TOTAL ASSET AWARENESS
Focusing on asset integrity management
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INVESTING FOR GROWTH

Aegion invested in future growth in 2016—the largest of which was the acquisition of Underground Solutions. In addition to our Tite Liner® high-density polyethylene (HDPE) lining system, Insituform® cured-in-place pipe (CIPP) and the Tyfo® Fibrwrap® fiber-reinforced polymer system, we can now offer Fusible® PVC pipe to customers for pipe bursting and horizontal directional drilling pipeline applications.

2016 was a tough year for the energy industry, and while we certainly felt the impact in our upstream technologies and services, we did relatively well in the midstream markets. In addition, we finished the last half of the year very strong with maintenance and turnaround work in the downstream markets.

We continue to focus on sharing technical expertise and working together to advance our product and service offerings. We have regular teleconferences and technology review meetings to review R&D projects and identify opportunities to SOLVE PROBLEMS and BE BETTER.

VALUES

Our values are core to defining who we are as a Company. They bind us together. We are committed to safety and believe that ZERO INCIDENTS ARE POSSIBLE, you can trust us to DO WHAT’S RIGHT, we work every day to SOLVE PROBLEMS, we are accountable and recognize that RESULTS MATTER and we constantly strive to BE BETTER. We are also employing The Aegion Way, our method to live these values through continuous improvement. These are not just words—they are guiding principles that define how we treat each other and our customers.

We are making the transition to one company with one culture. Our people work together to support all. This includes not only those with scientific and engineering expertise, but also our sales teams and administrative departments.
2016 BROUGHT SOME MAJOR ACCOMPLISHMENTS

Broadening our expertise

• We continue to hire and expand our staff with great people. The Corrosion Protection platform hired more than 75 engineers, specialists and technical service personnel in 2016.

• Professional development is key to our success. In 2016, 13 of our people become licensed Professional Engineers.

• Aegion has well-established relationships with our technology partners to stay abreast of new materials and emerging technologies. Our list of technology partners and resources grows each year.

• We continue to be active in developing industry standards, serving on technical task committees, presenting at conferences and publishing articles in technical journals.

• The Energy Services platform received Tesoro’s highest recognition at its inaugural awards ceremony. The Supplier of the Year award was received based on Energy Services’ outstanding performance and additional support provided to Tesoro on key refinery activities.

Corrosion Protection platform innovations

• We developed a laser tool to enhance the profiling of internal girth welds for inspection prior to coating with our robotics technology.

• The construction of an advanced pipe coating facility was completed, enabling the application of a new high-temperature corrosion and flow assurance insulation coating needed in deepwater Gulf of Mexico.

• The new C Gate project management tool tracks cathodic protection and alternating current (AC) interference mitigation surveys and designs for new pipeline construction.

• A new “hot spot” system helps protect water pipelines from external corrosion at point repairs.

• We introduced the new LinerWatch™ system to monitor liner integrity and transmit data to Aegion’s asset integrity portal platform for real-time monitoring of pipeline data.

Infrastructure Solutions platform innovations

• Our team reengineered the Tyfo® Fibrwrap® system for enhanced performance at lower cost.

• Progress was made in 2016 to develop a Tyfo® Fibrwrap® carbon fiber CIPP solution for rehabilitation of small-diameter pressure pipelines.

• We successfully completed a field test to validate an innovative design that protects infrastructure from the blast effects of a close-range bomb.

• We implemented the newly improved InsituMain® CIPP for pressure pipe rehabilitation on several projects. These improvements include new liner materials and resins to increase strength and constructability and provide a watertight, pressure-rated end termination.

We want to thank all members of the Aegion team who work every day to practice our values and reach our goals. Most importantly, we want to thank our customers for their continued support.

Sincerely,

David Kroon, P.E.
Chief Technical Officer
Aegion Corporation
COATING PLANT BEGINS FULL PRODUCTION ON NEW THERMAL INSULATION SYSTEM

by Randall Perkins

Our new Advanced Coating Systems plant opened in late 2016 and is now in full production of the ACS™ HT-200 thermal insulation system. This new subsea wet thermal insulation system is rated to 205 °C (400 °F). The plant coats 80-ft. pipe joints with a liquid-applied anticorrosion coating using a fully automated process. Insulation is then applied to the coated joints in the same facility. A final abrasion resistant topcoat is applied over the insulation to achieve a tough, effective solution that answers the challenge of subsea wet insulation requirements of high-pressure and high-temperature environments. The ability to mold insulation on 80-foot sections saves on field joints and reduces extra handling of the insulated pipe. The selection of a liquid coating for an entire pipeline is economically and logistically feasible because of this ability to apply liquid anticorrosion coatings in a fully automated environment. Protecting the pipeline, its product and the environment (wet or dry) are top priorities for corrosion prevention, but surface preparation is the foundation of applying protective coatings, both in the factory and the field.
A MILLION HOURS
by Todd Brabson
The basis of Aegion’s core values is ZERO INCIDENTS ARE POSSIBLE. Aegion’s Corrosion Protection platform in the Middle East embodied that value in 2016. The Middle East team surpassed one million hours worked without a recordable injury in December 2016. While this was accomplished in part because of their commitment to ZERO INCIDENTS ARE POSSIBLE, it was also driven by proactive safety management. The team focused on management commitment, employee involvement, hazard assessment and training. This proactive approach to safety allowed the team to complete nearly 1,200 leading indicator activities, almost 850 action items more than their original goal!

AEGION’S INFRASTRUCTURE SOLUTIONS PLATFORM TAKES TOP HONORS
by Jayne Shepherd
Trenchless Technology magazine, the premier publication of the trenchless industry, recently acknowledged Aegion with two Project of the Year awards.

The Indian River HDD Crossing project was awarded New Installation Project of the Year. The project set new standards by which electrical conduit is installed underground by using Fusible PVC® pipe and HDPE pipe. Parallel sections of 7,000-foot-long 32-inch diameter Fusible PVC® pipe was installed under the Indian River using the intersect method by the Mears Group. Each Fusible PVC® pipe casing housed four 10-inch and two 3-inch HDPE conduits in a specially formulated thermal grout/slurry. The casing installation is the longest thermoplastic HDD installation of any diameter to date. At approximately 385 tons per casing, this was the heaviest single installation of Fusible PVC® pipe ever.

The Eldorado Springs Canyon Pressure Pipe Rehabilitation project also received recognition as the runner-up for Rehabilitation Project of the Year. This project involved the installation of 1,200 lineal feet of the InsituMain® CIPP system, a cured-in-place pipe product for pressure applications, in a degrading raw water main along the side of a mountain in Colorado. Completed in the middle of winter, the project overcame logistical challenges while meeting the demands of the pressurized system.

Awards were announced during a live webinar on the inaugural World Trenchless Day on Thursday, September 22, 2016, and recipients are set to be honored at the 2017 No Dig Show in Washington, D.C.
Aegion employees take pride in ensuring our customers are satisfied with our products and services. One of our core values is BE BETTER—we never settle for the status quo, and we strive each day to do better and to be better.

A consistent customer feedback process was implemented across North America in 2016 to provide our customers with an opportunity to provide feedback on every project. A customer satisfaction survey is sent electronically near the time of project closeout, and results are routinely monitored by Aegion’s leadership.

Benchmarking customer satisfaction with our performance is a critical component of The Aegion Way. Because RESULTS MATTER, another Aegion value, we have implemented a monthly score card to track the new customer feedback process.

There are four categories of questions on the survey. The score card displays the results for each category, the survey return rate and the net promoter score. The net promoter score is an index ranging from -100 to 100 that measures the willingness of customers to recommend a company’s products or services to others. It is used as a proxy for gauging the customer’s overall satisfaction with a company’s product or service and the customer’s loyalty to the brand.

The category of executing the work asks the customer to provide specific feedback on safety measures and jobsite conduct because we know ZERO INCIDENTS ARE POSSIBLE. Safety is our top priority, and every Aegion employee is expected to deliver best-in-class safety performance at all times.

Now that the process is in place, each company is taking initiative to SOLVE PROBLEMS. Corrective actions are initiated when necessary to prevent recurring issues. We support our customers’ success by understanding better than anyone how to identify and solve problems.

All of these continuous improvement actions are an effort to DO WHAT’S RIGHT. Honesty, integrity and respect guide our decision-making, our actions and our relationships with our customers, stockholders, colleagues and communities. Doing what’s right—day in and day out—ultimately translates into higher-quality products and services.
Aegion inspects over 25,000 miles of pipeline each year. The number of miles we survey and the massive amounts of data these activities generate is unmatched in the industry. With 30 years of operational data and offices all over the country, the amount of data we have accumulated is extraordinary. Aegion assembled a team of technologists in 2016 to implement an advanced platform to better manage both legacy and current survey data. This improved management will allow us to better serve our clients. **Our goals for the project were simple:**

1. Better manage client data through the development of a GIS-based central repository
2. Extract more information from the data we collect through advanced visualizations and analytics
3. Provide faster, secure reporting to our clients

The result is a scalable framework collectively called the Aegion Asset Integrity Management (AIM) platform. This secure platform leverages technology from Esri, Microsoft and Amazon Web Services to provide internal and external services using the data we collect and manage. Initially focusing on corrosion protection, data from close interval surveys (CIS) is being input into the system. A parallel effort for annual cathodic protection surveys will begin in 2017.

**ONLINE ACCESS**

The Asset Integrity Portal, the online component of AIM, provides direct customer access to pipeline integrity information, including a variety of reports, tabular data and geospatial datasets. The portal also features analytical applications that leverage Aegion’s engineering knowledge and expertise and provide a comprehensive set of asset integrity tools, transforming data into information that is used to analyze and solve problems.

The result is better and faster decision-making with increased confidence that resources are being allocated intelligently—where they provide the greatest results.

**ANALYTICAL APPS**

The Asset Integrity Portal framework was established around several analytical apps that our customers can use to interrogate their data. As the platform grows, new special purpose apps will be developed and added to the platform. The first app is FieldLine™ and will be used for select customers in early 2017. Others, including LiveLine™ and ScanLine™, will soon follow to provide additional services and capabilities.

- **FieldLine™** provides quick access to survey inspection data in the form of a job summary or map visualization. Simple search tools help users quickly access data and then output it in a variety of formats for easy loading into other systems.

- **LiveLine™** provides real-time visualization and streaming analytics for monitored points on a pipeline. With alerts and notifications, users are automatically and continuously kept informed of key metrics at each location.

- **ScanLine™** provides an interactive charting and analytical tool for viewing current and historical CIS data at specific points along a pipeline segment.

More apps will be coming in the future to provide additional services and capabilities. Customers will not only be able to get to the raw data collected by our surveyors and CP technicians, but will also have access to powerful analytical apps to help them be more efficient in their everyday work.

**INVENTIVE NEW WORKFLOWS**

The AIM technology platform and the Asset Integrity Portal are helping Aegion leverage its world-class engineering and remediation capabilities to create new workflows and improve existing ones. Through this new technology, an automated process was created to analyze potential AC interference on pipelines. Our engineering professionals use this information to create full lifecycle pipeline integrity programs, including corrosion prediction, risk modeling and trend analyses.
ACCA PIPELINE COATING ASSESSMENT

by Steven Brannigan

Corrpro was recently asked by Rotterdam Antwerpen Pippleiding (RAPL) to perform an ACCA (alternating current/current attenuation) and depth survey followed by a close interval survey (CIS) and direct current voltage gradient (DCVG) survey to assess the overall coating condition, pinpoint and size any coating faults and then assess their influence on the cathodic protection potentials as well as the effectiveness of the pipelines’ cathodic protections systems.

The RAPL pipeline grid consists of two pipelines: a 30-inch diameter spur line and a 34-inch diameter mainline. Both coal tar-coated and in service since the late 1960s, the pipelines run 4.5 miles and over 63 miles, respectively.

The ACCA technique provides a qualitative assessment of the pipeline coating quality independent of ground conditions, as long as they are magnetically transparent (e.g., dry earth, snow, ice, concrete, water, tarmac, etc.).

The assessment began with the application of a 4Hz AC signal between the coated pipeline and a remote earth. The signal flowed along the pipeline in both directions, decreasing in magnitude as the signal leaked to earth through the pipe coating. If the coating had a uniform dielectric strength and was electrically isolated from the pipe metal in the surrounding earth at all points, the strength of the signal current on the pipe attenuated according to a logarithm. If holidays were present, the current attenuated more rapidly. The strength of the AC signal that remained on the pipeline was then determined at discrete points along the pipeline. Finally, standard mathematical formulas were used to calculate the rate of attenuation for each surveyed section.

Survey results were presented in tabular format and plotted as an average attenuation in millibels (mB) [1 decibel (dB) = 100 millibels (mB)] per unit length (mB/m or mB/ft). Expressing the current attenuation results in mB per unit length allowed the comparison of the coating quality of different pipeline sections.

The coating condition was evaluated by assessing the current attenuation magnitude and interpreting the current attenuation plots. The interpretation of the plotted results by assessing the magnitude of the current attenuation enabled the location of sections with poor coating condition. This indicated the possibility of coating faults present in that section, direct metallic shorts and current discharge or pickup areas to foreign structures. A more detailed investigation could then be carried out in the identified sections with complementary techniques like alternating current voltage gradient, DCVG or CIS.

During the ACCA survey, the pipeline center depth and all the measurement location coordinates and points of interest were recorded using a handheld GPS device. These GPS coordinates were later used for chainage calculation and to create a Google Earth map with the pipeline route, test post locations and measurement locations layers.

The ACCA and pipeline depth survey were completed in fall 2016 with the second phase of the DCVG and CIS campaign starting at the end of November 2016. A comprehensive report cross-referencing the results of the ACCA, CIS and DCVG recommendations along with prioritization of the coating repairs and cathodic protection system effectiveness will be issued.
THOROUGH FIELD ASSESSMENT OF PIPELINE AC INTERFERENCE SAVES MONEY

by Vera Kustova

Aegion continues to be a prime mover providing detection, engineering and other turnkey solutions for alternating current interference mitigation (ACIM). With over 20 engineers dedicated full-time to this highly technical aspect of corrosion control, Aegion is an active participant in the development of related standards and industry-sponsored research.

Our AC mitigation solutions are practical and save money for our customers. A typical project example relates to an extensive AC mitigation system for a 40-mile-long section of a dual-high pressure natural gas transmission pipeline, previously recommended and designed by another engineer. Awarded to Aegion following a competitive bid process, the design basis included substantial computer modeling with little real-world pipeline data. Based on a peer review of the earlier work, our engineers devised a comprehensive field evaluation plan and coordinated with power companies to determine the existing and projected AC threats—culminating in the development of a suitable long-term AC mitigation and monitoring strategy.

The final recommendation based on our extensive analysis of the field data we collected was to install cost-effective mitigation equipment along with enhanced monitoring, including remote surveillance, in just a few of the many areas previously recommended. All of this was well received by our client and completed at a fraction of the anticipated installation and operating and maintenance cost.

The AC mitigation installation exclusively relied on Aegion’s in-house construction staff, project management personnel and equipment including parallel mitigation conductors, deep ground mitigation, equipotential gradient control mat arrays for personnel electrical safety and test stations. The varied right-of-way included agricultural fields, pastures, urban areas, wetlands and two horse racing tracks. Safety, landowner coordination and routine communication with stakeholders were paramount to a successful project.

SOLUTION PROVIDES CATHODIC PROTECTION ON EXISTING ABOVEGROUND STORAGE TANKS

by Jeffrey Delorme

The protection of aboveground storage tank (AST) bases from external corrosion is an important aspect of cathodic protection. However, this aspect also presents many challenges. Various distributed and remote under-tank cathodic protection systems may be installed within the tank foundation or remotely from the tank. When it is desirable to protect an existing tank with a non-permeable membrane installed below the foundation in close proximity to the tank base, complications from proximity and inadequate current distribution often arise. This non-permeable membrane prevents the installation of remote or directionally drilled semi-distributed anodes.

Retrofitting existing tanks built upon non-permeable membranes is a developing area with little data supporting the viability of the proposed solutions. This presented the unique opportunity to study and quantify the complications related to current distribution. With the existing monitoring equipment, it was possible to ascertain whether or not adequate cathodic protection is being provided to the entire tank base.

Our Canadian operation was recently tasked with developing a solution to protect an in-service AST in western Canada. This storage tank was approximately 65 feet in diameter and was installed on a 3-foot-deep sand and gravel foundation over an HDPE liner. Existing under-tank monitoring equipment provides various means of obtaining under-tank structure-to-soil potential measurements. The proposed solution consisted of five CorrFlex® impressed current linear anodes installed concentrically around the perimeter of the tank. Within the same trench, a continuous ring of slotted 2-inch PVC pipe with Nilex™ filter sock was installed adjacent to the anodes, providing a means of distributing volatile corrosion inhibitor as a contingency option.

Structure-to-soil potential data indicates that adequate cathodic protection was achieved throughout the entire cross section of the 65-foot tank. This solution is contrary to conventional current distribution design approaches and provides an economical option for achieving cathodic protection on existing aboveground storage tanks installed over dielectric liners.
MAGNESIUM ANODES MANUFACTURED IN CHINA PROVIDE CATHODIC PROTECTION IN OFFSHORE APPLICATION

by Steven Pease

Supplier consistency and quality is paramount, even with commodities such as magnesium anodes. A project valued at approximately $2 million (USD) was secured in 2015 to supply more than 2,500 magnesium anodes, each weighing almost 170 pounds. Mounted on mild steel sleds, the anodes would provide cathodic protection for an offshore platform in the North Sea located off the coast of the United Kingdom.

Audits were conducted to determine a supplier in China for magnesium anode casting facilities. These audits primarily assessed quality management systems and established if any facilities were capable of casting the large number of anodes and delivering them to the United Kingdom by the end of March 2016.

Tianjin Dongyi Magnesium Products facility in Xiaoyi City, Shanxi, China, was audited in mid-December 2015 and was found to have excellent facilities, full ISO 9001:2008 certification and the necessary manpower and capacity to cast the requisite anodes within the required timeframe. Another anode facility in China was also audited and determined to also have excellent facilities and full ISO 9001:2008 certification.

After extensive evaluation of the two facilities, Tianjin Dongyi Magnesium Products was given the order and manufacture commenced in early January 2016.

After a visit to inspect the first batch of anodes, manufacturing progressed and anodes were supplied in container loads of 120 anodes each. Aegion’s commitment to using ISO-certified manufacturers helped ensure quality and timely delivery. Final delivery was received in the United Kingdom on time.
Recently, Aegion completed a project for the design, supply, installation and commission of an impressed current cathodic protection (ICCP) system for over 240 nos. of driven H-piles. During the upgrading project for a government sewage treatment works, it was determined that one of the treatment tanks near seawater uses a deep foundation, which is supported by 242 pieces of large driven H-piles. These 12-inch square H-piles, roughly 150 lbs/ft universal bearing piles, are an average length of about 150 feet and are spaced between 6.5 and 16 feet from each other. To achieve a facility design life of 100 years and prevent the undue corrosion of the steel piles, an ICCP system was adopted to provide a cost-effective solution.

In the design stage, special considerations were taken in light of several specific project constraints:

- Increased current requirement due to large total surface area of the piles and assumption of bare surface exposed to corrosive environment
- Congestion of piles
- Adjacent metallic objects near the H-piles that may be affected by stray current
- Allowance for maintenance and replacement

After considering the factors above, an open-hole deep anode groundbed was adopted with an MMO anode placed in 32 holes at the same depth as the piles. The holes were distributed inside the pile caps to achieve a more even current distribution and terminated on the top of the tank structure to facilitate future inspection and/or replacement of anodes, if required. The whole ICCP system was powered by a total of seven transformer rectifiers. To mitigate the current interference to adjacent objects, stray current mitigation measures using bonding cables were adopted. Finally, performance of the ICCP system was monitored through silver/silver chloride and zinc reference electrodes installed at representative locations.

The ICCP system for the piles was commissioned in late 2015. The commissioning criteria was consistent with internationally recognizable standards, including EN13174:2001 and NACE SP0169-2007, with results showing the ICCP system performing satisfactorily.
GOING TO GREAT HEIGHTS TO PROTECT OUR CLIENT’S INFRASTRUCTURE

Aegion’s Corrosion Protection inspection group consists of NACE and SSPC trained coatings inspectors who will go just about anywhere to inspect a coating application project. One of our more interesting assignments was a recent overcoat painting project atop antenna towers.

SPECIAL CONSIDERATIONS

The towers are approximately 1,000 feet tall and have been in place for decades. Because there is no miracle paint product that will last forever, maintenance painting is necessary to protect the integrity of the structures from corrosion. The structures are located in a marine atmosphere in close proximity to the Atlantic Ocean and require chloride contamination testing and remediation.

The color scheme for these antennas is set by FAA guidelines due to their height. White and orange are alternated every 100 feet, adding a level of complexity to the project.

PROJECT EXECUTION

The general scope of work began with pressure washing the entire structure to remove any dirt, dust, chalk residue or loose paint from the old existing coating. Power tool cleaning and feathering off of all chipped areas was required in areas where old paint was removed. Two coats of primer were then applied to those areas prior to application of the appropriate colored topcoat.

Accessing all points on these towers required personnel to take a specialty tower climbing safety class. Additionally, specific safety harnesses and other related equipment were required. In line with Aegion’s value, ZERO INCIDENTS ARE POSSIBLE, safety on this project was paramount and the necessary safety equipment was provided.

The work, which began at the top of the structures and moved downward, was inspected at each step of the process. This required many trips up and down the towers. A winch system was required to bring personnel, equipment and coatings products up the exterior of the towers. This winch system delivered a basket with materials and personnel to permanent platforms at various levels of the structures. The platforms were helpful, but the limited number required extensive climbing between them to get close enough to inspect all areas being prepared and coated.

Throughout the project, daily inspection reports documenting every aspect of the work along with photos to show compliance with project specifications were generated. These reports were provided to the owner along with all other documents generated during the process throughout the duration of the project.

The building in the foreground is a six-story building.
PROTECTING WIND TURBINE TOWERS

Wind turbine towers can be found all over the globe. As with all steel structures exposed to the elements, corrosion will eventually take over and degrade the structural integrity of the tower if no protective coatings are applied to form a barrier between the steel structure and moisture. Aegion’s Corrosion Protection platform’s coatings inspection group was onsite to inspect the complete removal of existing coatings on the exterior of a 178-foot-tall turbine tower and perform spot repairs on the inside of the tower. The tower is owned by a wastewater treatment plant that uses the generated electricity to help power the facility. The owner of the tower realized the added benefit of having an Aegion NACE certified coatings inspector onsite each day to ensure all aspects of the project were carried out by the contractor according to the specification. The added cost of an onsite NACE certified coatings inspector was minimal.

The tower consists of a concrete foundation with three separate sections that were hoisted by crane and bolted together on the inside of the structure. The structure has a tapered shape, with a 13-foot inside diameter at the base and an 8-foot inside diameter at the top. To access the entire exterior, scaffolding was installed from the ground to the top of the tower. A containment system was then installed around the scaffolding, forming a sealed work area to prevent any paint chips and other debris from escaping the work area during abrasive blasting. This process also removed the old coatings and rust. The scaffold and containment structure was engineered and designed with specific wind load ratings to both ensure the safety of the workers and prevent more stress on the tower than it was designed to tolerate.

The scope of work consisted of the following:

- Blast clean the outer surface according to SSPC-SP10/NACE No. 2
- Near white blast cleaning followed by a zinc-rich epoxy primer
- Epoxy stripe coat to all welds and connection seams
- Full epoxy intermediate coat
- Full polyurethane topcoat

The interior of the structure also needed repairs in many locations. The interior of the structure had multiple cables and an array of electronic equipment inside. This required using vacuum-shrouded power tool cleaning to repair this area. Wrapping of all electronic components in plastic was also needed to protect the equipment from paint chips and other debris prior to cleaning and painting.

Two coats of the same epoxy used on the exterior were applied to the interior. The blasting work prior to applying this coating started at the top of the tower. At the end of each blasting day, the primer was spray applied to all cleaned surfaces to ensure no flash rusting occurred overnight. It took several days to complete the blasting and priming work. The stripe coat was then completed by brush and roller, ensuring the product was worked into the segment seams as well as on the weld seams. Finally, the full epoxy and polyurethane coats were spray applied, resulting in a smooth and shiny appearance.

Every step of the process was documented by Aegion’s NACE certified inspector. This includes measuring the thickness of each coat applied and making sure any rework was completed prior to the next step. All inspection reports, as well as photographs taken, were included in a project binder and given to the owner at the end of the project. It is expected that this coatings rehab project will extend the life of this tower for at least 30 years.
Aegion has been providing turnkey cathodic protection services for a major chemical facility being constructed in southwestern Louisiana since 2015. Once completed, the $5 to $7 billion facility is expected to produce 1.5 million tons of ethylene per year. Cathodic protection systems will protect aboveground storage tanks and buried steel process piping. The project currently consists of 16 units that are being designed, built and operated by independent teams. Aegion’s cathodic protection group has been tasked to satisfy the requirements of each of these teams while working through the main front-end engineering design contractor.

Currently, this project consists of the following major components:

- 87 impressed current cathodic protection (ICCP) systems
  - 54 external bottom systems for aboveground storage tanks
  - 15 internal systems for aboveground storage tanks
  - 18 external pipe systems
- Monitoring system including test station and soil access locations

The design approach within each unit is to electrically isolate the underground piping from foreign structures using flange insulation kits while creating an electrically continuous piping network using strategically placed pipe bonding stations. This unified piping network within each unit is protected by a combination of sacrificial anodes and ICCP systems.

Some ongoing project challenges include:

- **Change management** – As project requirements evolve, we must react swiftly and accurately.
- **Concurrent construction** – Simultaneous design and construction of several units has been addressed by strategic deployment of Aegion’s engineering and construction resources.
- **Project size** – The size and scope of the project requires that we maintain a full-time site presence including site superintendent, construction crews and quality assurance personnel.
- **Non-uniform electrolytes** – During both the tank bottom and underground piping CP design phases, non-uniform electrolytes were encountered. Varying sand backfill sources and the use of flowable concrete pipe backfill in certain areas were addressed by Aegion’s subject matter experts. Where warranted, design recommendations and commissioning practices were altered to address the use of several backfill materials.

In addition to the technical challenges of this project, Aegion’s core value of **ZERO INCIDENTS ARE POSSIBLE** has been top of mind. Roughly 20,000 hours have been worked on the project with zero lost time or recordable incidents. Corrosion Protection platform President Greta Voss added,

“The work being done on this project is not only significant to Aegion, but also provides an opportunity to demonstrate to our customers our ability to consistently deliver quality project results—safely and on time.”
Thousands of pipelines dramatically expedite the process of oil transportation by making it both quicker and cheaper. In fact, many argue that pipelines are the safest means of transport available. However, some risk is associated with operating pipelines from events that may occur due to the effects of corrosion and the challenges of managing this process.

Corrosion occurs when materials made from metal return to their original state through a chemical reaction known as oxidation. Corrosion is accelerated when the pipe wall is exposed to water and contaminants such as O₂, H₂S, CO₂ or chlorides. Unresolved, internal corrosion can cause gradual reduction of the wall thickness of a pipe, resulting in the loss of pipe strength, leading to overpressure events, leakage or rupture of the pipeline due to internal pressure. Events like these can result in undesirable regulatory actions and litigation against pipeline operators.

Effective strategies can be implemented to deter corrosion and prolong the service life of an owner’s asset. The traditional strategy most often implemented is the ongoing chemical treatment of the products moving inside a bare steel pipeline using corrosion inhibitors, biocides or anti-scaling chemicals. Corrosion inhibitors can act as a barrier between oxidizing agents and a metal surface. The inhibitor adsorbs onto the steel surface and slows down the electrochemical reaction by blocking the reaction site. The degree of protection that a corrosion inhibitor provides is heavily dependent on the properties of the inhibitor, the properties of the steel and the fraction of the surface covered by the inhibitor.

Coating the bare steel on the outside of the pipeline has been standard practice for decades, but coating the inside of the pipeline has been somewhat ignored. However, internal coatings are receiving more recognition and are proving to be a more effective and cost-efficient strategy compared to just chemical treatment. Owners who elected to apply a coating to the inside of their pipeline have experienced reduced operational costs versus a chemical treatment strategy. Internal coating has been difficult to adopt in the past due to the unavailability of adequate coating materials and the inability to coat the internal field joints during construction. These barriers no longer exist, clearing the way to use coatings as a primary corrosion strategy for a pipeline interior.

In a recent NACE International IMPACT study, the global cost of corrosion was estimated at $2.5 trillion (USD), with an estimated savings of 15 to 35 percent with the use of available corrosion control practices. The study further explains the relationship between the design/construction group’s focus on meeting or beating capital expenditures (CAPEX) and corrosion maintenance operations:

“... Often the operations group is not consulted for corrosion design considerations. This group can provide valuable input for the long-term cost effectiveness of an asset because they see the problems, but this input is not always heard and can conflict with the management objectives of the project team.”

The study further explains that proper communication between design/construction and operations is crucial in order to identify areas for corrosion maintenance and to keep future costs to a minimum.

A few leading oil & gas EPC (engineering, procurement and construction) companies are now performing lifecycle cost analyses comparing using chemical treatment alone versus internal coatings with supplemental chemical treatment to better determine the total cost of corrosion over the life of the asset. Although a chemical treatment corrosion strategy costs less to construct than a coated line, the lifecycle cost, including the operational expense (OPEX) on chemical treatment over the life of the asset, is extremely high. While internal coatings cost more initially and have higher CAPEX, the OPEX is relatively low. Most studies are showing the coating expense has an ROI of less than three years and provides reduced OPEX for the remaining life of the asset due to the greatly reduced chemical spend. This yields a lower lifecycle cost than chemical treatment alone. Coatings also yield better flow characteristics and reduced friction, reducing power demands by as much as 15 percent.

Along with material selection, it is important to make sure internal field joints are coated properly during construction on the right-of-way. Aegion pioneered untethered robotic joint coating machines over 30 years ago that travel through the constructed pipeline to apply coating material to internal field joints. This technology has enabled the industry to remotely and automatically coat internal field joints for 8-inch to 60-inch diameter pipelines.

Pipelines have been around a long time, and the industry has learned a great deal about how to construct and maintain these assets. While many traditional methods are still the best known solutions, some new technologies perform better than their predecessors. An internally and externally coated pipeline with supplemental chemical treatment will provide owners with a reduced total lifecycle cost compared to chemical treatment alone. Acceptance of this solution will lead to cost savings for owners and operators alike.
CRITICAL BRIDGE RETROFIT IN HAWAII USING THE TYFO® FIBRWRAP® SYSTEM AND TYFO® FIBER ANCHORS
by Scott Arnold & Gaetano Bologna

Many bridge structures throughout the world contain significant corrosion that can lead to catastrophic failures during a seismic event or after long-term usage. For the hiihilauakea Bridge on the island of Oahu, Hawaii, accelerated degradation due to a corrosive marine environment and significant aging had increased the need for rehabilitation. A bridge inspection report from February 2012 stated if repair could not occur within the year, “load restrictions or even complete closure of the bridge may become necessary.” As a vital link on the island’s main highway, long-term shutdown was not an option. Replacement was not possible either because the bridge was designated as a historic structure.

Before the Tyfo® Fibrwrap® system installation

Several different repairs had to take place for this complex and extensive rehabilitation. Some traditional concrete repairs, including crack injection, concrete removal and replacement, were necessary along with steel treatment and/or replacement in some cases. Once the reinforced concrete repair work was completed, the bridge required additional strengthening as directed by the engineer of record. The Tyfo® Fibrwrap® system, installed by Aegion crews, were used to supplement both longitudinal and transverse steel reinforcement.

The complex geometry required unique detailing and anchorage using Tyfo® fiber anchors. At the arch rib locations, strengthening was required in the longitudinal direction equivalent to two grade 60 #8 rebar along the inside and outside faces. Similarly, transverse strengthening equivalent to grade 60 #4 rebar spaced 3 inches on center were required. For the columns, cross struts, transverse beams and cantilevered beam ends, strengthening equivalent grade 60 #4 rebar at 3 inches on center was required in the transverse direction. At the soffit, tension equivalency to 40 grade 60 #6 bars were required, and fiber anchors provided continuity through the existing beams.

Some of the features of the Tyfo® Fibrwrap® system are as follows:

• High strength comparable to that provided by traditional steel reinforcement
• Long-term and durable solution
• Low profile doesn’t change geometry of structure
• Relatively quick and non-intrusive installation allows for continued vehicular and pedestrian traffic during the installation
• Proven track record – The Tyfo® Fibrwrap® system has been used successfully on thousands of civil infrastructure projects
• Lightweight system does not affect the seismic weight of the structure
• Cost-effective alternative to traditional seismic rehabilitation methods

Bonding to sound substrate is necessary when utilizing advanced composite materials in design and construction. Despite the majority of the project involving contact critical (full-wrap) applications, other locations were bond critical and required more aggressive surface preparation and mechanical anchorage to ensure the longevity of the design. After the surface prep was completed, locations to receive the Tyfo® fiber anchors were marked and predrilled. Upon completion, epoxy was then mixed onsite and a prime coat that had been applied to the substrate was allowed to become tacky to the touch, before a thin coat of thickened epoxy was installed to ensure the proper application of the precut and pre-saturated sheets.

Continued next page →
Aegion has been involved in lining pressure pipe systems for decades through engineering, manufacturing and installing solutions that improve the lifespan of the existing pipeline. This array of solutions spans Aegion’s Infrastructure Solutions and the Corrosion Protection platforms.

Over the past few years, Aegion has built a pressure pipe portfolio unparalleled in the industry through research and development as well as external acquisitions. These solutions now allow Aegion to respond to almost any pressure pipe need—whether it be for a municipal agency, industrial environment or power generation plant.

Below is a brief snapshot of each product:

- **InsituMain® glass reinforced cured-in-place pipe**
  - Diameter range = 6 inches to 96 inches
  - Maximum operating pressure = 250 psi
  - Applications – potable water, wastewater raw water, fire suppression, industrial/nuclear

- **P3 carbon reinforced cured-in-place pipe**
  - Diameter range = 6 inches to 12 inches
  - Maximum operating pressure = 250 psi
  - Applications – fire suppression, industrial/nuclear

- **Tite Liner® tight-fit HDPE system**
  - Diameter range = 2 inches to 52 inches
  - Maximum operating pressure = 250 psi
  - Applications – potable water, wastewater, raw water, fire suppression, industrial, electric

- **Tyfo® Fibrwrap® carbon or glass hand-applied reinforced polymer system**
  - Diameter range = 30 inches and greater
  - Maximum operating pressure = 450 psi
  - Applications – potable water, wastewater, raw water, fire suppression, industrial/nuclear

- **Fusible PVC® pipe**
  - Diameter range = 4 inches to 36 inches
  - Maximum operating pressure = 305 psi
  - Applications – potable water, wastewater, raw water, fire suppression, industrial, electric

A three-year inspection was performed in October 2016 in order to assess the retrofit, given its exposure to the aggressive marine environment. The only noticeable change to the structure was the addition of some graffiti that appeared to have the Aloha spirit. All observed areas were in excellent condition with no signs of continued corrosion.
Underground salt dome storage facilities provide a safe and efficient means of storing hydrocarbons. The corrosion and abrasion issues related to handling brine, however, create integrity challenges that impact operational reliability and cost. A recent project to replace a brine handling system allowed Pemex to permanently address corrosion and abrasion issues.

The Tuzandeptl Strategic Hydrocarbon Storage Center (CAE-Tuzandeptl) is an underground salt cavern storage facility that uses brine to receive, store and deliver excess crude oil production. The facility plays a vital role in providing Pemex with operational flexibility. It consists of 12 underground caverns with a 7.1 million barrel storage capacity and 2 brine dams with a holding capacity of 12 million barrels. When crude is deposited into the caverns, brine flows from the caverns to the brine dams. The reverse occurs when crude oil is taken out of the caverns. A brine pumping station directs the flow of brine to and from each salt cavern, and a brine discharge system directs the flow to and from the brine-holding dams. This system is designed to displace large amounts of crude oil and brine in a short period of time, with 16-inch pipelines going to each cavern and 36-inch discharge pipelines going out.

With average sodium chloride concentrations in brine of 26 percent, the corrosion rate of carbon steel can exceed 200 mils per year (mpy) depending on flow rate and temperature. The Tuzandeptl facility was originally built of bare carbon steel with a substantial corrosion allowance to take into account the expected wall loss due to the corrosive and abrasive nature of brine used. The corrosion rate is further exacerbated by turbulence in the flow streams, explaining why a facility like Tuzandeptl would be prone to high corrosion rates. After years of operation, actual corrosion loss far exceeded the initial design of the system. This created integrity problems that started to compromise the operational reliability of the facility, requiring regular replacement of pipe sections and service disruptions due to leaks.

In seeking a solution, the reliability and integrity issues arising from internal corrosion and abrasion were first addressed with epoxy paints, high solids epoxy coatings, thick wall steel and active steel pipe replacement programs. Nonetheless, by 2012, wall loss due to corrosion had reached a critical level and more assertive steps were necessary to address the facility’s internal corrosion issues.

After analyzing various alternatives, a total thermoplastic coating system was selected as a comprehensive long-term solution. A complete reconfiguration project was launched in 2013, and the new facility was commissioned in 2016 to yield a solution that will provide Pemex with years of trouble-free operation.

**TITE LINER® SYSTEM INSTALLATION**

One of the key benefits and appeal of the Tite Liner® thermoplastic system is the ease of installation in new and existing pipelines. First, interactive, tight-fitting thermoplastic liners are custom sized so that the outside diameter of the liner is larger than the inside diameter of the host pipe. The liner pipe is then delivered to the jobsite in 45-foot sections that are thermally fused into...
long monolithic sections equivalent to the pipe section being lined, up to 6,500 feet in length.

Field installation of the Tite Liner® system is achieved by sectioning the pipeline and inserting fused liner sections. A blow-down pig and sizing plate attached to a steel cable are blown down each section of the host pipeline. The roller reduction box is used to compress the liner in order to provide sufficient clearance to pull the liner through the host pipeline. Once the liner is pulled through, the material expands and locks itself inside the pipeline providing a tight compression fit. Although the resulting inside diameter is somewhat reduced, the flow characteristics and transport capacity of the pipeline are not affected due to the smoother surface of the thermoplastic compared to bare steel.

To reconnect the lined pipeline sections, various connection methods are available, which include flanged and flangeless connections. Once the system is reconnected, the pipeline is tested and recommissioned.

ROTOMOLDING PROCESS

Rotational molding, or rotomolding, is a process where a thin layer of thermoplastic material is applied onto the interior surface of the fitting to provide a smooth corrosion- and abrasion-resistant surface. For in-plant piping, wellheads, headers and other piping systems where a straight liner pipe cannot be installed, a thermoplastic coating can also be applied through the rotomolding process. This creates a seamless one-piece, thermoplastic coating that can be applied to complex geometries, large pipe assemblies, tanks and process equipment.

During the application process, rotational-grade polymer resin in granular form is placed inside the metal fitting and heated while being rotated simultaneously about two perpendicular axes. During the heating cycle, the polymer particles melt and adhere to the metal fitting, forming a thin, uniform layer of seamless thermoplastic coating less than 1/3 inch thick. This coating thickness makes rotationally molded coatings extremely durable and resistant to abrasive wear. The metal fitting is then cooled by a combination of forced air and water mist and the part is then removed from the machine. Finally, coated end connections are machined to tight tolerances and finished to be fitted and assembled with other coated fittings, forming a complete corrosion-resistant piping system. Rotomolding is part of Aegion’s corrosion protection solutions through its strategic partnership with RMB Products, Inc., of Fountain, Colorado.

PROJECT EXECUTION

The Tite Liner® system was designed into 150 sections between 10 and 3,200 feet in length, and ranging in size from 4 to 36 inches in diameter. Engineers employed a computer-generated design to drive the fabrication, fit and installation of a complex series of pipeline spools and fittings of various sizes, where even the slightest dimensional variation could impact proper fit of the entire system. The general contractor then fabricated the steel fittings, and Aegion coordinated the fitting of the system spools and pipelines.

Because of integrity issues and continuous leakage problems, the first phase of the project addressed replacement of brine pipelines connecting the dams to the pumping station. For the second phase, 450 spool pieces were rotolined and then installed on site. Once the redesigned facility was completed, a system switchover was executed over a one-week period with the new system successfully commissioned in May 2016.

CONCLUSION

Given its complexity, execution of the project involved careful and detailed planning and coordination by Aegion between Pemex’s design engineers, RMB Products, Inc., the fabrication crews and the field installation team. With the successful completion of this project, Pemex ensured the integrity of the Tuzandeptl brine handling system by eliminating recurring corrosion concerns and potential leaks for decades to come.

REFERENCES

- “High Density Polyethylene Liners for High Temperature and Gaseous Applications” – 13th Middle East Corrosion Conference & Exhibition, Paper 10073, Jim Schmitz, United Pipeline Systems, Inc.
The city of American Canyon, located just south of Napa Valley in northern California, had an aging 14-inch steel transmission line from the 1940s that had become increasingly susceptible to leaks. The city’s proximity to the Napa River, San Pablo Bay and San Francisco Bay creates highly saturated soils and marshlands. Over 70 years of exposure to this environment had corroded the city’s primary steel water supply pipeline into a brittle, thin-walled conduit with a 7,400-foot segment so damaged that it could no longer be spot repaired. In fact, the equipment and operations used to complete repairs were actually further damaging the pipe.

Although more than 200 spot repairs had been performed on the main over the last 30 years as leaks were identified, it was still hemorrhaging between 120 to 190 gallons of potable water per minute. This resulted in roughly 200 to 300 acre-feet per year of unaccounted water. At its worst, approximately 98 million gallons of water—or 10 percent of the city’s total water demand—were lost in a year. As one of only two primary transmission mains, the line was critical to meeting the city’s daily water demands for both residential and commercial use. The governor’s drought declaration in April 2015 served as the catalyst to rehabilitate or replace the long-leaking 70-year-old steel transmission main. Rehabilitation of this line would help the city meet the California-state-mandated 25 percent reduction in potable water usage due to the drought.

The existing 14-inch steel pipe was installed at the bottom of the roadside drainage swale along California State Route 29 (CSR 29) with a minimum cover of 3 feet and only 5 to 10 feet of distance from the swale to the southbound lane of the highway. The highway consists of two southbound and two northbound lanes with approximately 50,000 vehicles passing by daily. A typical open trench installation would require lane closures, severely hindering residents’ daily commutes, and damage swale habitats, going against the city’s preservation efforts. The city decided that the most cost-effective and minimally invasive way to address the failing 14-inch steel transmission main was to rehabilitate the line using pipe bursting technology with 12-inch Fusible PVC® pipe. Pipe bursting is a rehabilitation method that simultaneously bursts or fractures an existing pipeline in situ, while a new pipe is pulled into place.

Fusion joining of the 12-inch Fusible PVC® pipe began on November 4, 2015, for the first pipe burst run of the project. Fusion equipment was set up along the western shoulder of CSR 29 where the pipe could be assembled for the total length needed for each pipe burst run. Traffic control was minimal since all lanes of the highway were kept open for the duration of the project. However, several side streets and businesses were accessed off of CSR 29. Access to the side streets had to be maintained at all times and driveways needed to be open to the public during business hours. Since long pipe strings would occasionally cross these accesses, shallow trenches were excavated across the road and then covered with steel plates.
to maintain vehicular access while allowing the pipe to cross. At some crossings, the contractor was able to use existing drainage culverts to pull a fused pipe length under a road. Both methods allowed the pipe to be fused to the full length required for each run.

A total of six pipe burst runs were completed at lengths up to 1,200 feet. For four of the six runs, pulling the new pipe string into place did not obstruct access to any facilities, allowing them to be installed during the day. Two of the runs, however, required blocking off several driveways during installation and so were pulled into place at night, outside of business hours.

The pipe bursting equipment and pits were set up away from any driveways and intersections to avoid disruption. For each run, the contractor set up the static bursting unit in the exit pit and then fed the bursting rods through the existing steel line to the entrance pit. On the entrance pit side, a roller cutter and expander head were attached to the new 12-inch pipe and connected to bursting rods. At that point the assembly was pulled back through the existing line, bursting open the 14-inch steel while pulling the new 12-inch water line into place behind it.

The existing steel pipe was deep enough to allow pipe bursting for most of the alignment, except for one 500-foot segment at the southernmost end of the project. Not only was it too shallow to pipe burst, but city leaders requested that the new line be installed deeper than the existing alignment, requiring standard open trench methods instead.

Over 25 appurtenances were reconnected to the newly installed line, including water meters, air release valves, tees and the existing 14-inch steel line on either end of the project scope. Most construction was completed by the end of January 2016, within 90 days of the project’s initiation, with only minor excavation and testing required in February.

The city of American Canyon now has a noncorrosive, leak-free water line due to Fusible PVC® pipe’s monolithic, fully restrained piping system. Installing the pipeline with trenchless technology not only saved water and minimized the impact of the construction to the environment and American Canyon residents, but also drastically reduced the duration of the work.