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TRENCHLESS NORTH AMERICA

The Official Magazine of the North American Society for Trenchless Technology

NASTT 2022 No-Dig Show Proves Infrastructure is Essential!

Minneapolis, MN
April 10 - 13, 2022

SUMMER 2022
Volume 12 • Issue 2

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ANYWHERE.

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SUMMER 2022 – VOLUME 12, ISSUE No. 2

BACK IN THE SWING OF THINGS AT THE NASTT 2022 NO-DIG SHOW!

The world's largest trenchless technology conference was in Minneapolis this past April looking to continue the momentum built during the 2021 conference. By all accounts, it was a triumphant return to business-as-nearly usual, demonstrating once again the resilience passion and purpose of the trenchless technology industry and the people who drive it forwards!

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FEATURES

APRIL 10-13 | MINNEAPOLIS, MN
NO-DIG SHOW 2022

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GREEN ABOVE. GREEN BELOW.

WELCOME TO THE SUMMER 2022 EDITION OF TRENCHLESS NORTH AMERICA!

This issue focusses on innovation and reviews the NASTT 2022 No-Dig Show in Minneapolis, where over 1,700 attendees gathered over three days for a successful conference to celebrate the best in trenchless and share their knowledge and experience.

Microsoft Co-Founder Paul Allen said, "As long as we work together, with both urgency and determination, there are no limits to what we can achieve." Famously starting out with two people working from a garage, by constantly challenging innovation Paul Allen and Bill Gates grew not only their leading company, but an entire industry.

Innovation can be driven by new opportunities or as a solution to a problem. Over the last 50+ years trenchless technology has proudly continually developed new equipment and techniques, broadened ranges of applications and capabilities to enable the 'impossible' to become practical delivered projects, improving the sustainability of underground infrastructure for everyone.

"Working together to deliver effective innovation is our responsibility"

The NASTT Abbott Awards for Innovative Products & Services for New Installation and Rehabilitation are central to recognizing some of the leading products and ideas that our industry has to offer, and this year's quality and quantity of entrants only strengthen the evidence that trenchless technology is moving forward through consistently challenging the boundaries of the possible. Congratulations to all 24 selected finalists who had the opportunity to present on their entry and especially to our winners - more of them later!

Taking a moment to stand on the busy NASTT No-Dig Show floor in Minneapolis and see and hear the energy of everyone attending was testament to all our determination and passion. Well supported by exhibitors, sponsors and delegates who participated in the event, I would like to thank all of you for your time and commitment invested in attending the technical sessions, awards, networking events and exhibitions. We look forward to seeing many of you again in 2023 as we head to Portland, returning to the Pacific Northwest after several years. Working together to deliver effective innovation is our responsibility to continually improve the world we live in. Investment in R&D, manufacturers, suppliers, engineers, contractors, and owners all play a key role in embracing the future as projects consistently set new benchmarks in effectiveness and the need and utilization of trenchless technology continues to grow.

To paraphrase Mr. Allen as we increasingly commit to being greener – above and below: if we have Innovation, determination and working together – there are no limits to what trenchless technology can achieve.

Finally, thank you to all the companies who support our magazine and submit articles, please support them, and enjoy your read!

Matthew Izzard

Matthew Izzard, Executive Director
North American Society for Trenchless Technology (NASTT)
mizzard@nastt.org

"We look forward to seeing you at a regional or national conference or training event soon!"

INNOVATION IS THE CORNERSTONE OF OUR INDUSTRY

The NASTT 2022 No-Dig Show held in Minneapolis this past April was an extremely successful event full of industry-leading networking and educational events. Take a look throughout this issue for a recap and overview of the 2022 show and make sure to mark your calendars so you can join us in Portland in April 2023 for another outstanding conference.

With over 1,700 attendees after some unprecedented years, it was a busy and fun week for all, including the university students from our Student Chapters and Municipal Scholarship recipients from all across North America. Thank you to our Technical Program Committee Members and the 2022 No-Dig Show Chair, John Milligan of Vermeer and Vice Chair, Joe Lane of Aegion for all your time and efforts. Our volunteers are the backbone of this society, and we are grateful and appreciative of everyone's contributions to making NASTT what it is today.

One of the highlights of the No-Dig Show is the Abbott Award for Innovative Products & Services. This year each finalist was given the opportunity to present during a forum dedicated to innovation in the trenchless industry and the winners were recognized in the exhibit hall during the Educational Fund Auction event. Innovation is the cornerstone of this industry and the advancement and growth is something for us all to be proud of. Check the section in this issue where we celebrate the winners and finalists of the 2022 Abbott Award for Innovative Products & Services in New Installations and Rehabilitation.

We look forward to the coming months and the events we have planned to bring the underground infrastructure community together. This fall we hope you will join us in Toronto, ON for the 2022 No-Dig North conference, October 17-19. No-Dig North is hosted by the Canadian Chapters of NASTT and offers two full days of training, education and networking. This is a must-attend event for trenchless training and networking in Canada. Visit www.nodignorth.ca for details!

In keeping with our mission of education and training, we regularly review and update our training materials and offerings and are excited to roll out updated educational resources this year along with more frequent opportunities for both in person and virtual education. For the latest information on upcoming events, visit our website at nastt.org/training/events.

Be sure to mark your calendars and save the date for the NASTT 2023 No-Dig Show in Portland, OR, April 30 – May 4. The city of Portland is a perfect location for our industry to come together to celebrate and educate with the theme, Green Above, Green Below. It is important that our industry is a steward of our precious natural resources, and we welcome the opportunity to provide a forum to learn about the latest in innovative trenchless products and services. Learn more at www.nastt.org/no-dig-show.

For more information on our organization, committees, and member benefits, visit our website at www.nastt.org and please feel free to contact us at info@nastt.org.

We look forward to seeing you at a regional or national conference or training event soon!

Alan Goodman

Chair
North American Society for Trenchless Technology (NASTT)

Q A with

David Haug P.E.

David Haug, P.E., BCEE is a Project Manager at Black & Veatch in Los Angeles, California and has over 25 years of experience in designing and building conveyance systems by conventional and trenchless installation methods. He also has a unique perspective on the industry having been both a consultant and an owner. Since 2018, David has volunteered with NASTT being a session chair, peer reviewing abstracts, papers, and presentations for the No-Dig conferences.

BLACK & VEATCH

What first inspired you to become interested in the construction & engineering fields, particularly underground construction?

I tell people becoming an engineer was woven into my DNA from birth. The reason is I'm a third-generation civil engineer. My interest in the underground world was influenced by hearing my father and grandfather "talk shop" at family gatherings as a young boy. My grandfather, Les Haug worked for the Los Angeles County Sanitation Districts (LACSD) after World War II and built several of the agency's sewers by tunneling methods. While in college, my father, Tim Haug, worked at the City of Los Angeles Bureau of Engineering and was involved with the North Outfall Replacement Sewer (NORS) and the North Outfall Sewer - East Central Interceptor Sewer (NOS-ECIS) projects. My university's student chapter of ASCE was given the opportunity to tour the NORS project while it was under construction. Walking through the tunnel made me realize the underground world had to be part of my future career.

Outline your experience of first being introduced to trenchless technology methods and applications.

While my family "talk shop" conversations and the NORS tour are introductions to the tunneling world, I did not have any exposure to the other trenchless technologies until I started my career after finishing college. One of the first design projects I was involved with proposed installing a new sewer by microtunneling methods. The concept of using a bentonite slurry to remove the cuttings from a machine that was controlled from the surface was fascinating. Early in my career, I was fortunate to design projects which installed large diameter sewers by two pass tunneling methods to rehabilitating smaller trunk sewers using cured-in-place pipe liner and sliplining methods. I also worked as a construction manager building projects which used the same type of trenchless construction methods I had previously designed. A memorable project was the first tunnel project I managed. It was a two-pass tunnel using wood lagging with steel rings installing a new sewer along the Los Angeles River. The coolness of the tunnel was a welcome break during hot summer days. When the water level in the river rose during a storm event, we eventually saw groundwater seep into the tunnel invert.

How did you first get involved with NASTT? What are some of the goals and initiatives you would like to see NASTT pursue?

My involvement with NASTT started when I transitioned from the public sector back to consulting. After being focused on the design of a large diameter tunneling project for over a decade, I realized the best way to get re-engaged with the other trenchless technologies in our industry was to attend No-Dig conferences and volunteer with the organization. An initiative I would like the industry to explore is a partnership between engineering firms and contractors to allow young professionals the opportunity to shadow field crews to learn those aspects of our industry that cannot be taught in school.

What are your thoughts on the current state of the trenchless industry? What areas do you see evolving in STEM education and post-secondary academics?

It is amazing to see how the technology in our industry has grown. An example of this is with cured-in-place pipe lining. When I first entered the engineering field, CIPP liners were cured using water heated by a boiler truck. Now we are curing liners using UV lights. As impressive as the technology advancements are, it is the people in this industry who are making the biggest impact. Seeing student chapters being established at universities is very encouraging to get the next generation of professional into the field. To help prepare those students, we need more professionals disseminating their knowledge to them through some type of partnership between academia and the industry.

Is the trenchless industry generally doing a good job of attracting young professionals? What do you think can be done to better engage students and young professionals in the trenchless industry?

Yes, the industry is doing a good job of attaching young professional, but as mentioned above, we need professionals to become more engaged to pass our knowledge to them. With the increasing amount of people retiring, passing along that knowledge takes on an increasing importance so the industry as a whole does not slide backwards in our advancements.

What do you see as the biggest challenges facing the trenchless industry today? Has acceptance and understanding of trenchless technology improved?

The biggest challenge I see facing the trenchless industry is making sure we have enough talented staff entering the professional and more importantly, the construction work force. Each year, we see numerous articles discussing the aging and failing infrastructure throughout the United States. In my current position, I am encouraged by the number of young professionals involved with some aspect of the trenchless world. What I don't have a good understanding of is how is our industry working with trade schools to bring more talent into the contracting side of our industry?

"How is our industry working with trade schools to bring more talent into the contracting side of our industry?"

What do you personally enjoy most about working in the trenchless technology field?

There are two aspects of the trenchless field that I enjoy, the development of a project and the people. When working on a conveyance project, the part I enjoy the most is the process of figuring out how to get the pipe from point A to B while balancing all the project constraints. The people aspect is the comradery everyone has in the trenchless industry. I have mentioned to staff who are interested in this field, the trenchless industry is a small umbrella under the bigger engineering and construction umbrella. It doesn't matter if you are dealing with the largest tunnel bored to date or lining a small sewer, we are all part of this trenchless world.

Design Considerations for Direct Steerable Pipe Thrusting:

Understanding the Behavior of Drilling Mud, Slurry, and Lubrication

By: Kimberlie Staheli, Ph.D., P.E., Staheli Trenchless Consultants

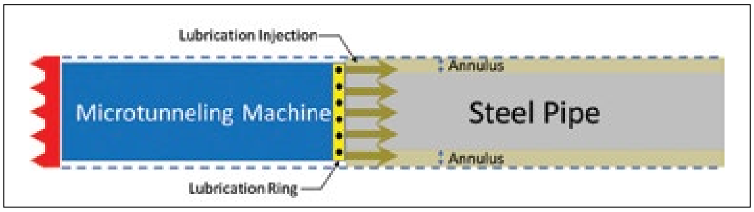
Direct Steerable Pipe Thrusting (DSTP) is the generic name for the installation of a steel pipeline that is a) installed into a bore using a pipe thruster, b) steerable, and c) typically installed along a designed bore path that includes curves. Herrenknecht Corporation was the first manufacturer to bring this technology to the market with their Direct Pipe system with the first installation occurring in 2007. Since that time, the application of DSPT has increased substantially, approaching 200 installations worldwide. The vast majority of DSPT projects that have been installed in North America have been for the energy sector and the installations are typically privately owned. As such, case studies and evaluation of case histories have been limited.

DSPT is often described as a combination of horizontal directional drilling (HDD) and Microtunneling (MT) as DSPT has operational and behavioral characteristics that are similar to microtunneling while allowing the installation of pipelines with geometric characteristics that are similar to HDD installations. However, the Engineering community needs to understand the features of DSPT that make it distinctly different from HDD and MT, and when the use of the technology is advantageous. To understand the mechanisms that govern the behavior of DSPT installation, the engineer can look to both microtunneling and horizontal direction drilling engineering analyses. However, it is important to isolate the features of MT and HDD that are also present in DSPT operations to determine which analysis methods apply directly or indirectly to DSPT.

Critical to the analysis of DSPT is understanding the difference between:
- Drilling Mud
- Microtunnel Slurry
- Microtunnel Lubrication.

The three systems serve very different functions, and it is necessary to have an understanding of both MT and HDD behavior to understand DSPT.

Drilling mud that is used for HDD provides two critical functions: supporting the borehole and removing the excavated material



Microtunnel Lubrication

from the borehole. As such, drilling mud often contains a significant amount of soil. In addition, drilling mud must be continually circulated to ensure that the borehole is stable.

MT slurry is similar to drilling mud because it removes the excavated material from the face of the microtunneling machine. However, the slurry system is completely contained within the machine, isolating the surrounding soil from the slurry pressure. The MT slurry pumps the excavated material through a 4- to 6-inch pipe at high velocity. Some microtunneling contractors add bentonite to the slurry; however, the volumes added are far less than used to stabilize the borehole in HDD. Adding bentonite to the slurry increases the soil carrying capacity however it makes soil separation difficult. Unlike HDD, the soil-laden slurry is not in contact outside of the MT machine or the pipe.

MT lubrication is performed with a system that is completely independent from the microtunnel slurry system. Lubrication is pumped to the outside of the pipe through slurry ports, filling the annulus between the pipe and the soil. Unlike HDD drilling mud, the lubrication is clean and does not carry excavated material. The purpose of the lubrication is to lower the jacking forces to allow longer installations. MT does not rely on any fluid to stabilize the borehole. Only the annulus requires stabilization as the borehole is mechanically supported by the machine and trailing pipe. Many microtunnels have been installed when the annulus has collapsed or is not filled with lubrication; however, the jacking forces can increase substantially if no lubrication is applied.

Direct Steerable Pipe Thrusting (DSPT)

Inadvertent returns and their risk with DSPT

DSPT was invented to allow construction of a pipeline beneath a sensitive structure without the risk of inadvertent returns to the ground surface. When designing an HDD, it is necessary to determine an appropriate bore depth to confine the drilling fluids within the borehole. This is done by calculating the annular pressure required to create the HDD pilot hole and comparing it to the confining stresses of the soil overburden. If the borehole is shallow or the geotechnical conditions have low strength, the pressurized drilling fluid may escape to the ground surface when the bore pressure exceeds the soil confining strength (inadvertent returns/hydrofracture), or the drilling mud may leave the borehole by dispersing into permeable material or traveling along preferential flow paths such as existing utilities, foundations, or fractures. The desire to eliminate inadvertent returns has resulted in the installation of pipelines that are significantly deep, especially beneath critical environmental structures.

DSPT is used as an alternative to HDD because the MT machine does not rely on fluid pressure to support the face. The slurry pressure is maintained to match the groundwater pressure and as such, does not have the potential to result in inadvertent returns. This has been proven by annular pressure sensors on DSPT that indicate the annular pressure mimics the groundwater pressure. This is consistent with the assumptions made during the development of jacking force predictive models for MT. The lack of pressurization in the annulus is very significant as pipelines can be designed at much shallower depths, resulting in shorter bore profiles and the elimination of inadvertent return risk.

On critical crossings, pipeline Owners and permitting agencies are accustomed to evaluating HDD installation methods and regulations are in place that require evaluation of the drilling fluid pressure and the confining earth pressure, called a HFIR (hydrofracture inadvertent return) analysis; however, slurry pressures generated at the DSPT machine are not analogous to HDD drilling mud pressures. As such, the trend in the industry is to use the full column lubrication load to determine HFIR; however, it is important to note that unlike drilling mud, the lubrication is "very clean" (does not contain excavated soil), should have a low yield point (for frictional reduction) and weighs only slightly more than water (typically between 8.8 and 8.9 pounds per gallon). As such, using full column mud loading in the annulus, the calculated annular pressure is approximately 5-10 percent higher than groundwater pressure, assuming the groundwater is near the ground surface. This makes DSPT feasible for critical crossings without the risk of inadvertent returns.

Thrusting Forces for DSPT

Measures for calculating the amount of thrust required for a DSPT project are largely developed from the HDD industry. However, one must consider the differences in the mechanism of installation: pulling v. pushing, an annulus that is supported with drilling mud v. lubrication, a borehole that is largely supported by the microtunneling machine v. reliance on mud properties to stabilize the borehole. Perhaps the most important differentiation is the coefficient of friction that is used to represent the frictional resistance of the borehole. In HDD, the ASTM F1962 recommends a friction coefficient between the pipe and the borehole of 0.3, corresponding to an interface friction angle of 16.7 degrees. The use of this value in DSPT calculations results in significant over-estimation of thrust forces. For DSPT, one must consider an interface friction value based on a lubrication/pipe contact rather than a drilling mud/pipe contact. Goerz (2019) reviewed installation data and found interface friction coefficients as low as 0.015, 95% lower than the interface friction values used for HDD (ASTM F1962). Additional work by Sparks and Hotz (2019) indicates that the thrust force has a high correlation with the buoyant weight of the pipe, with a correlation coefficient ($R > 0.8$). Evaluation of thrusting records indicate that a factor of 0.3 times the buoyant unit weight results in a reasonable estimate of the total and peak thrust loads.

Information and analysis of DSPT data is increasingly moving the engineering community towards understanding the mechanisms that control the thrust loading. As the DSPT industry draws from previous work completed on estimating microtunneling jacking forces, as opposed to the HDD pullback forces, a model can be developed that more closely represents the mechanisms that control the thrust loading.

Kimberlie Staheli, Ph.D., P.E., is President of Staheli Trenchless Consultants, offering innovative solutions to trenchless challenges.

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NASTT NO-DIG SHOW 2022

Back in the Swing of Things at the NASTT 2022 No-Dig Show!

The Trenchless Industry Shows No Signs of Slowing Down!

The world's largest trenchless technology conference headed to Minneapolis, Minnesota this past April looking to continue the momentum built during the 2021 conference return after the 2020 shutdown. The NASTT 2022 No-Dig Show was a triumphant return to business-as-nearly usual, demonstrating the resilience, resourcefulness and innovative nature of the trenchless industry, and the people who pursue it with a passion.

As a premier educational opportunity for forward-looking underground infrastructure professionals, the NASTT No-Dig Show can be counted on to provide countless environmentally friendly trenchless solutions and cost-saving opportunities that municipalities and utilities can utilize within their communities. With six tracks of peer-reviewed, non-commercial presentations, nearly 200 informative trade exhibits and multiple networking opportunities, the NASTT 2022 No-Dig Show again fulfilled its promise as one of the must-attend underground construction conferences for anyone involved in this industry.

The NASTT No-Dig Show demonstrated that trenchless technology offers both innovative rehabilitation and technically advanced replacement options for communities and utilities looking for cost effective, non-disruptive and greener infrastructure solutions.

As preparations begin for the 2023 No-Dig Show in Portland, Oregon April 30 – May 4, NASTT looks forward to continuing steady growth in use of trenchless technology and being in place as the go-to resource for knowledge, networking, education, and training in trenchless technology all across North America.

Kick-Off Breakfast - Welcome to the NASTT No-Dig Show!

Monday morning opens with the Kick Off Breakfast which features peer networking, awards, a plated breakfast and fantastic entertainment to set the tone for the week!

NASTT's Volunteer of the Year Award recognizes members who exemplify the mission, vision and core values of NASTT and make an impact in the trenchless industry through their dedication, leadership and volunteer contributions during the past year. One NASTT member is chosen annually at the discretion of the NASTT staff. The 2022 NASTT Volunteer of the Year is Brian Avon of Carollo Engineers. Brian was recognized during the Kick-Off Breakfast and is shown here with NASTT Executive Director, Matthew Izzard

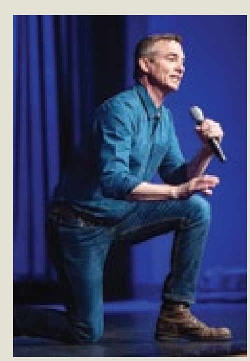
2021 Outstanding Paper of the Year Award in New Installations was awarded to "HDD Lessons You Can Only Learn in the Field", written by Kimberlie Staheli, Ph.D., P.E., and Jake Andresen, P.E. of Staheli Trenchless Consultants. Shown here: Kim and Jake receive the award from NASTT Board Member, Jim Williams of Brierley Associates

2021 Outstanding Paper of the Year Award in Rehabilitation was awarded to "Columbia Canal Brick Arch Tunnel Geopolymer Lining in South Carolina", written by Joe Royer, Ph.D., of GeoTree Solutions, LLC and Bill Sharpe, of Inland Pipe Rehabilitation, LLC. Shown here: Joe Royer receives the award from NASTT Board Member, Jim Williams of Brierley Associates

"Trenchless Technology" magazine Person of the Year: Derek Potvin of Robinson Consultants awarded by "Trenchless Technology" magazine Publisher Kelly VanNatten and Trenchless Ambassador Dan Sisko of Benjamin Media

"Trenchless Technology" magazine awards their Trenchless Project of the Year in Rehabilitation and New Installations each year during the NASTT No-Dig Show Kick Off Breakfast. Awards were presented by Sharon Bueno and Michael Kezdi, editors of "Trenchless Technology" magazine

Attendees were treated to a wild ride with exciting stories, motivational content and music by the dynamic speaker and musician Keni Thomas, a former Army Ranger who was present during the infamous Black Hawk Down battle in Somalia. The crowd was riveted throughout his presentation and left the breakfast feeling energized and ready to take on the week of learning and networking with gusto!



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NO-DIG SHOW
2022

Ribbon Cutting & Exhibit Hall

The annual ceremonial ribbon cutting opens the exhibit hall and welcomes sponsors, exhibitors, attendees and guests to the NASTT No-Dig Show! L-R: NASTT Board Vice Chair, Matthew Wallin of Bennett Trenchless Engineers; NASTT Executive Director, Matthew Izzard; 2022 No-Dig Show Program Vice Chair, Joe Lane of Aegion; and NASTT Board Chair, Alan Goodman of HammerHead Trenchless

NASTT University Student Chapter Members attend the No-Dig Show and volunteer throughout the event while also having the opportunity to attend technical sessions, walk the exhibit hall and network and engage with attendees and future employers!

Networking and education are always top of mind during the NASTT No-Dig Show. The exhibit hall is buzzing with the latest innovations in the trenchless industry with product and equipment demonstrations and lively technical discussions. Exhibitors offer raffles, food and beverages give-aways, and more, in their booths for attendees to explore and enjoy


PICOTE

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NO-DIG SHOW 2022

NASTT Municipal & Public Utility Scholarship Reception

The NASTT Municipal & Public Utility Scholarship program is all about connecting trenchless contractors with municipal and public utility decision makers. Doing business with municipal agencies and public utilities is crucial to the trenchless industry. NASTT's Municipal & Public Utility Scholarship brings hundreds of decision maker agency representatives in-person to the No-Dig Show. Since its inception, over 2,000 delegates have been onsite looking for solutions to their infrastructure challenges that trenchless technology can provide. Municipal and public utility scholarship winners from all over North America attended the NASTT 2022 No-Dig Show and a reception specifically for these winners was held at the start of the conference for networking and some fun, too!

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NASTT NO-DIG SHOW 2022

Technical Sessions & Forums

A core feature of the NASTT No-Dig Show is the unparalleled technical schedule which spans six tracks over the course of three days. Over 130 sessions on all aspects of trenchless technology were presented and also included panel forums with industry experts offering topic discussions where audience Q&A and participation is encouraged! Registrants are able to earn Continuing Education Units to support their professional development with their attendance to the technical sessions

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2022

Gala Dinner & NASTT Awards

Long time NASTT member and tireless volunteer, Dennis Doherty, was inducted into the 2022 NASTT Hall of Fame. Dennis was instrumental in the formation of the Northeast Regional Chapter of NASTT and is a staunch advocate of our University Students!

Trenchless Industry veteran, Paul Nicholas, was inducted into the 2022 NASTT Hall of Fame. Paul has spent over 32 years in the trenchless technology industry promoting the development and use of microtunneling

Former NASTT Executive Director, Michael Willmets, was inducted into the 2022 NASTT Hall of Fame. Mike's career in infrastructure management and trenchless technology has spanned nearly 50 years!

Gala Awards Dinner attendees dressed to impress for a festive evening that included a cocktail hour, a delicious meal, plenty of time to socialize and network with industry friends and colleagues as well as recognize and honor award recipients and enjoy fabulous entertainment!

University Student Chapter Members from Louisiana Tech University enjoyed the networking reception held prior to the Gala Awards Dinner

The Ralston Young Trenchless Achievement Award applauds savvy members under 36 who have demonstrated excellence early in their career by making valuable contributions to the trenchless technology industry. The 2022 recipient is Matthew Olson of Lithos Engineers. Matthew is shown here flanked by NASTT Board Member, Chris Sivesind and Board Chair, Alan Goodman

The NASTT Chair Award for Distinguished Service Award recognizes trenchless professionals that have provided both NASTT and the trenchless industry with meritorious, prominent and long-standing service. One recipient each year is chosen at the discretion of the NASTT Chair. The 2022 honoree is Tiffanie Mendez of Sunbelt Rentals. Tiffanie serves as the Secretary on the Executive Board of Directors for NASTT. Tiffanie received her award from Chair Alan Goodman and is also shown with Executive Director, Matthew Izzard

CELEBRATE TRENCHLESS AWARDS

NASTT Celebrate Trenchless awards honor the growth and advancements in the trenchless industry. NASTT recognizes the many ways that these individuals contribute significant time, energy and intellect to developing trenchless technology and fostering its success.

Chair Award for Distinguished Service

Recognizing trenchless professionals that have provided both NASTT and the trenchless industry with meritorious, prominent and long-standing service. One recipient each year is chosen at the discretion of the NASTT Chair.

Tiffanie Mendez
National Sales Director, Sunbelt Rentals

NASTT Executive Director, Matthew Izzard and NASTT Board Chair, Alan Goodman present Tiffanie her award at the NASTT Gala Awards Dinner at the NASTT 2022 No-Dig Show

NASTT Chair, Alan Goodman, selected Tiffanie Mendez, NASTT Board of Directors Secretary and National Director of Sales for Sunbelt Rentals, Pump Solutions for the 2022 Chair Award for Distinguished Service. Tiffany recalls, being asked to volunteer to join the No-Dig Show Program Committee in 2016 by NASTT Program Director, Michelle Hill. "Once I attended the first meeting, it was wonderful! All the volunteers were so welcoming, and the atmosphere was filled with so much passion around trenchless. I've been hooked ever since!" she said. "I keep coming back for the networking and for the wonderful friendships I've made over the years, and the industry mentors that are always there for me."

Alan says of Tiffanie, "Tiffanie Mendez always brings a 'can do attitude with care'. She is a true reflection of what a volunteer can do within this organization. Her passion and enthusiasm for students will bring a whole new level of excitement with prestige. I want to thank Tiffanie from the bottom of my heart for making NASTT a better society to get engaged."

A 25-year liquids solutions management professional, Tiffanie began her career in the early 90s in Yuma, AZ., focusing on specialty equipment rental systems and design/build liquids handling systems. Her early focus was groundwater dewatering, filtration systems, sewer bypass systems and construction storm water runoff management. After relocating to Northern California in 2005, the design/build systems focus grew to include temporary plants for environmental remediation, low and medium voltage electrical power systems and compressed air systems.

Tiffanie is currently the National Sales director for Sunbelt Rentals' Pump Solutions Business Unit. "Thanks to Sunbelt, for being amazing and super supportive of me and other employees who are involved in organizations that support their initiatives," Tiffanie shared. She especially acknowledges Vice Presidents Jason Thompson, Brian Elbrecht, Dan Winkowski and Scott Sabo. "I also want to thank Craig Vandaelle, Michels Corp, and Dr. Kim Staheli, Staheli Trenchless, for being amazing mentors to me in trenchless and in construction business."

She holds a BSBA from Northern Arizona University and an MBA, General Management from California State University, East Bay. Tiffanie has been a part of NASTT's No-Dig Show Program Committee since 2016 and believes the future of the industry lies in preparing the new leaders of the trenchless industry now. She brings that passion to her role as the chair of the NASTT Student Activities Committee engaging engineering students across North America in programs and activities including the NASTT Student Research Competition, scholarship programs and regional chapter activities. She makes sure to "pay it forward" by getting others nvolved in their regional chapters and committees.

Ralston Award for Young Trenchless Achievement

Applauding savvy members under 36 who have demonstrated excellence early in their career by making valuable contributions to the trenchless technology industry, achieving noteworthy professional success, and actively participating in NASTT or its regional or student chapters. With their talent and ability, these impressive people are the future of trenchless.

Matthew Olson
Associate, Lithos Engineering

Matt Olson lives and breathes NASTT's mission to be the premier resource for knowledge and education in Trenchless Technology, according to Lance Heyer, Associate at Lithos Engineering, who was thrilled to nominate Matt. "Trenchless is truly in his blood," he said, referring to Matt's father who was a trenchless new installation contractor with Bore Masters in Pewaukee, WI. Matt's academic career included a thesis on pilot tube jacking forces. Matt gave his heartfelt thanks to his dad in his acceptance speech at the NASTT Gala Awards Dinner. "I got to operate TBM loci, unload pilot tubes covered in fat clay and bentonite, and shovel sticky clay away from the auger boring machine. I then decided to be an engineer." This early exposure to trenchless technology and how his father demonstrated "hard work, leadership, and fair and equitable decision making" – values that guide him today – continue to propel Matt's success. Matt also attributed the honor to the mentorship of many industry friends. He highlighted Dr. Kim Staheli, Dr. Jason Lueke and Dr. Sam Ariartnam who were "extraordinary" influences and provided opportunities, resources and help.

Matt Olson accepts his award with NASTT Young Trenchless Award Committee Chair, Chris Sivesind and NASTT Board Chair, Alan Goodman

"Matt truly embodies the spirit in which this prestigious award was meant to represent with an astounding track record of service and dedication to the trenchless industry," says Matthew's former Master's Program co-supervisor, Samuel T. Ariaratnam, Ph.D., P.E., Professor at the Ira A Fulton School of Engineering, Arizona State University.

As a NASTT volunteer, Matt has served on the Rocky Mountain Chapter Board, No-Dig Show Technical Program Committee, participated as No-Dig Show track leader and has chaired the NASTT Young Professionals committee and judged the Student Poster Competition at the No-Dig Show. He has six technical papers in the NASTT technical paper library, including "Pipe Ramming Through Challenging Subsurface Conditions in the Pacific Northwest" and "Into the Void: Case Study of an Emergency Pipe Burst Beneath the West Seattle Bridge" which won the NASTT Outstanding Paper of the Year in 2016 and 2017 respectively.

Celebrate Trenchless Award recipients are recognized at the NASTT No-Dig Show and promoted through NASTT communication outlets which may include nastt.org, social media, NASTT E-News, and NASTT's Trenchless North America. Find out how you can become a NASTT award recipient at www.nastt.org/awards.

STUDENT RESEARCH AWARDS

NASTT University Student Chapter Members are encouraged to participate in the Trenchless Research Competition with a poster and presentation explaining a research project they have been working on. The 2022 winning student was Stephen Gordon of Louisiana Tech University with his research presentation entitled: Ohmic Curing Technique for GPC Pipe. The prize for the winner was a generous cash donation donated by Sunbelt Rentals.

Student members Mohammad Alnahari of Arizona State University and John Kraft of Louisiana Tech University were the additional finalist participants in the research competition

Student Member Stephen Gordon of Louisiana Tech University and NASTT Executive Board Member Tiffanie Mendez of Sunbelt Rentals

North American Society for Trenchless Technology Announces

The Abbott Innovative Product & Services Award celebrates companies with a state-of-the-art product or service making a significant impact in advancing the trenchless industry in the areas of rehabilitation or new installation.

The selected winners met the highest-level of standards for each category. Products were judged on Innovation (concept, method, development); Value (need, advantages, cost); and, Impact (sustainability, social/environmental responsibility and potential). The Innovative Product & Services Award is a testament to the skill, ingenuity and vision of the creative teams that research, develop, design, market and operate these products.

Presentations about each product were made at the Innovative Products Forum at the NASTT 2022 No-Dig Show and are available online at https://nastt.org/no-dig-show/awards/abbott-innovative-products-services-rehabilitation-new-installation/. To learn more about NASTT awards, visit nastt.org/awards.

"Testament to the skill, ingenuity and vision of the creative teams that research, develop, design, market and operate these products"

NASTT Abbott Award - New Installation

Sam Boyd, Boyd Tech President accepts the award from Brian Dorwart, NASTT Innovative Products Selection Committee

BOYD TECH, INC. - B-TECH CONNECTIONS™

In the category for New Installation, the award was given to Boyd Tech, Inc. for its B-Tech Connections™. A means to mechanically connect HDPE piping for pulling, pushing and transitions, B-Tech Connections provides a pipe-to-pipe connection wherein ID & OD remain the same. Either permanently locked or temporarily installed, connections are water-tight with a broad range of applications in trenchless and non-trenchless applications. In confined space applications, work crews save time and resources when compared to other, time-consuming connection techniques or bulky mechanical methods. Connections can be supplied in short spools to 36 inches, or pre-fused to any length of pipe to produce custom length spools. Long life span, fast assembly times, make this connection method, efficient and cost-effective for any HDPE project or application.

Sam Boyd, Boyd Tech President tells how a well-known contractor posted on LinkedIn about pipe-bursting manhole to manhole using short threaded segments of polypropylene (PP) imported from Denmark. Sam contacted the contractor and asked, "Why PP and not HDPE?" His response? "No one produces a pullable HDPE threaded segment system." And that's how it started. Sam was curious and set out to find a supplier or find out why no one makes one. "As a result of this research and exploration, the basis for B-Tech Connections™ took hold in my mind," Sam explains. "I couldn't let go until we found a way to solve this problem."

After an extensive search across the globe, Boyd Tech learned that it was indeed true: No current manufactured HDPE connection would guarantee pipe pull-ability over 2,000 US Pounds! Sam tells the rest of the story. "We started like everyone before us; experimenting with the 'common threads.' We soon realized, mostly from our failures, why previous companies probably gave in. HDPE is a very soft and supple material, it expands over itself, so traditional threads don't hold." Then the out-of-the-box thinking took over. "We developed a way to use the suppleness against itself – a negative positive force configuration for positive output."

Boyd says he is honored and humbled to have B-Tech Connections™ be recognized as a game-changer in the industry. "All I set out to do was assist the trenchless industry. It has been professionally invigorating and rewarding to be able to take B-Tech Connections™ across multiple industries solving countless operational issues."

For more information, contact Sam Boyd, President at samboyd@boydtech.us or visit https://boydtech.us.

North American Society for Trenchless Technology Announces

NASTT Abbott Award - Rehabilitation

AEGION
Stronger. Safer. Infrastructure.
Insituform

Dennis Pivin, Insituform VP Environmental, Health, Safety and Security accepts the award from Alan Ambler, NASTT Innovative Products Selection Committee Chair

INSITUFORM - CIPP CARBON FILTER SYSTEM

In the category for Rehabilitation, the award was given to Insituform, for its CIPP Carbon Filter System, a carbon filtration solution for CIPP steam-cured product that exhausts Volatile Organic Compounds (VOCs) and accompanying odors. Aegion is the parent company for Insituform. The innovative filtering system uses selected carbon and other filtration media in a filter canister design to capture the VOC. This device will significantly reduce or eliminate (depending on the diameter of the CIPP installation) the amount of VOCs from the emissions. Created to be small, portable and include a photoionization detector (PID), the results have shown a potential reduction of reportable greenhouse gas emission of greater than 90 percent.

“The CIPP industry has seen an increase in concerns regarding the industry impact on the environment,” explains Dennis Pivin, Insituform VP Environmental, Health, Safety and Security. “The concept originated as an opportunity to be good stewards of the environment and address public concerns regarding odor and health industries by reducing VOC emissions.” Dennis elaborates on how it works, “This Filtration system is designed to be placed at the downstream end of the CIPP tube during the cure process. The steam is piped through the carbon filter and baffle system and thus reduces potential VOC emissions.”

Dennis considers the win as a highlight in his career as a Board Certified Safety Professional. “I strive to continue to improve both the environment and safety for our employees and the public. The NASTT Abbott Innovative Product and Services Award in Rehabilitation is the culmination of hard work and succeeding in that effort.”

For more information, contact Dennis Pivin, VP Environmental, Health, Safety and Security, at dpivin@aegion.com or visit aegion.com.

NASTT also honors the finalists in each category:

AWARD FINALISTS - New Installation

Ditch Witch:
AT32 All-Terrain Direction Drill

Built to enhance utility contractors' productivity while drilling through hard rock, Ditch Witch's AT32 offers maximum performance in an innovative, compact design for increased operator efficiency and productivity on a variety of rural and urban jobsites. It is equipped with 32,000 pounds of thrust and pullback, which offers boosted power and stability for efficient nstallations through tough ground conditions. The AT32 is powered by a 155-horsepower Cummins Stage V diesel engine, which meets European emissions standards for a safer, cleaner and more environmentally friendly jobsite. ***ditchwitch.com***

Herrenknecht AG:
AVN 800 HR – MTBM

Herrenknecht's AVN 800 HR (OD 975 mm), equipped with a stronger main bearing and an adapted cutting wheel design excavates hard rock with a three times higher jacking force on the cutting wheel in comparison to the traditional AVN of the same size. This technological achievement will push the boundaries of what is possible in small-diameter microtunnelling in terms of feasible drive length in hard rock conditions. Longer drives make microtunnelling a more economic and more environmentally-friendly construction method. The number of shafts can be reduced, impact on the surface can be minimized, and the construction of larger tunnels only for access reasons can be avoided in certain projects. ***herrenknecht.com***

LaValley Industries: PITPUMP™
powered by the EMPOWER™ electric generator

PITPUMP™ is the most advanced, purpose-built mud pump ever to be introduced into the HDD industry. PITPUMP™ features a flow rate of up to 1,400 GPM pumping 14lb slurry at a viscosity of 120 with a discharge length of up to 250 feet. The specialized inlet and reversible impeller are built to handle particles up to 5 inches in diameter preventing blockages and reducing the need for frequent cleaning. PITPUMP™ is offered with LaValley Industries' purpose built Efficient Modulated Power (EMP-40) EMPOWER™ electric generator designed with a specialized system architecture to output both traditional synchronous power and specialized modulated power from a single EPA Tier 4 diesel engine. ***lavalleyindustries.com***

Primus Line:
Primus Line® Overland Piping

Primus Line® Overland Piping is a safe and reliable solution for the temporary above-ground fluid transfer including demanding and potentially hazardous media. The flexible F-Liner consists of thermoplastic polyurethane (TPU) and offers high chemical resistance that withstands highly corrosive hydrocarbon compounds. The reinforcement made of aramid fabric gives an extremely high tensile strength that allows for very high operating pressures. Its cover made of TPU offers maximum protection from UV-light and abrasion as well as flexibility for reuse. Primus Line Overland Piping is an eco-friendly solution, designed for numerous deployments with a design life of 20 years, and rapid installation. ***primusline.com***

AWARD FINALISTS - New Installation - cont'd

Subsite Electronics: Marksman™ HDD Guidance System

Subsite Electronics' Marksman™ HDD Guidance System is designed to improve tracking in high-interference areas. With the widest range of frequencies in a single beacon available on the market, the Marksman is the tracker of choice for interference mitigation/avoidance, beacon performance and ease of use. The Marksman offers improved communication between the tracker and beacon at extended depths (130-plus feet) – saving operators time and helping them stay efficient. Designed with streamlined controls the Marksman View is easy to learn, featuring intuitive graphics and clear data helping operators stay productive on the jobsite. **subsite.com**

AWARD FINALISTS - Rehabilitation

AppliedFelts: Envirocure

Envirocure is a styrene barrier coated polyester felt (or glass reinforced) tube for cured-in-place pipe (CIPP) applications when using styrene-based polyester or vinyl ester resins. Envirocure was developed to mitigate the potential of styrene emissions and odor during handling, installation and cure of resin impregnated CIPP liners. Its innovative materials and construction deliver with the quality and proven performance of liner tubes that have been manufactured by Applied Felts for over 50 years. **appliedfelts.com**

Aries Industries: Wolverine 2.0

Cut through challenging material rapidly and accurately with Aries Industries self-propelled, electric cutter, Wolverine 2.0. Its advanced controls and cutting power allow you to complete lateral reinstatements or pre-lining prep work in 6" -18 diameter pipes. Quieter than air cutters. **ariesindustries.com**

- *Designed/manufactured in the U.S. by Aries.*
- *Longest cable length (850') for an electric cutter*
- *Single cable – not bonded pair*
- *One cutter body for 6" -18" lines*
- *Full operator control of motor RPM & torque*
- *Main and rear viewing cameras*
- *Completely independent system*

Electro Scan Inc.: Electro Scan KINGFISHER

The Electro Scan KINGFISHER electrical resistance lead detection quickly identifies and prioritizes pipe replacements and rehabilitation. Using a consistently applied electric current and measuring the change of resistance as a probe passes through a pipe, the fully surcharged pipe allows the measurement of pipe materials for full-length 360-degree pipe walls. Capable of navigating multiple 90-degree bends over distances of up to 100-feet, KINGFISHER also allows entry into pipe diameters of ¾" without interruption in water services. Electro Scan KINGFISHER also provides the world's first field direct-to-homeowner notification system, using Amazon Sidewalk's a low-bandwidth long-range wireless communication protocol. **electroscan.com**

AWARD FINALISTS - Rehabilitation

HammerHead Trenchless: Bluelight LED CIPP System

The next generation Bluelight system features user-friendly enhancements and expanded capabilities making it an ideal solution for the rehabilitation of laterals and small sewer pipes 3 to 10 inches in diameter. The innovative Bluelight technology is empowering CIPP lining professionals by alleviating the time pressures of other CIPP systems and curing methods. The specially formulated single-part resin only cures under light in the "blue" wavelength, giving installers significantly longer working time between liner wet-out and curing and curing the resin almost instantly (up to 5x faster than traditional curing methods). Key features of the redesign include an intuitive touch screen interface, interchangeable reels, improved portability with lightweight and ergonomic frame, and an expansion of service with a new 3-inch light head. ***hammerheadtrenchless.com***

HK Solutions Group: Monoform PLUS

Monoform+ is a rehabilitation system that addresses aging manholes and lift stations using a two-part system that combines technology that gives the structure a full, concrete manhole with an HDPE thermoplastic membrane. This combination is trenchless and allows our team to rehabilitate the problem manholes and lift stations without disturbing the surrounding area or shutting down major roads for long periods of time. Our system using the HDPE liner provides a much longer lifespan for the structure and a problem-free solution because it also provides I&I protection enabling this to be installed in areas where high groundwater backpressure is expected or encountered. ***hksolutionsgroup.com***

Nukote Coating Systems International LLC: 360 Ringtech Robotics

360Ringtech® Robotics are equipment used for installation of Polymeric SIPP/ SAPL trenchless pipeline rehabilitation. 360Ringtech® Robotics are able to consistently apply high pressure, heated, fast set plural component polyureas, polyurethanes, and ancillaries for use as liners in the rehabilitation and new construction of liquid gathering, storage and distribution systems. 360Ringtech® Robotics flexibility allow for their use in pipe, vaults and other structures and provide a complete liner solution, regardless of the effluent type, structural integrity of the substrate, internal pressure, head pressure, soil conditions or expected ground movement. 360Ringtech® Robotics deliver a complete application process, all remotely controlled, from vault to vault or manhole to manhole. The products deliver consistent liner thicknesses, regardless of substrate type, diameters, transitions, risers or penetrations, with little disruption to traffic flow.

AWARD FINALISTS - Rehabilitation - cont'd

PipeFusion CIPP: PipeFusion Xtreme

PipeFusion XtremeTM is a 100 percent solids epoxy system recommended for applications that require extended working times. Complete curing in the host liner can be achieved in 3 hours at 200F. With the elimination of toxicity and odors of typical lining systems, PipeFusion XtremeTM is ideal for CIPP installations that are performed for municipalities in innercity, suburban, and rural locations – making it the universal product application and dual value proposition for municipalities and installation contractors alike. PipeFusion XtremeTM is designed to maximize application diversification. Ideal for Health Care, Manufacturing, Institutional, Food and Pharmaceutical, the enhanced eco-friendly characteristics and robust features of PipeFusion XtremeTM also make the product essential for Green Construction and high-quality project results. ***pipefusioncipp.com***

Waterline Renewal Technologies: LMK Technologies for UV T-Liner Shorty

The Shorty and Stubby are one-piece, structural, standalone, homogenous main-to-lateral CIPP connections that incorporate all the performance factors and benefits of our T-Liner®. The Shorty UV goes one step further by incorporating a high-strength fiberglass liner with a UV cast resin that arrives ready to install. All Shorty and Stubby products use Insignia compression sealing gaskets. The Shorty and Stubby are designed for municipalities requiring the value and quality of a watertight connection seal without the costs or legal issues associated with cleanout installations. The liner cures only when exposed to our proprietary cold LED light launcher and light train which are required to cast the liner. The system does not create excess heat and a Shorty UV liner can be cast in as quickly as 10 minutes. ***waterlinerenewal.com***

To learn more about NASTT awards, visit nastt.org/awards.


ParaTrack™
Gyro Guidance
The most accurate HDD guidance system available
+/- 0.04° azimuth
Greatest range of secondary tracking methods
Fully integrated with RivCross guidance management software
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Vylon® Pipe
The Vylon product line includes Vylon Slipliner, Vylon Direct Bury, and Vylon Riser Pipe.
• Installation in live flow eliminates the need for bypass pumping
• Fully structural PS46 pipe installed inside of the old pipe
• Snap lock coupler for easier installation
Vylon® PVC Slipliner Pipe
21” - 42” Diameters
Cost Effective and Proven Performance for Live Flow Sewer Rehabilitation
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The Most Advanced Steering Tool in the HDD Industry

Drillguide
GYRO STEERING TECHNOLOGY

Brownline's Drillguide GST is the original, standalone Gyro Steering Tool specifically designed for HDD operations used as the primary survey and reporting system. The industry leading technology consists of highly accurate components and software which provide a proven accuracy of 0.01° in pitch and 0.04° in azimuth. The Drill-guide GST provides real time, highly accurate navigational information which allows for a smoother bore trajectory and has proven to reduce drag and stress during installation.

To complement the GST, Brownline has developed a comprehensive selection of Steering Systems for a multitude of HDD projects;

For Intersecting Projects, Brownline has developed the Drillguide Radar System. As the bore paths reach the point of intersect, the RADAR Systems are activated and the two systems Actively communicate with each other to establish their relative position. Unlike the passive magnetic systems, the RADAR System has proven to be more accurate and allows HDD Intersects to be completed faster and seamlessly.

For Secondary Tracking, Brownline has developed the Drillguide GPS Tracking System. Based upon the proven RADAR System, this portable unit can be placed in any position along the bore path to confirm the location of the GST. This system has proven to be essential to tight tolerance windows along the bore trajectory and provides on target Punch-Outs.

Having been deployed on thousands of projects since 2004, the Drillguide Gyro Systems have a well-documented record for providing a safe and cost-efficient pilot hole. 4,300,000 feet drilling with over 700,000 feet of intersect drills successfully completed. Contact Brownline to discuss how we can assist with your project.

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NO-DIG SHOW 2023

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THE NASTT 2023 NO-DIG SHOW **MUNICIPAL & PUBLIC UTILITY**

Scholarship Program

The NASTT No-Dig Show Municipal & Public Utility Scholarship Award has been established to **provide education and training** for North American municipalities, government agencies and utility owners who have limited or no travel funds due to restricted budgets.

Selected applicants will be awarded **complimentary full conference registration** to the NASTT 2023 No-Dig Show in Portland, Oregon, April 30 – May 4, 2023. One day conference registrations will also be available. Registration includes **full access to all exhibits and technical paper sessions**… all you have to do is get yourself to the conference! Selected applicants will also be eligible to receive **overnight accommodations**. Selection based on responses to the application as well as need.

APPLY TODAY! Application deadline is November 1, 2022.

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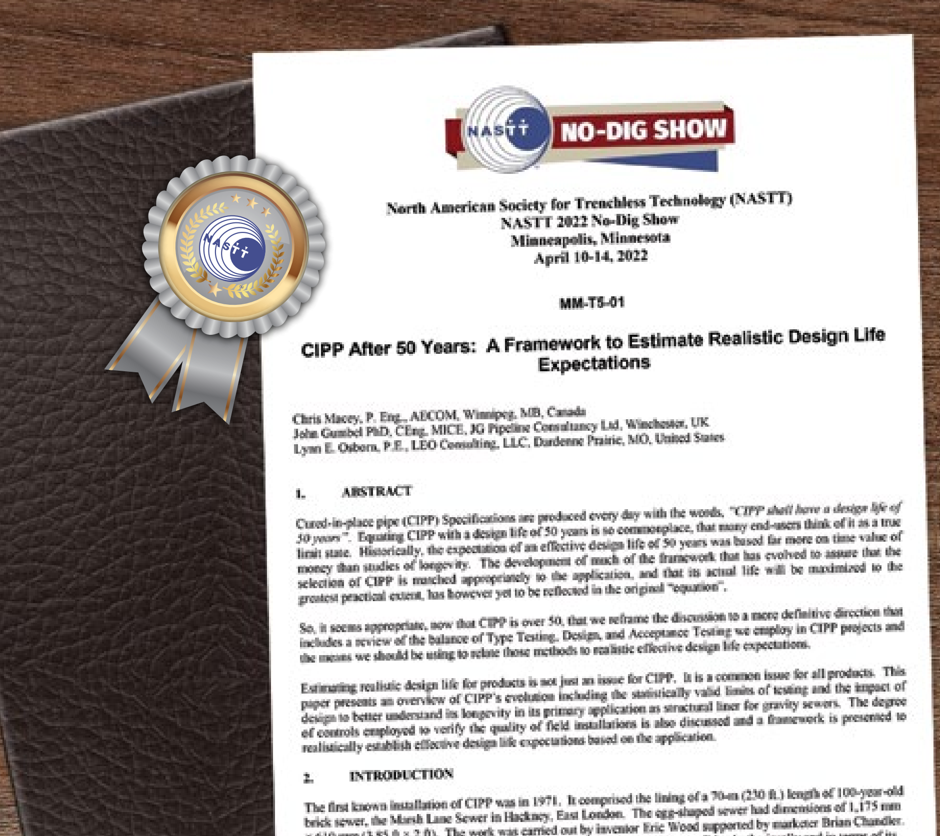
The No-Dig Show is owned by the North American Society for Trenchless Technology (NASTT), a not-for-profit educational and technical society established in 1990 to promote trenchless technology for the public benefit. For more information about NASTT, visit our website at nastt.org.



North American Society for Trenchless Technology (NASTT)
NASTT 2022 No-Dig Show
Minneapolis, Minnesota
April 10-14, 2022

MM-T5-01

CIPP After 50 Years: A Framework to Estimate Realistic Design Life Expectations

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John Gumbel PhD, CEng, MICE, JG Pipeline Consultancy Ltd, Winchester, UK
Lynn E. Osborn, P.E., LEO Consulting, LLC, Dardenne Prairie, MO, United States

1. ABSTRACT

Cured-in-place pipe (CIPP) Specifications are produced every day with the words, *"CIPP shall have a design life of 50 years"*. Equating CIPP with a design life of 50 years is so commonplace, that many end-users think of it as a true limit state. Historically, the expectation of an effective design life of 50 years was based far more on time value of money than studies of longevity. The development of much of the framework that has evolved to assure that the selection of CIPP is matched appropriately to the application, and that its actual life will be maximized to the greatest practical extent, has however yet to be reflected in the original "equation".

So, it seems appropriate, now that CIPP is over 50, that we reframe the discussion to a more definitive direction that includes a review of the balance of Type Testing, Design, and Acceptance Testing we employ in CIPP projects and the means we should be using to relate those methods to realistic effective design life expectations.

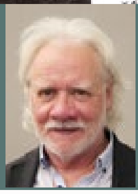
Estimating realistic design life for products is not just an issue for CIPP. It is a common issue for all products. This paper presents an overview of CIPP's evolution including the statistically valid limits of testing and the impact of design to better understand its longevity in its primary application as structural liner for gravity sewers. The degree of controls employed to verify the quality of field installations is also discussed and a framework is presented to realistically establish effective design life expectations based on the application.

2. INTRODUCTION

The first known installation of CIPP was in 1971. It comprised the lining of a 70-m (230 ft.) length of 100-year-old brick sewer, the Marsh Lane Sewer in Hackney, East London. The egg-shaped sewer had dimensions of 1,175 mm

CIPP AFTER 50 YEARS: A FRAMEWORK TO ESTIMATE REALISTIC DESIGN LIFE EXPECTATIONS

AUTHORS



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This paper was one of the best-rated sessions at the 2022 NASTT No-Dig Show in Minneapolis. NASTT No-Dig Papers are available for download, free to members, at www.nastt.org

Estimating realistic design life for products is not just an issue for CIPP. It is a common issue for all products. This paper presents an overview of CIPP's evolution including the statistically valid limits of testing and the impact of design to better understand its longevity in its primary application as structural liner for gravity sewers. The degree of controls employed to verify the quality of field installations is also discussed and a framework is presented to realistically establish effective design life expectations based on the application.

CIPP after 50 Years: A Framework to Estimate Realistic Design Life Expectations

2. INTRODUCTION

The first known installation of CIPP was in 1971. It comprised the lining of a 70-m (230 foot) length of 100-year-old brick sewer, the Marsh Lane Sewer in Hackney, East London. The egg-shaped sewer had dimensions of 1,175 mm × 610 mm (3.85 × 2 feet). The work was carried out by inventor Eric Wood supported by marketer Brian Chandler. The sewer remains in service to this day and the liner is still in excellent condition both visually and in terms of its mechanical properties which were verified after 20 and 30 years of service.

The development of CIPP after its invention spread across the globe. The first UK Patent was granted on August 21, 1970. After four years of testing in Great Britain, the first Insituform® licenses were granted to British contractors to rehabilitate sewers. In 1976, licenses were granted to European and Australian contractors. At about the same time Insituform® came to North America with the first North American installation in Fresno, CA in 1976. The first US patent was granted in 1977.

The first installation pre-dated the development of standard design procedures by over a decade. Initially all liners were routinely sized as 6 mm thick liners with no consideration of applied load. Mapping out design procedures for a product well behind invention of a product is not uncommon with new technologies to this day. Formal design processes were first published by the UK Water Research Centre (WRc) in their pioneering Sewer Rehabilitation Manual (SRM) in 1983, largely as a result of empirical testing carried out by Aggarwal and Cooper (1984). That landmark work provided some of the initial critical understanding of the forces and structural failure modes associated with close-fit lining technology. While we have learned much since that time, the original design research, though conceptually simple, has served the industry well in terms of understanding the degree to which a structurally deteriorated and leaking host sewer pipe can both be stabilized by a relatively low stiffness flexible liner, and at the same time provide geometric restraint to the liner that substantially enhances its buckling resistance.

Figure 1: Sampling of the Original Installation of CIPP

While the chemical resistance of composites like CIPP was reasonably well understood there were no protocols in place to assess longevity in the early 1980s. The first estimates that the product should last 50 years or more were based on sound engineering judgement at the time, not time-dependent testing to derive long term material properties or the influence of exposure environment which the liners would commonly be subjected to.

Initial discussions of a 50 year design life in North America were likewise not based on consideration of material limit states, but rather driven by time-value of money computations. CIPP was typically used in urban settings where municipal bonds were commonly financed over a planning cycle of 50 years. So, the question at the time was "will it last 50 years?". The answer based on sound engineering judgement, was a resounding "of course". Over the 1980s into the 1990s this rationale gradually found expression in industry specifications as the mantra that "CIPP shall be designed to last a minimum of 50 years". And while good engineering judgement suggested that it would, testing to verify CIPP longevity, and the means to make it last, began in earnest only once we began to gain a better understanding of the actual forces imposed on the liner, the environment to which it would be exposed, and the time-dependent ramifications of the same.

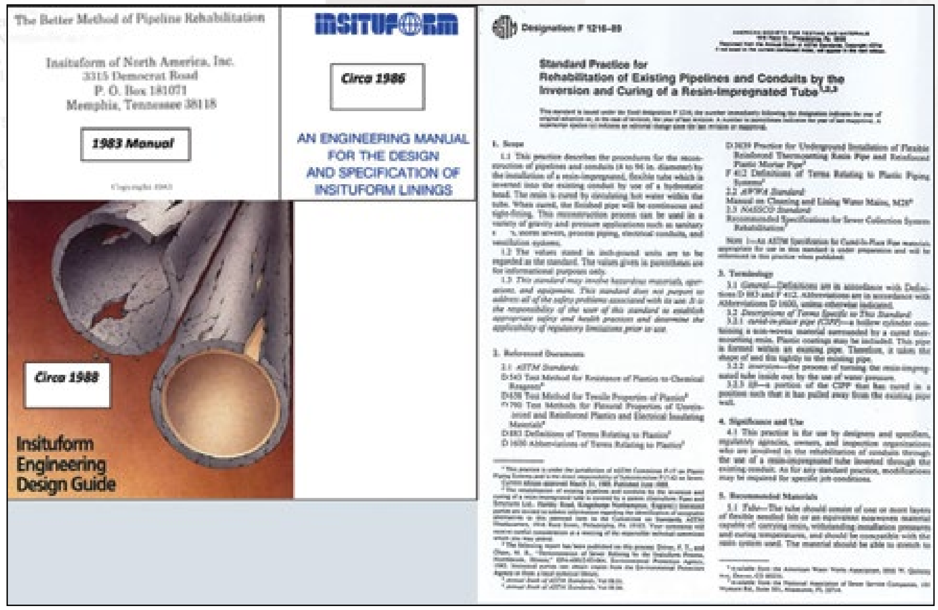

Figure 2: Insituform 1980s Design Manuals Leading to ASTM F1216-89

3. EARLY TIME DEPENDENT STUDIES

Based on the work of Aggarwal and Cooper, Insituform had developed some of the first empirically derived design formulae to examine the short and long-term performance of the "new" close-fit lining class. Initially a modified Timoshenko buckling model was used to estimate the primary failure mode of circular CIPP subject to a sustained external head of groundwater. This evolved over the 1980s from Insituform Design Manuals (1983, 1986, and 1988) to the eventual adoption in North America of ASTM F1216, which documented the first accepted design practice in its Appendix X1 (Figure 2). As plastics were known to be subject to creep, the original design processes indicated the need to account for long-term as well as short-term material behavior.

CIPP after 50 Years: A Framework to Estimate Realistic Design Life Expectations

The Aggarwal and Cooper buckling models were used in North America to carry out one of the most comprehensive early studies by the U.S. Army Corps of Engineers and Trenchless Technology Center in 1994 (Guice et al 1994). It was the first practical North American study that examined creep effects associated with continuous application of load to both close-fit CIPP and thermoplastic liners.

The liner pipes were encased in circular steel pipes, with hydrostatic pressure applied in the annulus between the two. In contrast to the Aggarwal and Cooper tests, the liners were installed directly into their casing pipes so that any initial annular gap reflected the characteristics of each lining system tested. To measure long-term performance, each test remained under constant pressure for up to 10,000 hours or until failure, whichever occurred first. The test results were plotted and extrapolated beyond the test period to estimate behavior up to 50 years. Was the test limited to extrapolation of results to 50 years? No, but the test results were deliberately analyzed in that manner to verify vendor claims that indeed it would last 50 years. While much has transpired since the 1994 TTC testing, including the development of more accurate design models for close-fit liners, the transition beyond the "time-value-of-money" design life model to a more quantitative approach has not really been mapped out. Because the test method developed by TTC in 1994 was difficult and expensive to run, later in the 1990s the flexural creep test in accordance with ASTM D2990 began to gain traction. Of some concern was that the creep modulus, typically projected to 50 years in the D2990 test, is not the Young's flexural modulus used in CIPP design equations. This observation was correct, but as explained further below need not be a cause of concern once understood that "creep modulus" is just a way of expressing the effect of time-dependent deformation under load and is not indicative of any reduction of instantaneous stiffness in the long-term. So how do we move from qualitative methods in estimating useful design life to a more quantitative approach? When should we and how do we move beyond the 50 year bar that has been so firmly implanted in so many engineers' brains? We can initially do this by establishing a very logical framework and proper application of existing design, testing, and statistical techniques. In the end, the process should also include a "sufficient dose" of good engineering judgement, however, it needs to be firmly founded in good science.

4. FRAMEWORK TO ESTIMATE USEFUL DESIGN LIFE

An initial framework is presented conceptually in Figure 3. It comprises 5 distinct steps, each potentially the responsibility of a different entity, but collectively contributing to the quality and ultimate longevity of the installed liner. The steps of the overall process are as follows:

1) **Functional design** to identify the range of structural and environmental demands on the liner for its intended application – provided by a sector-

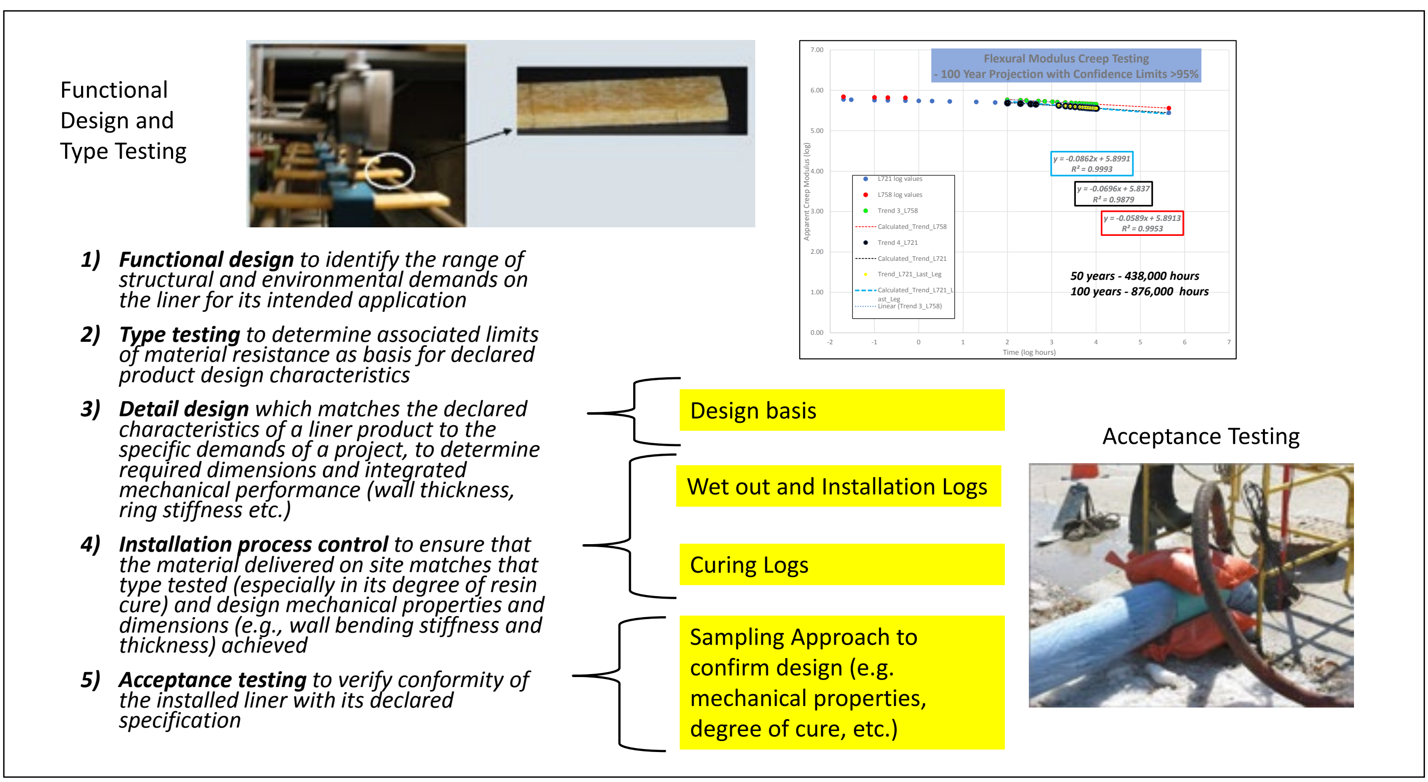

Figure 3: Key Steps In Verifying CIPP Useful Design Life

specific industry design code that accurately predicts ultimate limit states;

2) **Type testing** to determine associated limits of material resistance as basis for declared product design characteristics – performed by or on behalf the product designer/ manufacturer;

3) **Detail design** which matches the declared characteristics of a liner product to the specific demands of a project, to determine required dimensions and integrated mechanical performance (wall thickness, ring stiffness, etc.) – can be undertaken by any party (installer, manufacturer, specialist consultant or the client) but optimally always subject to independent checks;

4) **Installation process control** to ensure that the material delivered on site matches that type tested (especially in its degree of resin cure) and design mechanical properties and dimensions (e.g. wall bending stiffness and thickness) achieved – joint responsibility of system designer and installer.

5) **Acceptance testing** to verify conformity of the installed liner with its declared specification – done by or on behalf of the client.

The following sections review each of these steps in more detail for the most common application of CIPP for the structural renovation of gravity sewers and drains. Although similar principles apply to the much less common but growing use of CIPP for renovation of pressurized sewers and water mains, these more demanding and hitherto less well researched and documented applications are not considered in this paper.

5. FUNCTIONAL DESIGN AND APPLICATION-RELATED LIMIT STATES

Reasoned prediction of the design life of a CIPP liner starts with correct identification of ways in which it may ultimately fail in service. These limit states may be associated with structural or environmental demand, or more generally a combination of the two.

The structural demands on a flexible, close-fitting gravity sewer liner are reflected in the various leading national design standards, of which the most up-to-date are the French (ASTEE 3R 2014), German (DWA-A 143-2, 2015) and the recent ASCE MOP 145 (2021), which draws largely on the French approach, now available in North America. All of these, as well as the imminent next (7th) edition of the WRc SRM in the UK, identify buckling and/or overstressing of the liner in response to a sustained external head of groundwater as the most commonly critical limit state, and have converged on application of the well validated 'modified Glock' theory to account for the restraint provided by the host pipe, replacing the simpler 'modified Timoshenko' model of ASTM F1216 Appendix X1. Significantly the updated design theory, unlike the ASTM, extends to non-circular as well as circular shapes, and takes explicit account of annular gap and other shape imperfections in addition to the ovality considered by F1216. It also indicates that long-term flexural stress, not just buckling, can limit the performance of circular liners in some circumstances, and that many non-circular shapes are susceptible to buckling, not just overstressing – see for example Thépot (2000) or Boot et al (2014).

Where current structural design methods still diverge somewhat is in the treatment of the impact of external earth load and traffic surcharge, in the event that the host pipe continues to deteriorate after lining. The liner limit state of soil-supported buckling postulated by the so-called "Fully Deteriorated" equation X1.3 of ASTM F1216, which completely neglects the presence of a host pipe, is however a demonstrable fiction. In over 50 years and many thousands of kilometers of successful field applications of CIPP, not a single case of such buckling failure of a flexible liner has, to the knowledge of the authors, ever been observed or reported. Instead, experimental research has shown that the actual demand on a liner if a deteriorating host pipe loses both its flexural and compressive ring stiffness in due course, and/or where unfilled erosion voids in the soil surround eventually collapse, is an imposed post-lining ring deflection. The potentially critical ultimate limit state of the liner arising from such post-lining deformation is that of long-term overstraining of the material, which is typically made worse by interaction of the liner with broken pieces of the host pipe – see e.g. Gumbel (1998), Law & Moore (2003, 2007), Gumbel et al (2003), Spasojevic et al (2007).

Regarding environment, all sewers and drains are by their nature wet, and in the case of septicity, municipal sewers can expose a liner to high concentrations of sulfuric acid (pH ‹ 1). Compared with traditional pipe materials (especially concrete and iron) CIPP resins are particularly resistant to chemical attack under such conditions, but the phenomena of stress and strain corrosion nevertheless need to be considered, especially for glass-reinforced liners. Given the high cost of any long-term testing of mechanical characteristics, it makes sense to test all CIPP products in the typical worst-case environment for municipal sewer or storm drain applications, which is at very least wet, and not infrequently highly acidic.

For industrial sewer applications, there may be additional purely environmental demands on a liner from chemically aggressive or abrasive effluents, but these can generally be addressed by selection of suitably resistant and durable resin systems and/or reinforcing fibers, tested by direct exposure to the environment concerned.

6. TYPE TESTING TO CHARACTERISE CIPP MECHANICAL PROPERTIES FOR DESIGN

Type Testing, by definition, is carried out on products to aid in their assessment as being "fit-for-purpose". Fitness- for-purpose in this type of application involves meeting long term design objectives, so the testing must include short- and long-term testing and statistical analysis to confirm the extent to which continued application of load under various exposure conditions can reasonably be predicted. A full range of such tests is specified in ISO 11296- 4:2018 *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 4: Lining with cured-in-place pipes*, with considerations such as size grouping, and the extent of retesting required when there is a change of a material (e.g. resin system), product design (e.g. modification of wall structure) or extension of the product range set out in an accompanying Technical Specification ISO/TS 23818-2:2021 *Assessment of conformity of plastics piping systems for the rehabilitation of existing pipelines — Part 2: Resin-fibre composite (RFC) material.*

An important feature of these international standards is their prescription that samples for the majority of type tests are taken at the "I" stage, defined as "stage as installed" (i.e. in final configuration after any site processing of components associated with the particular renovation technique). This means that CIPP samples must be acquired from actual or simulated (e.g. above ground) installations which have been subject to the full installation process, and not from specially prepared lab plates, for example.

Type testing also serves as basis for deriving *characteristic values* of liner mechanical properties for design. For non-pressure applications of CIPP this generally involves short and long-term testing for:

a) Ring stiffness and associated creep factor from parallel plate tests subject to constant load; and/or
b) Constant load 3-point bend tests to determine apparent flexural modulus of elasticity versus time in the circumferential (hoop) direction, at a representative working stress level causing secondary creep deformation but not failure;
c) Similar constant load 3-point bend tests over a range of higher stress levels producing flexural creep rupture with time: the resulting relationship of applied stress and time-to-failure allows extrapolation to a projected flexural strength at 50 years or other desired design life objective (stress corrosion test);
d) Constant deflection ring tests in a representative chemical environment that similarly allow extrapolation to a projected long-term failure strain by regression of deflection versus time-to-failure data (strain corrosion test);
e) Short-term tensile strength and elongation in the longitudinal direction

With the exception of item c) all the above tests are the subject of ASTM standards more or less equivalent to those referenced by ISO and already routinely implemented in North America, but for the purposes of predicting design life of CIPP more important than the detail of test procedures is an understanding of the terms highlighted in italics above.
The term "characteristic value", defined in the context of limit state or Load and Resistance Factor Design (LRFD), indicates a value of a parameter derived by statistical reduction of test results, typically as a 90 percent lower

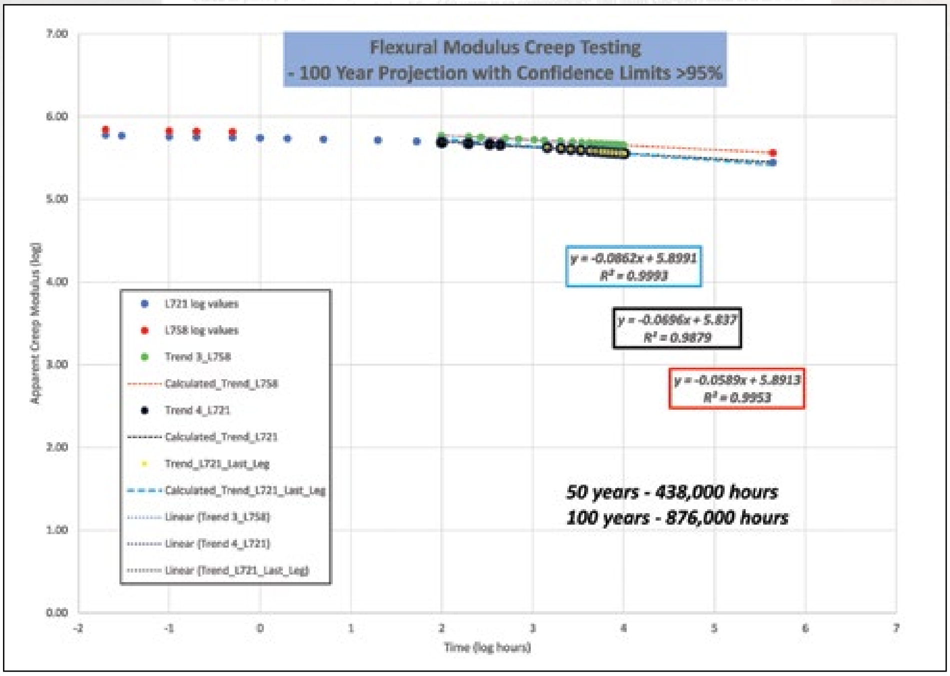

Figure 4: Flexural Modulus Creep Testing

confidence limit (LCL) or 5 percent fractile value, to which a further partial safety factor is applied for input to structural calculations. In practice for CIPP there are usually only sufficient data to derive meaningful LCL values from short-term tests, and in applying the output of long-term tests the values of properties extrapolated to 50 years or beyond are commonly expressed simply as a mean reduction factor applied to the characteristic short-term value. The justification for this is discussed further below.

The creep stiffness tests of a) and b), whether performed on complete pipe rings or flexural coupons, simply provide a measure of long-term deformation of the test piece under constant load. In the case of a ring (parallel plate) test the *creep factor* α at time x is defined simply as the initial vertical ring deflection (generally set at 3 percent of the pipe diameter) divided by the deflection at time x. Running the tests for a standard 10,000 hours produces a plot of deflection vs time which allows extrapolation of creep factor to a design life of 50 years or beyond.

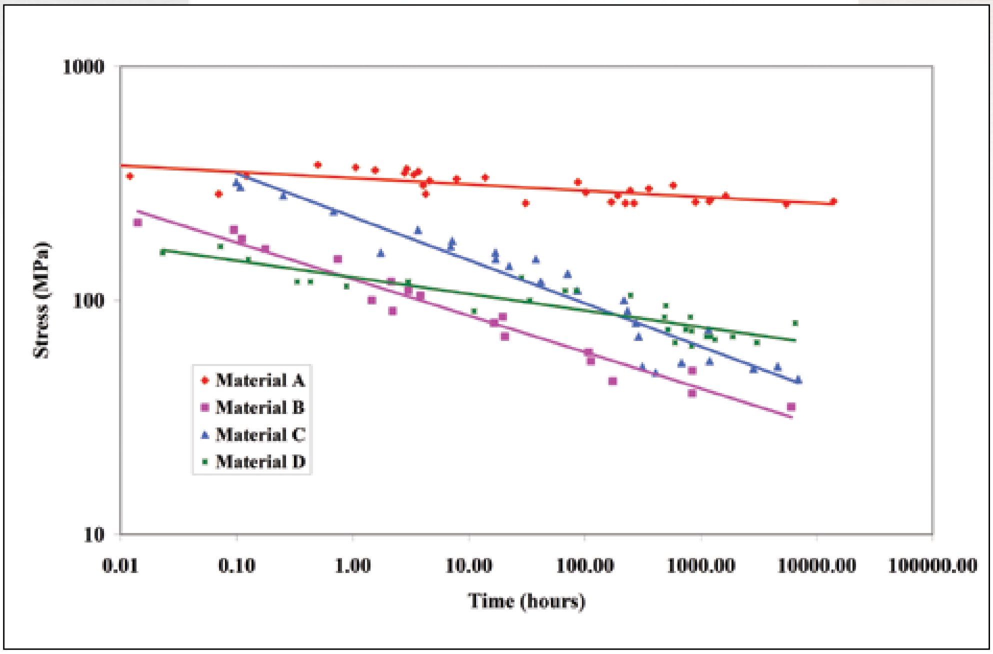

Figure 5: Flexural Strength Reduction over Time (Gumbel & Lowe - 2015)

In the reduction of the output of long-term 3-point bend tests, the creep deformation of the test piece under constant load is again the primary measure of performance, but expressed in this case as an *apparent* long-term flexural modulus *Ex*, sometimes referred to as creep modulus, defined as the applied stress divided by the measured or extrapolated strain at time x. This should not be confused with Young's modulus E_0 of the material, measured in a short-term flexural test, which does not change with time, or if anything has been found to increase slightly over the years due to aging of the CIPP composite (Sterling et al, 2012; Macey et al 2016). It is nevertheless valid and safe to use this apparent long-term or creep modulus in design calculations of the limit state of restrained hydrostatic buckling, because the mechanism of such buckling is indeed governed by the accumulation of deformation of the liner over time under the action of a sustained external head of ground water.

In circular liners, the most critical time dependent property to understand is almost invariably the apparent flexural modulus or stiffness of the material. While the design projection that is commonly sought is the 50-year modulus, the vast majority of resins that are common in use in CIPP have statistically valid creep retention characteristics to at least one log decade beyond that or a design horizon of 114 years of more. As long as core data for secondary creep is statistically valid, the projections to a 100 year design horizon as opposed to a 50 year horizon are readily achievable as noted in Figure 4.

Non-circular liners by contrast can fail over time due to excessive bending stress in large radius or flat wall sectors subject to sustained external groundwater pressure. The latest design theories also show that, depending on precise profile geometry and annular gap, buckling can in fact remain critical. Therefore, it is necessary in general to characterize the liner material for non-circular applications by its long-term flexural strength in addition to its flexural stiffness.

A major mistake still commonly made, however, is to apply the *creep factor* α_x or E_x/E_0 obtained from a test for creep deformation to a short-term characteristic flexural strength in order to predict a safe limit for long-term flexural stress. The physical mechanism of flexural *creep rupture* (tertiary creep) is completely different, involving the initiation and propagation of a fracture in the CIPP composite that eventually leads to runaway failure with time under load. This contrasts with the viscoelastic/viscoplastic deformation of secondary creep at working stress levels of which the rate decreases exponentially with time under load.

Fortunately, a default flexural strength reduction factor of 0.5 applied historically has turned out to be safe, at least for the original CIPP liners based on synthetic fibres. We know this as a detailed test for long-term strength, described by Gumbel and Lowe (2015) and since adopted as Annex D to ISO 11296-4:2018, is now available. The mistake of confusing long-term strength and stiffness factors has however become more concerning with the more recent development of highly glass-reinforced liners that exhibit relatively high retentions of ring stiffness in creep deformation tests (up to 0.75 at 50 years). As demonstrated by Gumbel and Lowe (2015) by reference to tests on factory GRP pipe, 50-year strength reduction factors can in practice vary markedly from anywhere between 0.1 and 0.7, with no prior clue given by short-term strength performance – see Figure 5. There is therefore no substitute for product specific testing for safe and reliable application of such highly reinforced CIPP to non-circular shapes in particular. Provided this is done, there is again no obstacle in principle to extrapolating test data to provide a design value of flexural strength at 100 rather than 50 years, especially if as recommended, testing is done in the worst case sewer environment of 0.5 mol/l sulfuric acid, rendering test c) into a stress corrosion test.

It is, however, acknowledged that assessing changes in flexural strength over time is far more onerous than assessing changes in apparent flexural stiffness, which may explain why few North America CIPP have so far been evaluated in this manner.

Unlike long-term flexural stiffness which can be determined by extrapolation from constant load creep tests on 3- point bend specimens or complete pipe rings (as noted above), where each individual test yields a value of the targeted design parameter; the determination of long-term flexural strength requires regression of time-to-failure data from larger data sets and testing samples to failure as opposed to single sample tests. A minimum of 18 tests of between 0.1 hour and 10,000 hours duration are required to assess flexural rupture in a time-dependent manner. To achieve a distribution of the failure data over time that will pass statistical tests for suitability for extrapolation to a 50-year design value of strength, it is generally necessary in practice to run tests (including short-term tests) on between 25 to 30 individual specimens cut from a single sample. Projection to longer time frames can require larger sampling sets.

Testing for *strain corrosion* (item d) in list above) is similarly onerous if applied correctly to predict a safe long term flexural strain, as invoked by the latest methods of design for liner resistance to the effects of earth and traffic loading. A simple pass-fail test at a set level of ring deformation is not sufficient. A pretext commonly used hitherto for avoiding such testing is that neither the polyester fibres used in synthetic felt CIPP nor specially designated corrosion-resistant (ECR) glass fibres are susceptible to the strain corrosion phenomenon, but this has never been fully proven, and regardless of any corrosion effect a time-to-failure regression requiring tests on multiple samples remains the only sure way to predict a safe long-term strain limit for design cases involving imposed deformation rather than load.

Finally, although for gravity liners response of the liner pipe cross-section in the circumferential (hoop) direction is almost invariably critical, longitudinal stresses arising from thermal effects including in particular shrinkage during initial cool-down of CIPP from its peak resin curing temperature, should not be overlooked. For this reason, the ISO standard also includes tests e) for longitudinal tensile strength and elongation. Any longitudinal stresses developed between the typically locked ends of the liner will however tend to relax out with time, so in this case short-term testing suffices to enable assessment of the risk of possible circumferential cracking.

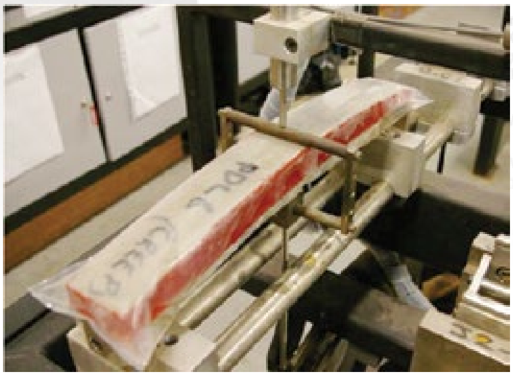

Figure 6: Wet Creep tests under load (Gumbel 2009)

Gumbel (2009) and Gumbel and Lowe (2015) explored a variety of innovative test regimens that achieved a broad number of objectives to assist in establishing longer term design life objectives (see Figure 6). This included:

- Modifying the traditional 3-point bending tests to utilize curved samples as opposed to flat testing samples. This better matched actual field samples and allowed for direct testing in the hoop direction which was critical for anisotropic materials such as most reinforced CIPP products.
- Examining a broader array of stress levels to assess the changes in both strength and stiffness over time, and
- Carrying out "wet" creep tests to examine creep behavior in an environment more consistent with a true sewer exposure environment. While this didn't preclude the need for independent chemical resistance testing, it greatly enhanced our understanding of long term behavior in the most common of exposure conditions and it complemented data generated by strain corrosion testing in reinforced composite materials.

As already commented, the results of all this work were incorporated into ISO 11296-4:2018 for CIPP gravity sewer liners which is, therefore, particularly recommended to North American users.

Again, how do we move to 100 year design life aspirations as opposed to limiting our window to 50 year applications? We make sure that that data sets are large enough that the extrapolation of data is valid to the 100 year level with significant confidence limits. From past reviews of time dependent testing carried out in the manner noted above, this is readily achievable.

7. INSTALLATION PROCESS CONTROL

Key to CIPP achieving its projected design life is that when installed on site in the typically variable and somewhat unpredictable environment of a deteriorated sewer, it achieves both the geometric (e.g. thickness, maximum annular gap) and mechanical characteristics assumed in its design.

Recognizing that installation process parameters differ for each individual CIPP lining system and may be proprietary, the ISO standard requires only that each system supplier should furnish the installer with a detailed Installation Manual which should be followed on each and every site and be capable of audit. This is not an uncommon practice in North America, however, not a mandatory requirement under most Standards.

Of paramount importance is that the degree of cure of the resin achieved should be no less than that of the samples used for type testing from which the declared design characteristics of the product were derived. This is because long-term characteristics, especially flexural modulus, are more sensitive to any undercure than the short-term characteristics used for routine acceptance testing, and also more difficult to verify independently. Further with certain processes, (e.g. UV-curing) it is difficult or impossible to make good any failure to achieve full cure on the first pass.

While successful installation to the required specification is always the contractor's responsibility, it should anyway be part of an ISO 9001 compliant QA plan that such an Installation Manual should exist and that comprehensive logs are kept of the liner insertion and curing processes. It is also reasonable that customers of CIPP should require that such documented procedures exist and are followed in accordance with ISO 11296-4 or equivalent standard.

8. VERIFICATION THROUGH FIELD TESTING AT THE INSTALLED ("I") STAGE

The process of verification or acceptance testing is critical to ensure that the precise site-specific designs and actual installations are commensurate with the Type Testing and time dependent behavior that the designs were based on.

Quality assurance need not be re-invented to achieve longer design life objectives, it just needs to be carried out in accordance with recognized Best Practices. While much has improved on the testing front, the core NASTT Good Practice Guidelines include:

- Design for each and every site. While standardized design sections can be used, the process needs to include verification that site specific designs are appropriate on a site-by site basis. Further, design needs to reflect appropriate design theory for circular and non-circular pipe so the basis of design properly reflects the Type Testing that has been carried out to verify long term exposure to the loads and exposure conditions that will govern design life.
- Timely use of CCTV inspection (for simplicity, we'll reference these as V1 through V4 as noted below) during the QA process to:

- o Confirm pipe preparatory works (V1)
- o Confirm that the pipe is ready for relining and that the site specific design is still adequate (V2),
- o Confirm that the installed liner visually met visual classification standards of design intent (V3), and
- o Confirm that that the liners are initially responding to time dependent effects by carrying out inspections on a representative proportion of installed liners prior to completion of the Standard Contract Warranty Period (V4, typically about 1 year after install)

- Site-by-site sampling and testing to confirm that the mechanical properties meet design objectives (see Figure 7) and that the testing methods are representative of the installed product.
- Design reconciliations in instances where one or more parameters are at variance with design values to confirm that the overall product still fully meets overall design objectives for site specific conditions

The new and highly detailed Assessment of Conformity specification ISO/TS 23818-2:2021 goes further in setting out this process, by prescribing for example:

- The minimum number of individual CIPP units (i.e. separately installed liners) installed by the same contractor as part of a single contract in the same area and under demonstrably similar conditions that need to be sampled and tested, as a function of the total number of installations;
- The increase in such sampling frequency required in the event of a detected non-conformity;
- A detailed methodology for statistically validated reduced long-term testing (RLTT), primarily for use for any repeat type testing required where there have been changes to a CIPP product's material or design etc., but also suitable as basis for verifying creep performance in say a 1000 hour test of any installed liner that has failed in field QC testing to fully meet its short-term stiffness specification.

The ISO committee responsible continues to explore improved and quicker ways of verifying degree of cure of liners in the field, and, as well, to consider a mandatory link between declared short term properties used as basis for acceptance testing and their statistically derived characteristic values obtained for the material used for long-term type testing. At present CIPP system suppliers and installers are at liberty to declare deliberately low design values of short-term flexural stiffness to improve their chances of achieving conformity in field QC tests, even if this requires slightly increased design thicknesses. If, however, these values are significantly lower than actual type test values and only just met it cannot be assumed that the creep factors obtained from type testing will still apply. By contrast if a higher bar, consistent with a 90 percent LCL value from actual test data, is set for the short-term modulus to be verified in the field, the application of a mean extrapolated 50 or 100-year creep factor to this value to derive a design value of apparent long-term modulus is justifiable.

Hitherto these continuous improvements to the EN ISO standards for CIPP in support of ever greater longevity and sustainability have been driven entirely by experts based in Europe, but a representative from Canada has recently joined the relevant working group, and further inputs from the wealth of CIPP installation experience in North America would be both greatly valued and helpful.

9. CONCLUSIONS

CIPP Specifications are produced every day with the words, "*CIPP shall have a design life of 50 years*". While the original premise of CIPP having a design life of at least 50 years was based on good engineering judgement, just saying so won't make it last 50 years or any other desired timeline.

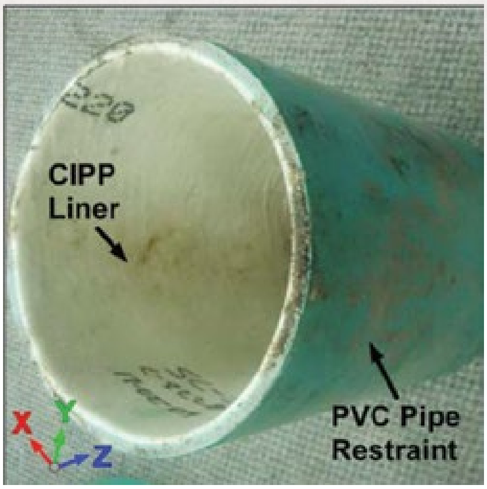

Figure 7: Typical Restrained Sample for Testing (courtesy Paragon Industries)

CIPP has now been in service for over 50 years. To reasonably ensure it lasts for 50 years, 100 years or longer requires the establishment of a framework to do so. The evolution of design and short and long term testing over the life of CIPP has readily enabled us to develop such a framework. Making that target 100 years or more is not overly complex. The same fundamental time dependent tests that we use to establish confidence in a 50 year design life expectation are often statistically valid to periods of 100 years or more. We just need to do the proper engineering up front to understand the applied loads and exposure conditions associated with the installations we are carrying out with CIPP and match the Type Testing and verification processes during installation to match.

CIPP has already celebrated its 50th birthday. If the original installations followed recognized best practices, it is likely that many, many of them will still be in service when they reach their 100th birthday. If the framework described herein is followed to establish desired design life windows of 100 years or more, they will be around for at 100 years or more; by design.

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NASTT Events Calendar

Since its inception in 1991, NASTT's No-Dig Show has been the premier North American conference and trade show for the trenchless technology industry. Thousands of professionals from around the globe attend to learn new methods and systems that will save money and improve infrastructure. This conference provides attendees an opportunity to learn trenchless methods, network with peers and gain knowledge from vendors during exhibit hall hours. NASTT's No-Dig Show is the ideal event for municipalities, contractors and engineers.

Upcoming Conferences, Courses & Events

August 4
Municipal Sewer Grouting Good Practices Course
Virtual

August 10
New Installation Methods
Free Webinar, presented by Michels Corporation

August 24-25
New Installation Methods Good Practices Course
Virtual

October 17-19
No-Dig North 2022
Toronto, ON

October 19
Trenchless Elevated 2022
West Valley City, UT

October 26-27
CIPP Good Practices Course
Virtual

November 16-17
HDD Good Practices Course
Virtual

November 30
Trenchless Technology International Seminar
Santa Fe, Mexico

December 14-15
Pipe Bursting Good Practices Course
Virtual

April 30 - May 4, 2023
NASTT 2023 No-Dig Show
Portland, Oregon

April 15-17, 2024
NASTT 2024 No-Dig Show
Providence, Rhode Island

March 30 – April 3, 2025
NASTT 2025 No-Dig Show
Denver, Colorado

April 30–May 4, 2023
Oregon Convention Center
Portland, Oregon

April 15-17, 2024
Rhode Island Convention Center
Providence, Rhode Island

March 30 - April 3, 2025
Colorado Convention Center
Denver, Colorado

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Introducing **EnviroCure®**

Let the Liner Do the Work.

Your answer to CIPP styrene emissions

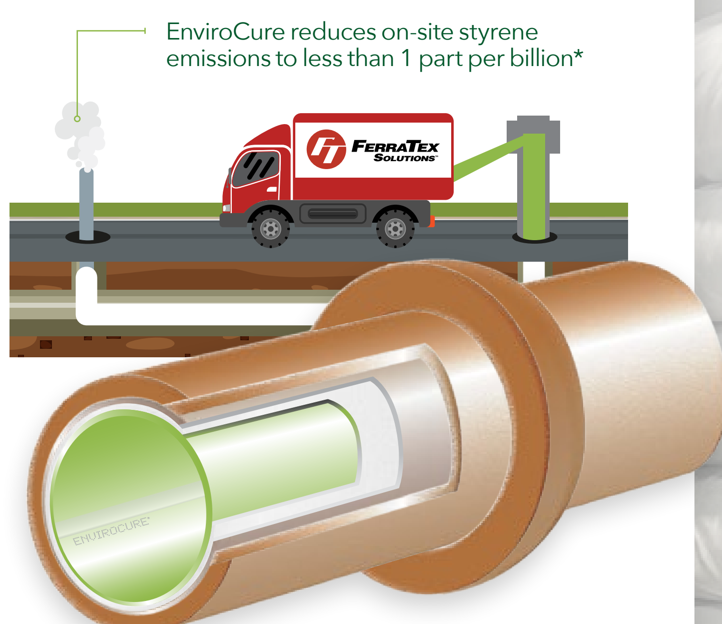
The Global Leader in CIPP Liners Introduces Groundbreaking Benefits to the Mainline CIPP Industry. Applied Felts' proprietary multi-layer felt liner coated with a styrene barrier, vastly reduces if not eliminates styrene odors and emissions on the jobsite before, during and after your installations – taking away the significant cost and unpredictability of styrene-free resin systems.

Advancing the CIPP Industry Since the 1970s. From traditional all-felt and fiberglass reinforced AquaCure® to today's EnviroCure® liners, Applied Felts' culture of listening, innovating and growing to supply customers' needs is still in full force.

It's even easier with FerraTex!
Streamline the job with pre-impregnated liners from our regional wet-out facilities at FerraTex Solutions.
Ferratex.com | 844.433.7728

EnviroCure®

A heat-cured, STYRENE IMPERMEABLE polymer coating that eliminates styrene emissions and odor.



*IUPUI Test, Oct. 2021

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