Presented by:
NASSCO

In Partnership with:
Jon S. Schladweiler
AZ Water Association

In Cooperation with:
Underground Construction Magazine
ASCE Trenchless Installation of Pipelines and Pipeline Infrastructure Systems Technical Committee
Water Environment Federation, Collection System Committee
The RehabZone, exclusive to UCT and now in its 18th year, is the original hands-on, interactive educational experience for the sewer and water industry and continues to be an overwhelming favorite among UCT attendees. Commonly called “The ‘Zone”, this exhibit includes exciting live demonstrations and is located in the UCT exhibit hall. Complete with a museum-quality, historical display of infrastructure from yesteryear, this dedicated interactive “arena” enables attendees to learn and experience the latest in trenchless technologies. The products and technologies available for sewer collection system rehabilitation and replacement have come a long way over the last 200+ years, and the RehabZone is one place to see it all.

The ‘Zone will take the educational missions of UCT and NASSCO to the next level with the addition of new technologies, live demonstrations, skill challenges, emerging technologies and a variety of products available for the pipeline rehabilitation industry.

The RehabZone remains the only industry event of its kind with nearly 10,000-square-feet on the UCT exhibit floor featuring exhibits that provide general information about water and sewer rehabilitation technologies. Its sole goal is to educate attendees, in an objective manner, about the growing need for rehabilitating the world’s underground utility infrastructure and provide information about the various innovative technologies available to accomplish that job. One of the key elements that sets the Zone apart from other similar exhibit events is that it is strictly a “no-sell” zone. This allows attendees to tour the Zone at their leisure, seeking information about particular technologies or even applications specific to their needs. If an attendee requests more information on specific technologies, RehabZone staffers can direct them to technology vendors in the main UCT exhibit hall.

The RehabZone is presented by NASSCO in partnership with Jon S. Schladweiler and the Arizona Water Association and in cooperation with the ASCE Trenchless Installation of Pipelines and Pipeline Infrastructure Systems Technical Committee, Water Environment Federation Collections System Committee and Underground Construction Magazine. It is funded by contributions from private, sponsoring organizations and participating companies.

What's featured in The RehabZone for 2019

Back by popular demand is the safety section and the Cutter Challenge, a highly competitive test of skills. There will be an area set aside in the Zone for lateral reconnection cutting with a few different cutter systems available. During the competition attendees will be able to compete against each other and quality for a prize, and it's free to participate! Prizes will be given for the fastest time using each cutter system.

In many cases, the displays in the Zone will be interactive with the audience. Hands-on demonstrations, combined with the technical displays, will bring an educational opportunity to attendees that will be more in-line with real world trenchless applications and solutions. Emphasis will again be on water and wastewater including lining and replacement pipe technologies, as well as additional emphasis on water technologies and manhole rehabilitation techniques. In addition to the many featured trenchless technologies, NASSCO's popular Sewer History Exhibit will be displayed. It presents a history of underground infrastructure and includes displays of pipes, tools and equipment of past eras in the industry with new artifacts added annually.

The RehabZone is planned, staffed and set-up by a variety of industry volunteers, including NASSCO staff, members, consulting engineers, municipal representatives, manufacturers, contractors and other industry professionals.
# 2019 REHABZONE COMMITTEE

**Chairperson**
Andy Rothenberg, Primeline Products, Inc.

**Vice Chairperson**
Jake Saltzman, Picote Solutions

## Industry Team
- **Chairperson:** Andy Rothenberg, Primeline Products, Inc.
- **Vice Chairperson:** Jake Saltzman, Picote Solutions

**Heather Myers, NASSCO**
- **Joanne Hughes, Raven Lining Systems**
- **Gerry Muenchmeyer, K.R. Swardfegler**
- **Wayne Long, Rinker Materials**
- **Rod Thornhill, White Rock Consultants**
- **Ed Kampbell, Rehabilitation Resource Solutions**
- **Dave Kozman, R. S. Lining Systems**
- **Dave Kozman, R.S. Lining Systems**
- **Karen Francis, Underground Construction**
- **Lorenzo Lopez, PipeLogic**
- **Laurel Maranto, Strong Seal**
- **Chad Miller, MaxLiner**
- **Clayton Muenchmeyer, Michels Corp**
- **Gerry Muenchmeyer, Muenchmeyer Associates**
- **Rusty Nezat, Nezat Train & Consult.**
- **Don Rigby, Avanti International**
- **Kathy Romans, Raven Lining Systems**
- **Greg Stanley, Wade Trim**
- **Katie Nesbitt, Picote Solutions**

**RehabZone Leadership - Years 2002 -2018**

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<td>2019</td>
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<td>Jake Saltzman, Picote Solutions</td>
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ASSESSMENT

ACOUSTIC PIPE INSPECTION

Sanitary sewer overflows (SSOs) are most often caused by the long-term buildup of roots, fats, oils or grease within a pipe. An acoustic inspection is a cost-effective way to detect blockages before an overflow or maintenance issue occurs. A transmitter is installed in a manhole that transmits a series of tones through the air gap within the pipe. A receiver is installed in an adjacent manhole and it listens for degradation in tones compared to a clean pipe. The data are analyzed in less than three minutes and rate the severity of the blockage on a scale from 0 to 10.

CCTV INSPECTION & CONDITION ASSESSMENT EQUIPMENT

The most basic information needed to define pipeline rehabilitation requirements is the condition of the sewer pipe from a structural, maintenance, and physical dimension perspective. The most important tool for assessing the condition of a sewer pipe is by means of a detailed internal television inspection (CCTV). Yet, the growth of our communities with their associated new underground infrastructure, along with rehabilitation of existing pipe installations, has generated a growing need for more detailed dimensional inspection techniques.

There are many CCTV cameras available on the market, which function in a variety of pipe sizes. The rule of thumb is that a camera designed for a small pipe size should not be used in larger pipe because the quality of the picture will be significantly diminished. Larger pipe should be surveyed by a camera system designed specifically for that application. Adequate lighting, centering, and focus are critical to a good video picture and a good inspection. Today’s cameras with their remotely controlled focus and iris functions, light adjustments and the ability to pan and rotate provide the customer with excellent clarity and quality. Major advancements include color CCTV, DVDs, pan and tilt heads, self-leveling cameras and software to manage CCTV video, defect codes, database and photos.

Today, a wide array of CCTV and remote inspection technologies are available and utilize state-of-the-art methods such as sonar, infrared, laser profiling, panoramic imaging, gas detection, 3D modeling, wireless remote control and robotic cutters.

IMPACT ECHO TESTING

Testing concrete pipes is a critical element of utility efforts to develop cost management strategies and identify, repair or replace weak elements before they fail. Non-destructive testing (NDT) uses sonic/ultrasonic techniques to conduct internal and external testing of concrete pipes to evaluate the structural integrity and identify pipe thinning due to internal hydrogen sulfide corrosion or external carbonization. Hundreds of miles of large diameter (48 to 120 inch) concrete water mains and hundreds of sections of concrete wastewater pipes have been evaluated using the impact echo technology. Internal sonic/ultrasonic impact echo and pulse velocity measurements are used to determine the integrity, strength,
and condition of the core concrete and if broken pre-stressing wires have slipped and core concrete is
delaminated from the cylinder. For wastewater pipes sonic/ultrasonic measurements are made on the
exterior of an excavated pipe to determine if concrete core has thinned and weakened due to hydrogen
sulfide corrosion.

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LATERAL ASSESSMENT

Lateral assessment is a vital component in
the inspection, maintenance and renova-
tion of collections systems. The CCTV
Inspection is generally done using one of
two methods; inserting a small diameter
camera designed for 3-inch to 6-inch pipelines via a clean-out
towards the mainline, or using a robotic mainline/lateral inspec-
tion camera system that launches a camera from the mainline
connection up towards the building connection/clean-out.
Newer equipment now has the capability of panning and tilting
the lateral camera while inspecting lateral pipes; as well as laser
profiling the lateral pipe ensuring the right sized liner is installed
during lateral pipe renewal projects.

Assessment data gathered by either of these two methods
(typically in a standardized format, such as LACP®, to merge
with mainline assessment data) is used to determine the need
and/or appropriate methods for long-term successful renovation
of the collection system.

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Laser & Sonar Profiling Tools

The need for more detailed dimensional inspection
techniques is now being met
with laser profiling in open
pipes and sonar profiling of water filled pipes that cannot
be easily drained or bypassed. Dimensional analysis using
these technologies reveals and quantifies absolute diameters,
ovality, offsets, cracks and dis-
continuities in a pipe structure that effect the life and perfor-
mance of the pipe line. This
dimensional information is just
now starting to be used by the engineering and design agents
to accept, evaluate and design
new, existing or rehabilitated pipe structures.

The systems consist of the laser profiler attachment, calibration equipment and analysis software. A
light ring is projected onto the pipe wall and recorded onto DVD for analysis in the field or in the office.
The system is capable of inspecting from 6" to 72" pipelines. When used as a video survey tool it can
provide accuracies up to 1 mm while measuring pipe size, deformation, erosion, encrustation, debris,
grease, flows, joint displacement, lateral protrusion, surface damage, and holes.

Attention to proper equipment calibration and operator training are issues that are being addressed
by the industry to raise the level of confidence in the data produced through the laser profiling technol-
ogy.

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The panoramic mainline CCTV systems use specially designed wide-angle cameras. As the system moves through the pipeline, the integrated high-power strobes flash and the cameras capture images of the pipe wall. After inspection the data is compiled to create a complete 360° view of the pipeline. Users can then move through this virtual pipeline, take measurements and log defects. These types of cameras do not need to stop as they move through the pipeline and can inspect at speeds up to 70 feet per minute without motion blur.

The panoramic type manhole inspection systems feature inspection speeds of up to 14” per second, 100% coverage, geometric measurements from any point inside the manhole from 300 up to 2000 feet of cable, and pipe capabilities from 10” diameter and up. The software allows you to view the manhole from any angle, at any position creating a “virtual-reality” style view of the manhole. This file can be viewed from any computer, anytime. The system also automatically generates a three-dimensional model of the inside of the manhole that can be rotated, viewed, measured or output to a CAD file for further analysis.

Panoramic camera improvements allow for accurate measurement of 3D features in the structure. Giving more accurate information to the end user, applications include inlet and outlet measurement and a 3-D measurement option whereby all of the items inside the asset can be visually seen and measurement of any part of the structure can be achieved using the point cloud. All measured assets can be seen within the entire structure.

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Pipe penetrating radar (PPR) is the underground in-pipe application of ground penetrating radar (GPR), a non-destructive testing method that can detect defects and cavities within and outside mainline diameter (>18 in / 450mm) non-metallic (reinforced concrete, vitrified clay, PVC, HDPE, etc.) underground pipes. PPR has the unique ability to map pipe wall thickness and deterioration including voids outside the pipe, enabling accurate predictability of needed rehabilitation or the timing of replacement.

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Side-scanning relies on the proven inspection crawler platform to gather visual data from within a pipe. However, it implements digital image processing technology to deliver richer visual information in a format that is easier to analyze. Side-scanning also relies on software to manipulate video frames into a flat digital scan. This scan resembles a long mural or scroll, and it bears an image where length corresponds to the length of the pipe, and where height represents the full circumference of the pipe, from 0 to 360 degrees. These scans capture a level of detail far greater than conventional video, and present it in a format that is easier to review and analyze. Rather than sit through hours of inspection video, an analyst can view an entire length of pipe at one time, quickly pinpointing problem areas and making annotations and measurements directly on them.

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SOFTWARE

After the CCTV inspection on the pipe, lateral or manhole is completed, what happens to the video and collected condition information? Previously it used to sit in boxes or shelves in a closet somewhere but now everyone realizes that data is too valuable, to too many people, not to share it between departments. With the NASSCO coding standard it is easy to share that data with other software programs. With a published list of codes and a data dictionary outlining field requirements, the NASSCO transfer file can be easily imported into a variety of other software programs. Most have added a standard import process for bringing the survey data into their management software so that costs can be easily tracked and additional work orders created for repair work or other scheduled maintenance.

Many of the data collection software vendors have incorporated an interface with GIS to access survey detail from the GIS program by the engineering staff in the office. The user can select the pipe on the map and open the video for playback. Some interfaces include the survey history of the pipe allowing the user to track the conditions and their changes over time. Usually the collection database can be “searched” and pipes highlighted in the GIS program that contain specific conditions or pipe grades making it much easier to plan additional work like repairs or jetting.

The data is also used by the GIS departments to verify that the map data is correct. Many maps have been created from old, historic mapping data and may not relate to actual in ground conditions. GPS coordinates can be collected in the field during an inspection and saved in the NASSCO inspection format. Other asset details like location, diameter, material, lining, and pipe lengths are also collected. This information can be exported so the GIS department can update their maps. Buried manholes that are found are added to the map creating new assets, both manhole and pipes.

Many engineering firms have built analysis modules to search these databases and make recommendations based on built-in risk assessments. It is not enough to know there is a fracture or a hole in the pipe, it is also important to consider the risk of failure of that particular pipe. Factors like public impact, environmental impact, age, and cost of repair versus replacement are all considered and built into their analysis.

When NASSCO introduced the PACP® standard in 2002, training the inspector to understand the different conditions was a major component of the program. Since then NASSCO established a re-certification program that each inspector will take every three years to bring them up to date on the new codes added for different survey types like grouting and storm inspections, as well how to handle new technology like scanning cameras and laser inspections.

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SIDEWALL SCANNING

Perimeter scanning relies on the proven inspection crawler platform to gather visual data from within a pipe. However, it implements digital image processing technology to deliver richer visual information in a format that is easier to analyze. Perimeter scanning also relies on software to manipulate video frames into a flat digital scan. This scan resembles a long mural or scroll, and it bears an image where length corresponds to the length of the pipe, and where height represents the full circumference of the pipe, from 0 to 360 degrees. These scans capture a level of detail far greater than conventional video, and present it in a format that is easier to review and analyze. Rather than sit through hours of inspection video, an analyst can view an entire length of pipe at one time, quickly pinpointing problem areas and making annotations and measurements directly on them.

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BY-PASS PUMPING

Bypass pumping is a key element in the successful installation of most pipeline rehabilitation technologies. The existing sewage flow is temporarily re-routed until the project is completed. A variety of pump types and system configurations can accommodate most any flow volume and configuration. With most small diameter pipelines, particularly on short sections of sewer, plugging should be adequate but must be monitored on a regular basis to prevent backup of sewage into adjacent homes.

It is important to design the bypass system to accommodate the specific flow conditions encountered. The pump system suction lift capability must be matched to the depth of the sewer, which must be matched to the size and length of the discharge piping system. Also, emergency or stand-by capacity should be designed into the system in the event of a pump failure during operation of the system. Many cities require 50% additional capacity in the event of a pump failure and in critical areas 100% has been required.

In commercial and industrial applications, it may be necessary to bypass flow from each individual service connection, since flow interruption may not be an option. Individual cleanouts or sewage pick-up points are identified and a small pump is set-up directing the flow to the mainline pumps.

PIECE CLEANING

The cleaning of a pipeline is performed for a number of reasons including pipe blockages due to roots, grease and sand buildup. Pipes are cleaned to increase available capacity taken up by debris and other materials, as well as to prepare a pipe for the installation of a renewal technology. Most renewal technologies require that the host pipe be totally free of any debris and accumulation before the new product is installed. Cleaning devices will vary depending on the type and amount of debris in the pipe. Most equipment uses a combination of mechanical equipment and water pressure. NASSCO has published a Jetter Code of Practice (available in English and Spanish) which
reviews different devices and nozzles that are typically used to clean pipes using high pressure water. This manual is available from NASSCO at www.nassco.org

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ROOT CONTROL & GREASE CONTROL

Root and grease control is the foundation of any good sewer maintenance program. The EPA states, “Sewer line root intrusion is the single most destructive element facing those responsible for maintaining the wastewater collection system.” Controlling the infiltration of roots into the pipeline preserves the integrity of the joints and keeps the pipeline open and flowing. If roots are allowed to grow into the sewer, sanitary sewer overflows (SSOs) will continue to occur. Routine maintenance of the system for root intrusion by deploying a chemical treatment program has proven far superior to the “historical method of cutting roots out mechanically”, which can damage pipes and lead to thicker re-growth, requiring more cutting. Cutting off the appendages of these intruders is just like pruning a tree top; they very quickly grow back. A properly administered chemical root control program, however, allows for the effective eradication of the roots in a zone that extends to approximately 12” outside the pipeline. Initially developed in conjunction with UC Davis and the University of Sacramento, chemical root control today has become one of the most beneficial methods used to combat SSOs and pipeline deterioration.

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MAINLINE PIPE REHABILITATION

CURED IN PLACE PIPE (CIPP) HEAT CURED

CIPP is a thermostet resin system (polyester, vinyl ester, or epoxy) that is installed into the existing pipeline to be rehabilitated, with either a polyester felt or fiberglass tube of the approximate thickness designed for the application. The resin-saturated tube is installed either by directly inverting the tube into position using water or air pressure, or by pulling the resin saturated tube into place and inflating the tube. Once in place and properly inflated the resin system is cured using either heat (hot water or steam) or ultraviolet light. Recent technology developments include tubes that are reinforced with various high tensile fibers capable of increasing the overall strength of the finished CIPP. Because CIPP does not bond to the host pipe in sewers, groundwater may track between the CIPP and the host pipe. Supplemental technologies that provide a watertight seal between the host pipe and the new CIPP should be employed wherever groundwater infiltration may enter the collection system, such as at laterals and manholes.
Seal technologies have been developed that have hydrophilic properties that can be installed in conjunction with the CIPP product.

CIPP is available in sizes ranging from 2” through 120”. It is most cost-effective in sizes 8” through 48”; though it is routinely used for larger diameters due to a project's site-specific parameters. The resin-saturated tube can be installed in a variety of common shapes for sewer lines; round, egg, arch, and elliptical. Square or rectangular pipes can be lined, but can provide many challenges to fitting the CIPP tightly. Multiple bends up to 90° and transitions in size and shape have been accomplished successfully and can be accommodated by fabricating the tube accordingly.

Typically the house service connections are reconnected robotically, requiring no excavation.

Hundreds of millions of feet of CIPP are in service throughout the world today and it is considered the most widely accepted pipeline rehabilitation technology worldwide. CIPP has been installed successfully in continuous lengths of over 2500 LF.

Notes

CIPP TEMPERATURE SENSOR STRIPS

Sensors are strung via a cable, inside the pipe that is to be repaired, prior to insertion of the CIPP liner. Once the liner is inserted, and the heating process via steam or water has started, temperature readings from the sensors that are distributed all along the pipeline are transmitted to an on-site computer. Designed to monitor the CIPP wall temperature during curing of the pipe in the field, the technology is a CIPP cure measurement technique using a 3mm diameter probe that is pulled through the pipeline to be rehabilitated. Temperature is measured every 1.5 feet, displaying the average temperature across each 1.5-foot section of the liner. The sensor wire is pulled into the host pipe, then the liner is installed over the wire. Temperature readings are displayed on a computer connected at the end of the sensor wire.

Notes

INSTALLATION EQUIPMENT

Installation equipment for water and air installations has improved over the years. Newer equipment is more compact and is operated using pump pressure in lieu of static pressure.
The liner is typically winched into place using a constant tension winch, then inflated using air pressure. A special light train, including CCTV, UV lights, and infrared sensors is pulled through the inside of the inflated liner before it is cured. The uncured liner is televised to determine if there are any defects before curing. The UV lights, on the light train, are turned on and the train is pulled back through, causing the liner to cure. Infrared sensors record the entire cure process.

**Notes**

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**CURED IN PLACE PIPE (CIPP) ULTRAVIOLET LIGHT CURED**

Cured-in-place-pipe (CIPP) cured with ultraviolet light is expanding the market by offering an additional rehabilitation option. UV curing technology is widely used in Europe and its use is now gaining traction in North America.

This rehabilitation method uses a light train that emits ultraviolet light as it is pulled through the flexible, resin-impregnated liner. The UV light causes the liner to cure and harden forming a new tight-fitting, joint-free pipe.

Light trains with various configurations are now available to match the pipe diameter and profile. An integral video camera allows inspection of the pipeline while the train is initially pulled through the inflated liner. This ensures that the liner is properly fitted. Adjustments to the liner can be made before the curing process begins.

After the initial inspection, the UV lights are powered up and the train is pulled back through the pipe. A computer controls the speed of the train, predetermined by the diameter of the liner. The curing speed, liner pressure, ambient and liner wall temperature, and light settings are carefully regulated and monitored. The computer logs the inspection video and data to provide complete documentation.

Various UV curing systems are offered to meet application requirements. A portable unit can be trailer-mounted or retrofitted to an existing truck. This system, for lining pipe diameters from 6- to 18-inches, controls the light train speed and powers the UV lights on the light train. It includes a monitor, automatic cable feed and 100 m (328 feet) of cable.

The truck-mounted system provides a professional platform for lining pipe with diameters to 60 inches. The reel assembly contains 200 m (565 feet) of cable, with an option for 300 m (985 feet). The unit ensures that the light train is retracted through the pipe at the preset speed to exactly meet the prescribed curing time. The electronic panel inside the control room monitors and records the curing process, controls the UV lights on the train, and displays and logs the inspection video and data. An 80 kW diesel generator powers the mechanical systems, the CCTV camera and the UV lights. The blower system is sized to accommodate large lining for pipe diameters to 60 inches.

The complete system typically includes two light trains and two sets of packers with air couplings.
SECTIONAL CIPP

A number of different trenchless technologies are available that are specifically designed for the repair of pipe joints and/or localized pipeline defects. They can vary in length from several feet to 30 feet or longer and can be provided with hydrophilic-type seals installed at the ends of the sectional liner.

Inverted sectional liners are available in a variety of lengths, sizes and thicknesses to accommodate the needed structural repair. The liner tube is vacuum saturated with resin in the field with an approved thermoset resin and loaded into a flexible air inversion launcher. The launcher is pulled through the pipe to the point of repair; air pressure is applied causing the liner tube/bladder tube to invert through the defective pipe section. The liner is held under pressure until cured approximately two hours at ambient temperatures, or the liner may be steam cured, reducing cure time from two hours to as little as 30 minutes.

Short sectional liners are saturated in the field, typically with an epoxy resin system, wrapped around an inflation packer and winched into the existing pipeline to the defective section. The packer is then inflated, and the resin is allowed to cure (typically two hours @ 75°F) depending on the temperature of the sewer. Heated packers can be used to speed up the cure time. The key to effective installations is to thoroughly understand the effects of temperature on the cure time for the short liner repair system. Some short liners use ultraviolet light cured systems. The short liner is installed in the pipe and positioned over the defective area. Once in place the ultraviolet light is switched on and the short liner is cured in less than 10 minutes. Short liners can be used for patching pipe joints, pipe leakage, mis-cut service connections and any defect that may need repair in the pipeline.

Geopolymer coatings and linings are used in the restoration of highway culverts and drainage structures. The product is typically spun cast applied to provide a uniform lining for concrete and corrugated culverts.
**EQUIPMENT & MATERIALS**

Shotcrete, which dates back to 1907 in the USA, is an all-inclusive term to describe the spraying of concrete or mortar that may be accomplished through either a dry- or wet-mix process. Gunite refers only to the dry-mix process in which the dry cementitious mixture is blown through a hose to the nozzle, where the water is injected immediately prior to application. Because complete mixing of the water and dry ingredients is not possible in the nozzle, mixing is completed as the material impinges on the receiving surface, through manipulation of the nozzle. This requires a very highly skilled nozzleman, especially in the case of thick or heavily reinforced sections. It is used for pipeline rehabilitation, slope stabilization, structure restoration and new construction.

**GUNITE / SHOTCRETE**

As the concrete is centrifugally cast evenly around the interior of the pipe, the application head is retracted by a computer-controlled motor at the properly calculated speed to ensure an even thickness predetermined by the engineer. The spin caster can be started and stopped as needed without joints or gaps, resulting in a seamless, high strength, fully structural pipe.

**CEMENTITIOUS LINING**

As the concrete is centrifugally cast evenly around the interior of the pipe, the application head is retracted by a computer-controlled motor at the properly calculated speed to ensure an even thickness predetermined by the engineer. The spin caster can be started and stopped as needed without joints or gaps, resulting in a seamless, high strength, fully structural pipe.

**SELF PROPELLED CUTTER/CAMERA ROBOTS**

State-of-the-art self-propelled, remote operated cutting tools are specifically engineered to remove protruding taps, trim off-set joints smooth prior to CIPP lining, and quickly reinstate service connections. These grinding/cutting robots are outfitted with a pan/tilt camera that includes a lens washing device, allowing one single unit to perform pipe rehab work by accessing only one single manhole, and ensuring the operator has a clean, clear view of the robotic work being performed. These robots are also capable of cutting straight forward and 360-degrees, enabling the robot to grind and crawl through collapsed cured-in-place pipe linings. Robots today are outfitted to insert mechanical plugs up into service lateral connections, grind, trim, reinstate, chisel, video inspect and install main to lateral CIPP connection seals.
INSERTION SADDLE TEE CONNECTION

The saddle tee connection is a three-piece compression fitting designed to give the installer a water-tight, air-testable connections to any type of mainline pipe. Lateral connections are available in 2” through 30” in size for virtually any type of commonly used pipe. Installation of the tee requires that a hole be cut into the mainline to match the size of the lateral. The hole-saw must be ordered from the manufacturer, as they are size specific to the fittings. They are available in all configurations, depending on the type of material being cut. Once the hole is cut, the rubber sleeve is installed into the host pipe. There are guide lines and installation instructions supplied with every fitting. After the sleeve is installed, the PVC hub is installed using a small mallet. This part of the installation gives the fitting the necessary compression against the side wall of the host pipe, ensuring the water-tight seal. A stainless-steel band is installed last, before the fitting is ready for backfill.

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MANHOLE END SEALS FOR PIPE LINER INSTALLATIONS

Manhole end seals for pipe liner installations provide a water-tight seal of the liner pipe at the manhole wall. Some end seals are constructed for the mainline and manhole connection in the shape of a low-profile sleeve consisting of a hydrophilic neoprene material that swells upon contact with water, creating a compression gasket seal similar to that of new pipe installation.

Other designs include an internal rubber seal that is installed over the liner and the host pipe. This unique design captures the rubber and compresses it against the host pipe and new CIPP liner creating a permanent mechanical seal.

Cured-in-place pipe seals can be used to repair minor defects in unlined pipes close to their junction with manholes and can be used to seal CIPP to manhole walls or manhole liners.

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FOLDED THERMOPLASTIC PIPE

Folded high density polyethylene (HDPE) is commercially available in sizes ranging from 6” through 24”. The most common sizes used for sanitary sewer lines are 6” through 12”. The larger diameters are typically used to renovate pressure pipelines and culvert piping. Folded HDPE is extruded in a round shape, folded and coiled on reels for delivery to the project site. In the field the folded pipe is winched into place and then un-folded to fit tightly within the host pipe. The un-folding process is accomplished by the application of air pressure and steam. In order to ensure a tight fit and no post-installation movement of the liner, a precise re-rounding procedure, to anneal any
residual installation stresses and stretch of the HDPE pipe, is performed by the contractor. The liner is typically sized 2-2.5% smaller than the host pipe to ensure a tight fit, which limits the amount of stretching required, providing a consistent wall thickness. Typically, the house service connections are reconnected robotically requiring no excavation.

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**PVC**

Folded polyvinyl chloride (PVC), depending upon the manufacturer, is available in size ranging from 6" through 24" and in some cases up to 30". For sanitary sewer applications it is typically installed in sizes 6" through 15". Bends up to 90° can be accommodated. Folded PVC is extruded in a round shape, deformed, and coiled on reels for delivery to the project site. In the field the coil of pipe is placed into a steam cabinet to soften the material to allow it to be winched into place. The folded PVC is then reformed to tightly fit the host pipe using air pressure and steam. Typically, the house service connections are reconnected robotically requiring no excavation. Materials are shelf-stable and able to be reprocessed. Thermoformed liners have been installed successfully in continuous lengths up to 1500 LF.

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**INJECTION GROUTING**

**PIPE JOINTS & CRACKS**

Injection grouting is a soil sealing process with a two-component chemical grout injected under low pressure through pipe defects into soils and voids around mainline pipe, laterals, lateral connections, manhole structures and into lined pipe annulus to stop leaks, stabilize soils and control infiltration. The non-structural sealing is achieved by filling voids between the soil grains on the exterior of the structures. Grout mixes, additives and grouting techniques provide long lasting repairs.

While many pipelines appear structurally sound, the joint integrity (water-tightness) has probably been lost due to deterioration of the joint seal material. As a result, infiltration and fines will find their way
into the pipeline. Infiltration is the root cause of structural decay and grouting is most cost-effective prior to structural demise of the collection system. Injection grouting has been used successfully for more than 50 years by many utilities across the U.S. Key to the successful use of injection grout is in choosing the right grout mixes and pumping procedure to ensure that the void in the soil surrounding the joint is properly filled. A common myth or misunderstanding of injection grout is that it lasts only two or three years; that it dehydrates, cracks, and/or disintegrates. When acrylamide or acrylic grout is mixed and injected properly, and injected in a soil that has a relative humidity of 72%, it will not dehydrate. Almost all sanitary sewer piping is installed at depths where the soil meets this criterion. In areas subject to some seasonal drying out, additives such as ethylene glycol and latex can be added to the grout mixture to retard the dehydration of the grouted soil.

As the first defense against infiltration, a holistic approach with injection grouting at all four points of entry will extend the service life of the underground assets, reduce flow to WWTP, improve capacity and minimize the frequency and cost of sewer jetting or cleaning.

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MAIN/LATERAL CONNECTION SEALING

The connection is prepared for sealing by a cutting/milling robot operated remotely from a truck above ground. Broken or damaged pipe wall is removed by milling, opening larger pathways for injected resin and exposing new pipe free of grease and debris. After milling preparation, a mainline packer is positioned at the connection from inside the sewer main. From the mainline packer a lateral bladder is launched up into the lateral 18-24”. Both mainline packer and lateral bladder are inflated isolating the prepared connection for injection. A two-component resin or epoxy material is injected under pressure into the isolated area. Resin permeates into the soils and voids surrounding the lateral pipe connection to structurally re-establish bedding and spring-line support for the connection. Simultaneously, the resin bonds with cleaned, new pipe surfaces exposed during the milling preparation stage.

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PIPE REPLACEMENT

Pipe bursting is referred to, by many, as trenchless technology whereas it really is “less trench” technology. Translated this means that there is some excavation required but significantly less than traditional dig and replace methods. Pipe bursting, mostly applicable to replacing “frangible” or “brittle” materials, is also sometimes referred to as “Pipe cracking”. “Pipe splitting” more correctly refers to replacing such materials as ductile iron, plastic and steel pipes.

Unlike lining system technologies, pipe bursting is a pipe replacement system. The existing host pipe is fractured or displaced with a new pipe, manufactured from a variety of factory produced materials. These new pipe materials are designed to sustain the full loading conditions encountered in a pipe replacement project.
Pipe bursting is a unique pipe replacement system. Unlike most pipe renewal technologies, pipe bursting allows the customer to replace an existing pipe not only with a new pipe using a number of different pipe materials, but also a larger pipe, with higher flow capacity.

Pipe bursting has been used commercially since the 1970s in Europe. In the early 1980s pipe bursting became more popular and was used to primarily burst thousands of miles of defective, cast iron gas main for British Gas in England.

Until the late 1970s and early 1980s sewer renewal in the United States was accomplished primarily by digging the old deteriorated pipeline and replacing it with newer pipe materials. With directional drilling developed in the U.S. as an effective tool for the replacement of small diameter gas mains, the need for pipe bursting was not immediately apparent.

Initially pipe bursting was primarily used in the replacement of friable type pipe materials that would crack or shatter to allow for insertion of a replacement pipe material such as cast iron, concrete, cement, clay and others. Over subsequent years the pipe bursting technology has expanded to include the replacement of such materials as ductile iron, steel and plastic pipe materials. The pipe bursting technology can be applied to water mains, water service connections, sewer mainline, sewer laterals, gas mains, gas service connections, industrial, telephone and other applications.

Pipe splitting technology is a system that uses static pressure to cut and split the existing pipe, expand it out and insert a new structural replacement pipe material. The system is designed to allow upsizing of existing mains thereby improving capacity and flow characteristics.

A variety of materials can be used with the technology including HDPE, ductile iron, steel and plastic pipe. Service taps are typically excavated and re-connected to the newly installed pipe.
One of the older technologies, continuous sliplining pipe is available in sizes ranging from 4” through 60”. Continuous sliplining is installed using a number of different materials including HDPE, fused PVC, restrained joint PVC, ductile iron and steel. HDPE is still one of the more popular materials installed using the sliplining technique. In the case of HDPE, lengths of round pipe are fused together to make up the length of the pipeline being rehabilitated. The fused liner is winched into place and the ends sealed. Sliplining results in a smaller pipe being pulled into the existing pipe and some final capacity loss should be anticipated. In some cases, the annulus is grouted. Service re-connections are typically accomplished by excavation.

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Segmental pipe is available in sizes ranging from 12” to 102” and is accomplished using short lengths of profile wall PVC or GRP. Profile wall PVC is applicable to round pipe restorations while the GRP systems can accommodate round, egg, arch, and elliptical shaped host piping. The annulus is grouted and the ends sealed. Bends and transitions in size can be accommodated by the GRP systems, as well. Service re-connections are typically accomplished by excavation.

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Sectional pipe sizes range from 12” to 120” (or larger) with panel systems for larger sizes. This process is generally accomplished by inserting short lengths of PVC or GRP pipe or panels through existing manhole openings. The panel systems typically have two or more pieces making up a “ring” that is assembled inside the pipeline. After these systems are put into place, a non-shrink grout is pumped into the annulus. These systems are applicable to round, rectangular, egg, arch and elliptical shaped host piping. Bends and transitions in size can also be accommodated by the panel systems. Service re-connections are typically accomplished by excavation.

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**GROUT IN PLACE LINING SYSTEMS (GIPLS)**

A GIPLS is typically composed of a thin sheet of plastic, either PVC or HDPE, which is bonded to a structural grout layer. The GIPLS is a composite structure with the original pipeline. Owing to its method of installation (forms are typically constructed to support the grouting operation), it is typically limited to worker-entry size piping. The exception to this is the PVC spiral wound-in-place system, which can be installed in sizes starting as small as 8”.

Spiral wound trenchless pipeline renewal process is designed for and used primarily in large diameter pipelines, typically worker entry. This process is unique as it can provide a customized structural solution to aging pipelines.

**SEGMENTAL PANEL**

Segmental panel systems are a series of molded or translucent PVC panels, that when assembled, form a new pipe or culvert within the existing damaged structure. A structural grout may be used to fill the annular space between the new segmental panel pipe and its host. This restores the structural strength of the original pipe, as well. The unique see-through walls allow visual monitoring the grouting process.

**SPIRAL WOUND PIPE**

Spiral wound pipe is manufactured in narrow continuous strips of PVC. The PVC strip is manufactured with an interlocking edge which, when installed, locks the strips together as they are machine wound into the host pipe. The material has a ribbed structure and can be reinforced with steel rings for greater strength. PVC spiral wound-in-place systems can be installed in sizes starting as small as 8”.

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**MECHANICAL SEALS**

These type repair systems can be installed either using a crawler-deployed inflation type packer or by worker entry. Joint seals can vary in size from as small as 6" to over 200" in diameter. These seals typically require trained and experienced personnel to insure proper installation of the products. Some of these technologies have been available in the market for over 30 years with a long installation history for both water and sewer applications. Materials will vary including stainless steel, PVC and rubber. PVC systems can be installed in a variety of shapes and sizes.

**JOINT SEALS**

The internal joint seal is typically manufactured of EPDM or polyisoprene rubber and the expansion bands used to compress the rubber against the pipe wall are 14 gauge 304 or 316 grade stainless steel. In this manner, it provides both structural repair and abatement of infiltration. Unlike other rehab technologies, a mechanical sleeve requires no digging, resin mixing, cure time, or bypass pumping; has no pot life; and can be installed amidst active infiltration without the risk of wash-out. Mechanical sleeves are ideal for addressing infiltration, offset joints, root intrusion, abandoned laterals, and longitudinal and circumferential cracks.

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**LATERAL LINING**

Lateral liners, like mainline CIPP, can be used with hydrophilic materials to prevent ground water from infiltrating into the lateral pipe. Lateral CIPP also requires the same quality installation and a trained inspector to observe, verify, inspect, document and test the installation of a lateral rehabilitation liner.

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**LATERAL PIPE LINING**

Repair by lining the entire lateral pipe. There are several installation techniques available.
LATERAL AND MAIN/LATERAL CONNECTION LINING

Repair by lining a portion of the lateral pipe or the entire lateral pipe, and lining the lateral/main connection.

LATERAL CONNECTION CIPP

Lateral connection CIPP is commonly used to repair broken service taps where they enter the mainline, to connect mainline linings with lateral liners to establish a watertight connection between the two systems. They are also used to stop leakage between the installed liner and the host pipe from entering the sewer at the service connection. A sealing technology should be used together with the connection hats. The connection liner may be shaped like a hat or a structural full-circle repair, and typically consists of a polyester/fiberglass assembly which is impregnated with a curable liquid resin. These technologies may incorporate hydrophilic gasket or grout or resin paste injection sealing technology, ensuring a non-leaking connection, and are installed using ambient, heat or ultra-violet light curing techniques. Each type of sealing technology must, however, be evaluated and selected for its recommended application and proven long-term capability. Lateral connection hat installation can be performed with or without the use of a clean-out.

LARGE DIAMETER LATERAL CONNECTION

Large diameter lateral connections allow for a water-tight connection to be made to either a liner or to the original host pipe. This is a mechanically anchored liner that also includes the use of molded gaskets made of hydrophilic material and a metal brim flange. The liner system consists of a fabric tube of the desired length with a factory attached brim and a thermo-set CIPP resin system. The mainline brim and lateral tubes are vacuum impregnated with the resin, the hydrophilic gaskets are installed, and then the liner is mechanically placed inside the pipes via man entry into the mainline. The connection stays in place with the stainless-steel compression ring that is fastened to the main pipe to create a one-piece lateral lining and sealed connection.
MAIN/LATERAL CONNECTION LINING

Repair by lining the lateral/mainline connection.

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SECTIONAL PIPE LINING

Repair by lining a portion of the lateral pipe.

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MAIN/LATERAL CONNECTION SEALING

Repair by sealing the main/lateral connection by use of hydrophilic gasket or paste materials.

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CLEANOUT INSTALLATION

Trenchless cleanouts are an alternative to digging, shoring, and using trench boxes for installing a lateral cleanout. Cleanouts typically can be installed in two hours with a small footprint and restoration is performed in the same day.

The method consists of locating a lateral pipe and utilizing a vacuum excavator to make a 20-inch hole exposing the lateral pipe. A tapping saddle and riser pipe are remotely attached using a water activated adhesive as the saddle is inserted into the bore-hole and snapped onto the lateral pipe. A leakage test is typically performed before the lateral pipe is cored to complete the installation.

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LATERAL PIPE REPLACEMENT

PIPE BURSTING

The replacement of a section or an entire lateral pipe by pipe bursting.

Several of the technologies provide either pipeline rehabilitation or a watertight seal solution. Some technologies provide solutions to both. Owners must determine their expectations for a rehabilitation project in order to select the best, most applicable products and technologies. For example, if the goals of the project are to reduce infiltration entering the sewer system, then the technologies that provide a long-term watertight seal should be selected. If the goals are to renew the pipe structurally to as good as, or better than, original condition, then the technologies with proven and accepted design and service life concepts should be selected. The goal may be to eliminate both infiltration and rehabilitate the pipe to original standards. Many lateral rehabilitation technologies pro-
Cured-in-place liner systems are typically installed in pipe sizes of 6”-12”. These liners span and seal leaking joints, pinholes and minor cracks. Services/laterals are reinstated from inside the pipe with no excavation typically required except for access pits. Resins used with potable water are typically NSF 61 approved resin systems. Installation lengths of up to 500 feet are not unusual and liners can negotiate bends in the existing main.

LATERAL PIPE GROUTING

LATERAL AND MAIN/LATERAL CONNECTION GROUTING

Repair by sealing the main/lateral connection and the entire lateral pipe or a portion of the lateral pipe by chemical grout injection.

It has been determined, through a number of studies, that laterals and main to lateral connections can contribute as much as 50% of the infiltration in a collection system.

WATER MAIN LINING

Most water main lining technologies require that the existing pipe be thoroughly cleaned and prepared for application of the coating. Some cleaning techniques include: hydraulic, mechanical, chemical, swabbing, scraping, pigging and air scouring.

CEMENT MORTAR LINING

Generally, a type I/II or type V Portland cement is used, depending upon the salinity of the liquid flowing through the line. Specialty cements are available to withstand high temperatures, heavy salinity concentrations, and hydrogen sulfide gas and associated corrosives.

This system is used for the internal sealing and corrosion protection for water lines first installed as early as 1930 in the USA.

CURED-IN-PLACE PIPE

Cured-in-place liner systems are typically installed in pipe sizes of 6”-12”. These liners span and seal leaking joints, pinholes and minor cracks. Services/laterals are reinstated from inside the pipe with no excavation typically required except for access pits. Resins used with potable water are typically NSF 61 approved resin systems. Installation lengths of up to 500 feet are not unusual and liners can negotiate bends in the existing main.
The PE or PVC material is either site or factory folded or radially reduced prior to insertion into the host pipe. Glass fiber reinforcement gives the liner static, self-supporting properties and allows it to withstand higher internal and external pressures than traditional liners. An individual pipe can be up to 800 feet in length.

EPOXY LINING

Spin cast pipelining technology combines specially designed equipment with proven processes for the cleaning, preparation and application of an ANSI/NSF Standard 61 approved epoxy to deteriorated 3” to 36” diameter pipes. Metal and cement-based gravity and pressure pipes can be lined in both horizontal and vertical configurations.

In 2007, the AWWARF study, “Service Life Analysis of Water Main Epoxy Lining” [Project #2941] estimates a 50-year design life for epoxy. The epoxy will provide a high level of water quality that will not affect pH levels.

INTERNAL JOINT SEALS

Internal joint seals require worker-entry for installation. The seal bridges the existing joint with a rubber material allowing continued movement of the pipe joint. Internal seals typically provide a bottle-tight, leak-proof joint repair and can withstand both internal and external hydrostatic pressures.

MODIFIED SLIPLINING SYSTEMS

The PE or PVC material is either site or factory folded or radially reduced prior to insertion into the host pipe. With the pipe liner profile reduced in size, allowing for an easier installation, the pipe liner is inserted utilizing techniques similar to that used in traditional sliplining applications. Air or water pressure and/or steam are used to revert the liner back to its original round shape, thereby forming a close fit with the host pipe. The new liner isolates the flow stream from the host pipe wall, eliminating internal corrosion and typically providing a full structural renovation solution.
In addition, the new liner allows for service connections to either be reinstated externally to the new liner or reinstated internally with newly developed robotic technologies.

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SLIPLINING

The sliplining method incorporates the installation of a smaller or reduced size steel, ductile iron, polyethylene, PVC or other pipe materials inside the existing pipeline. Pressure rated pipe capabilities can be selected for most main applications. In some cases, grouting is required to fill the gap between the host pipe and the new PE pipe. Very long lengths can be installed using this method. Service taps are typically excavated and directly reconnected. Sliplining can be applied in transmission and distribution mains of 6”-60” in diameter.

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MANHOLE REHABILITATION

Manholes are an important part of wastewater collection systems. They provide access to the wastewater collection system pipelines for maintenance, inspection, and renovation. The term manhole derives from the fact that these structures were designed to provide worker entry for cleaning and inspection. Although most access to wastewater collection system pipelines in the United States is by manholes, other types of access points are also found such as small diameter cleanouts (and/or lamp holes) and large junction boxes.

Technologies for the renovation of manholes are many. They include specialty products installed to primarily stop leakage; a variety of coatings for leakage control, structural enhancement and corrosion protection.

CEMENTITIOUS MANHOLE COATING SYSTEMS

These materials are either spray (low pressure) or trowel applied. They have a long, established history with recent improvements in fast setting high strength corrosion resistant mortars. Some are reinforced with fibers for added tensile strength and crack resistance.

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CURED-IN-PLACE MANHOLE (CIPM) LINER

These systems utilize a variety of resins. They are used for renewal of the manhole structure, have excellent chemical resistance and strong, long-term physical properties. Typical methods and equipment for installation can line diameters from 2 to 10 ft and up to 60 ft deep. Liners are typically designed for full depth hydrostatic head conditions and to withstand earth pressure and traffic loading. They can also be designed as a stand-alone structure.

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CURED-IN-PLACE MANHOLE TUBE LINERS

The CIPMH (cured-in-place manhole) liner is a unique one-piece liner made to fit all manholes including barrel sections, eccentric and concentric cones constructed of brick and mortar, precast or block. CIPMH for chimney or full-depth manhole repair eliminates infiltration & inflow through manhole walls. The universal sized manhole liner is engineered to resist freeze-thaw cycles and create a watertight, corrosion resistant lining.

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URETHANE MANHOLE COATING SYSTEMS

These materials are typically spray applied. Many variations are available from elastomeric to rigid formulations. Generally, they are 100% solids only used for underground coating, but can be adapted to use in environments where UV exposure exist. They have good to excellent chemical resistance and elastomeric qualities that range from rigid formulations to highly flexible. Urethanes generally have strong long-term physical properties. A hallmark of the urethane family is their quick-curing capacity which allows for a rapid “return to service” for the structures that are coated.
Solvent free (100% solids) coatings are operator and environmentally safe and require no evaporative curing process making them ideal for underground coating applications. These high build coatings are either spray or trowel applied and can be specified at structurally enhancing thicknesses. Current generations of epoxy coatings will adhere to moist or damp substrates and have excellent chemical resistance and long-term physical properties.

Generally, the top of the old manhole is cut off and removed and the interior is pressure washed to remove any debris and loose material. The channel is typically removed and replaced after the installation of the pre-cast inserts. If this is not possible, the precast manhole inserts can be shaped to fit the existing bench configuration. The precast inserts typically come in either one continuous section or in different lengths for easy assembly.

Geopolymer cements can be used to restore a manhole’s structural integrity and permanently stop infiltration and corrosion.

These systems have an extensive installation history. Excellent chemical resistance with both PVC and HDPE sheet materials; they are typically used with cementitious or polymer mastic basecoats.

Leakage control technology that is injected into the ground surrounding the manhole. The chemical grout is injected through the manhole structure to mix with the surrounding soil to provide a waterproof seal and prevent infiltration from entering the manhole. A variety of grouts are available for specific applications.
Double Stack:
The double stack lateral lining system process utilizes a single piece of cured-in-place pipe (CIPP) that rebuilds the main/lateral connection (including compression gaskets). A main liner tube measuring is installed in the main pipe and includes a vertical lateral portion that forms a T-shape. This T-shaped liner is outfitted with a flange shaped compression gasket that is seated into the lateral connection. The vertical lateral liner portion extends to another upside-down TEE (hence the term double stack). From this point, two lateral liner tubes would extend laterally toward properties on opposite sides of the road. Additionally, it is not uncommon for the liner to transition in diameter. To ensure water tightness, hydrophilic O-rings are attached to the terminating ends of the lateral liner tubes.

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POURED-IN-PLACE

Poured-in place concrete manhole reconstruction includes the formation of a new integrated liner wall within the existing manhole structure. The new manhole liner wall generally conforms to the existing inside dimension and is often combined with epoxy coating, or a plastic (HDPE or PVC) liner for corrosion protection.

CHIMNEY/FRAME SEALS, LINERS & JOINT SEALS

Used to seal the casting/chimney and wall area against leakage into the manhole. Capable of withstanding surface traffic impact and freeze/thaw pressures.

PANEL LINERS

Plastic panel that is glued to the manhole wall with a pre-applied mastic on the structure. Generally unaffected by water vapor pressure, characteristics include resistance to corrosive environments, monolithic protective coating, encapsulation all areas of the manhole structure, is pin-hole free, stops infiltration and is bonded to the host structure.

EMERGING TECHNOLOGIES

Over the years, the pipeline rehabilitation industry has continued to grow through the development of new technologies as well as significant improvements to well established technologies. Each year the RehabZone will feature an area in the exhibit to showcase those emerging technologies that have been recently launched. Recent emerging technologies include:

1. BRUSH COATING SYSTEM

Renovate old or deteriorated drains and sewers from 1½” to 12” diameter with a brush coating system. The coating applied provides a damp-proof, corrosion resistant, wear-resistant and non-corrosive lining. Several coats can be applied within the same pipe. Renovate entire piping systems; for example, apartments or blocks of flats with minimal disruption, avoiding costly excavation.

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2. LINING OF MULTIPLE LATERAL PIPELINES DURING A SINGLE INSTALLATION PROCEDURE

Double Stack:
The double stack lateral lining system process utilizes a single piece of cured-in-place pipe (CIPP) that rebuilds the main/lateral connection (including compression gaskets). A main liner tube measuring is installed in the main pipe and includes a vertical lateral portion that forms a T-shape. This T-shaped liner is outfitted with a flange shaped compression gasket that is seated into the lateral connection. The vertical lateral liner portion extends to another upside-down TEE (hence the term double stack). From this point, two lateral liner tubes would extend laterally toward properties on opposite sides of the road. Additionally, it is not uncommon for the liner to transition in diameter. To ensure water tightness, hydrophilic O-rings are attached to the terminating ends of the lateral liner tubes.
**Double Stack:**
The multi-lateral lining system process allows for two opposing service connections to be renewed at the same time. In the past, the process of renewing service connections across from one another involved multiple steps. The main liner tube is inverted into and through the main pipe, and as it reaches the service lateral pipes, the lateral liner tubes simultaneously invert and extend up into the lateral pipes. The end result is a continuous liner with uniform CIPP thickness, requiring no reinstating of service connections.

**Sectional Connection Liner:**
The sectional connection liner process renews mainline pipes from 8 to 12 inches in diameter and in continuous a length up to 6 feet while simultaneously renewing a connection and the lateral service pipe. The liner can be inverted anywhere in the pipe with no trimming or cutting. The result is a structural, root proof, water-tight liner. Gasket sealing technology is used at the terminating points of the liner by embedding seals made of hydrophilic material between the liner and the host pipe to ensure a water-tight seal.

**3. MANHOLE ADJUSTMENT RINGS**
Manholes have traditionally been adjusted to final grade using brick, block and precast adjustment rings. Alternatives to these construction materials have entered the market over the years and the most recent to do so is an adjustment ring system manufactured from expanded polypropylene (EPP). The EPP material provides for the most advanced concrete-alternative manhole and catch basin grade adjustment system available today. EPP is renowned for its exceptional strength to weight ratio, durability, chemical resistance and long service life under harsh conditions. Available in round, square and rectangular shapes, one worker can install the EPP grade ring system in just minutes to within a quarter inch of finished grade without the use of mortar or shims. The rings are HS-25 traffic rated, are watertight, and, where concrete rings break and may cause injury, the EPP system eliminates the hazard, helping minimize the risk of injury. The EPP system dramatically speeds manhole installation or repair time and increases the life expectancy to 50 years or more.

**4. NEW MANHOLE LINING SYSTEM**
This new hybrid epoxy manhole lining system with high chemical resistance, offers over 250 times the chemical resistance of calcium aluminate and is 200 times more chemically resistant than pure fused calcium aluminate, according to a study conducted by Florida Atlantic University, July 2016. In addition, the product incorporates a formula that contains a broad-spectrum, highly effective antimicrobial agent that has been clinically tested and has been shown to react with key proteins in a microbe's outer membrane, blocking the transfer of necessary nutrients into the cell.

It can be effectively used as a re-surfacer and liner in a single, simple application. It has been in development for over five years, for use in the wet, humid conditions typically found in manhole environments.

**5. SPIN CAST AND INFUSION PIPE LINING FOR WATER PIPELINE REHABILITATION**
State of the art SIPP pipe lining technology including automatic robotic application, manual operation, remote control, remote monitoring, fail safe shutdown. Infusion CIPP lining includes s-glass and/or carbon fiber liners, extreme strength and performance, rapid installation, return to service and seamless/jointless fabric installation in conjunction with structural epoxy systems, flexible epoxy systems, potable water epoxy systems, BPA Free epoxy systems incorporating the safety characteristics of epoxy systems.
The MACP was developed by NASSCO as a complement program to the PACP but specific to manhole inspection. MACP is a standardized inspection coding and data management system that makes it possible to benchmark manhole conditions which can then be evaluated and compared from one point in time to another and be consistent from one utility to another across the entire United States and the world.

The goal of the PACP standardized coding system is to create a comprehensive and reliable reservoir of data to assess a sewer pipeline, which data can subsequently be used for the prioritization, planning, and renovation of wastewater collection systems. Data collection software has become an integral part of pipeline assessment. The new PACP certification requires that all software programs import from, as well as export correctly to the exchange database. Testing is also done to make sure all defect code requirements are used correctly.

A number of software vendors have been certified to these standards. No changes can be made to the code standard or fields required for PACP. The CCTV operator is prompted when entering a code to enter required information and if he or she should enter the information incorrectly (i.e. use the wrong percentage for a defect) he or she is prompted to correct it before the defect can be saved. At the user’s option, the PACP picture used as a reference in the manual for the code can be produced within the survey for comparison before saving. The score values assigned to the defects are used to create a score report evaluating the selected pipes and ranking them based on score total. The PACP quick rating is displayed on the report.
The LACP has been launched by NASSCO as another complementary program to PACP, but specific to lateral pipeline inspection. LACP is a standardized inspection coding and data management system that makes it possible to benchmark lateral conditions which can then be evaluated and compared from one point in time to another; and be consistent from one utility to another across the entire United States and the world.

LACP codes are based on the PACP program codes with new codes developed specific to lateral pipelines.

Over the last several years municipalities and engineers have asked for additional training, particularly training that is applicable to pipeline and manhole rehabilitation technologies.

In response, NASSCO developed ITCP for cured-in-place pipe installation and for manhole rehabilitation, the first two of a number of pipeline renewal technology programs being developed by NASSCO.

This training is intended for consulting engineers who provide inspection services, municipal engineers who perform inspection on their projects, inspectors who are onsite inspecting the project, and all who need a comprehensive understanding of the cured-in-place pipeline renewal technology and installation inspection requirements.

The ITCP courses cover specific areas of expertise that are needed to ensure that a rehabilitation project is built correctly and meets the requirements of the contract documents.

The course includes 1-1/2 days of technology and specification information that the inspector needs to know. It also includes a detailed and illustrated reference manual and sample forms which can be used by the attendee as the basis for recording information on the project site. The forms, provided within the reference manual, have specific quality assurance/quality control requirements for the CIPP technology, the inspection procedures required, and the information which needs to be documented for a complete inspection record.

Each course attendee is required to pass an open book exam which demonstrates their basic knowledge of the specific technology. Upon completion of the training program, the attendee receives a certificate and an inspector identification card, confirming that he/she has successfully completed ITCP for either cured-in-place pipe or manhole rehabilitation.
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