSH

Pipe relining has long been a staple of the trenchless technology industry, and indications are that it will continue to be for the foreseeable future, according to a sewer relining survey conducted by *Trenchless Technology*. The survey was sent out to municipal representatives in the United States and Canada, and included a range of utilities across North America.

Despite the general downturn in the economy that began in 2007-2008, the trenchless rehabilitation market remained fairly strong. One of the reasons of the strength is the mounting need to upgrade and maintain infrastructure that is approaching or exceeding its design life. The American Society of Civil Engineers' well-cited infrastructure report card gave wastewater a 'D' in 2013. According to the report, U.S. utilities need to spend approximately $300 billion over the next 20 years in wastewater infrastructure (with pipes representing about 75 percent of that figure).

In many instances, cities in the United States are mandated to upgrade their sewer systems. According to published reports, more than 770 cities across the United States have negotiated or continue to negotiate long-term plans to address sewer discharges.

One of the most common contributors to sewer overflows is inflow and infiltration (I/I), which is the combination of extraneous water entering a sewer system through cracked pipes or leaky joints in mainlines, laterals and manholes. One common method for addressing infiltration is pipe relining.

"The market continues to grow, and a big driver for that has been the EPA consent decrees that require cities to address sewer overflows," said David Rosenberg, a senior manager with Michels Pipe Services. "The need to address overflows to comply with mandates is not something that is going to go away any time soon."

Pipe relining has been around for many years, with the use of sliplining dating back to the 1940s (Najafi, 2013). With the introduction of cured-in-place pipe (CIPP) in the 1970s, the pipe relining market segment began to grow. Since its introduction into the U.S. marketplace in 1976, CIPP has continued to grow as the method has become more accepted and understood by utility managers and consulting engineers.

Additionally, more research, education and technical developments have occurred to make trenchless processes more effective and less costly. "Aging pipelines, coupled with the availability of technical specifications, design guidelines, educational materials and increased public awareness of social costs of open-cut, engineers and owners are more comfortable with using relining methods," said Mo Najafi, professor and director of the Center for Underground Infrastructure Research and Education (CUIRE) at the University of Texas-Arlington. "Therefore, the market for relining methods is certainly increasing."

According to Lynn Osborn, senior applications manager with Insituform, increased productivity of relining crews — specifically CIPP crews — has helped the growth of the market. "For CIPP, one of the most striking changes is the improvement in production rates through improved procedures, equipment, training, logistics and materials," said Osborn, who has been in the relining market for 29 years. "At one time, a small diameter CIPP crew was doing well if they installed four shots per week, totaling maybe 1,200 to 1,400 ft at most. Today, many crews have joined the 'mile' club by installing over one mile of CIPP in one week. Also, the critical path in installing small diameter CIPP is often reopening the house service laterals. With the robots available today, we are able to meet these higher production rates."

SURVEY RESULTS

The survey showed that a majority of utilities are routinely using trenchless relining methods: 89 percent of respondents indicated that their utility uses trenchless relining. Additionally, 94 percent reported that their use of trenchless relining is increasing (62 percent) or staying the same (32 percent) while only 6 percent said that their use of trenchless relining was decreasing.

Of the types of relining methods used, CIPP was the most common with 84 percent of utilities using that process for pipe rehabilitation. Sliplining was the next most popular at 39 percent, followed by spray-on lining (18 percent) and close-fit lining (15 percent).

For CIPP, steam (67 percent) and hot water (62 percent) curing methods are still the most commonly used, with ambient cure (23 percent) and light cure (13 percent) also being used.

When using trenchless relining, just less than half of the respondents indicated that they address manholes and laterals at the same time (44 percent), while 34 percent addressed the pipes alone, 15 percent addressed pipes and manholes, and 7 percent addressed pipes and laterals.

Not surprisingly, funding was the most common issue related to trenchless relining, with 42 percent of respondents reporting a lack of available funding as an issue. Other common issues included: finding qualified contractors (32 percent), knowledge and experience of staff or consultants (32 percent) and inspection (22 percent). An encouraging sign was that the fact that only 10 percent of respondents said that finding acceptable products was an issue.

The survey also showed that the vast majority of relining is done in the smaller diameters — which comprise the majority of sewer collection systems. The most common size range of pipes being relined is 6 to 12 in. (83 percent), followed by 13 to 24 in. (80 percent), 25 to 48 in. (53 percent), 48 to 72 in. (25 percent) and 73 in. and greater (8 percent).

Clay (81 percent) and concrete (71 percent) are the most commonly relined pipes, followed by cast iron (41 percent), ductile iron (36 percent), steel (25 percent), AC (25 percent), PVC (15 percent), HDPE (8 percent) and brick (6 percent). Interestingly, two utilities reporting relining wood stave pipe.

Respondents gave a range of age of pipe being relined with 25 years old being the youngest and 100-plus being the oldest. The most common age of the pipe being lined was approximately 40 to 60 years old.

Finally, we asked participants to tell us about the criteria they use in planning their relining program. Condition assessment data, typically via CCTV, along with break history were commonly cited. Other factors that led to the use of trenchless relining included the depth of pipeline, age (old pipes may be replaced instead of relined), location (relining more likely in urban areas) and cost.

FUTURE

As there is an increased emphasis on asset management by water professionals, this may also help drive the relining market. Trenchless pipe relining meets the "triple bottom line" evaluation approach of asset managers by providing economic, environmental and social benefits.

NASSCO agrees, stating: "It is a commonly accepted fact that we do not have the resources to keep up with the rate of deterioration of the nation's infrastructure. The deteriorating condition of the underground pipeline infrastructure is just beginning to be understood through standard inspection techniques like Pipeline Assessment and Certification Program (PACP) and advanced asset management programs. Trenchless technologies are generally much more cost-effective in extending the life of underground infrastructure compared to traditional excavation, mainly due to the reduction of surface restoration (paving, sidewalks, etc.). Lower costs, along with numerous environmental and social benefits will cause the market for lining to continue to grow at an accelerated pace."

A limiting factor for the growth of relining may be availability of contractors. "One of problems we are seeing is a strain in finding craftsmen," Rosenberg said. "We are always looking for good people."

Osborn concurred, and added that quality work is critical to the health of the market: "With the multitude of CIPP installers at work today, installer training, or lack thereof, could be limiting. It only takes one bad shot or job to turn a customer off for years."

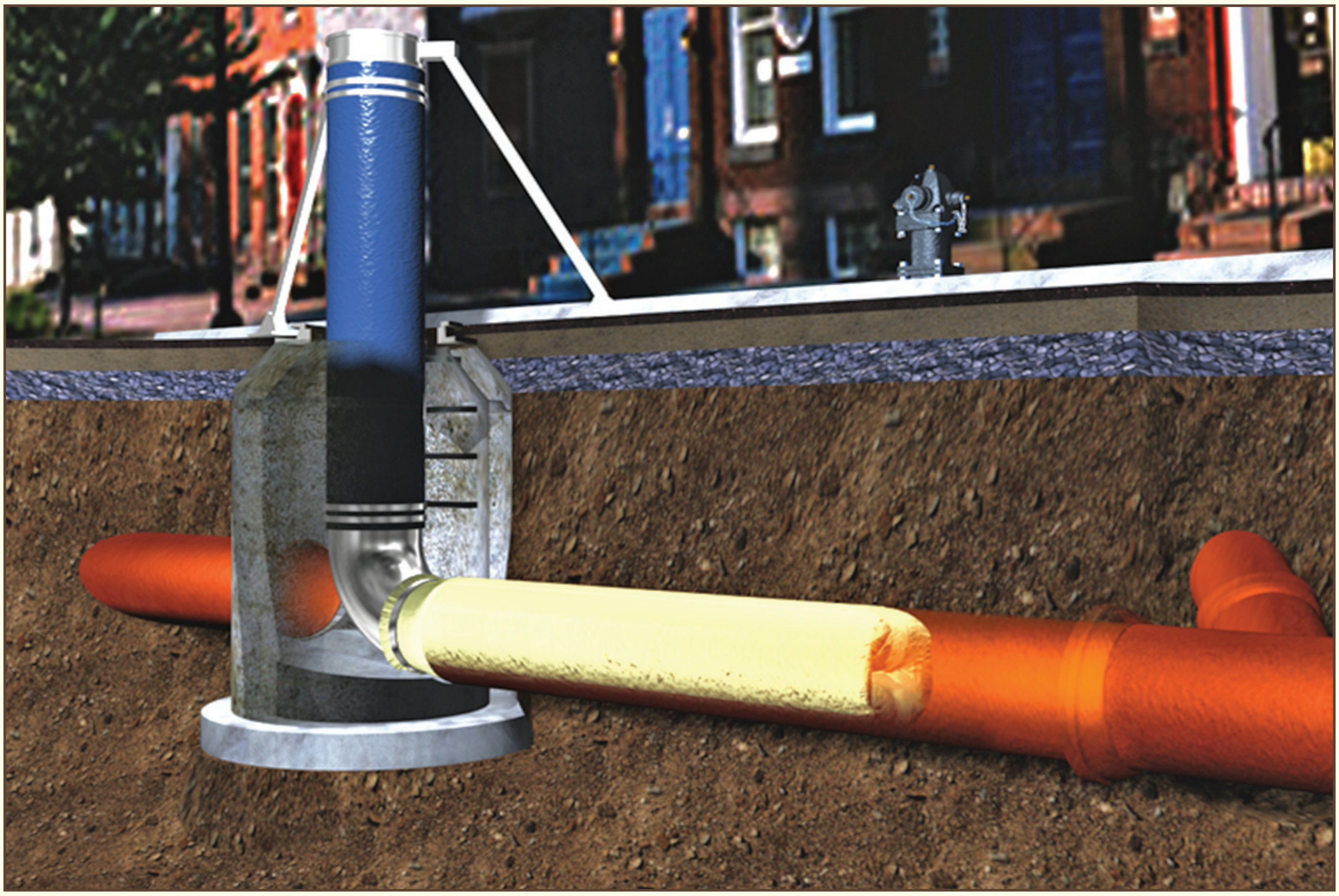
As more work is completed, that will open the door for further growth, according to NASSCO: "The pipelining market continues to grow. As more successful projects are completed, system owners are becoming educated on the benefits of non-disruptive, green construction at a lower cost to rebuild their sewer and water infraAs more work is completed, that will open the door for further growth, according to NASSCO: "The pipelining market continues to grow. As more successful projects are completed, system owners are becoming educated on the benefits of non-disruptive, green construction at a lower cost to rebuild their sewer and water infrastructure.

Jim Rush is editor of *Trenchless Technology*.

PIPE LINING

THE GREEN TECHNOLOGY OF THE 21ST CENTURY

BY GERHARD "GERRY" P. MUENCHMEYER, P.E.



The shift from excavation and replacement of the failing underground piping infrastructure in favor of using a variety of minimally invasive lining techniques, now commonly known as trenchless technology, has saved municipalities and utility owners hundreds of millions of dollars over the last 40 years in North America and throughout the world. But the savings are not only measured in dollars. The success of the pipe lining industry can be measured by environmental benefits, social advantages, and the high quality of the rehabilitated infrastructure.

On a typical pipe excavation and replacement project, the work requires the use of diesel-powered excavators, earth movers, trucks, paving machines and a variety of fuel-driven support equipment. Traditional construction activities can take weeks or more, resulting in increased air and dust pollutants, site runoff, and noise pollution. Traffic disruptions result in higher carbon monoxide emissions from driver delays and detours, as well as the loss of business activities in the affected construction area. Site restoration is probably the most invasive and expensive part of this work, which usually requires pavement and sidewalk replacement, tree and shrub replacement, and, many times, repairs to adjacent utilities.

Trenchless pipe lining is much more efficient than traditional open-cut projects. Lining technologies involve minimal or no excavations and require significantly less construction time (commonly a matter of days and hours), resulting in less equipment usage. Faster installation means less crew time and a safer work environment, as well as decreased runoff and noise pollution and minimal traffic controls. Efficiency also results in a significantly smaller carbon footprint, with estimates of 80 percent[1] less carbon usage over traditional construction for some projects.

Trenchless pipe lining can be defined as green technology. Green technology is environmentally friendly, and has been developed and used in such a way so that it doesn't disturb other utilities, the existing environment and natural resources. The objective of green technology is to find ways to create new technologies that do not damage or deplete the planet's natural resources. Green also imposes less harm to human, animal and plant health, as well as damage to the world in general. Pipe lining using trenchless technologies surely can be classified as green technology. These technologies allow us to rebuild our rapidly failing underground pipeline infrastructure for future generations in a responsible and cost-effective manner.

Pipe lining technologies have a proven design life comparable to traditional replacement, and there are other advantages to the final product. Since a completely lined pipe segment has no joints, there is less potential for infiltration. The smooth surface of the cured material provides increased capacity, while the material itself is generally more resistant to corrosion and abrasion and can be designed to accommodate structural strength requirements.

All materials used in our infrastructure have an expected useful service life. In many parts of the world this service life has been exceeded, and pipeline deterioration and failure is now becoming a way of life. Pipe lining encompasses many green methods for lining or replacing existing underground pipelines at a time when the reconstruction of the underground pipeline infrastructure is no longer a wish but has become an eminent need. Green pipe lining systems, however, use a variety of materials that are designed for cost-effective installations and provide a safe and environmentally sound solution for the challenges of rebuilding the world's pipeline infrastructure systems.

One such material known as "styrene" is a major component of the green pipe lining technology generally referred to as cured-in-place pipe (CIPP). Although styrene occurs naturally in many foods such as cinnamon, coffee and strawberries, styrene derived from petroleum and natural gas by-products have raised many questions about whether its usage in polyester and vinyl ester resin systems commonly used in CIPP to rehabilitate piping systems has the potential to adversely affect human health and/or the environment. While the CIPP process is a potential source of styrene, studies done to date have concluded that these type of resin systems do not appear to be a significant source of styrene or any of the other volatile organic compounds (VOCs) that are typically of concern in occupational or air quality studies.[2]

The CIPP industry and its many related materials and equipment suppliers employ tens of thousands of people. The use of CIPP saves cities and towns billions of dollars on pipeline rehabilitation when compared to traditional excavation and replacement. This significantly lower cost technology has provided cities and towns with the financial ability to reconstruct their pipeline infrastructure at a more aggressive rate in their attempt to keep up with their continuing deterioration, while creating large employment opportunities throughout the country.

In June 2011, however, styrene was listed in the *12th Report on Carcinogens* published by the U.S Department of Health and Human Services as "reasonably anticipated to be a human carcinogen." One definition of this classification would be "there is limited evidence of carcinogenicity from studies in humans, which indicates that causal interpretation is credible, but that alternative explanations, such as chance, bias, or confounding factors, could not adequately be excluded."[3]

It is important to note that styrene has not been listed as a carcinogen or even a probable carcinogen. Additionally, the organizations involved in identifying substances as "reasonably anticipated to be a human carcinogen" are extremely conservative. So conservative, in fact, that they do not require direct evidence, nor even potential exposure levels that would put people at risk above normal background exposure levels. What's more, federal agencies — including the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) — are aware of scientific data regarding styrene and yet neither had concluded that there is sufficient risk to require additional protections.

On Dec. 16, 2011, an agreement was reached, which includes $1 million for the Assistant Secretary of HHS to contract with the National Academy of Sciences (NAS) to conduct a scientific peer review of the *12th Report on Carcinogens* determinations related to formaldehyde and styrene. This scientific review is currently under way, with the final report to be delivered in September 2014. Included in the reviews should be all relevant, peer-reviewed research related to both formaldehyde and styrene.

Regardless of the outcome of the NAS peer review and how minimal the potential risk, all materials where exposure to workers and the general public are a concern must be managed with good housekeeping practices to minimize risks to human health and the environment.

The EPA Gap Analysis made it clear that our pipelines are deteriorating at a rate faster than we can replace or repair them with the resources we have. Pipe lining technologies in use today provide system owners with an option to help stretch their limited resources by providing quality results with lower project costs, while significantly decreasing environmental and social impacts.

Gerhard "Gerry" P. Muenchmeyer, P.E., is technical director of NASSCO.

REFERENCES

[1] Carbon Calculator; What does this do for Utilities, Rate Payers, Contractors and Engineers; we are "GREEN" by David O'Sullivan, President, PW Trenchless Construction, Inc.

[2] Guideline for the use of styrenated resins in cured-in-place pipe" prepared by the NASSCO CIPP Committee

[3] U.S. Department of Health and Human Services Public Health Services National Toxicology Program Research Triangle Park, NC 27709 dated Sept. 29, 2008

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HOW TO?

SELECT THE PROPER RELINING METHOD FOR YOUR JOB?

BY JOHN C. MATTHEWS, PH.D.

When it comes time to select a relining method to rehabilitate water and sewer mains, available technologies are increasing in number and complexity. Established methods evolve and new techniques continue to develop. Given the number of methods and parameters to consider, the decision of which relining method to use can be intimidating. This article will summarize available relining methods and discuss key selection criteria.

WATER MAIN RELINING METHODS

Water main relining methods vary for small-diameter (i.e., 12-in. diameter and smaller) and large-diameter pipes (i.e., greater than 12-in. diameter). Small diameter mains are typically easier to replace than large-diameter mains, except in areas in which access is limited or impossible. Small-diameter mains are typically less consequential when they fail and can be monitored on the basis of their break and leak histories to determine when to replace. Large-diameter mains are typically more consequential when they break and therefore require a more proactive strategy to determine the condition of the main and an appropriate renewal strategy.

Relining methods are typically categorized into four classifications based on the American Water Works Association (AWWA) M28 Manual. Lining systems that act as corrosion barriers are considered Class I non-structural. Close-fit lining systems that span holes in the host pipe, but require support from the host pipe to prevent collapse are considered Class II semi-structural. Class III semi-structural linings also span holes, but have sufficient thickness to resist buckling from external hydrostatic load or vacuum load. In Class IV fully-structural linings, the existing pipe acts merely as a right-of-way for the installation of the structural liner.

The available relining methods for water mains are shown in Table 1 and include spray-on lining, sliplining, cured-in-place pipe (CIPP), close-fit lining systems, and pipe bursting. For more information on available water main relining methods refer to the U.S. EPA report *State of Technology for Rehabilitation of Water Distribution Systems* at *http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100GDZH.txt*.

METHOD SELECTION

When selecting a relining method, the problem to be addressed needs to be well defined and understood. Typical issues that may need to be addressed include: structural condition, hydraulic capacity, external corrosion, joint leaks and/or water quality.

Once the problem is defined, different solutions can be developed based upon a review of the technologies that can address the current asset condition and extend the remaining asset life. Next, an appropriate relining method should be selected based upon consideration of several factors in-

TABLE 1

Technology	Description	Dia.	Max. Pressure1	Max. Length	Class	Service Connections	Cleaning Required 2
Cement Mortar Lining	Cementitious lining applied to a cleaned and dried host pipe wall	4″ and up	N/A	1,500 ft	Class I	Reinstated when blocked	High
Epoxy Lining	Spray-on lining applied to a cleaned and dried host pipe wall	4″ to 36″	500 psi	650 ft	Class I	Not normally blocked	High
Polymeric Lining	Spray-on lining applied to a cleaned and dried host pipe wall	4″ to 60″	200 psi	650 ft	Class II/III	Not normally blocked	High
Sliplining	Insertion of a new pipe and grouted for structural support	4″ to 110″	300 psi	1,000 ft	Class IV	Must be excavated	Medium
CIPP	Insertion of impregnated liner and cured with water or steam	4″ to 60″	250 psi	1,000 ft	Class IV	Reinstated robotically	High
Close-Fit Lining	Insertion of a deformed liner reverted back to a original shape	4″ to 60″	500 psi	3,000 ft	Class II-IV	Must be excavated	Medium
Pipe Bursting	Insertion of new pipe while bursting or splitting the host pipe	4″ to 48″	300 psi	1,000 ft	Class IV	Must be excavated	Low
Expandable PVC	Insertion of a pipe heated and pressurized to the host pipe shape	4″ to 16″	150 psi	500 ft	Class IV	Must be excavated	Medium
Melt-in-Place	Liner heated by an air driven pig and pressurized tightly to the host	6″ to 12″	150 psi	500 ft	Class IV	Reinstated robotically	High

1 The maximum pressure will vary for different materials and products within a technology category.
2 (High): thorough cleaning and preparation required; (Medium): moderately cleaning required; (Low): very little cleaning required.

cluding costs, maintenance requirements, bypass piping requirements, disinfection requirements, accessibility and criticality of the water main.

Cost is the most important criteria used to make method selection decisions. Costs evaluations should include both direct costs (i.e., equipment, labor, materials and disposal) and indirect costs (i.e., administrative and legal costs, engineering fees and contractor profit and overhead). Other cost items include replacement of valves and fire hydrants, traffic control, utility interference, obstruction removal, bypass piping and temporary service connections. The life-cycle cost of a method should be taken into account as well, which includes operation & maintenance (O&M) and social costs.

Maintenance of lined pipes requires additional steps that may not be understood by crews in charge of O&M. Adding a new unfamiliar material and/or technology can be a factor in technology selection as it may be reluctantly received by utility crews. Therefore, the O&M requirements should be considered early in the method selection process to understand the requirements.

Any lined water main must be thoroughly flushed, disinfected and tested for bacteriological quality before it can be put into service. Flushing is primarily necessary to remove any mud or debris that was left in the pipe from the installation. Chlorine compounds are the most common chemicals used to disinfect large pipes and calcium hypochlorite and sodium hypochlorite solutions are generally used for smaller pipes. These chlorination requirements should normally conform to the AWWA Standard C651 for disinfecting water mains, unless there are other overriding local, federal or State requirements.

Access to the pipe that is to be renewed is a critical factor in choosing a method. Deep pipes can be below cable and electricity lines, while some water mains are laid close to the surface. In each of these cases, the cost and application of technologies will be different. Excavation to make service line reconnections can increase the cost of restoration work, fees, and the number of permits required. Mains that have risers, bends, valves, and hydrants at fairly short distances can affect the total project cost, too.

Customers expect access to drinking water on a 24-hour a day basis, so pipe relining jobs have to be well managed. Establishing bypass lines, providing water to hospitals and other emergency services, and understanding the complexity of the job are necessary for completion of the work within the designated time.

Once the issues are identified and the criteria above are evaluated, a decision can be made to select the proper relining method for your project.

SEWER MAIN RELINING METHODS

Sewer main relining methods are more established and commonly used than water main methods, yet there are still many parameters that must be considered when selecting the proper tool. Relining methods are typically considered suitable for partially deteriorated (i.e., meaning the lining system will partially rely on structural support from the host pipe) or fully deteriorated applications (i.e., the lining system will act as pipe independent of the host pipe).

The available relining methods for sewer mains are shown in Table 2 and include spray-on lining, sliplining, cured-in-place pipe (CIPP), close-fit lining, pipe bursting, and spiral wound lining systems. For more information on available water main relining methods refer to the U.S. EPA report *State of Technology for Rehabilitation of Wastewater Collection Systems* at *http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1008C45.txt*

METHOD SELECTION

As with water main methods, first the problem must be clearly defined as either is structural or hydraulic in nature. Appropriate relining methods should be selected based upon consideration of several factors including pipe geometry (i.e., bends, ovality, shape, crown curvature, etc.), access requirements (i.e., manhole entry available or not), and level of deterioration if a structural problem. Once a subset of methods is selected as technically viable, cost will become the primary deciding factor. Key factors affecting cost include cleaning and access requirements, lateral reinstatement process and surface restoration requirements.

John C. Matthews, Ph.D., is a principal research scientist at Battelle Memorial Institute in Columbus, Ohio.

TABLE 2

Technology	Description	Dia.	Max. Length	Deterioration	Latera Con-nections	Cleaning Required1	**Cleaning Required 2**
Cementitious Lining	Cementitious lining applied to a cleaned and dried host pipe wall	4" to 160"	2,000 ft	Partial	Reinstated when blocked	High	High
Polymeric Lining	Spray-on lining applied to a cleaned and dried host pipe wall	4" to 108"	2,000 ft	Partial	Not normally blocked	High	High
Sliplining	Insertion of a new pipe and grouted f or structural support	6" to 160"	1,500 ft	Partial or Fully	Must be excavated	Low	High
CIPP	Insertion of impregnated liner and cured with water, UV, or steam	4" to 108"	2,000 ft	Partial or Fully	Reinstated robotically	High	Medium
Close-Fit Lining	Insertion of a deformed liner reverted back to a original shape	4" to 60"	1,500 ft	Partial or Fully	Must be excavated	Medium	High
Pipe Bursting	Insertion of new pipe while bursting or splitting the host pipe	4" to 48"	1,000 ft	Fully	Must be excavated	Low	Medium
Spiral Wound Lining	Insertion of a thermoplastic profile that is grouted for structural support	6" to 120"	450 ft	Partial or Fully	Reinstated robotically	Medium	Low
Expandable PVC	Insertion of a pipe heated and pressurized to the host pipe shape	4" to 16"	150 psi	500 ft	Class IV	Must be excavated	Medium
Melt-in-Place	Liner heated by an air driven pig and pressurized tightly to the host	6" to 12"	150 psi	500 ft	Class IV	Reinstated robotically	High

1 (High): thorough cleaning and preparation required; (Medium): moderately cleaning required; (Low): very little cleaning required.

REHABILITATION OF 100-YEAR-OLD STORM WATER CULVERTS

The culvert was located in a major artery in Baltimore and presented several challenges in its repair

BY DATTA SHIRODKAR, P.E. AND MICHAEL SPERO, P.E.

Central Avenue in the City of Baltimore is a major artery that has four driving lanes, two parking lanes and a 20-ft wide median for most of the project length. Under the median, in the center of the street, is a storm drain that is more than 100 years old.

For this project about half the pipe length is brick and the remainder is cobblestone. When built, Central Avenue, was a divided street with a canal in between carriageways. Originally it was named Canal Street. The canal became a drainage way and eventually was replaced by the brick/stone storm drain and the area around the pipe filled in. The top of the culvert is only 2 to 6 ft below the road surface. At several locations where there is a cross street, the pipe had failed and was previously repaired in the form of timber or steel struts. Some of these median crossings were barricaded to prevent traffic loads on the pipe. As part of the $27 million reconstruction of Central Avenue, the City of Baltimore decided to structurally rehabilitate the existing failing brick/stone culvert. The culvert consisted of seven different sizes and shapes ranging from a 5 ft high by 7.5 ft wide oval to low arch pipes up to 6 ft high by 16 ft wide. The majority of the 3,275 lf of pipe rehabilitated was the latter.

PROJECT CHALLENGES

There were many challenges that had to be overcome; low working headroom in the existing culvert and even lower in the rehabilitated pipes (as low as 2.8 ft in the center and 1.5 ft at the sides so the crews got very good at "Duck Walking" by the end of the project), evacuation during storm events, continuously bypass pumped base flow and the downstream 500 ft was affected by tidal backflows from the Baltimore Harbor outfall. For the most part, traffic control was not a problem since the work was accomplished in the median.

The culvert rehabilitation had to be completed before the majority of the roadwork could start. The culvert rehabilitation subcontractor Boyer Inc., Houston, selected the Danby Pipe Renovation system for this project. Danby consists of PVC panels that are mechanically sealed and locked together resulting in a watertight and corrosion-resistant form for the high-strength, cementitious grout that fills the annular space between the liner and the host pipe. The installation sequence was as follows:

1. The culvert was cleared of sediment and debris, consisting primarily of loosened bricks or stones that fell from the ceiling and sand/silt deposited from storms.
2. All the interior surfaces of the drain were cleaned with a high pressure water blast.
3. The steel rebar on the sides and top was placed according to the contract drawings.
4. Steel slab bolsters were installed longitudinally in the bottom as spacers for the bottom PVC panels.
5. The bottom panels were installed, 90-degree PVC corner fittings attached, and the vertical side panels placed.
6. The bottom panel bracing system was a combination of steel and wood sections braced to the ceiling.
7. High-strength, cementitious grout was poured to fill the annular space under the bottom panels and a few inches up the side panels and allowed to obtain an initial set.
8. Curved corner panels bent to the required angle were placed on top of the side panels. The angle varied depending on the size and shape of the culvert.
9. Grout was poured behind the curved corner panels.

10. The grout was allowed to set and the bracing and forms moved to the next section.

11. The top panels were installed.

12. Moveable bracing was placed to support the top panels.

13. Top panels were grouted.

14. After the grout reached a strength of at least 2,000 psi (about 24 hours), the bracing was moved to the next section..

Essentially this was a "leapfrog" type of installation where the crews kept moving ahead and were working on different aspects of the installation as each sequence was completed.

The grout was a 5,000-psi compressive strength design mix, which consisted of Portland

Cement, fly ash, sand, ground granulated blast-furnace slag and super-plasticizer. The test cubes consistently broke at 9,000 to 10,000 psi. Since this was a shallow pipe and the culvert was under the roadway median, it was not necessary to pump the grout. Holes were drilled down from the surface into the existing drain and 4-in. PVC pipes were installed. The grout was delivered in transit mix trucks and poured through a funnel arrangement into the 4-in. pipe and into the culvert. It was directed to the bottom panels and curved corner panels through piping connected to the 4-in. down pipes. The top panel was grouted directly. The grout injection pipes were placed about every 25 lf. A total of 4,400 CY of grout was used for the 3,275 lf of rehabilitated pipe with 118 CY being the most placed on a single day. The manner in which the grout was placed ensured that the entire annular space between the liner and the host pipe was completely filled with grout. Since the grout is very fluid when placed, it flowed into any cracks and replaced any missing mortar or bricks creating a solid composite structure.

There were numerous service connections and connected drains ranging from 4-in. VCP to 54-in. diameter brick, including some box shapes that all had to be connected and sealed.

The $9 million rehabilitation portion of the project was successfully completed in July 2013. The result is a storm culvert that will support the current and future traffic loads, has an increased hydraulic capacity in spite of the reduced cross-section due to the smooth liner surface, a corrosion-resistant pipe that is sealed against infiltration and exfiltration and a part of the City's storm system that will be worry-free in the future. All the stakeholders; the owner, design engineer and the construction manager were extremely pleased with the finished product and we anticipate that the rehabilitated storm drain will function for at least another 100 years.

Datta Shirodkar, P.E., is project manager at Boyer Inc., Houston. Michael Spero, P.E., is president of Danby LLC, Houston.

Owner:
City of Baltimore Department of Transportation

Design Engineer:
Whitman, Requardt & Associates LLP

General Contractor:
Monumental Paving

Liner Installation Subcontractor:
Boyer Inc.

Liner Supplier:
Danby LLC

LARGE DIAMETER

SLIPLINE COMPLETED IN MILWAUKEE

BY ERIN BOUDREAUX

With a population of approximately 600,000, Milwaukee is the largest city in Wisconsin. Milwaukee is situated along the shores of Lake Michigan, one of the five Great Lakes of North America and the only one located entirely within the United States. One third of Milwaukee's sewer system is served by combined sewers that carry both wastewater and storm water. During heavy rain events, the flow in combined sewers can reach capacity due to the rainwater that runs off of the streets (inflow), as well as infiltration from leaking infrastructure.

Milwaukee, like many cities, is working to upgrade and separate its complex sewer system. As part of the upgrade, a 4,500-ft section of an existing combined sewer was identified as being in need of rehabilitation.

"The combined sewer was constructed in 1925 and varies in depth from 63 ft to 103 ft within the project limits," explained Timothy Thur, chief sewer design manager for the City of Milwaukee. "The sewer was showing structural distress, developing cracks throughout the sewer. There were multiple leaks through the cracks and significant groundwater infiltration was occurring. Large mineral deposits were also present in the sewer at various locations."

After rehabilitation, this line still operates as a combined sewer. The City of Milwaukee looks for strategic opportunities to separate the combined sewer system, especially when they are near a river. "In addition, we look for opportunities to install green infrastructure as part of paving projects and public works projects," continued Thur.

The existing 144-in. monolithic concrete sewer was in need of repair in order to restore hydraulic capacity, structural integrity and to eliminate infiltration. It was sliplined with 126-in. centrifugally cast, fiberglass reinforced, polymer mortar (CCFRPM) pipe manufactured by HOBAS Pipe USA. This is the first project where HOBAS Pipe USA has custom manufactured pipe of this diameter and it was the largest fiberglass sliplining job done in North America at that time.

"We see a trend in the sewer market toward larger diameters and we are investing in our facility to ensure we meet the needs of our customers. Recent investments in our manufacturing plant and test facilities allow for future diameter growth," stated Kimberly Paggioli, P.E., vice president, marketing and quality control at HOBAS Pipe USA.

RESTORING HYDRAULIC AND STRUCTURAL INTEGRITY

"When the project was being designed, we looked at both cured-in-place (CIP) and sliplining for rehabilitating the existing sewer," Thur said. "Due to the depth and amount of flow in the sewer, we chose to bid the project specifying sliplining using 126-in. diameter fiberglass mortar pipe. The successful contractor, Michels Corp., selected HOBAS as the supplier for the 126-in. diameter fiberglass mortar pipe."

Sliplining is one of the oldest and most reliable methods for trenchless rehabilitation of existing pipelines. This installation

OPPOSITE PAGE:
Hobas pipe was lowered into a pit during the sliplining rehabilitation of a failing sewer built in 1925.

LEFT:
The 126-in. CCFRPM pipe was sliplined into an existing 144-in. monolithic concrete sewer.

method is used to repair leaks, restore structural stability and increase hydraulic efficiency to an existing pipeline. It may be performed by slipping a pipe into the existing host from an access shaft, or can be completed by installing a smaller "carrier pipe" into a larger "host pipe" placing one at a time. Typically, the annular space between the two pipes is grouted and each manhole-to-manhole run is sealed. Sliplining allows for a limited surface footprint, which is especially important in populated areas since it minimizes disruption to businesses, highways, railways, etc.

On the N 26th St. – W. St. Paul to W. McKinley Blvd. project, the existing line was 144-in. diameter and it was sliplined with nominal 126-in. diameter CCFRPM. With an outside diameter of 132 in., the clearance was only 6 in. radially at the pipe barrel. An important consideration in sliplining is the hydraulic requirements of the project. The capacity of a pipeline is modified due to sliplining and the effect will be dependent on the relative sizes of pipes and their respective hydraulic characteristics. Even though there was a reduction in diameter, the capacity of the line was not only maintained, but even improved.

A tool for evaluating a rehabilitated pipeline can be found at *http://hobaspipe.com/7159*. The tool assumes that two pipes of different diameters are installed on the same grade in a gravity flow situation, which would be the case in most sliplining instances.

To meet the structural requirements, the liner pipe was designed with a stiffness class of 46 psi and manufactured with low profile bell joints. The low profile bell-spigot joint consists of an integral straight bell fixed to one pipe end that seals to the spigot end of another pipe by compressing an elastomeric gasket contained in a groove on the spigot. This joint is intended for sliplining applications for non-pressure service and provides leak-free capability.

"The ASTM standards require the pipe manufacturer to factory test the product line through a variety of tests including, in this case *ASTM D4161, Standard Specification for Fiberglass Pipe Joints*," explained Truong Do, process quality control, HOBAS Pipe USA. "HOBAS performed this test on low profile bell pipe joints of this configuration at a test pressure of 50 psi, well above the anticipated operating pressure of the gravity pipeline."

EASE OF INSTALLATION

Michels Tunneling of Brownsville, Wis., was the installation contractor for this project. A leader in the tunneling industry, Michels has installed CCFRPM on previous projects. "In addition to pricing, Michels selected to install HOBAS because of an excellent past working relationship," stated Russ Pollard, project manager for Michels Corp.

The field service department from HOBAS was onsite during installation. "The specification required our input on their plans regarding grouting and floatation restraint systems (blocking), along with their general installation plans," stated Randy Whiddon, field service manager at HOBAS Pipe USA. "We are, however, happy to provide input regardless of spec requirements. HOBAS supported Michels with numerous communications regarding installation, grouting, and blocking and provided on-site support via a HOBAS field service technician visit. Open communication is important for the success of critical projects such as this one. While onsite, the HOBAS field service technician greeted Milwaukee Mayor Tom Barrett, who was visiting the jobsite on the same day, which highlights the high-profile nature of the job."

The pipe was carried in one length at a time on rails. "It was a live tunnel, the water was only about 6 to 12 in. deep," stated Pollard. Michels used a tugger to pull the pipe through the tunnel and a skid steer to follow and assist in pushing, setting in place and final blocking. The pipe was installed in only four runs through two drop shafts and three manholes. The runs were 1,372 ft, 1,638 ft, 1,300 ft and 267 ft.

"Due to the size of the pipe, it was little more cumbersome than smaller diameter pipe, but once we developed a safe procedure and system of installation, the install went smoothly," explained Pollard.

With the pipe installed, grouting was the next step. The line was grouted in three stages filling the annular space between the existing pipe and the new fiberglass pipe. Proper grouting of the annular space safeguards a long life for the pipeline, as well as minimizing the possibility of subsidence as the original host pipe further deteriorates.

There was a final visual survey done at the completion of each section to verify the installation. With the line in regular service, Thur concluded, "We are very satisfied with both the product used for the lining and with the way the project was done."

Erin Boudreaux is marketing manager at HOBAS Pipe USA, based in Houston.

POLYMERIC LININGS

CAN REDUCE RED AND BROWN WATER ISSUES TO IMPROVE WATER QUALITY AND PROVIDE RAPID RETURN TO SERVICE.

BY DR. RYAN PRINCE

Of the nation's 880,000 miles of drinking water distribution piping, about 23 percent is unlined ductile iron, cast iron or steel.[1] These pipes can be prone to internal corrosion and tuberculation build-up that results in water quality issues and eventual flow or capacity issues.

When utilities are asked about their main criterion for determining the replacement of a water main, 15 percent cite water quality issues and 40 percent cite low flow.[1] Historically, spray-applied coatings have been used to improve the water quality of potable water drinking pipes. The liner's purpose is to serve as a barrier to the corrosion, abrasion and/or tuberculation/scaling of the host pipe and to the contamination of the pipe contents by the host pipe.[2] The application of a Class I/D liner also generally reduces surface roughness for improved flow capacity.[2]

In the United States, the historical trenchless remediation options have been either Cement Mortar Lining (CML) or Epoxy Lining. Under the guidance of the *AWWA Manual of Water Supply Practices M28*[3] and ISO 11295:2010[4], these coatings are classified as non-structural (AWWA Class I or ISO 11295:2010 Class D) lining systems. More recently, 3M has introduced a new 100 percent solids, VOC-free and BPA-free, quick-cure polyurea formulation, which may be inspected after a 15-minute cure and flushed/disinfected after one hour. The advantage is avoidance of pH issues that can occur with CML installations and the long cure times typical of both CML and Epoxy resins.

Few existing standards for spray-applied linings make any references to the fitness for use requirements of a spray-applied, polymeric coatings that are intended to serve as a long-term, corrosion barrier to improve water quality. In the United Kingdom, there is a Water Industry Specification (WIS 4-02-01)[5]. that covers the operational and legal requirements, as well as a code of practice for the in situ lining of water mains. In the United States, the *AWWA Manual of Water Supply Practices M28* discusses the use of spray-applied linings such as Epoxy and CML along with alternative structural rehabilitation options. However, none of these documents describes the fitness for use requirements of a spray-applied, polymeric coating, which is intended to serve as a long-term, corrosion barrier to improve water quality. In the United Kingdom, there is a requirement that materials used in this application withstand maximum chlorine concentrations of 1000 mgl^{-1}, without damaging the lining.[5] IGN 4-02-02[6] has requirements that only relate to the effect of the applied product on water quality and ASTM F2831-12[7] has initial performance requirements for epoxy barrier coatings, but neither document indicates fitness for purpose in terms of long-term, physical performance.[5]

The fitness for use requirements of non-structural (AWWA Class I or ISO 11295:2010 Class D), spray-applied, polymeric coatings are therefore not well defined. The goal, however, is to have these kinds of coatings serve as a long-term, corrosion barrier to improve water quality. 3M has actively worked to detail a few of the relevant physical performance attributes along with the appropriate test methods to assist the end user in their assessment of a materials' fitness for use. Although it may not be exhaustive, the following list of considerations is meant to provide the essential requirements to show that non-structural coatings are fit for purpose of a spray-applied, polymeric coating,

TABLE 1: TEST METHODS FOR DETERMINATION OF WATER UPTAKE AND ITS EFFECT ON ADHESION

TEST	AWWA C222-08 REQUIREMENT	TEST METHOD	
		ASTM	ISO
WATER UPTAKE	<2% OVER 21 DAYS	D570-98	62
PULL-OFF ADHESION	1500 PSI (10.3 MPA)	D4541-09E1	4624

TABLE 2: TEST METHODS FOR EVALUATION OF MATERIALS EXPOSED TO WATER.

TEST	TEST METHOD	
	ASTM	ISO
BLISTERING OF COATINGS	D714-02	4628-2
RUSTING AND UNDER-FILM RUSTING	D610-08	4628-3
PARALLEL SCRIBE ADHESION	D6677-08	NONE IDENTIFIED
HOLIDAY UNDERCREEP	D1654-08	4628-8
PULL-OFF ADHESION	D4541-09E1	4624
ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY	G3-89-(2010)	NONE IDENTIFIED

TABLE 3: TEST METHODS FOR EVALUATION OF MATERIALS EXPOSED TO SALT SPRAY FOG.

TEST	TEST METHOD	
	ASTM	ISO
BLISTERING OF COATINGS	D714-02	4628-2
RUSTING AND UNDER-FILM RUSTING	D610-08	4628-3
HOLIDAY UNDERCREEP	D1654-08	4628-8
PULL-OFF ADHESION	D4541-09E1	4624
PULL-OFF ADHESION	D4541-09E1	4624

TABLE 4: TEST METHODS FOR EVALUATION OF MATERIALS EXPOSED DISINFECTION CHEMICALS.

TEST	DESIRED TEST RESULT	ASTM TEST METHOD
△ MASS%	SAME AS FOR WATER	D6284-09
△ VOLUME%	NO SWELLING	D6284-09
△ SHORE D HARDNESS	DOES NOT BECOME BRITTLE	D6284-09
BLISTERING OF COATINGS	NO BLISTERING	D714-02

which is intended to serve as a long-term, corrosion barrier to improve water quality:

FITNESS FOR USE CONSIDERATIONS FOR A NON-STRUCTURAL (AWWA CLASS I OR ISO 11295:2010 CLASS D) COATING:

1. The material to be used should be moisture-tolerant upon application. OR 6.1 of WIS 4-02-1 states that after cleaning, the pipe shall be smooth, clean, and free of dust, standing water and particulate matter.[5] However, after the pre-lining camera inspection, there is the possibility for the reintroduction of water, through ingress of a hole or crack or a leaking service connection. In addition, if a pipe is not dried using an air vortex cleaning/drying method, there will be higher levels of humidity present in the pipe. Aromatic isocyanate-based polyurethane systems, which are used as non-structural barrier coatings, are more susceptible to blistering as a result of the competitive reaction between hydroxyl/polyols of the resin system and the water present, and can occur when as little as 5 percent humidity is present.[8] On the other hand, aliphatic isocyanate-based polyurea systems can be applied on substrates almost saturated with water, which will not invoke blistering nor will blistering occur when the air contains high levels of humidity.[8] There are no standard test methods to determine a materials' potential for blistering upon application, so this will need to be determined through other lab or field based application of the material under a variety of potential, field conditions.

2. The material to be used should have low, long term water absorption to prevent loss of adhesion to the pipe substrate. AWWA C222-08 requires polyurethane coatings intended for the interior of steel, potable water pipes to exhibit less than 2 percent water absorption over a 21-day period.[9] The effect that any water uptake has on the adhesion of the material to the host pipe should be further qualified by measuring the pull-off adhesion of the material to the substrate after the maximum water uptake has been achieved (see Table 1).

3. The material to be used should exhibit corrosion protection properties over the design life of the rehabilitated system. There are two primary methods that allow for the determination of a materials' corrosion protection properties. The first of these is by immersion of coated coupons of the material in water for an extended period of time, typically six months or greater.[10] Over the course of the immersion time, the materials corrosion protection properties are studied using a combination of test methods, which are described in Table 2.

The second of these methods, which is even more valuable when combined from the data of the first method, is exposure of the material to a salt spray fog for an extended period of time, typically 5,000 hours or greater.[11] Over the course of the exposure time, the materials corrosion protection properties are studied using a combination of test methods which are described in Table 3.

4. The material to be used should exhibit long-term resistance to the disinfection chemicals used in potable water systems.[12] Chemical resistance is determined by the immersion of material samples in water containing relatively high levels of disinfection chemicals (typically 50 ppm) for an extended period of time, typically six months or greater. Over the course of the exposure time, the material's chemical resistance is studied by using a combination of test methods, which are described in Table 4.

CONCLUSIONS

A variety of liquid-applied coatings and linings can be formulated to meet national and international regulatory requirements for contact with drinking water. However, the majority of the approval schemes, including the NSF/ANSI Standard 61 in the United stated and Drinking Water Inspectorate Reg 31(4)(A) in the United Kingdom, do not embody any assessment of likely in-service performance or fitness for purpose. As the properties and performance of "approved" products can and does vary widely, specifiers and end users are strongly advised to review manufacturers' data packages in assessing the suitability of a particular product for their intended application.

Dr. Ryan Prince is senior product developer at 3M Water Infrastructure and is also president-elect of the Polyurea Development Association.

References

1. Distribution System Inventory, Integrity and Water Quality. Issue brief. Environmental Protection Agency, Jan. 2007. Web. 2 Sept. 2013. <http://www.epa.gov/ogwdw/disinfection/tcr/pdfs/issuepaper_tcr_ds-inventory.pdf.

2. Ellison, D.; Sever, F.; Oram, P.; Lovins, W.; Romer, A.; Duranceau, S; Bell, G.; Global Review of Spray on Structural Lining Technologies. Water Research Foundation: Denver, Colorado, 2010.

3. American Water Works Association. (2001). Manual of Water Supply Practices M28: Rehabilitation of Water Mains, AWWA, Denver, Colorado.

4. Classification and information on design of plastics piping systems used for renovation (ISO 11295:2010). (2010).

5. WIS 4-02-01 "Operational Requirements: In Situ Resin Lining of Water Mains". Water UK. (2009).

6. IGN 4-02-02 "Code of Practice: In Situ Resin Lining of Water Mains". Water UK. (2009).

7. ASTM F2831, 20012 "Standard Practice for Internal Non Structural Epoxy Barrier Coating Used in Rehabilitation of Metallic Pressurized Piping Systems," ASTM International, West Conshohocken, PA, 2012, DOI: 10.1520/F2831-12, www.astm.org.

8. Broekaert, Marc. Polyurea Spray Applied Systems for Concrete Protection. Presented at the Fourth European Conference on Construction Chemicals, Nurnberg, Germany, April 10, 2003

9. ANSI/AWWA Standard C222, 2008, "Polyurethane Coatings for the Exterior and Interior of Steel Water Pipe and Fitting," American Water Works Association, Denver, CO, 2008.

10. Water immersion testing can be completed by using the following test method: ASTM D870, 2009 "Standard Practice for Testing Water Resistance of Coatings Using Water Immersion," ASTM International, West Conshohocken, PA, 2009, DOI: 10.1520/D0870-09, www.astm.org.

11. Salt spray fog testing can be completed using the following test method: ASTM B117, 2011 "Standard Practice for Operating Salt Spray (Fog) Apparatus," ASTM International, West Conshohocken, PA, 2009, DOI: 10.1520/B0117-11, www.astm.org.

12. Resistance to disinfection chemicals can be completed using the following test method: ASTM D6284, 2009 "Standard Test Method for Rubber Property—Effect of Aqueous Solutions with Available Chlorine and Chloramine," ASTM International, West Conshohocken, PA, 2009, DOI: 10.1520/D6284-09, www.astm.org.

STONEY CREEK SANITARY DISTRICT SAVES 100,000 GALLONS A DAY THROUGH UV-CIPP REPAIR

Up to 100,000 gals per day of fresh rainwater were leaking into the clay sewage pipes serving Basye City remote vacation homes and ski resorts in southeast Virginia.

The additional water burdened Stoney Creek Sanitary District's water treatment plant, decreasing efficiency and expending valuable resources to purify what was, essentially, clean water. The solution was found with leading-edge innovations that included AOC's resin, Reline America Inc.'s UV-curing technology and RedZone Robotics' machinery. The entire project involved 8-in and 10-in pipe, covering 2,000 ft.

The Stoney Creek Sanitary District, created in 1986, is dedicated to providing quality wastewater collection, treatment and disposal services to the residents and businesses of the Basye-Bryce Mountain Resort area of Shenandoah County, Va.

Using in-pipe camera systems provided by RedZone Robotics, Stoney Creek located the sources of the leaks: deteriorating rubber O-rings that connected the original clay pipes. Stoney Creek had previously used cured-in- place pipe (CIPP) rehabilitation and so its officials knew that using the trenchless application would be an ideal solution. But the project did not come without challenges to work through.

The problem was the cool spots that were created by the leaks. Using traditional CIPP curing methods, these cool spots can lead to a potentially incomplete cure and can result in lower mechanical properties for the rehabilitated pipe.

THE SOLUTION: UV CURE

Stoney Creek contacted Reline America for its Blue-Tek UV-curing technology. With traditional CIPP applications, the

"Stoney Creek Sanitary District is proof that even a relatively small utility can utilize new technologies in-house with significant cost-savings over traditional methods of pipe replacement."

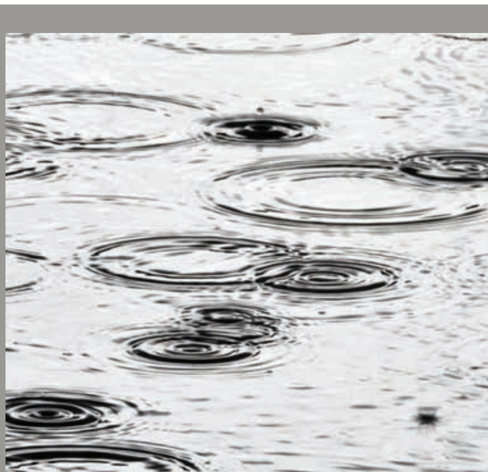
new liner is impregnated with resin that chemically hardens when exposed to heat. Reline's Blue-Tek technology cures the resin with UV light instead of heat and, therefore, is not affected by cool spots. AOC's Vipel unsaturated polyester resin was the resin of choice because it was formulated specifically for UV cure. AOC designs and produces the resin to exacting specifications to cure at specific wave lengths of light. The resin creates an extremely efficient and thorough cure, and therefore, a high performance composite. As an added benefit, Reline's liners can be shipped without costly refrigeration, unlike traditional liners, which cure when exposed to heat.

ADDITIONAL BENEFITS

"This technology has come of age," said Rodney W. McClain, director of public utilities at the Stoney Creek Sanitary District. "The Stoney Creek Sanitary District is proof that even a relatively small utility can utilize new technologies in-house with significant cost-savings over traditional methods of pipe replacement."

Specially-equipped trucks were created to reach the project site, which was located in a residential area with narrow roads, steep inclines and difficult terrain. CIPP was the most logical option for this project. Grant Whittle, technical sales and marketing at Reline America said, "CIPP technology has proven to be a less disruptive and more cost-effective alternative to traditional open-trench replacement methods."

This article was provided by Reline America Inc., headquartered in Saltville, Va.



MARKET SEGMENTS: CIPP SEWER REHABILITATION

COMPOSITE APPLICATION: CURED-IN-PLACE PIPE

RESIN: VIPEL UV-CURE POLYESTER

HOST PIPE: CLAY SANITARY SEWER PIPE

DIAMETER: 8-IN. AND 10-IN.

TOTAL LENGTH INSTALLED: 2,000 FT

PENN STATE

SEWER LINES AND LATERALS TO BENEFIT FROM RELINING

BY SHARON M. BUENO

Penn State University is one of the largest public universities in the United States, with more than 45,000 students attending its main campus on 8,500 acres in the small city of State College, Pa. During football season, more than 100,000 people are on campus cheering for their beloved Nittany Lions.

Known for its academics, research and athletics, the University is undertaking a large sewer line rehabilitation project that will take several years to complete. The University Park campus is also home to many school monuments, historic buildings and beautiful landscapes that campus officials needed to be sensitive to when taking on such a project.

The decision to use trenchless technology for this rehabilitation project — specifically cured-in-place pipe (CIPP) — was a smart one, saving the University significant savings on various fronts, including construction costs, as well as social and restoration costs. A critical component to this project was that the work could disturb or disrupt everyday campus life.

Joseph Swanderski, is supervisor of Water Quality at Penn State University and has been with the University for 11 years. Before utilizing CIPP and even CCTV to proactively maintain its underground lines, a different approach was sought.

"When I first came here it was management by crisis of these lines," he says. "Whether it was a break or a plug, we would dig and fix it."

Now the University has a pumper truck, a jet/vac truck and CCTV equipment to see what is happening underneath the ground and determine where the most troubled areas are, needing immediate attention. "What we started seeing with the camera wasn't very good in some of the places," Swanderski says.

A long-term solution, plan and program were needed. Enter CIPP and the ability to do the work in-house.

ABOUT PENN STATE

Penn State University was founded in 1855 and its sewer system dates back to the early 1900s. The University owns and operates a wastewater collection, treatment and disposal system that serves the University Park Campus and parts of the borough of State College, Pa., treating on average more than 2.6 million gallons of wastewater per day. Since 1983, Penn State has recycled all of its treated wastewater by spray irrigating over 500 acres of local farm crops and forest areas on soils that vary depths of more than 100 ft. There is no surface runoff to any stream, thereby promoting groundwater recharge.

Swanderski has been working to rehabilitate the University's aging sewer lines, which are experiencing cracks, offset joints and missing pieces. The lines are mainly 6, 8, 10 and 12 in. in diameter. The University had been using a local contractor to use CIPP to reline its lines, costing about $100 per lf, he says. The work the contractor was doing was great but in seeing how they were doing it, Swanderski came to realization that his crews would be able to handle the relining themselves — with the proper training and equipment.

Swanderski learned about Perma-Liner at a recent industry tradeshow and inquired about its systems and whether his crews would be able to use the equipment.

"[Perma-Liner] came out here and did a demo for us and we were definitely very interested," Swanderski says, and they decided to move forward with his plan to do the work in house. Penn State purchased a F-18 model Top Gun Continuous Air Inversion System and received intensive and thorough onsite training from Perma-Liner.

"We sought out a lining contractor who actually saved us money over the cost of digging and restoration but it was still costing an average of $100 per ft," Swanderski says. "At [the 2012] Pumper Show we watched the Perma-Liner demo and started to ask some questions. We were still on the fence when we attended the No-Dig Show in Nashville a few weeks later and we had a serious talk with Rich Cristi from Perma-Liner. He clearly explained in detail what was involved and what the initial cost would be and the cost per foot of doing the lining ourselves."

The additional savings the University

would receive by doing the relining themselves sealed the deal. "We jumped in with both feet," Swanderski says. "Shooting 1,400 ft during our training week at $25 per ft for the liner vs. $100 per ft for the contractor, we were in the "black" already and the equipment paid for itself."

The Perma-Liner Top Gun Continous Air Inversion System can install liner in pipes from 6 to 24 in. in diameter, with pipe diameters from 6 to 12 in. completed in about an hour. Swanderski's crew is primarily relining 8-in. lines. The system uses air to invert the liner and steam to cure it in place. The use of compact 750,000 BTU dry steam generators allows the liner to harden without the use of large boiler trucks.

Since January, the campus crews have relined 2,143 ft and that is just a small portion of the relining work that is planned for the Penn State University system, with the University looking to address its laterals in the future and plans to buy a smaller Perma-Lateral air inversion unit to rehab them. "We did not purchase the [pipe relining] equipment for one specific project but for use in general," Swanderski explains. "We need to reline all the lines on campus that can be rehabbed instead of dug up. This is going to be an ongoing project. We are currently video inspecting all the lines on campus and then we will categorize and prioritize which lines need to be done first."

This project will be taking place over the next several years, as the work will be done during the "down times" of the school's calendar year. "The reason it will take years to complete is because we have more than 45,000 students here and the campus is very tight quarters," Swanderski says. "We can do a lot of the relining during the summer months and over the various holiday breaks when campus traffic is lower. We have to be very sensitive to the students. They are our customers and we don't want to disrupt what they are here for. We can do the outlying areas, which aren't considered the core campus areas but in general we have to be sensitive about the noise outside of classrooms and student safety."

Swanderski doesn't hide his excitement when discussing what this project means to Penn State and how it is going so far. "This is the most exciting and significant project we are doing," he says. "Because it's all underground and nobody sees it, nobody knows we are doing it. But it is work that must be dealt with and using trenchless technology is the best possible way we can deal with it. [Campus management officials] are very excited with what we are doing because we are not tearing up the campus or disturbing the students."

Another benefit of using CIPP for its sewer lines is the environmental impact it is making. "Penn State is trying to go 'green' with its carbon footprint and the amount of machinery we eliminated in running backhoes and trackhoes, etc. to do the digging plus the disturbance to campus life is an added benefit. The social impact really wasn't taken into account when we first did the cost-analysis," Swanderski says.

"We have our own power plant, drinking water system, chilled water system, wastewater system — we are basically an independent city here," he says of the campus. "We have blue slate sidewalks, monuments, landscapes, stone work and trees. It's phenomenal what relining does for us. It's been a lifesaver for us."

Sharon M. Bueno is managing editor of *Trenchless Technology*.

CULVERTS AND PIPE RELINING IN CALIFORNIA

PROJECT INVOLVED A 48-IN. CULVERT ON HIGHWAY 49 IN GRASS VALLEY AREA OF CALIFORNIA.

BY JAYNE BRINGER

Not all projects are in and out in a day, but when they are, they are typically routine. However, Insituform Technologies LLC recently completed a project that was technically and logistically as complex as projects come — in less than 24 hours.

The project encompassed the rehabilitation of a tapered 48-in. culvert of Highway 49 in the Grass Valley area in California. The jobsite was roughly 50 miles outside of Sacramento in the Sierra Nevada foothills. Those familiar with northern California are familiar with the varied, sometimes rough, terrain.

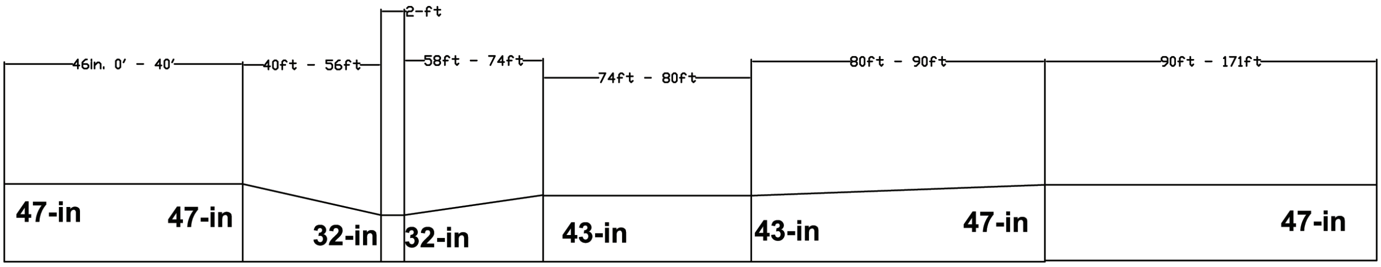
The culvert rehabilitation was part of an emergency project that was identified in December 2012. The 171-ft, corrugated metal pipeline was plugged along with a nearly complete collapse of the roadway. Starting in January 2013, the road repair was made immediately, but during that time, the pipeline — which carried a live stream — was inspected and found to be in a less than serviceable condition. The pipeline had deteriorated with age, and had become crushed due to its external load and saturated soil condition.

Insituform business development manager Chris Hansen explained, "The client knew this was a very difficult project from the start. The road had been partially washed away and was being repaired when we were called to take a look at lining the culvert. Since Highway 49 is a major thoroughfare from Grass Valley to Auburn, the last resort was to shut the highway to dig-and-replace the culvert."

As the client did not want to have to completely shut down the highway, cured-in-place pipe (CIPP) was chosen as solution to the crumbling culvert. Insituform ultimately designed and manufactured a highly customized tube to fit the exact pipe dimensions and mobilized a very experienced crew from its Littleton, Colo., office to perform the installation.

"We first met onsite with Caltrans and Stewart Engineering, which was the prime contractor for the project. Caltrans was willing to let us give

The project involved relining a 171 ft of corrugated metal pipe and necessitated work to be done at night.



them our game plan to make the project and installation a success," Hansen explained.

The project was complex because the pipe diameter varied throughout the length of the culvert. The diameter of the tube tapered from 47 in. to 32 in. to 43 in. and back to 47 in. to accommodate the section of pipe that had previously been crushed.

Air Inversion rather than water was required due to the sensitivity of the surrounding environment, which is not common with tubes of this dimension and thickness. However, the air-inversion steam-cure process meant less water was required to be transported to the remote jobsite.

In addition, nighttime work required significant traffic control. The installation was right off the roadway and a 90-ton crane was used to lift the large, heavy tube. Construction of a temporary working platform at the point of inversion allowed workers a flat surface to work on amid the rugged terrain and support the installation equipment.

While the project as a whole spanned nearly seven months, the CIPP installation portion only took one day. The installation was performed the night of July 21 and morning of July 22. The July installation was planned to be well ahead of the wet season, which is generally considered to begin in northern California on Oct. 15.

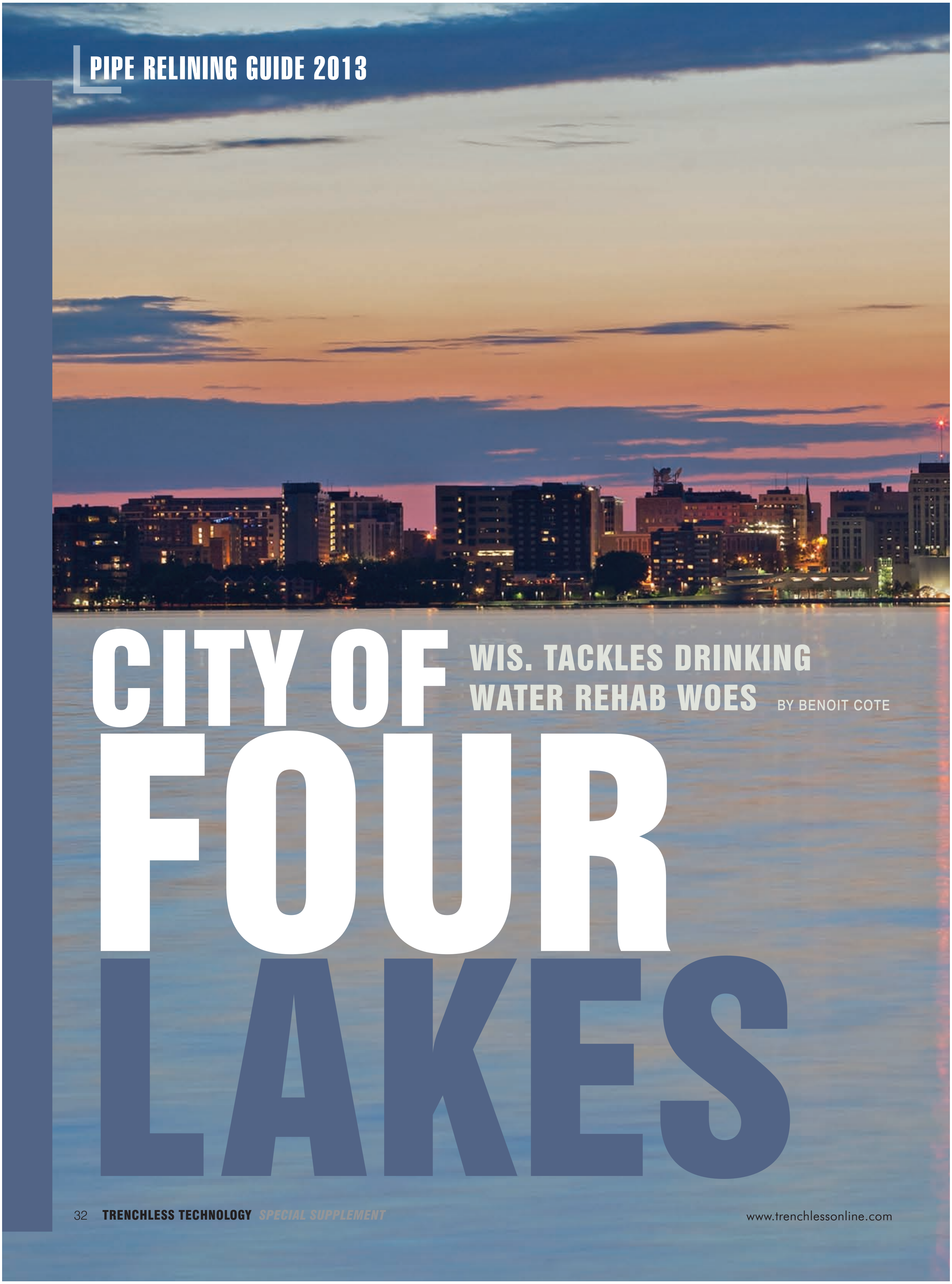
A five-member crew, including superintendent Michael Gallegos, performed the work at night under one-way traffic control with flaggers and pilot car. Access to the point of inversion was approximately 100 ft horizontally from the roadway — 25 ft to 30 ft below the roadway surface.

Naturally all of the planning, special manufacturing and crew scheduling took time, but the planning and effort resulted in a successful installation.

Hansen noted, "The Insituform operations team worked through each step of the project to a successful installation."

Senior project manager Spencer Boyer said, "We successfully completed this challenging project on time and within Caltrans time and material budget. Caltrans and Stewart Engineering were a great team to work with."

Jayne Bringer is senior marketing communications specialist at Aegion Corp.



CITY OF FOUR LAKES

WIS. TACKLES DRINKING WATER REHAB WOES

BY BENOIT COTE

Who would have thought that Madison, Wis. — dubbed the City of Four Lakes — would have water system problems? But this second-largest city in the state (population 240,323), despite the four lakes, and like every other city and town in America, does have serious water system problems.

Why? As in most towns and cities across North America, the age of the water mains, originally installed in the late 19th and early-to-mid 20th century, are now leaking or deteriorating. Only a small opening remains in the mains, restricting water flow while there appears to be a breach on the left outer wall, causing a leak. The 8-in. main has been rehabilitated (actually cleaned and relined) using cured-in-place pipe (CIPP). This approach has been proven to be infinitely more efficient and far less costly than replacing the water main. It restores flow capacity to the water main without having to dig trenches and extends the life of the water main for at least another 50 years.

Such was and is the case in the City of Madison, where the drinking water doesn't come from the lakes surrounding it, but from a deep groundwater aquifer. Water mains originally installed underground between the 1930s and even the 1950s, need attention quickly, for new breaks and leaks keep developing on a more and more frequent basis.

Now, thanks to pioneers and thrifty managers like Adam Wiederhoeft, P.E., project manager at the Madison Water Utility, the city is not only actively moving forward rehabilitating its aging water mains, but as compared to traditional open-cut methods, also saving Madison a lot of money.

Wiederhoeft recalls he was confident that CIPP could work as well in water main rehabilitations as it has in wastewater rehab woes. Because Madison was the first town or city in Wisconsin wanting to try this technology, the pilot projects were approved at the state level on an experimental trial basis.

"Longevity and durability tests are currently under way at Louisiana Tech. Their goal is to quantify and verify the long-term strengths, features, benefits and cost-savings of the process," Wiederhoeft admits. "Now, based on these first two successes and savings, two additional 'trial' projects are now in the works, with each trial renewing longer and longer water mains. We are hopeful our successful project history will help the CIPP process become the standard rehabilitation method throughout Wisconsin."

Wiederhoeft worked closely and will continue to do so with two outside partnering firms on these projects: Sanexen Aqua-Pipe in Brownstown, Mich., for U.S. installations. The firm's headquarters is located in Montreal, Canada for Canadian installations. Sanexen licenses the proprietary CIPP trenchless water main technology to select installation firms; and Fer-Pal Infrastructure Water Main Rehabilitation Services, headquartered in Toronto, Canada. Fer-Pal also has satellite offices in Taylor, Mich., and Elgin, Ill. Fer-Pal is a certified licensee for Aqua-Pipe installations in the Midwest, and has experienced exceptional growth — doubling in size this past year and looking forward to a continued growth of 40 percent to 50 percent over each of the next few years.

"The good folks in Madison managed to get special budgeting and approval to initiate a trial for a 1,200-ft section of 8-in. water main near the downtown area," recalls Blaine Preston, general manager of Fer-Pal, the installers of the Aqua-Pipe liner. "They chose us/Aqua-Pipe because of the savings, the speed and the benefits realized with minimal disruptions trenchless technologies provide when compared to traditional open-cut water main replacements. With this approach, Madison also didn't need to get addi-

tional funding for repaving the entire road, since the only disruption, as it were, were two small shafts (or access pits) at either end of the work area."

In a few short weeks, the entire project was completed, with only a day and a half required for Fer-Pal to actually reline the pipe. No additional maintenance or repairs have been necessary on this job or on the slightly longer 2,500-ft CIPP installation a year later; two more projects are scheduled with each renewal slightly longer than the last — one in fall 2013 stretching 3,500 ft and another in 2014 (now being budgeted) spanning a mile or more. Wiederhoeft notes that these projects will help other towns and cities see the benefits of trenchless CIPP technologies as the preferred route to go for giving new (50-plus years) trouble-free lives to existing water mains.

While the actual steps for rehabilitating water mains can be found in greater detail on the Internet (dig access pits, install temporary water service to residences or businesses, inspect and clean pipe robotically, insert the CIPP lining, re-instate service connections, backfill shafts, clean area), all parties involved in the ongoing projects in Madison realize there are also numerous other benefits than just economic — there are social and environmental factors that were also considered. Among them were and are minimal disruptions while maintaining a high standard of water quality in the systems.

The environmental considerations and benefits considered were:

- Minimal disruptions to residents and businesses,
- Decreased restorations,
- The reduction of the carbon footprint by 85 percent or more, meaning this technology is an environmentally significant solution,
- Disruption to environmentally sensitive areas is decreased (including rivers, streams, greenbelt), and

Other benefits include:

- Cost-savings can be as much as 50 percent,
- Safe and fully structural water main renewal,
- Service connections are reinstated from inside the pipe using a remote controlled robot. This eliminates the need for local excavations at every house,
- Can negotiate bends,
- Improved flow due to higher Hazen Williams coefficient greater than 120,
- Extends life of pipe by 50 years or more, and
- Low dig solution eliminates the need for major repaving as compared to digging long trenches.

Savings realized by officials in Madison for the first job was in the range of 20 percent. "But," Wiederhoeft is quick to point out, "it is a matter of economies of scale — we recognize that the same equipment is needed for a job only slightly longer than a football field as for the second project on a 3,500-ft stretch. And the savings may increase as each project renews longer sections of water mains. On the second project, savings were more than 30 percent. A portion of these increased savings can be attributed to municipal employees being charged with digging the access pits and assuming cleanup responsibilities. The next two, even larger projects, are expected to save Madison even more," he concludes.

It should be noted that Fer-Pal and Sanexen Aqua-Pipe report typical savings in dozens of installations, as compared to open-cut replacement, have been in the 30 percent to 50 percent range.

Benoit Cote is vice president of Aqua-Pipe, Sanexen Environmental Services Inc.

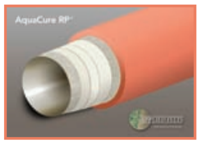
CIPP TECHNOLOGIES AND INSTALLATION EXPLAINED

Trenchless CIPP structural pipe lining technologies allow for the rehabilitation of damaged or aging water mains made of materials such as cast iron ductile iron, steel and asbestos cement pipe (6 inch to 16 inch) by inserting a patented composite material liner into the host pipe. The liner comprises two polyester jackets with the inner jacket fused onto a water tight thermoplastic polyurethane (TPU) membrane. Aqua-Pipe is certified by Underwriters Laboratories (UL) and NSF to ANSI/NSF Standard 61.

Following insertion, the liner is impregnated with a curable polymeric resin epoxy that allows the tubular liner to bond to the host pipe; and the curable resin once reticulated, completes the formation of the composite structural liner.

PIPE RELINING MARKETPLACE

APPLIED FELTS



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FOR MORE INFORMATION ON LMK AND ITS PRODUCTS, PLEASE VISIT WWW.LMKTECHNOLOGIES.COM OR CALL 815-433-1275

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AD INDEX

LEADING THE WORLD OF CIPP IS IN OUR FIBER.

Everything we do at Applied Felts — from maintaining full control of our raw materials to helping ensure each and every felt liner we make is successfully installed — makes us the global leader in supplying the world's finest CIPP liners. It's who we are because Applied Felts was there from the beginning, helping take the first innovative steps to invent the CIPP process more than 40 years ago. Now we are taking the next big leap by introducing our latest innovation, AquaCure RP®. This breakthrough liner combines the benefits and performance of fiberglass reinforcement with our existing, best-in-class felt liner design and construction. Our exclusive technology fully integrates and blends state-of-the-art strength with millions of feet of proven results to provide the strongest, most robust liner on the market today. AquaCure RP is just one more reason customers from Singapore to San Francisco depend on us year after year. They know what we're made of.

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