United Pipeline Systems Completes Highest Ever Pressure Project in Kuwait | page 14
PROTECTION
OUR SOLUTIONS SAFEGUARD OIL AND GAS PIPELINES—EXTENDING THEIR DESIGN LIVES AND PROTECTING OUR CLIENTS’ RESOURCES AND THE INTEGRITY OF THEIR INFRASTRUCTURE.

Corrpro offers a full spectrum of AC safety and AC corrosion detection and mitigation services. With thousands of miles of pipeline protected, Corrpro’s proven solutions are practical, cost effective and specified to our clients’ needs.

CCSI and CRTS specialize in field joint coating application and pipeline inspection services for onshore and offshore pipeline projects throughout the world.

Utilizing the latest application methods and modern extrusion equipment, Bayou offers polyethylene and polypropylene three-layer coating systems along with SLPP and molded GSPU insulation coating systems.

Responding quickly with specialized personnel, equipment and materials, United offers thermoplastic lining systems for the protection and rehabilitation of pipelines used to transport corrosive or abrasive components.

The Bayou Companies, LLC, CCSI, LLC, Corrpro Companies, Inc., CRTS, Inc. and United Pipeline Systems, Inc. are proud to be a part of the Aegion Corrosion Protection platform.

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www.corrpro.com
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Welcome Letter
Chief Technical Officer David Kroon Recaps 2014.

Corrosion Highlights From Around The Globe
CRTS completes project in Chile; Fibrwrap and Insituform tackle twin pipelines; CCSI’s new automated liquid ring cuts down on waste.

Ask The Expert
CCSI’s Rick Kimpel answers your coating questions.

Product Showcase: United Pipeline
Debuts New Thermoplastic Liner Joints
United’s new thermoweld joints help cut down on leaks.

2014 A Safety Success for Aegion’s Corrosion Protection Platform
Aegion companies achieved multiple safety milestones in 2014.

Addressing the Challenges of ACIM
Corrpro completed a large AC Mitigation project in 2014.

Refinery Flare Line Repair in California
Fyfe/Fibrwrap helps meet the customer’s needs on a Brinderson project

Locating DC Stray Current on Pipelines
Corrpro’s Hayward office conducts stray current interference testing on natural gas pipelines

Rehabilitating a Force Main: Keeping Up the Flow in Waikiki
Insituform completes its first pressure project in Oahu

United Completes Highest Ever Pressure Pipeline Project Using Tite Liner® in Kuwait
United Pipeline Systems sets another record in the Middle East.

Bayou and Wasco Continue Partnership into 2015
The partnership started in 2011 continues into 2015.

Corrpower Team Helps Rehabilitate Seawater Intake Structure
Corrpower International uses cathodic protection to protect concrete intake structures in Saudi Arabia.

Protecting Tower Anchors For Future Communication
Cathodic protection of tower anchors helps to meet regulatory requirements.

Cathodic Protection and Structural Assessments of Aging Jetties
Corrpro surveys marine structures in England.
AEGION HAS A GREAT YEAR

This has been a great year for Aegion, marked by increased sharing of engineering, technology and know-how among the Aegion family of companies. To better align our business units with our markets and to maximize the benefits of shared sales and engineering expertise, we have realigned the three business platforms: Infrastructure Solutions, Corrosion Protection and Energy Services.

With this reorganization, we still share a common purpose, which is to preserve the infrastructure that enables health and economic prosperity. Aegion is globally positioned in the business of pipe protection and infrastructure life extension with corrosion control engineering and cathodic protection by Corrpro Companies, protective coating systems by The Bayou Companies, CRTS and CCSI, thermoplastic lining systems by United Pipeline Systems, infrastructure life extension and repair by Insituform, Fyfe and Fibrwrap, and construction and maintenance services for the upstream and downstream oil and gas markets by Brinderson.

FOCUS ON SAFETY

In addition to aligning our business units, we are all keenly focused on our Zero Incident Safety Culture, which is at the forefront of our operations. Our safety program flourished in 2014 because of unwavering attention to our injury prevention processes, comprehensive leading indicator reporting and rigorous driver safety program. Engineering safeguards and eliminating hazards will get us even closer to zero incidents.

EXPANDING MARKETS

In 2013, with the acquisition of Brinderson, we expanded our service offerings and presence from primarily midstream oil and gas to the upstream and downstream markets.

UPSTREAM – Exploration and Production
- Corrosion and abrasion protection for pipe gathering and extraction supply lines
- Facility maintenance programs

MIDSTREAM – Transport
- Cathodic protection
- Engineering inspection services
- Pipe lining and maintenance
- New pipe coatings
- Pipeline field coatings
- Terminal facility maintenance
- EPC services

DOWNSTREAM – Processing and Refining
- Facility maintenance programs
- Turnaround planning and execution
- EPC services
- Corrosion engineering and cathodic protection of facility structures

Since NACE CORROSION 2014, many exciting things have happened at Aegion. Some of these are highlighted below:

- Chuck Gordon is the new Aegion CEO. He has an established record in effectively leading engineering and specialty contracting businesses. His core values are safety, customer focus, trust and respect, and accountability for results.
- Aegion continues to recruit, hire and train the very best people in the pipe protection business. Our professional development program is without equal.
- Aegion is participating in the Pipeline Research Committee International (PRCI) as a technical program associate member.
- After the first year of implementation, we are reaping the benefits of our formal stage gate process for managing R&D projects across all of the business units.
- Aegion introduced the 2014 Chairman’s Award for innovation—marking a new era of our focus on applied technology. The response was exceptional, with 12 highly creative projects from employees worldwide.
- Aegion actively seeks out and builds relationships with our technology partners for the development and deployment of new materials and systems.
- Bayou, in partnership with CCSI, continues to develop and apply new corrosion and flow assurance coatings for high temperature, deepwater pipeline construction. Areas of focus include both plant operations and field joints.
- After final engineering of the plant design last spring, the new Bayou Wasco facility is up and running, having successfully completed projects for the application of glass syntactic polyurethane (GSPU) coating insulation for subsea pipelines.
- Aegion’s Bayou Canada operations developed a unique method for coating threaded pipe.

- Brinderson continues to develop and enhance innovative maintenance and EPC services for upstream and downstream markets, while introducing alternative approaches to terminal facility maintenance in the midstream market.
- CCSI completed the development of a liquid epoxy coating ring and has successfully deployed the equipment necessary for application.
- CCSI continues to advance field coating inspection technology.
- Corrpro continues to enhance their superior EPC tools for AC corrosion and AC interference mitigation, including field test equipment and procedures, predictive modeling, mitigation designs, system construction and fit-for-purpose monitoring.
- Corrpro completed two pipeline survey R&D projects this year: the first related to survey techniques where pipelines are colocated with overhead AC transmission lines and the second related to the detection of disbonded coatings.
- Corrpro and Fyfe demonstrated the effectiveness of a combined steel reinforced concrete repair/reinforcement and corrosion protection system. Field trials are planned for this year.
- CRTS completed extensive R&D to develop a new electronics platform to improve the operation and reliability of the robotics for applying internal girth weld coatings.
- CRTS took to market their patented, internal coating inspection robot for both underground and offshore pipelines.
- CRTS worked with Insituform to improve the camera and control systems associated with the robotic equipment used for CIP.
- Insituform continues to expand its range of pressure pipe lining capability, securing projects to install over 25,000 feet of 30-inch and 36-inch diameter InsituMain® cured-in-place pipe.
- Insituform and Fyfe are collaborating in the development of a premium pressure pipe rehabilitation solution for small-diameter water and wastewater lines.
- Fyfe developed a pressure barrier replacement for piping systems in the nuclear industry which satisfies ASME B31.1 code requirements.
- Fyne and Corrpro are participating in the Cooperative Industry Program to test the Fibrwrap® composite pipeline repair system.
- United completed development and received a patent on their welded connection, limiting the need for flanged connections for pipe lining.

In addition to the accomplishments in 2014, we are excited about 2015 and our many research and development projects to continue to advance our products and services.

The response was exceptional, with 12 highly creative projects from employees worldwide.

Sincerely,

David Knoen, P.E.
Chief Technical Officer
Aegion Corporation
SURFACE PREPARATION CRITICAL TO PIPELINE PROTECTION

Protective coatings are the foundation of corrosion management. Coatings are the unseen yet very environmentally-friendly aspect of oil and gas projects and are known to counteract the corrosive effects of oxygen, carbon dioxide, hydrogen sulfide and other corrosion agents. CRTS specializes in protecting the most vulnerable part of a pipeline, the uncoated internal field joint.

Surface preparation is critically important when coating a pipe’s internal field joints. Stringent surface preparation by CRTS includes pre-weld and post-weld blasting procedures. The robotic equipment includes a system that cleans each internal field joint before coating, strengthening the bond between the coating and the pipe. This process is sensitive to the environment because the vacuum recycles the debris that would potentially be left in the pipe.

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.

CRTS USES ROBOTICS TO HELP PROTECT SCARCE WATER IN CHILE

CRTS recently completed a project at the Candelaria open-pit copper mine near the mining and agriculture town of Copiapo, Chile. The project consisted of the application of the coating of nearly 4,600 internal field joints along more than 50 miles of 24-inch-diameter pipeline. The primary goal of the project was to coat the joints to prevent leaks of the process water line. This would help to protect scarce water in the desert climate.

CRTS was able to complete the project using its revolutionary robotic coating system.

CLEANING AND INSPECTION

The Candelaria coating project faced several challenges. Environmental challenges, such as the desert’s dust, required the entire length of pipe to be cleaned multiple times prior to the coating process. The entire length of each pipe was inspected in addition to a standard internal field joint inspection using circumferential line travel holiday detection equipment. Located on the inspection machine, the detection equipment was used to inspect the lining of each pipe after the internal field joint were completely cleaned, coated, visually inspected and holiday inspected. Real-time feedback provided the field technician with immediate verification of each pipe section’s quality status and detection of any anomalies in the factory-coated pipeline. When holidays were found, the required repairs were made.

MULTIPLE APPLICATIONS, ONE SOLUTION FOR TWIN PIPELINES UNDER MAJOR RIVER

In Spring 2014, the City of Reading, Pennsylvania needed to upgrade the capacity of a 60-year-old, 42-inch force main running beneath the Schuylkill River. Working with Entech Engineers, the city devised a multi-faceted solution.

First, FACT Construction would install a new 42-inch pipeline beneath the river using the high density directional drilling (HDD). This pipeline would serve as the new main line.

The length of the existing 400-ft. steel pipe force main was then rehabilitated using two methods and served as a standby tie-in to the system. The pipe required two separate methods due to two 45° bends in the system. The straight portion of the pipeline was rehabilitated using the Insituform® RPP system, a fiber-reinforced cured-in-place pipe (CIPP) liner for pressurized piping systems. The bends were rehabilitated by Fibrwrap Construction using Tyfo® Fibrwrap®.

The Tyfo® Fibrwrap® is a fiber-reinforced polymer (FRP) that provides added structural strength to infrastructure, including buildings, bridges and pipelines. The combination of multiple solutions, including HDD, Insituform® RPP and Tyfo® Fibrwrap® provided a structural solution to the original pipeline, and essentially doubled the capacity of the system as a whole.

CCSI'S NEW AUTOMATED LIQUID RING CUTS DOWN ON WASTE

In response to industry trends toward technological advances in automation and traceability, CCSI engineers have developed a field joint coating robot that automatically applies plural-component liquid coatings to field joints. Its development represents the intersection of functionality and consistency and provides more reliable corrosion protection.

The Liquid Coating Ring operates with the push of a button and automatically rotates around each field joint after being lowered into position on the pipe. This automatic rotation ensures a consistent and even coating process. Additionally, the speed, number of passes, thickness, width, temperature and pressure can all be monitored with this new system, reducing variability in the final product.

The Liquid Coating Ring is engineered not only to be user-friendly, but also to help alleviate the issue of overspray and waste. The Paint and Solvent Reclaim System helps cut down on the issue of overspray during installation. This highly innovative system redirects the entire waste stream into a receptacle for easy disposal.
HOW IMPORTANT IS SURFACE PREPARATION?

Proper surface preparation is the foundation of any reliable coating corrosion system. Without adequate cleaning, proper coating is not possible. When a surface is not properly cleaned, applied coatings will stick to mill scale or oxide layers rather than to the true substrate. Additionally, having a properly-applied anchor profile provides the roughness and interface area to maximize the adhesion of the coating. CCSI’s CoatCheck® robot helps inspectors verify surface preparation as well as monitor any variation or abnormality. This provides inspectors with useful data which in turn can be reviewed with the applicator to prevent coating failures.

WHY DO COMPANIES CARRY OUT COATING ADHESION TESTS?

Adhesion tests ensure customers get the best protection possible and that coatings can withstand normal handling and backfill operations. The best coating in the world is completely irrelevant if it does not maintain good adhesion with the pipe. Normal pipe handling processes should not have any detrimental effect on the coating.

Another important reason to focus on adhesion testing is to verify that a coating will not disbond from the substrate in the event of a holiday.

HOW CAN YOU PREVENT INTERNAL CORROSION?

CCSI offers a number of internal diameter (ID) coating solutions at both branches. Additionally, CCSI offers ID coating solutions for field joints so that they can enjoy the same protection as the line pipe. When coatings are not enough, a corrosion monitoring system from a company like Cerrpro can help prevent corrosion and extend the life of the pipe by helping to identify and mitigate any corrosion issues.

WHAT ROLE DO DEFECT ASSESSMENT TOOLS PLAY IN COATINGS INTEGRITY?

Defect assessment tools, such as CCSI’s CoatCheck® robot play an important role in verifying coating integrity. By providing repeatable, traceable, and non-editable results, CoatCheck® maintains the accuracy of the field joint coating data throughout the entire process. Additionally, results are tabulated on a daily basis, allowing the inspectors to detect any changes in production quality at a glance. This can also assist operators to fine-tune their processes and reduce operating costs and variability. Since the coating data is directly correlated with GPS location data, less time is spent looking for particular field joints.

CCSI and CRTS specialize in field joint coating application and pipeline inspection services for onshore and offshore pipeline projects throughout the world.

• Outside diameter – automated rings
• Inside diameter – robotic equipment
• FBE (fusion bonded epoxy)
• Multi-component liquids
• Holiday detection
• Dry film thickness measurement
• Real time video

CCSI and CRTS are proud to be a part of the Aegion Corrosion Protection platform which also includes The Bayou Companies, Cerrpro Companies and United Pipeline Systems.

PRODUCT SHOWCASE: UNITED PIPELINE DEBUTS NEW THERMOPLASTIC LINER JOINTS

by Ted Compton | Director of Technology

For decades, energy companies have used thermoplastic, or high-density polyethylene (HDPE) liners to protect pipelines from internal abrasion and corrosion. These liners help not only to extend the working life of the asset, but also help improve flow and protect the environment from unwanted leaks and spills.

MARKET NEED

Traditional flanges increase the risk for potential leaks to the environment. This can be a concern for some clients. New joining methods from United Pipeline Systems can help cut down on these leaks.

United’s new liner joints are fully welded, with no gasket needed. This cuts down on potential leaks and eliminates the flange component. The welded connection is also smaller than a traditional connector—roughly the same size as the pipe itself.

There are now two new methods of joining available. The CRA, or corrosion resistant alloy, Welded Connection allows for the connection of two HDPE lined sections of steel pipe without the use of flanges. The electrofusion method welds together two sections of HDPE using an HDPE electrofusion coupler.

Both types of connections create an end seal on the HDPE liner which is tested to over 9,000 psi and restrains HDPE liner ends from pull-out. The electrofusion and CRA joints are installed by drag-through or digging method. So far, United has successfully completed three commercial projects totaling hundreds of connections.

The primary concern with these new technologies is cost. While the cost might run higher than traditional methods, CRA and electrofusion joint liners are sometimes the only option if a project is aiming for zero leakage.

It is estimated that there is enough thermoplastic lined pipe currently in service to circle the diameter of the earth more than two times. Thermoplastic lined pipe systems continue to prove themselves reliable after more than 25 years in service and have gained popularity as a technical and commercially viable solution to internal corrosion and abrasion problems. Joining methods for the liner systems play a critical role in the overall reliability and function by providing a proper seal.
The Corrosion Protection platform achieved numerous safety milestones in 2014. These accomplishments were reached due to a commitment to a zero incident culture. At Aegion, the importance of participating in leading indicator actions such as near miss reporting, hazard identification, behavior based safety observations, training participation, and conducting audits is continually stressed. It is proven that these actions lead to safety excellence.

2014 HIGHLIGHTS
Aegion’s safety culture led to a number of safety accomplishments in 2014. Not only did The Bayou Companies in New Iberia achieve their lowest total recordable incident rate in twenty years, but they also reached two years and one million man hours without a lost time incident. United Pipeline Systems also globally achieved two million man hours without a lost time incident. Similarly, the global operations for Corrpro Companies globally reached 3.9 million man hours without a lost time incident. This included some highlights at Corrpro locations throughout North America:

- Corrpro’s Sand Springs, Oklahoma location achieved 10 years without a lost time incident.
- Corrpro’s regional office in Medina, Ohio has gone 8 years without a recordable injury and nearly two million man hours without a lost time incident.
- Corrpro’s Chicago and Farmington operations each achieved 20 years without a recordable incident.
- Corrpro San Diego has achieved 12 years without without a lost time incident.

In addition to these great accomplishments, over 20 locations in the Corrosion Protection platform worked completely injury-free in 2014. This includes global locations from Corrpro, Hockway and United Pipeline Systems in the United States, Canada, United Kingdom, Mexico and the Middle East.

Aegion companies also received external recognition from clients, organizations and state and federal agencies for their participation in the Federal Stand Down at Bayou and Corrpro, as well as several regional awards and the 2013 Golden Triangle Meritorious award a client-nominated award.

LOOKING TO THE FUTURE
Aegion’s Corrosion Protection platform’s safety accomplishments required management commitment and employee involvement. Aegion’s best-in-class safety culture is its highest priority because it’s the right thing to do for its employees, families, customers and communities.

Electromagnetically induced alternating current (AC) on underground pipelines is becoming a crucial aspect of pipeline safety and AC corrosion prevention. Induced AC is caused by the electromagnetic field created by the current flow in the wires of the transmission line. Induced AC is most prominent when a well coated pipeline travels parallel with a three phase transmission power line. Spikes in the voltage at any discontinuity or separation between the pipeline and the power line are possible. The amount of current density can be dependent on AC voltage, soil resistivity and coating condition.

The Sand Springs Manufacturing Plant achieved 10 years without a lost time incident.

Members of the Bayou team participating in the Federal Stand Down for Falls in June 2014. The group received recognition from Federal OSHA for their participation.

AC MITIGATION PROJECT
Last year, a large scale gas transmission company performed an AC study on approximately 60 miles of its pipelines to prove or disprove any influence that a newly installed power line, which was transporting power from new wind generators, was having on existing pipelines. The results of the study concluded that AC interference mitigation (ACIM) would be needed on approximately 32,000 feet of pipe located on five different pipelines. Corrpro was given 12 weeks to complete the AC installation, which included over 75,000 feet of horizontal zinc ribbon, 584 installations of vertical zinc ribbon, 82 solid state decouplers and installation of protective guards in 43 different locations.

INSTALLATION
The project kicked off in March 2014 with Corrpro’s Houston, Atlanta, New Orleans, and Santa Fe Springs offices all contributing personnel and equipment. To begin work, the pipeline had to be vacuum excavated to allow visual inspection at the location of the line at roughly 100-foot intervals. This was done using two vacuum excavation trucks, and took longer than expected due to the hard terrain in this part of the country. Simultaneous operations were run with the vacuum excavation crews, including two vertical installation five-man crews with auger rigs and one horizontal installation crew. The horizontal installation crew included two trenchers, one excavator, a skid steer and a rock saw. For a portion of the horizontal sections, a subcontractor horizontal directional driller (HDD) team was employed to bore under roadways, driveways, and creeks. At the height of these installations, Corrpro had as many as 25 employees working together.

OBSTACLES
• Very rugged terrain, including boulders and solid granite, contributed to the vertical installation crews falling behind schedule. To help combat this, a subcontractor provided two additional air drilling rigs to meet the requested completion date.
• During the course of the installation, it was discovered that there were multiple locations, such as areas with overhead power lines, in which field installation was not feasible. This resulted in the need for project redesign.
• Safety is always the first priority. As a precaution, a safety manager was available on the job site at all times and performed random audits, on site safety assistance, and overall safety presence. This resulted in zero recordable incidents in over 30,000 man hours.

CONCLUSION
After implementing change orders and making last minute adjustments to improve efficiencies, the project came in at budget. This was noteworthy considering the need for subcontract drilling, employee travel and expenses, and project delays.

The client was very happy with the overall product that Corrpro provided and now has a standing relationship with Corrpro who is now working on another project. Though the project took longer than was previously expected, Corrpro’s conscientious attitude toward safety, communication and eagerness to address all project challenges, helped to build a great working relationship for the future.
In 2014 a Brinderson client was looking to rehabilitate several long sections of a flare header system by encapsulating it with welded steel. The refinery’s inspection department had identified wall thinning on several sections of pipe and determined that immediate repair was needed to prevent the possibility of a hydrocarbon leak. The client had already performed several welded repairs on this header in the past and knew that since the flare header could not be shut down, repairing it while ensuring worker safety would be a challenge.

The client received an estimate of $1.6 million to perform the welded repair. That’s when Brinderson discussed an alternative repair method—wrapping the exterior of the pipe with carbon fiber reinforced polymer (CFRP)—with the client. CFRP is a highly engineered and rigorously tested product developed by Aegion, the project was completed on time and on budget. In working in partnership with Brinderson, a sister company of Aegion, the project was completed on time and on budget and has a highly positive relationship with the utility company due to the expert technical quality and presentation level of their reports.

After a comprehensive technical evaluation, the client awarded a contract to Fyfe/Fibrwrap in September 2014 to repair 1,000 feet of 24-inch pipe and 500 feet of 16-inch pipe. In working in partnership with Brinderson, a sister company of Aegion, the project was completed on time and on budget. The refinery’s inspection department had identified wall thinning on several sections of pipe and determined that immediate repair was needed to prevent the possibility of a hydrocarbon leak. The client had already performed several welded repairs on this header in the past and knew that since the flare header could not be shut down, repairing it while ensuring worker safety would be a challenge.

The client agreed to evaluate the alternative and Fyfe/Fibrwrap, a sister company of Brinderson, worked closely with the client to develop a solution that would both satisfy the client’s process safety requirements and be cost effective to install. A high temperature Tyfo® Fibrwrap® system was proposed that met the client’s needs and specifications. The cost estimate for this solution was only $500,000—a cost savings of over one million when compared to the original solution.

After a comprehensive technical evaluation, the client awarded a contract to Fyfe/Fibrwrap in September 2014 to repair 1,000 feet of 24-inch pipe and 500 feet of 16-inch pipe. In working in partnership with Brinderson, a sister company of Aegion, the project was completed on time and on budget.

Corrpro’s Hayward, California office recently conducted both static and dynamic stray current (DC) interference testing in the San Francisco Bay Area on parallel 25-mile and 30-mile long natural gas utility pipeline. The purpose of the project was to locate possible interfering current sources and quantify the amount of interfering current.

VERIFYING DATA
The static interference portion of the project began with a review of historical data to prioritize certain areas for further testing. Corrpro then conducted a site walk of the 25-mile long pipeline to verify existing pipeline crossings and determine any new crossings. Foreign pipeline crossings, DC transit systems, overhead AC power lines, and foreign rectifiers were noted and scheduled for possible interference investigation depending on previous indirect inspections.

To verify existing conditions, a potential test point survey was conducted at available test stations. Following-potential testing, sites were scheduled for stray current interference testing. To remove intentional current from the pipeline, the utility cathodic protection sources were turned off and the pipeline was allowed to depolarize for one week. Any current remaining on the pipeline would then be stray current from an unintended source.

To begin testing, Corrpro crews connected wire from test point to test point to measure current flows. Because this approach resulted in a number of challenges including wire breaks, traffic and even stolen equipment, a revised approach was selected. To deal with these issues, a radiodetection stray current mapper was used to measure the current flow without the need to attach wires between test stations. The use of this equipment sped up the measurement process and allowed testing to be completed more quickly.

LIGHT RAIL TESTING
The second portion of the project was much more difficult as it involved the nearby DC light rail transit system. Historical data was not helpful, as pipe-to-steel potentials would vary by upwards of four volts depending on the time of day measurements were made. Attaching wires between test stations was also not feasible as the survey area not only had approximately a mile between test locations, but was also located in heavily congested urban areas. To attempt to locate stray current sources, extensive data logging had to be conducted.

Stationary dataloggers were placed at the beginning of the alignment, halfway along the 30-mile pipeline, and the end of the pipeline. A fourth mobile datalogger was then used at 20 minute intervals to correlate by time stamp to the stationary dataloggers. By trending the data, areas of greater concern and possible pickup and discharge were determined. In high interest areas, Corrpro used the stray current mapper, stationary coupons and temporary coupons to attempt to quantify current magnitude and direction. This information was then compiled into reports to make recommendations to the client. Despite project challenges, Corrpro finished the project on time and on budget and has a highly positive relationship with the utility company due to the expert technical quality and presentation level of their reports.
The force main provides conveyance of sanitary sewage flows from a highly developed area to a major collection system, which discharges to the Sand Island Wastewater Treatment Plant. Traffic volumes on Kalakaua Avenue dictated limited working hours for all aspects of the installation except the cure portion, when it was not possible to stop work. During installation the system configuration allowed for the force main to be taken out of service for the duration of the rehabilitation project, as a parallel pipe continued to convey flow from the pumping station.

PROJECT PLANNING

Insituform was first contacted by the City’s design engineer in February of 2013 to assess the feasibility of using a cured-in-place pipe (CIPP) pressure rated liner to carry out the rehabilitation. While Insituform has done a good amount of traditional CIPP work on the island, this would be the first CIPP pressure pipe lining project on Oahu. Over the course of several months, the existing details and site conditions were identified, investigated and confirmed. These included pipe outside diameter, inside diameter, material, length of project, operating conditions and groundwater conditions.

Insituform’s Dahu office, with support from its Engineering and Pressure Pipe Operations, provided reviews and comments on the liner design and installation, as well as ancillary works required for the proposed project. There was some uncertainty about the pipe material, internal condition and grade of the ductile iron force main, installed in 1967, resulted in the City and County of Honolulu requesting design for an emergency repair. The force main in question exits the vault outside the Fort DeRussy wastewater pumping station and then crosses three lanes of Kalakaua Avenue, the major eastbound route through the Waikiki area. In 2014, Insituform Technologies, LLC completed a contract as a subcontractor to Hawaiian Dredging to rehabilitate a 65-ft. long section of a 20-inch force main crossing one of the busiest intersections in the Waikiki area of Honolulu, Hawaii. Line breaks and concerns about the reliability and integrity of the ductile iron force main, installed in 1967, resulted in the City and County of Honolulu requesting design for an emergency repair. The force main in question exits the vault outside the Fort DeRussy wastewater pumping station and then crosses three lanes of Kalakaua Avenue, the major eastbound route through the Waikiki area.

In 2014, Insituform Technologies, LLC completed a contract as a subcontractor to Hawaiian Dredging to rehabilitate a 65-ft. long section of a 20-inch force main crossing one of the busiest intersections in the Waikiki area of Honolulu, Hawaii. Line breaks and concerns about the reliability and integrity of the ductile iron force main, installed in 1967, resulted in the City and County of Honolulu requesting design for an emergency repair. The force main in question exits the vault outside the Fort DeRussy wastewater pumping station and then crosses three lanes of Kalakaua Avenue, the major eastbound route through the Waikiki area.

The force main was designed to incorporate reconnections to the existing system using Hymax compression fittings. This configuration is the preferred process for Insituform’s pressure pipe installations, and eliminates any need for adhesion to the host pipe to ensure a water tight application.

Since Fort DeRussy borders Waikiki Beach, the pipe was within the groundwater zone and subject to tidal influences. This fluctuation in water level, meant that the all the fittings installed would be subjected to additional corrosion considerations. To address this, all exposed bare metal components were covered with Trenton Wrap.

The project was installed in July of 2014, after several delays in securing approved materials and permits. Hawaiian Dredging provided the pipe cleaning, a standard component of CIPP rehabilitation. The liner was impregnated with resin, or wet out, at Insituform’s facility on Oahu, and then loaded into a roofer truck to transport to site for installation the following day. The installation method for these liners typically uses water head to invert or turn the liner inside out on itself, propelling it if the length of the host pipe. A scaffold tower provided the necessary 23 feet of water head to invert and install the liner. The liner was cured by heating and recirculating water in the tube until the desired temperature was achieved, then held for three hours, and finally allowed to cool.

The following day the liner was drained, ends were cut, and sizing rings removed. A fast setting resin was then applied to the exposed liner to smooth the surface, eliminating any rough areas that could impact the ability to achieve a proper seal with the Hymax couplings. Insituform’s pressure pipe crew specialists installed the Hymax fittings and pressure test components, then shored and braced the fittings in preparation for the pressure test.

During the course of the pressure test, weather forecasts predicted a significant storm for Oahu. The decision was made by the owner that the forcemain be made available for immediate use, should the storm hit, to provide any additional conveyance capacity that might be required. This meant the general contractor was required to quickly connect the newly lined segment of the force main to the rest of the system, delaying completion of the pressure test.

A storm did in fact develop over Oahu, and the system performed as required. The following week, Hawaiian Dredging opened up the site once more and an Insituform pressure pipe specialist returned to site, successfully completing the pressure test. Hawaiian Dredging then reconnected the lined segment to the system, and completed the project.

The force main provides conveyance of sanitary sewage flows from a highly developed area to a major collection system, which discharges to the Sand Island Wastewater Treatment Plant. Traffic volumes on Kalakaua Avenue dictated limited working hours for all aspects of the installation except the cure portion, when it was not possible to stop work. During installation the system configuration allowed for the force main to be taken out of service for the duration of the rehabilitation project, as a parallel pipe continued to convey flow from the pumping station.

PROJECT PLANNING

Insituform was first contacted by the City’s design engineer in February of 2013 to assess the feasibility of using a cured-in-place pipe (CIPP) pressure rated liner to carry out the rehabilitation. While Insituform has done a good amount of traditional CIPP work on the island, this would be the first CIPP pressure pipe lining project on Oahu. Over the course of several months, the existing details and site conditions were identified, investigated and confirmed. These included pipe outside diameter, inside diameter, material, length of project, operating conditions and groundwater conditions.

Insituform’s Dahu office, with support from its Engineering and Pressure Pipe Operations, provided reviews and comments on the liner design and installation, as well as ancillary works required for the proposed project. There was some uncertainty about the pipe material, internal condition and grade of the forcemain, so one of the first tasks after the project was awarded in May was for the general contractor to excavate the pipe. This allowed inspection of the force main, confirmation of the inside and outside diameters, and a CCTV inspection. These activities provided all the information required to order the liner material, as well as the vinyl ester resin, which is not commonly used in Hawaii.

The operating pressure for the force main was estimated to be about 35 psi, with a test pressure of 65 psi. To meet these and other design conditions, the Insitumain® product, a fiber-reinforced pressure pipe liner, was designed to be 9.5 mm thick. The system was designed to incorporate reconnections to the existing system using Hymax compression fittings. This configuration is the preferred process for Insituform’s pressure pipe installations, and eliminates any need for adhesion to the host pipe to ensure a water tight application.

Since Fort DeRussy borders Waikiki Beach, the pipe was within the groundwater zone and subject to tidal influences. This fluctuation in water level, meant that the all the fittings installed would be subjected to additional corrosion considerations. To address this, all exposed bare metal components were covered with Trenton Wrap.

The project was installed in July of 2014, after several delays in securing approved materials and permits. Hawaiian Dredging provided the pipe cleaning, a standard component of CIPP rehabilitation. The liner was impregnated with resin, or wet out, at Insituform’s facility on Oahu, and then loaded into a roofer truck to transport to site for installation the following day. The installation method for these liners typically uses water head to invert or turn the liner inside out on itself, propelling it if the length of the host pipe. A scaffold tower provided the necessary 23 feet of water head to invert and install the liner. The liner was cured by heating and recirculating water in the tube until the desired temperature was achieved, then held for three hours, and finally allowed to cool.

The following day the liner was drained, ends were cut, and sizing rings removed. A fast setting resin was then applied to the exposed liner to smooth the surface, eliminating any rough areas that could impact the ability to achieve a proper seal with the Hymax couplings. Insituform’s pressure pipe crew specialists installed the Hymax fittings and pressure test components, then shored and braced the fittings in preparation for the pressure test.

During the course of the pressure test, weather forecasts predicted a significant storm for Oahu. The decision was made by the owner that the forcemain be made available for immediate use, should the storm hit, to provide any additional conveyance capacity that might be required. This meant the general contractor was required to quickly connect the newly lined segment of the force main to the rest of the system, delaying completion of the pressure test.

A storm did in fact develop over Oahu, and the system performed as required. The following week, Hawaiian Dredging opened up the site once more and an Insituform pressure pipe specialist returned to site, successfully completing the pressure test. Hawaiian Dredging then reconnected the lined segment to the system, and completed the project.

This first pressure pipe lining project on the island is considered a success, providing a newly rehabilitated pipe over the course of several days, with minimal impacts to the busy roadway. Since the completion of the project, several other opportunities have been directed to Insituform in Hawaii for review, and it is expected that these will be undertaken in the next year.
UNIVERSAL COMPLETES HIGHEST EVER PRESSURE PROJECT USING TITE LINER® IN KUWAIT

by Jeff Schell | Senior Vice President & General Manager

INTRODUCTION

The lining specialists at United Special Technical Services (USTS) continue to expand the technical envelope of the United Pipeline Systems (UPS) Tite Liner® system in the Middle East. Only a year ago, the same team completed the longest-ever continuous compression-fit liner installation when they lined 8,200 feet of a 24-inch diameter offshore produced water pipeline in Qatar. Now, they have completed a large-scale lining project in Kuwait, with the highest design and test pressures ever recorded at more than 7,500 psi.

UNITED COMPLETES HIGHEST EVER PRESSURE PROJECT USING TITE LINER® IN KUWAIT

This project marked a significant milestone in the lining industry, with the design and installation of a 24-inch diameter offshore produced water pipeline in Kuwait. The project was completed under the watchful eye of Kuwait Oil Company (KOC) and WorleyParsons.

The lining teams at United worked closely with Petrofac, and United. Work began as soon as the technology was approved. The Tite Liner® Flange system was fit for its intended duty. The design of this system called for using carbon steel pipes to carry the pressure and a thin-walled compression-fit HDPE liner to protect the pipelines from internal corrosion and abrasion. Kuwait Oil Company (KOC), along with the engineering consultants at WorleyParsons, had specified compression-fit HDPE liner as the most effective solution to protect these high pressure pipelines transporting effluent water and sea water.

The mainlines, or trunklines, are unique in that they change diameter, starting out at 18-inch and decrease to just 6-inch diameter pipelines by the time effluent is delivered to the injection wells. The entire network of more than 150km diameter pipelines is distributed throughout the North Kuwait oil field to increase reservoir pressure.

The design of this system was approved. The lining crews were constantly adjusting to the environment, sometimes working a night shift to avoid the extreme hot weather. There were a variety of challenges associated with the project, ranging from 41°F to 110°F, for testing purposes. The pipelines were filled with water and gradually brought up to pressure at a rate of 15psi per minute to 50% of the test pressure. At this point the flange connections were visually inspected. A high pressure pump was then used to bring the pipelines up to full test pressure, or 1.25 times the design pressure. The majority of the pipeline network was tested to a pressure of 528.75 bar (approximately 7,668 psi). Once the test pressure was achieved, the pipeline was allowed to stabilize for 24 hours and then the pressure brought back up to the test value. The pressure had to be held for another 24 hours before each section could pass. The individual sections all passed the test and the next step was to conduct a full system hydrotest. All of the sections were connected and the system was again brought up to pressure. Once the entire system had stabilized, the test pressure was maintained for another 4 hours before the test results were accepted.

CONCLUSION

The project demonstrates the ability of the Title Liner® system to provide a solution for high pressure injection systems at larger diameters. It also demonstrates what can be accomplished through teamwork and close coordination between the client, engineer and contractors. USTS and Petrofac were partners in the field, and they both relied on the support and guidance of KOC and WorleyParsons.

The high pressure water injection network now has internal corrosion protection and will be a maintenance free system for its entire design life.

CHALLENGES

There were a variety of challenges associated with the project in addition to the record-breaking pressures. Site conditions in the Northern Kuwaiti desert are among the most extreme in the world. Weather can fluctuate throughout the year from extreme heat, approaching 112°F (50°C) in the summer, to near freezing temperatures in the winter — it has even been known to frost on occasion. The deserts are rugged and unforgiving and when the wind picks up, the dust storms can reduce visibility to nearly zero. The lining crews were constantly adjusting to the environment, sometimes working a night shift to avoid the extreme hot weather.

The specialty 14-inch and 18-inch 2500# flanges did not exist off-the-shelf and had to be designed exclusively for the project. Petrofac led the design of these custom-fabricated flanges. The tolerance of each component was critical to the success and sealing of the overall system. The quality control at site was strict — each flange and lining component had to be carefully measured and recorded at the time of installation. In addition, the flanges were massive to accommodate the larger diameters. This made the handling, rigging, and bolt-up no easy tasks.

Bolt-up of the huge flanges was a team effort between Petrofac and USTS. Petrofac provided the heavy equipment and operators while USTS provided the supervision and direction. A dedicated crew worked full-time bringing the flanges together, providing initial bolt-up, and then two additional passes to ensure the proper torque values were achieved. All of the work was completed under the watchful eye of KOC and WorleyParsons.

TESTING

USTS and was confident that the liner system was providing full protection to the carbon steel host pipe after performing a low pressure air test on the lined sections. The next step was to do a hydrotest under high pressure. The system was divided into groups by trunklines, lateral lines and flowlines, ranging from 1km to 9km, for testing purposes. The pipelines were filled with water and gradually brought up to pressure at a rate of 15psi per minute to 50% of the test pressure. At this point the flange connections were visually inspected. A high pressure pump was then used to bring the pipelines up to full test pressure, or 1.25 times the design pressure. The majority of the pipeline network was tested to a pressure of 528.75 bar (approximately 7,668 psi). Once the test pressure was achieved, the pipeline was allowed to stabilize for 24 hours and then the pressure brought back up to the test value. The pressure had to be held for another 24 hours before each section could pass. The individual sections all passed the test and the next step was to conduct a full system hydrotest. All of the sections were connected and the system was again brought up to pressure. Once the entire system had stabilized, the test pressure was maintained for another 4 hours before the test results were accepted.

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Installation of large flanges

The team prepares to bolt up
In early 2011, Aegion announced that it had teamed up with Wasco Energy Ltd., the world’s second largest provider of pipe coating, insulation and protection services to the oil and gas industries. Bayou Wasco Insulation, LLC, headquartered in New Iberia, Louisiana, was organized to provide offshore insulation services to customers in the United States, the Gulf of Mexico, Central American, and the Caribbean. The joint venture, which is owned 51% by Aegion and 49% by Wasco, combines Wasco’s expertise in the insulation market with the operational, sales and logistics capabilities of The Bayou Companies, LLC (Bayou), a subsidiary of Aegion.

For years, Bayou has served the offshore market in pipe coating products, but has sought to increase subsea product offerings. Wasco, headquartered in Kuala Lumpur, Malaysia, is a good choice to bring world class insulation technology to the Gulf region. Wasco’s polyolefin and polyurethane technology comes from years of refinement throughout the oil producing arena. This expertise meshes well with Bayou’s customer centered operational tradition.

Bayou Wasco began construction on the manufacturing facility in mid-2012 at Bayou’s 250-acre industrial complex in New Iberia. The facility is now complete and has already successfully manufactured two production orders—one destined for the Gulf of Mexico and the other for South America. A third order is currently underway and will be complete in mid-2015. In addition, qualification audits have been completed by several lay contractors, pipe suppliers, and owner companies.

GSPU

The plant offers primarily two different insulation systems. The first of these is glass syntactic polyurethane, or GSPU. GSPU insulation systems are composed of a special polyurethane formulation combined with hollow glass microspheres. The resulting composition is a temperature- and saltwater-resistant, lightweight material with excellent thermal properties. The material, in its uncured form, is injected into molds that encompass pipe joints in a process called reaction injection molding, or RIM. The RIM molding process is a dimensionally accurate method that results in effective centralizing of the pipe within the insulation coat. This feature is important in field-fitting of pipe joints for welding and also results in consistent resistance to heat flow.

SLPP

Bayou Wasco also offers a five-layered polypropylene syntactic system, or SLPP. The SLPP insulation system is comprised of an anticorrosion layer of FBE, a modified copolymer adhesive layer, an extruded solid polypropylene protective layer, a syntactic polypropylene insulation layer, and a final “tough” layer that is abrasion-, saltwater- and UV-resistant. The facility employs a new technique of extruder control and automated racking and that allow all passes of the entire fourth (syntactic) layer of insulation coating to be applied without the pipe ever leaving the protection of the indoor areas. This is important since the syntactic layer regularly requires multiple passes to meet required thickness levels. This new technology allows us to reduce handling damage and contamination that can lead to delaminations between the layers.

Why the different insulation systems? The primary difference is in service temperature ranges. GSPU is used in wet insulation service temperatures up to 175 °F, while SLPP systems are used in temperatures up to 300 °F. The SLPP section of the plant produces multi-layer insulation on pipe sizes ranging from 3-inch to 24-inch OD on lengths of pipe up to 80 feet in length. The molded insulation section of the plant insulates pipe sizes ranging from 2-inch to 24-inch. This wide range of insulation materials allows us to offer a full suite of solutions to our customers along the Gulf Coast.
CORRPOWER TEAM HELPS REHABILITATE SEAWATER INTAKE STRUCTURE
by Abdullah Hammoud | Engineering Manager, Corrpower International Ltd., Saudi Arabia

A fertilizer manufacturing plant in Saudi Arabia originally constructed in 1986 was experiencing serious deterioration of the concrete intake structures caused by corrosion of the embedded steel rebar. Since repairs to the concrete can only be accomplished during plant shutdowns when the intake channels are not in use, the repair costs are very high.

The plant’s technical team assessed the corrosion problem and recommended the application of a cathodic protection (CP) system to minimize corrosion of the embedded steel rebar, reduce maintenance costs and extend the life of the concrete intake structures. It was decided that cathodic protection would be provided on all repaired and un-repaired concrete surfaces plus other metallic components of the seawater intake and return bays. Corrpower International Ltd. was selected to provide technical services and supply the equipment for this rehabilitation project.

This project represented a significant challenge to Corrpower when considering different types of steel equipment and structures exposed to various environments in congested plant areas. Furthermore, the installation work had to be completed within the 21 day plant shutdown period. The Corrpower engineering team responded by developing an innovative cathodic protection design that considered construction costs and the tight project schedule.

PROJECT SCOPE
The concrete structures included in the cathodic protection scope consist of intake and return pits, a completely buried tunnel and a pumping pit. Additionally, the intake and return pits include various un-coated metallic items that are partially or completely submerged in seawater including; sluice gates, bar screens, traveling screens, stop logs, suction and return pipes, and ladder rungs.

The surface area of the steel being protected was 10,000m² and divided into 16 zones. The internal concrete structures are exposed to three environments: submerged, tidal, and humid. The external concrete surfaces are exposed to another three environments: atmospheric, buried in soil, and transition area from air to soil.

MATERIALS SELECTION
ELGARSTM 210 titanium MMO mesh anodes were selected for the tidal, humid, atmospheric, and air-to-soil transition zones. Prior to installation of the anodes, the concrete was prepared by replacing deteriorated concrete roughening the surface. The mesh anodes were fixed to the concrete surfaces using non-metallic pins and covered with a 75 mm layer of concrete mortar.

Tubular titanium MMO anodes were chosen for the submerged zones. The anodes were encased in perforated PVC pipes and fixed to the walls and slabs with non-metallic clamps. These anodes were used to protect the metallic equipment and were distributed strategically to promote uniform current distribution to all structures. Additional anodes were placed near the travelling screens which require the highest CP current densities. High silicon iron anodes were selected to protect the embedded rebar in concrete surfaces exposed to the soil. These anodes were encased in steel canisters and installed below the depth of the water table.

The individual anode lead wires were terminated in common junction boxes equipped with variable resistors. This feature allows the current output of individual anodes to be adjusted during commissioning of the systems.

The cathodic protection systems include permanent silver–silver chloride reference electrodes for obtaining structure-to-electrolyte potential measurements. The signal from these reference electrodes is used for the remote monitoring / control system. The reference electrodes for the rebar are embedded in the concrete. The reference electrodes for the submerged structure are mounted in perforated PVC tubes.

Six (6) multi-channel oil cooled transformer rectifier (T/R) units were installed to feed up to 16 zones. Each T/R is equipped with a Main Control Unit (MCU) which allows remote monitoring and control of the individual output channels. The MCU unit receives / sends data for control of the DC output voltage / current of each circuit and includes a circuit to automatically cycle the CP current on and off using a GPS synchronizable interrupter. This feature enables critical data including; instant off potentials and potential decay to be used to evaluate the performance of the CP systems and set alarms. The data is stored and saved in a printable spreadsheet format.

After the cathodic protection design was reviewed and approved by the owner, Corrpower’s next challenge was to procure and fabricate the embeddable materials in two months and deliver them to the job site prior to the plant shutdown. This required significant cooperation between Corrpower’s project team in Saudi Arabia, and the Corrpro US procurement team. The cathodic protection equipment was delivered in time to meet the construction schedule.

The cathodic protection equipment was installed by the General Contractor under Corrpower’s supervision. The installation component was conducted in accordance with the approved design and on time to meet the construction and shut down schedule. Delays requiring extension of the shutdown schedule would result in millions of dollars of losses to the owner. The installation was finished in 19 days which was 2 days ahead of schedule.

Commissioning activities are presently underway and the preliminary results indicate that the cathodic protection system is performing in accordance with the project specifications and industry standards.

completely submerged in seawater including; sluice gates, bar screens, traveling screens, stop logs, suction and return pipes, and ladder rungs.
In the later part of 2013, a major power utility in northern Canada suffered a failure of a telecommunications tower anchor. The failure occurred in an urban area where the possibility of personal injury, property damage, and downtime for the utility was significant. The failure prompted the utility to re-evaluate the risk assessments in place for the tower system and moved to the forefront the requirements for cathodic protection for these towers.

MEETING REGULATORY REQUIREMENTS

In Canada, the Canadian Standards Association Regulation S37-01 outlines the requirements for the protection of a steel (galvanized or bare) rod exposed to the soil. The anchor/guy wire configuration used by the utility is typically a solid rod or angle iron embedded in concrete and buried for stabilization. Unless the entire buried metal surface area is encased in concrete, the application of cathodic protection is mandated under S37-01.

For this project, Corrpro was asked to participate in the risk assessment process with both inspection and repair services, as well as in the development of a plan to prioritize the more than one hundred tower sites. Forty sites of varying age, anchor configurations and soil conditions were selected as “High Priority” and a full inspection plan initiated. The data collected at each site will be used in the SCE-API Soil Corrosivity Evaluation point system to categorize the remaining sites in to priority levels and establish a time line for inspection, upgrading and possibly replacement of the tower itself.

THE POINT SYSTEM

Today, the inspection process is near completion with 38 of the 40 selected sites inspected, repairs completed and the tower put back into service. Once all of the data is collected an analysis of the data will be completed and all sites prioritized based on the “SCE-API Soil Corrosivity Evaluation Point System.” The point system evaluates the soil type, moisture content, pH, redox potential, resistivity, tower age and any galvanizing that may be present on the anchors. These variables are then tallied and categorized accordingly based on the number of points. Based on the preliminary results, the degree of corrosion noted during the excavations correlates reasonably within the corrosion rates predicted in the point system.

The point system was originally used to determine when a structure in soil should be protected. The categories for this project have been modified to reflect the immediate need to inspect and repair, apply cathodic protection to extend the service life, or replace the tower anchors. Given the age of many of the towers, refurbishing is not always feasible. The project has been initiated to help define the high, medium and low priority sites.

FUTURE DESIGN AND SPECIFICATION

As part of the action plan going forward, Corrpro has prepared a generic design package and specification for clients. In order to minimize installation time and ground disturbance, the use of small remote anode impressed current system has been selected. The anodes are installed remotely in a single borehole and typically connected to a five ampere rectifier. Design and current requirement testing carried out at these facilities on past projects have confirmed that typically one to two amperes of current is required to protect the three main anchors and associated grounding. The installation time and costs are reasonable and can typically be carried out in a single day.

Given the growing need for both business and personal communication that has occurred over the past decade, communication towers will likely show increased activity in the sphere of corrosion prevention and mitigation.

The interface of the steel rod where encased in concrete and the portion of the rod exposed to soil are the areas where corrosion is most likely. Given the hot spot conditions at this interface, each of the anchors at every site were inspected and data collected. The condition of the rod from grade to the concrete interface was inspected by both Corrpro and a tower anchor design firm. The general condition of the tower anchor was evaluated based on the measurable corrosion of the rod. When this was determined, repairs were either completed or the rod was replaced. In most cases a coating and a sacrificial anode were installed as remediation.
Corrpro Companies Europe Limited recently performed an extensive Cathodic Protection (CP) survey of a large multiple jetty site in the North East of England. In continuous operation for almost 40 years, the jetty site supports a large oil refinery and a storage and export company. The jetties, eight in total, are structurally supported on coated tubular steel piles with a floating pontoon emergency response structure in the vicinity.

In association with the CP surveys, an underwater structural assessment and coating rehabilitation program was performed on one of the jetties. The estimated cost to the owner was in the region of $1 million (US) before any remedial work was undertaken.

The importance of good design, engineering and installation practice was evident during the survey as much of the original system has been operating for 40 years since its commission—more than 15 years beyond the anticipated design life. It is clear from the survey results that the application of CP to the structure has lengthened the operational life of the jetties, preserved the coating quality and reduced the rates of corrosion of exposed bare steel surfaces. While some maintenance will be critical to future performance, the system now operates in remarkably efficiently.

SURVEY INFORMATION

There are approximately 1250 piles supporting the jetties, both vertical and “raked” type in varying different diameters. The piles currently have a mixture of different coatings. The original coatings were thick bituminous based, however, subsequent coatings have been epoxy-based marine-compatible paints.

The jetty site uses an impressed current CP system with 11 transformer rectifiers (TRs) that power 76 platinised titanium anodes. All eight jetties are electrically continuous, with each jetty considered a separate zone, as is the pontoon structure. The current capacity for the entire system is 1250A. There are no fixed test points or permanent reference electrodes as the availability of original design and installation documentation is limited.

The ramit of the CP survey was to determine the condition of the TRs and their operating efficiencies and to determine what measures would be required for their continued operation for another 10 years. The performance of the CP system was to be validated by pile to seawater potential measurements. The current to all anodes had to be recorded and the presence of accelerated low water corrosion (ALWC) at low tides and the condition of the steelworks supporting the CP system cables and anodes were to be assessed from a boat. The assessment required no diving operations.

CORROSION OF HARBOUR PILES

Steel structures in seawater, including piles, are vulnerable to external corrosion resultant from many factors. Seawater has a very high chloride content that creates very low and corrosive resistivities in the order of 20 – 30 Ohm. In addition, the tidal waves inshore create an abundance of oxygen and differential aeration environment, which is also a factor in accelerating corrosion rates. Piles are subjected to heavy stresses not just from waves but also from abrasion and scouring from seabed sands and debris—even flotsam and jetsam has a part to play. Dissimilar surface conditions and coating defects create anodic areas on piles.

Corrosion rates are at their most virulent in the splash zone, tidal zone and atmospheric zone. In these locations the piles are attacked by waves and undergo cyclic wetting and drying. CP is not effective in these zones and so corrosion resistance is down to the material of the pile and the coating applied. CP is only considered to be effective up to the mean water level (MWL). Below this point, the piles are vulnerable in the submerged and the soil zones. They are specifically at risk where accelerated low water corrosion is prevalent. ALWC is caused by microbes that proliferate where levels of polarisation are low. Rates of corrosion of 3mm/yr have been reported—considerably more rapid than the splash zone rates recorded. To overcome this, the piles must be perfectly coated or the CP system must operate with at least -100mV more polarization than the minimum OFF potential of -800mV with respect to the silver/silver chloride seawater electrode.

To overcome this impact and vulnerability we can consider several possibilities:

• Material selection that may be more corrosion resistant
• Sacrificial allowances that tolerate the conditions
• The choice of coating
• Cathodic Protection

In many, but not all cases, it is generally a combination of all these that forms the basis of the corrosion resistance of a structure.

SURVEY FINDINGS

The survey work took four weeks to complete. During this time all equipment was inspected and potential values of 97% of all piles were recorded.

The TRs were found in varied condition. All were working except the pontoon unit and the TR on Jetty 4 which was switched off. Three out of five unit enclosures were so badly corroded they should be renewed. Others had oil leaks, perished seals, corroded fittings, or wet desiccants, and none had had oil changes in decades. All of this was reported and recommendations for repair were made.

All of the anodes were tested using a current clamp at low water. 70 of the 76 anodes passed adequate levels of current. One anode had been cut away for reasons unknown and five others did not pass any current. Of these, four anodes were recommended for replacement. One anode that was no longer working had a large calcareous deposit on the holding tube. The calcareous deposit had built up because the dielectric coating on the tube had failed. The chemical reactions at the cathode (local to the anode i.e. the dielectric tube) had generated vast amounts of magnesium chlorides on the surface of the tube because the tube coating had failed.

Potentials were recorded using a digital multimeter and a silver/silver chloride seawater reference electrode on an extendable cable with pile contact made via a file which was bolted to a test lead. Due to the low resistivity of seawater, the potential values were recorded with the CP system switched on. Potential values are considered to be IR error free. The survey found that over 95% of all piles tested were more negative than -800mV wrt Ag/AgCl/seawater. There was very little overprotection of piles (considered to be any potential more negative than -1200mV wrt Ag/AgCl/seawater). In fact the pile to seawater potential profile across all jetties was consistent. The range of pile to seawater potentials recorded was -818mV to -1256mV wrt Ag/AgCl/seawater. Only piles that were either not physically connected to the main structure, had lost the electrical continuity through failed cable connections, or were not under the influence of a working CP system were under-protected. During the survey, the TR on Jetty 4 was switched off for coating repair works. Some, but not all of the piles in this
The coating quality of the piles was found to be generally very good. There were examples of gouged coatings, blistering and flaking. Some isolated points were poorly coated and very brittle. ALWC was found on the pontoon only. This was expected given the time the CP system had been inoperative and the knowledge that ALWC was prevalent on this estuary on other structures.

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Other ancillary equipment such as brackets, pile connections, conduits and cable routes were assessed. Two anode connection systems had completely failed and 19 electrical continuity cables had been damaged, but most of the remaining equipment was in good condition.

The operating efficiencies of the TR outputs suggest the anodes are functioning well and have not been over burdened enough to consume the platinised anodes. The anodes have been well maintained and the TRs have been well built. Quality maintenance is a credit to the operator and has undoubtedly added to the operational life of the system. It is only the environment that would really affect the life of the system being extended for a further 10 years or more. As described above the TR enclosures are in a generally poor condition. If three are renewed completely and the others repaired and reconditioned, there is no reason why the system cannot continue to successfully operate for years to come.

Considering the pontoon and the presence of ALWC, this warrants the immediate upgrade of that system.

IN CONCLUSION
The CP system continues to operate well beyond the original design life. There is a requirement to renew some power supplies and replace several anodes however, this work can be performed during routine maintenance and inspection plans. The owner is undertaking anode renewals and cable and conduit repairs. They are reviewing optimal replacement programmes for all TRs, continue to perform routine monitoring of the CP systems and have committed to undertake a detailed assessment in this manner every 5 years.
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