Processing Plant Enters the Pipeline World

A Case Study of a Chemically Welded Anomaly Repair

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Introduction

A processing plant entered into the pipeline industry in what seemed like an instantaneous manner. Since 2009, when the processing plant took over ownership, operational and maintenance responsibilities of their plant facility's process feed pipeline. It had been somewhat uneventful and seemingly routine, however in October 2013 things took a turn for the worst when an incident occurred resulting in a release of product.

At this point in time the pipeline was determined to be jurisdictional to the Pipeline Safety division of the Rail Road Commission of Texas (TRRC), and was to be regulated under the requirements of not only the Texas Administrative Codes (TAC), but also the pipeline safety requirements of the Codes of Federal Regulations (CFR).

While the processing plant appears to have met this challenge with success, it had seemed almost insurmountable at times. This article is written to share some of the challenges that the processing plant personnel were faced with, and how they succeeded in resolving them with methods and procedures that were foreign to them just months previously.

In this article will be discussed just a few of the more notable achievements, such as; designing and energizing an impressed current cathodic protection (CP) system to replace the obviously old and spent galvanic system, developing and performing an external corrosion direct assessment (ECDA) process, and developing specifications for installing the Composi-Sleeve™ Reinforcement System repair provided by Western Specialties.

Background

The processing plant is located in the Houston, Texas area. Vinyl acetate (Monomer) (VAM) is the primary feedstock for one of their processes. It receives this feedstock by means of a 6” and 4” carbon steel pipeline between a tank farm, and the plant’s internal processing plant installed by the original plant owner in 1981. The plant became the owner and operator of this pipeline in 2009 when they acquired the plant.

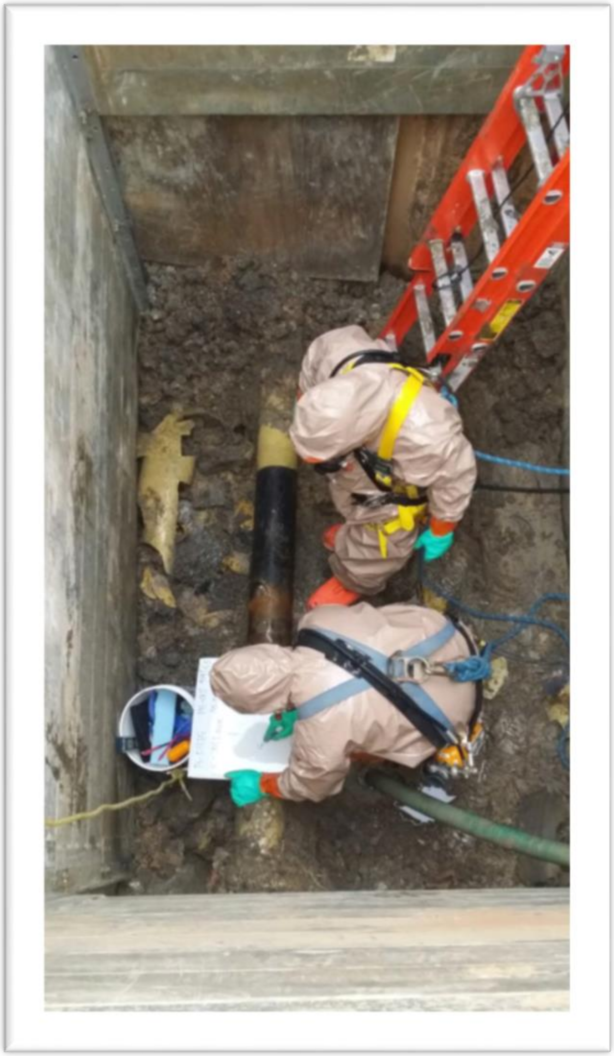
Because of the product transported, and because the maximum operating pressure is well below 20 percent of the specified minimum yield strength (SMYS) of the pipeline, it was originally thought to be non-regulated when first put into service in 1981. It continued to be shown as such, until a recent incident occurred at which time it was deemed jurisdictional by TRRC Office of Pipeline Safety (OPS).

Since the incident, and the subsequent safety inspection by the TRRC that followed, it has been the processing plant’s determination to meet all obligations that come from operating a jurisdictionally regulated pipeline head-on, and has chosen to do this in the most meaningful and correct manner possible.

Prior to all of this taking place, the plant had operated and maintained the pipeline as part of its Plant Safety Management (PSM) requirements, using those Standard of Operation (SOP) written primarily for plant operations and maintenance. The plant personnel began earnestly addressing the newly determined requirements as set forth in the CFR §195 and the TAC of the TRRC. All to ensure all necessary processes and written procedures for operations and maintenance, operator qualification, public awareness and emergency response were developed and in place as soon as possible.

An integrity management program was also developed and acted upon during this project. Basically what this meant was to take the SOP’s that previously pertained to the pipeline and adapting or “adding-to” so that they would now satisfy the newly determined regulatory requirements.

While this was under way, another leak occurred just north of the pipeline’s Port Terminal Railroad Authority (PTRA) crossing where the pipeline turns west as it enters the Port of Houston Authority (POHA) pipeline corridor. The leak was initially located by personnel of a neighboring pipeline company within the POHA pipeline corridor. After confirmation that the product that had leaked was their feedstock, the plant initiated their Emergency Response Plan (ERP). They reported the leak through proper channels, and an emergency one-call was issued by the plant personnel to begin locating the exact leak location, and begin excavations.



As the ERP was activated, and product remediation process was underway, a direct current voltage gradient (DCVG) survey was performed in an effort to more quickly locate any possible coating damage in the area of where product had surfaced, believing this would eventually pin-point the leak's failure location, and provide good centerline data that would be needed to eventually enter the pipeline into the "811 – one call system" for the first time.

The leak location was found and repaired using 2 leak clamps. Once the leak was located, a root-cause analysis yielded indications the failure may have initially began because of previous third party damage to the coating, eventually developing into an active corrosion cell and finally the failure. No serious physical damage to the line pipe's integrity was found, but abrasion of the coating was obviously due to mechanical damage. Once the clamp was in place, product was removed from the pipeline back to the product's storage tank, and filled with water and began a pressure test to ensure the integrity of the repair clamp and further locate any other possible areas in need of repair.

The leak was located in a very congested pipeline corridor, just north of the PTRA railroad.

After the repair, the pipeline still would not hold pressure, giving all indications that one or more leaks still existed. Locations were excavated that were thought to be suspect as a result of the DCVG survey data - keeping in mind that a large coating failure identified as a result of this survey's data does not always mean damaged pipe or possible pipeline leaks. Tracer gas was included with the water used to replace the product, bettering the chances for finding smaller leaks more quickly.

Four (4) additional leak locations were eventually identified and excavated, consisting of more than one leak at some location, and as with the first leak's root-cause analysis, the initial damage was done by third party. Interestingly enough, other pipelines in close proximity to this one were also damaged. It should be noted that because of soil contamination, and at the request of area pipeline operators, these excavations were all done with the use of hydro excavation rather than mechanical equipment, so damage to the pipelines were done before these excavations took place.

Contract personnel preparing to enter the excavation and make necessary repairs.

Port Terminal Railroad Authority Cased Crossing

Because of the close proximity of the pipeline's PTRA cased crossing to the initial leak location, both ends of the casing were exposed for visual examination to ensure that the actual leak found was the only one in the area, and one had not occurred in the cased crossing. Although the existing casing end seals (link-seals) appeared to be in good shape, liquid was found coming from both ends of the casing, indicating the casing was not completely sealed from moisture.

However once the casing was emptied of liquids, there was no evidence that the carrier pipe was leaking within the casing, and was only residual product from the actual leak earlier located. After two days of examination, both ends were backfilled, but not before an attempt was made to fill the casing annulus with wax to prevent any future water intrusion, and to prevent any possibility of external corrosion of the carrier pipe, but the waxing attempt failed.

South side of the PTRA cased crossing.

All indications are that the vent pipes were installed on the casing pipe, but the casing vent holes were either not made, or they were made too small to accommodate pumping wax through them. This cased crossing will be monitored for the next year, and should indications of an electrolytic short becomes apparent between the carrier pipe and casing, the cased crossing should be replaced or have the casing ends expose again, and complete the waxing process.

Direct Current Voltage Gradient

The DCVG survey is an assessment that was chosen because the determined risk/threat is considered to be the coating age, and because the pipe-to-soil potential readings recently taken have indicated the galvanic anode CP system had depleted over the years. Because of the location of the pipeline's congested right of way (ROW) and potential for third party activity, it was also determined that third party damage may be a structural integrity threat to the pipeline as well.

Although ECDA is not normally thought to be a good integrity assessment tool for third party threat, it has proven to do well in this particular case. However, it should be noted that all third party damage found so far has involved some coating damage, which means that should any third party damage to the pipeline that has not resulted in any coating damage could still exist. To fully address the threat of third party damage, the processing plant is considering a tethered inline inspection (ILI) tool run in areas where third party activity is known to exist.

The initial DCVG was performed using current generated by a temporary rectifier and anodes since the new rectifier and ground bed had not yet been energized. It is important to note this because no real protective polarization had taken place on the pipeline’s exposed surfaces, and ultimately could have an effect on the readings and their interpretations. With that said, the initial readings were good enough to find the leak, as previously mentioned.

The new rectifier and ground bed have since been energized using a temporary generator for power, and has been running now since soon after the initial leak was located. The new CP system’s rectifier is set at an output of 8 to 10 amps of protective current. Soon after energizing the system (approximately 2 days) reading were taken that showed the pipeline having a pipe-to-soil potential well within the readings of a negative 900 millivolts – more than satisfying the chemical plant’s chosen criteria of a negative 850 millivolts of protection. After 2 days of the new CP system in operation, another DCVG survey was performed to establish better, and more definitive readings.

Direct Examinations

Direct examinations were performed during all excavations, enabling root-cause analysis. All reading and collected data during these direct examinations have been well documented, and are filed in the pipeline’s Project File related to this incident.

Leak Repair Project Summary

An ECDA written procedure was developed earlier to address the pipeline’s determined structural integrity risks/threats of failing coating and a depleted galvanic CP system. The ECDA written process worked well and will later be used as an assessment tool to assist in assuring the pipelines integrity in the future.

As mentioned earlier, a root-cause analysis process was performed for each excavation, not only confirming the predetermined threat of coating failure, but identified a second threat as well. All indications are that the coating is holding up well, but as mentioned earlier, the CP system was depleted to a level where it is no longer able to protect areas where the coating has been damaged by third party activity. To adequately address this third party threat, an inline inspection (ILI) tool run should be performed in the near future.

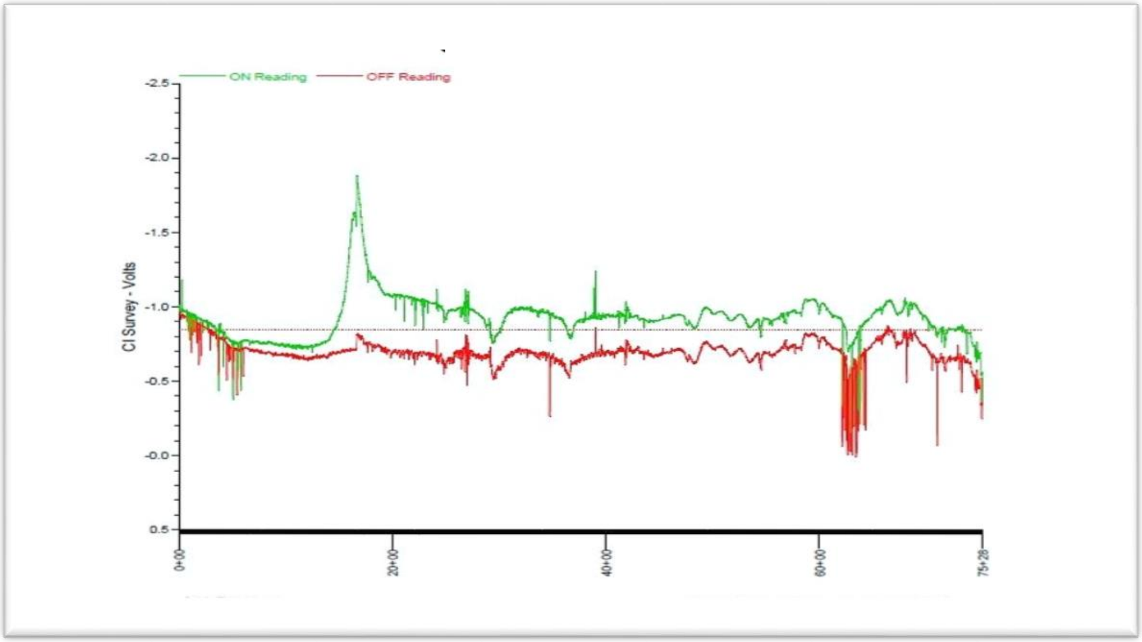
Through a root-cause analysis process, several common integrity threats believed to be inherent of older pipelines were also eliminated. The pipeline's electrical resistance welded (ERW) longitudinal seam was examined, and all indications were that the seam was intact and had no corrosion due to the welding process during the manufacturing of the line pipe.

No SCC was found in any of the exposed pipe. Dye penetrant nondestructive examination (NDE) process was used to address these SCC determinations. And the factory applied polyethylene extruded coating that was exposed showed no indications of any CP shielding issues. The presence of microbiologically induced corrosion (MIC) as a threat was also proven not to exist.

Three block valve were replaced at the tank farm storage facility, and an internal inspection while the valves were removed, proved-out that internal corrosion is not an integrity threat. The pipeline is now holding pressure and will soon be pressure tested in accordance with CFR §195, Subpart "E" to establish the pipeline's maximum operating pressure (MOP) of 125 psig.

To complete the ECDA process, a close interval survey (CIS) needed to be performed, but the new direct current CP system needed to be in operation for at least 2 months before good results can be obtained. Because CIS and DCVG are considered complimentary tools, another DCVG survey should be performed at the same time as the CIS survey for a good correlation of data from both surveys. The DCVG survey is a good coating condition survey, but it is difficult to make any real conclusions until the data is coupled with CIS data taken at the same time.

Several digs have already taken place with predetermined results verified using the ECDA data alone. Field verifications continue on this basis while the pipeline is back in service. Based on the results of the previous verification digs the remaining call out locations were given a monitored classification and will be revisited as spelled out in the written ECDA process.



Close Interval Survey results with the new impressed current CP system in operation.

Follow up

Preliminary hydrostatic pressure testing was performed during June 3rd thru 9th, 2014 in an effort to ensure all potential leaks were located and repaired. Upon finding 4 additional leak locations, and performing subsequent repairs, a pressure of 150 psig with no further leaks. On June 10, 2014 an officially documented hydrostatic pressure test was conducted per CFR195, Subpart E—Pressure Testing.

This official record, along with repair records are stored in the VAM Pipeline equipment file and in soft copy on the processing plant's secured drive. This Subpart E pressure test will also serve as the pipeline's current mechanical integrity assessment, as well as establishing the pipeline's maximum operating pressure (MOP).

A CIS and a more recent DCVG survey were conducted during the week of July 28, 2014. All indirect survey data was compiled, compared and examined closely. With these findings, and after further considerations of the earlier ECDA region determinations, and each distinctive variation; investigative digs were then selected to represent the worst case anomaly finds within each of the pipeline's ECDA regions earlier identified in the written process.

Based on previous, and most recent findings of these ECDA processes, these excavations are expected to validate all readings and findings of the indirect surveys and to further quantify the earlier determined risks and potential integrity threat of external corrosion due coating failures and previously occurring mechanical damage. These investigative digs, root-cause analysis and any needed repairs will serve as the direct assessment step of the processing plant's ECDA process and procedure, leaving only the post assessment step remaining.

Integrity Assessments and Improvements Continues

As a direct result of the post leak repair project, and the resulting ECDA, another excavation and direct assessment performance was required. Because of a survey reading indication, the pipeline was again exposed.

As anticipated one of the pipeline ninety-degree bends, or elbow had coating damage, and an area of apparent SCC cracking. This appeared to be a possible result of induced stress cracking caused during the pipelines initial installation, tie-in and backfill. Western Specialties was contacted to discuss possibility using their Composi-Sleeve™ Reinforcement System.

Composi-Sleeve™ Reinforcement System

It was suggested that the Composi-Sleeve™ Reinforcement System be use for the initial repairs, and a written process and procedure was even added to the processing plant's pipeline operations and maintenance manual. However, due to the time constraints and the having very little background or history of this type of repair, the chemical plant made the decision to use bolted and sealed clamps instead.

This looked to be a possible tie-in weld that was mechanically forced into place in order to actually make the tie-in.

Once the follow-up CIS and DCVG surveys were completed, and the new CP system had time to protectively polarize the entire pipeline system, digs of some of the less than desirable survey readings were performed. One such dig including the previously mentioned elbow near the railroad spur entering the chemical plant. It was thought that this would be a good opportunity to give the Composi-Sleeve™ Reinforcement System a trial run.

Once the pipe surface area was cleaned, it became apparent just how much mechanical damage was done to the pipe. Also a crack in the ERW longitudial seam weld of the pipe becomes very appartent.

COMPOSI-SLEEVE™

Pipe and elbow surface areas are given a good anchor profile to match the anchor profile of the designed steel sleeves to be used during the repair.

Application of patented adhesive to both the steel sleeves and pipe surface.

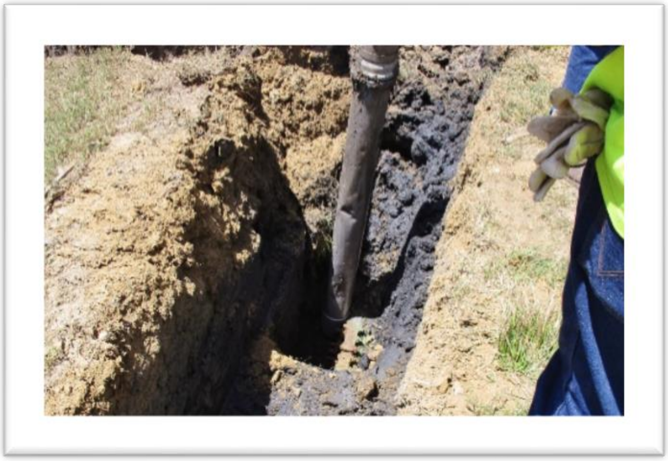
Finishing-off with the patented composite wrap.

Finished product, and ready for backfill.

The pros and cons of replacing the previously installed repair clamps using the Composi-Sleeve™ system were discussed, and as a result of digesting and studying testing results provided by Western Specialties including the August 2014 the publication by American Society of Mechanical Engineering: ASME PCC-2 Qualification Testing for the Composi-Sleeve™ System. In 2016 the processing plant made the decision, and allocated the funding necessary to do just that.

Composi-Sleeve™ System - Change-Out Project

The processing plant decided to remove the previously installed leak repair clamps installed during May and June of 2014, and replace them using the Composi-Sleeve™ Reinforcement System of Western Specialties - considered a more permanent repair. This project consisted of 5 excavations, with no 2 being alike. GPS readings of each repair were taken during the previous repair project of 2014 repair project, and with the use of these GPS readings each clamp was located and flagged prior to excavation.



The exposure of 2 leak clamps was found at excavation "D". Hydro-Vac was used for most of the excavation process.

During the actual clamp removals and Composi-Sleeve™ installations, the pipeline was depressurized and blocked-in, however VAM remained in the pipeline, having a positive pressure due to elevation changes along the pipeline route. Once the pipeline was blocked-in, or when the pipeline was in operation, contractor personnel coordinated, and followed the "Lock-Out, Tag-Out" procedures at all times to ensure the required status (in operation, or at static conditions) of the pipeline remained in place.

The pipeline tankage at the processing plant facility has only capacity for approximately 12 hours of plant operation, at which time the pipeline was started up again to allow for refilling the feed tank at the chemical plant so the plant could maintain continuous production, and allow for the next pipeline 12 hour blocking-in.

The clamp removal and Composi-Sleeve™ installation took place only during the 12 hours of operation using the feed tank at the processing plant for uninterrupted process feed. While the pipeline was in operation (during re-filling operation of the feed tank) the pipeline pressure was between 80 to 100 psig.

Prep work only near or around the pipeline was allowed during the refilling operation of the chemical plant feed tank. All work physically performed on the pipeline itself only took place within the 12 hours the pipeline was blocked-in, and the processing plant process was using the feed tank located at the processing plant for feedstock.

At a point when each excavation was completed, and made ready for the removal of the clamp and during the installation of the Composi-Sleeve™ the excavation was lined with a plastic sheet material to prevent any possible soil contamination. Just prior to clamp removal, a catch-tub (i.e. wading pool) was placed in such a manner to further the collection and containment of any possible product release from the exposed leak during the clamp removal process.

The removal of all clamps and the installing of each Composi-Sleeve™ were performed within the POHA pipeline corridor, and the tank farm of another operator contracted to store and shipped the VAM to the plant. The project was successfully completed at the end of the third quarter of 2016.

Excavation A

There were 5 excavations, with 5 Composi-Sleeve™ installations. The first excavation (Excavation A) was to be only an exploratory dig of the repair made of the first pipeline failure during October, 2013.

It was anticipated that Excavation A would be a difficult excavation, because it was believed that stabilizing sand was used as backfill near the repair, however that was not the case when exposed.

Concrete was poured over, and around the repair making it difficult to get to the repair itself. It was decided that attempts to break up the concrete should not be done in fear of damaging the repair. Any bare pipe found during this excavation was coated and the excavation was backfilled.

Oops! Not exactly what was not expected at the exploratory Excavation "A". Someone poured concrete. Recoated what pipe was exposed as possible and backfilled.

Attempts to remove concrete were not made for fear of damage to the repair.

Excavation B

The purpose of Excavation B was to replace a leak clamp installed during the 2014 project near an elbow. However, after locating the leak clamp, and while removing damaged coating to define a recoat area, another questionable area of wall loss caused by external corrosion was located. As a result of this find an additional Composi-Sleeve™ was installed.

Leak clamp removal of Excavation B. While looking for good coating to determine the re-coat area, once the sleeve is installed.

A big advantage to using Composi-Sleeve™ is that it can be installed on most pipe while it is in service with 20 pounds or less of pressure. This means, of course, the pipeline does not need to be purged of its product, or made hydrocarbon free to safely install the Composi-Sleeve™ in most cases.

Once the clamp is removed a temporary plug is install, and the pipeline external surface is cleaned and prepped for the application of the adhesive and steel sleeves.

Once the sleeves are in place, with the use of patented tensioning straps, the sleeves are compressed evenly to the specified tension using a torque wrench for the final tightening.

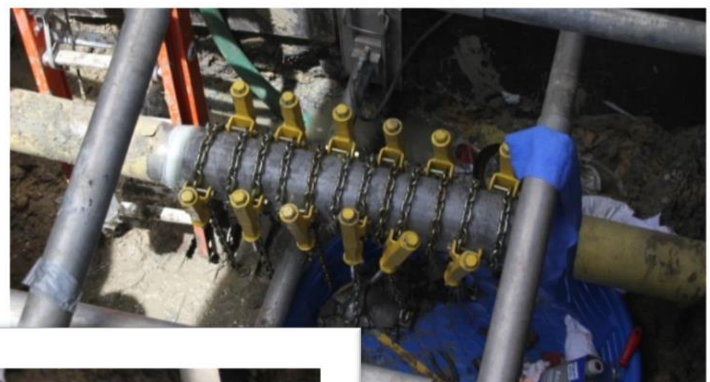
As the torqueing process is being completed, work begins on prepping the recently found area of concern for the next Composi-Sleeve™.

Excavation D

Excavation D was the original failure repair for the pipeline in May of 2014. This was located in a very congested area of the POHA pipeline corridor at a depth of some 15 feet. There were 2 clamps needed to stop the leak.

The 2 clamps are located and made ready for removal.

Clamps are removed, and a single Composi-Sleeve™ is in place and under tension.

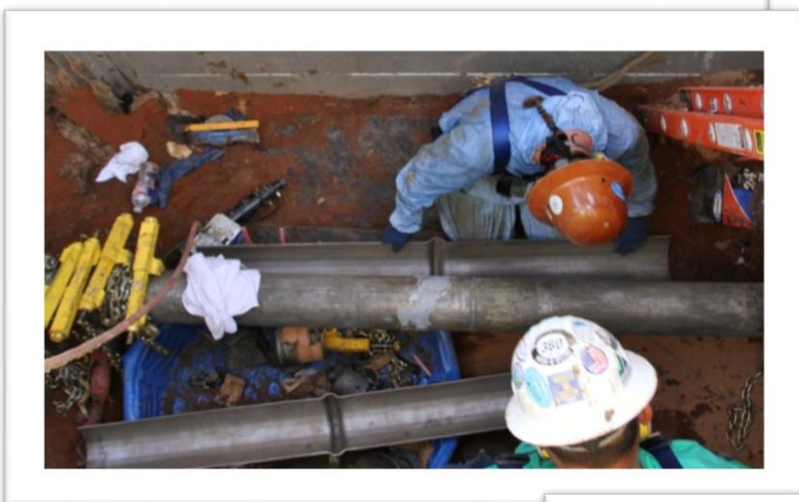


Finished process and ready for backfill.

Excavation H

In all, there were 5 excavations made and 5 Composi-Sleeve™ installed. Excavation H was one that merits some discussion, in that it consisted of 2 leaks – one on either side of a girth weld. The 2 clamps used in the earlier repair were removed and replaced by 1 Composi-Sleeve™ designed to accommodate the raised girth weld. Each Composi-Sleeve™ is designed and fabricated using strict specifications to conform for a tight fit and ensure both strength and durability, such as the case of Excavation H.

It would seem that just after a year these clamps were ready to be replaced.



Once the clamps are removed, a trial fit of the sleeves is performed.

Concerning the leak clamps, it appears the coating was not applied correctly, or perhaps the surface area for the clamps was not thoroughly prepared. At any rate, the clamps were not going to hold-up much longer. The active corrosion was obviously due the inter-action of dissimilar metals used to manufacture the clamps. It was fortuitous in this case that the processing plant made the decision to change out the clamps.

The Composi-Sleeve™ is ready for coating & backfill.

And Finally

It may seem, to many that the installation of Composi-Sleeve™ was a little over-kill in this case of repairing wall-loss on a small pipeline operating at less than 20% of SMYS, but it was either this, or cutting-out and replace pipe, or possibly just repairing in some fashion.

Installing the Composi-Sleeve™ Reinforcement System is comparable in cost, or less to these previously mentioned repairs, or replacement, and considering the environment (i.e. contaminated soil) it was very convenient not having to perform any 'hot' work.

As an added benefit; the chemical plant was able to operate without interruption, and dare we say - using the Composi-Sleeve™ Reinforcement System was "priceless".

About the Author

Randy Vaughn is current President of R&F Pipecon Resources, Inc. and has over 40 years in the pipeline industry, with a majority of the last 16 years in pipeline safety compliance.

He is retired from the Shell Oil Company and the State of Texas, and has taught classes at the PHMSA Inspector Training & Qualifications Center in Oklahoma City as an Instructor.

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