

Preparation

1.1. Soil-Side Corrosion on Storage Tank Bottoms

Before we start to learn about CorroLogic AST solution, it is important to recognize the importance and significance of the problem that we are trying to solve. Soil-side corrosion is a principal cause of storage tank failure and imposes a major environmental and operational challenge worldwide and requires effective control during the complete life cycle of the tank.

Several methods have been adopted to mitigate soil-side corrosion of Aboveground Storage Tank (AST) floors over the years, such as bituminous sand, impressed current cathodic protection and coatings. However, total effectiveness of these techniques, as standalone or combined, have been questionable in providing the required protection against soil-side corrosion. Bituminous layer proved to trap moisture and corrosive species between the underside of tank floor and construction pad resulting in creating a corrosive environment.

Another contributor to soil-side corrosion is the presence of gaps between annular plates and the tank ring wall. Such gaps allow ingress of moisture, rainwater, fire sprinkler or tank deluge systems creating water pooling and ponding around the base and diffusion airborne chloride, especially in facilities located in coastal areas.

It is not unusual for tank owners to have the underside of tank bottom plates coated during construction. However, due to unavoidable defects during coating application and handling, such as pinholes and scratches, thermal damage during welding of bottom plates and the natural deterioration or aging during tank operation, It is widely accepted that coating of bottom plates alone cannot prevent corrosion.

The presence shielding material and the inevitable air gaps between tank pad and bottom plates shields CP current at those locations and consequently prevents uniform distribution of cathodic protection.

Failures due to soil-side corrosion can happen and when it happens it can be catastrophic with major impact on operations and the environment.

1.2. What is CorroLogic AST Solution:

CorroLogic AST is an engineered solution to mitigate soil-side corrosion on storage tank bottoms. It is typically composed of four main system components:

1. Vapor phase corrosion inhibitor products which can be CorroLogic Powder or CorroLogic Slurry depending on the application methodology.
2. Corrosion monitoring system to monitor the corrosion before and after introduction of VpCI material.
3. A chime area seal system to close the gap between the annular plates and the ring wall.

4. Delivery and replenishment network to apply and replenish the content of vapor phase corrosion inhibitors when needed, during the service life of the solution.

CorroLogic products: provide protection against soil-side corrosion on storage tank bottoms. They provide protection to coated surfaces and previously corroded steel. They are organic salts, mixtures of amines and carboxylic acids. They come in the form of Powder or Slurry. They are environmentally safe and do not contain nitrates or other harmful chemicals.

Once VpCI material is introduced under the tank bottom plates, it vaporizes, diffuses through the sand and space, reach to the underside of the tank bottom plates, adsorb onto the surface and form a monomolecular protective layer on the plates that are in contact with the tank pad and in the air gap areas. *Note: If you want to know more VpCI technology, please review VpCI Basics course,*

Corrosion monitoring: The second component of the CorroLogic AST solution is the corrosion monitoring using Electrical Resistance (ER) probes and data loggers. Multiple probes, depending on the side of the tank, are installed by core drilling through the ring wall, pushing a 1" PVC tube under the tank and inserting the probes into the tank foundation through the PVC tube. Probes are usually installed 2 to 8 weeks to establish a corrosion rate base line prior to injecting CorroLogic AST. Once baseline corrosion rate is established, the suitable CorroLogic AST product is injected. Corrosion monitoring continues after injection and shows the reduction in the corrosion rate over time.

Chime area seal system: One of the requirements to maximize on the service life of CorroLogic VpCI solution and the protection of tank in general is a sound chime area seal system, which prevents the ingress of water, moisture and oxygen and help contain the CorroLogic VpCI under the tank. Tank chime area seal system is composed of a foam backer rods, used in case of gaps greater than 10mm, viscoelastic filler, wrapping band a topcoat to provide protection to the wrapping band against UV rays. *Do we need to expand on the chime area seal system PDS SDS etc...*

Delivery and replenishment network: Depending on the tank foundation type and the tank status whether it is in service, out of service or under construction, a delivery and replenishment system is selected. In the case of out of service, portable powder fogging tool is used to introduce CorroLogic Powder under the tank. in case of in-service tank, a network of straight perforated PVC injector tubes 1" in diameter are installed by core drilling through the ring wall and pushed in the tank pad to a prespecified depth. The injector tubes are usually installed 100 mm to 200 mm from the tank floor level and they are used to deliver CorroLogic Slurry and replenish it as needed during the service life of the system. In case of a tank under construction, concentric dispensing rings are integrated into the tank foundation to delivery and replenish CorroLogic Slurry. *Add the dispensing system. Do we need to expand on the system PDS SDS etc...*

Application methodologies: Depending on the tank status and type of its foundation, CorroLogic AST products can be delivered under the bottom plates by one of the following methodologies:

1. **Through-Tank-Floor Application:** This application method is done for tanks when they are out-of-service and it is applicable to tank foundation types; Tanks constructed on washed sand with ring wall and HDPE liner, Tanks with asphalt, bituminous, oiled sand pads or continuous concrete slabs. It is also more resilient to tank foundations without Release Preventive Barrier (RPB) compared to Through-Ring Wall application

After installation of the corrosion probes and establishing the baseline corrosion rate, prespecified number of holes, 8 mm in diameter, are drilled into the tank bottom plates using magnetic drilling machine. The number and distribution of holes across the tank floor is depends on multiple factors such the tank size and tank floor condition as per Magnetic Flux Leakage (MFL) floor scan report. In Through -Tank-Floor application, CorroLogic AST Powder is added to a pneumatic machine and then fogged through the holes. After Powder fogging, the holes are patch welded. The Powder trapped between the underside surface of the bottom plates and the tank foundation start to sublime delivering the protective molecules that adsorb on the surface and form a protective layer and reduced the corrosion rate.

2. **Through-Ring Wall Application:** This application methodology is applicable for tanks constructed on ring wall with washed sand foundation and release preventive barrier.

Perforated PVC tubes, 3 quarter an inch, are pushed under the tank in the sand pad to a prespecified depth which can go as far as almost to center of the tank. Multiple injector tubes are installed to ensure uniform distribution of CorroLogic Slurry. CorroLogic Slurry starts to evaporate, diffuse through the sand and space, reach to the bottom plates, adsorb on the surface and form a protective layer. The protective layer forms on the underside plates surface in the air gaps as well as the areas where the bottom plates are in contact with sand.

3. **Integrated Dispensing System:** The system is composed of concentric dispensing rings connected to straight transfer lines that pass through the concrete ring wall through PVC sleeve cast into the concrete wall during concrete pouring. The transfer lines terminate into a manifold box installed outside the tank foundation. This manifold box can later be used to inject the CorroLogic Slurry through the different dispensing rings which uniformly distribute the CorroLogic Slurry under the tank. This system can be used to provide protection during construction period until the CP system is commission and can be used as a provision to provide protection for the tank during operation. It also can be installed when the tank goes through complete bottom replacement.

1.3. What is CorroLogic AST Track Record

To ensure best performance for the clients, CorroLogic AST is offered on a turnkey basis. We gather the required information to assess the value and applicability of our solution to the client, supply the right material and supervise the installation of selected protects and monitor the performance of the system during its service life.

We have been successfully providing tank owners and operators with this solution for more than 20 years globally and for 10 years in the MENA region. So far, we have protected more than 600 tanks globally, 350 tanks in USA and more than 210 tanks in our region. The total surface area of tank bottoms we have protected with CorroLogic AST solution in the MENA region is more than 3000,000 square feet, which is equivalent to 40 football stadiums. We have protected 135 tanks in-service, 50 tanks out-of-service and 30 tanks during construction.

Our service team has extensive experience in implementing CorroLogic AST solution on tanks with different types of foundation. Tank with concrete ring all or crushed stone ring wall, tank constructed on sand, bitumen, or asphalt pad. Different size of tanks, from 5 m to 117 m. We have experience with cryogenic tanks, and tanks operating at temperature up to 85 C. Tanks with fully operating CP system, partially effective or faulty CP systems.

CorroLogic AST solution has been utilized by many operating companies across different industries, oil and gas, petrochemicals, storage terminals, power, and water. Such as Saudi Aramco, OQ, SABIC, VTTI and Saudi Water Conversion Company. Complete project reference list is available on Dropbox or SharePoint.

International Standards: The ever-increasing deployment of this technology in the field has been reflected through recognition of environmental protection agencies, government regulatory bodies, and international associations in the last 2 decades.

In 2003, The department of Environmental protection in Florida approved the use of VpCI for tanks where CP retrofits are infeasible.

The State of Florida has identified that VCI can be used in tandem with CP or a standalone solution in 2013.

In 2018, API STD 2610, the Tanks and Terminals standard outlines the use of VCI for tank bottoms in section 12.5.

API TR 655 is a technical report published in 2021. It provides details on utilizing volatile corrosion inhibitors (VCIs) for protection of the soil side of tank bottoms.

API 651, the CP standard, is being updated currently and VCI is being included as an option in this document.

AMPP (formerly NACE) is currently working on publishing a standard “NACE TG543”, which is a comprehensive document on the application of VCI under tank floors.

2. Prospecting:

2.1. Typical prospect profiles:

You can find qualified prospects in one of the following disciplines or job titles in an operating facility.

- Corrosion; corrosion engineer, lead corrosion engineer
- Cathodic protection: cathodic protection engineer or specialist
- Inspection; inspection engineer or inspection manager
- Asset integrity; Asset integrity engineer or manager
- Operations; operations manager
- Maintenance and turnaround; maintenance engineer or manager
- Facility Manager; General manager or terminal manager

2.2. How and where to find qualified prospects:

Existing list of clients and network referrals,

You can either ask your contact if they know someone in another facility or company that can benefit from your service. You can also visit their LinkedIn page and see who they are connected to and ask them to connect you with the target proposed from their network as per the following examples:

- Hello Jhon, I am happy that we have successfully deployed our technology on TK-455 and I was wondering if you could think about someone you know that can also be interested in our technology. Or,
- Hello Jhon, I saw that you are connected to Jack from ABC refinery and would like to know if you can put me in contact with him. I would like to see if they have a need for our technology.

LinkedIn

You can search for Individuals, facilities, and professional groups on LinkedIn as follows:

- Job Title/Demographic Search: Use LinkedIn's basic search feature to find prospects by job title, company, or industry. This gives you a direct connection to decision-makers or influencers without the hassle of cold calling.
- Advanced Keyword Search: You can leverage LinkedIn's advanced search features to fine-tune your scope. Use the People Filters when you search for a keyword to narrow your search results. Also, you can use Boolean filter words like AND, OR, or NOT to include or exclude certain terms, or put phrases in quotation marks to get exact matches.

- LinkedIn Groups: LinkedIn Groups connect you to user bases that share common characteristics, interests, or goals. Click the 'Work' icon on your LinkedIn home page, select 'Groups', then click 'Discover' to see suggested groups. You can request to join to get access to users within a group.
- The "People Also Viewed" Sidebar: This feature is like a shortcut to cloning your ideal customers. Go to the profile of one of your best customers, then look at the right-hand sidebar to see similar users. Your one prospect has now become several.

Online forums

- <https://www.ast-forum.com/>
- <https://www.eng-tips.com/threadminder.cfm?pid=1452>
- <https://forum.think-tankage.co>
- <https://www.tankstoragemag.com/tank-talk/>

Storage Tank Magazines

- <https://www.tankstoragemag.com/>
- <https://www.storageterminalsmag.com/>
- <https://www.tanksterminals.com/magazine/tanks-terminals/>

Other:

- Professional associations such as AMPP, SPE, API, EEMUA , local engineers associations
- Exhibitions and conferences
- Webinars

3. Connecting:

3.1. CP Prospects:

LinkedIn

You can start by identifying the target facility or company that you want to approach. Visit their LinkedIn page. Select people tab and filter by country to narrow down your selection. In the search field type cathodic protection and choose the most senior person from the list. Once selected, you can send him the following connection request message.

- Hello Mr. John, I work with CP engineers to help them improve soil-side corrosion protection on storage tanks failing to achieve NACE protection criteria. It would be great to connect with you!

Phone call:

You can use the following script if you have the telephone of the prospect which you could have got from the prospect themselves over LinkedIn or through a referral from an existing client or from a colleague.

Salesperson: Hello am I speaking to Mr. John? This is Eric from Cortec Middle East. Our company is specialized in supplementing cathodic protection in mitigating soil side corrosion on storage tank bottoms using vapor phase corrosion inhibitor technology. I have personally worked with CP engineers to help them to overcome limitations of CP where the tank floor loses contact with the sand pad such as in gap areas, and around the annular plates where they are resting on ring wall which shields the cathodic protection current.

Salesperson: CP engineers also utilize our technologies to overcome the immediate need to supplement deficient CP systems that are not achieving the protection criteria and avoid the costly retrofitting jobs.

Salesperson: Can you think of any tanks that do not achieve the protection criteria that we can take as example to demonstrate how our technology can help with such tanks? or

Salesperson: I would like to arrange for a meeting with you in person or online to share with you and your team in more detail how we can work with you to improve the protection of your tanks against soil side corrosion. When is a good date and time next week to setup the meeting?

Email:

The following email template can be used to send an introductory email to a cathodic protection engineer who you have got their email either after connecting on LinkedIn or through a referral from an existing client or from a colleague. You could mention how you got their email address to create an immediate connection with the recipient. In case you got the email through one of the email finder apps you can simply start your email directly.

Dear Mr. John,

Cortec Middle East is a solution provider specialized in supplementing Cathodic Protection performance in mitigating soil side corrosion on storage tank bottoms using Vapor phase Corrosion Inhibitor (VpCI) technology.

With more than 200 succesful applications in the region, our company has worked with CP engineers to help them achieve, but not limited to, the following objectives:

- Overcome limitations of cathodic protection systems in areas where the tank floor loses contact with the sand pad such as in gap areas, and around the annular plates where they are resting on ring wall which shields the cathodic protection current.
- Avoid costly retrofits when CP systems are not achieving the protection criteria.
- Provide professional assessment for the performance of a tank CP system.

I am happy to share with you several NACE technical papers on succesful field applications upon your request.

In this regard, I would like us to arrange for a meeting with you in person or online to share with you and your team in more detail how we can work with you to improve the protection of your tanks against soil side corrosion. Would Monday or Wednesday next week at 3 pm be suitable for you? If not, please suggest a date and time to arrange for the meeting.

Regards,

3.2. Inspection and Integrity Prospects:

LinkedIn

You can start by identifying the target facility or company that you want to approach. Visit their LinkedIn page. Select people tab and filter by country to narrow down your selection. In the search field type "inspection" "integrity" "RBI" and choose the most senior person from the list. Once selected, you can send them on of the following connection request messages.

- Hello Mr. John, I work with inspection and integrity engineers to help them switch from time-based inspection for tanks to risk-based inspection using vapor phase corrosion inhibitors technology. It would be great to connect with you!
- Hello Mr. John, I work with inspection and integrity engineers to help them extend next inspection interval of storage tank using vapor phase corrosion inhibitors technology. It would be great to connect with you!
- Hello Mr. John, I work with inspection and integrity engineers on risk assesment studies for storage tank bottoms using API 653, API 580 and API 581. It would be great to connect with you!

Phone call:

You can use the following script if you have the telephone of the prospect which you could have got from the prospect themselves over LinkedIn or through a referral from an existing client or from a colleague.

Salesperson: Hello am I speaking to Mr. John? This is Eric from Cortec Middle East. Our company is specialized in providing inspection and integrity engineers with solutions to enable them to switch from the time-based inspection of storage tanks to risk-based inspection using vapor phase corrosion inhibitor technology for mitigating soil-side corrosion. We work with inspection and integrity engineers to conduct tank floor risk assessment studies , provide input in developing cost-effective repair plans and implement Risk-Based Inspection for tank floors using , API 653, API 581 and EEMUA 159. we also provide corrosion monitoring systems to monitor the change in the corrosivity of environment before and after of application of our CorroLogic VpCI material.

Salesperson: Inspection and integrity engineers utilize our technology to assess the possibility for inspection interval extension and or deferral which results in tremendous cost savings for the facilities.

Salesperson: How many tanks will be coming out of service for inspection in the next 1 to 12 months? Do you have any tank that is out of service now?

Salesperson: I would like to arrange for a meeting with you in person or online to share with you and your team, in more detail, how we can work with you to improve integrity and inspection interval of the tanks. When is a good date and time next week to setup the meeting?

Email:

The following email templates can be used to send an introductory email to a cathodic protection engineer who you have got their email either after connecting on LinkedIn or through a referral from an existing client or from a colleague. You could mention how you got their email address to create an immediate connection. In case you got the email through one of the email finder apps you can simply start your email directly.

Subject: From tank time-based inspection to Risk-Based Inspection (RBI) using VpCI technology

Dear Mr. John,

Cortec Middle East is a solution provider specialized in mitigating soil-side corrosion on storage tank bottoms using Vapor phase Corrosion Inhibitor (VpCI) technology.

With more than 200 succesful applications in the region, our company has worked with inspection and integrity engineers to help them achieve, but not limited to, the following objectives:

- Switch from time-based inpection for storage tanks to risk-based inspection.
- Extend next inspection interval for storage tanks by up to 5 years.
- Defer scheduled inspection of a tank for up to 3 years.

I am happy to share with you several NACE technical papers on succesful field applications with inspection data upon your request.

Let us know if you have a candidate tank in mind that is currently out of service or expected to be out of service in the next 1 to 12 months. We can also arrange for a meeting with you in person or online to share with you and your team in more detail how we can work with you to improve tank floor integrity using vapor phase corrosion inhibitor technology. Would Monday or Wednesday next week at 3 pm be suitable for you? If not, please suggest a date and time to arrange for the meeting.

Regards,

Subject: Tank floor integrity assurance using vapor phase corrosion inhibitors

Dear John,

The implementation of CorroLogic VpCI solution combined with quantitative Risk Based Inspection (RBI) assessment enables inspection and integrity engineers help their management minimize tanks downtime, optimize spending on maintenance and achieve considerable cost savings associated with schedule-based inspection activities.

This quantitative approach is based on API 653 and 581 standards and can help:

- Increase remaining life of existing bottom plates up to 10 years.
- Extend next inspection interval by up to 5 years.

- Defer a scheduled T&I for up to 3 years.
- Develop an economic and effective repair plan.

I am happy to share with you several NACE technical papers on successful field applications with inspection data upon your request.

We can demonstrate this approach and associated cost savings for one or group of tanks that are currently out of service or scheduled to be out of service in the next 12 months. What date and time in the next 2 weeks would be suitable for you and your team to have an in person or online meeting?

Resources

Below are resources or information you can share with the prospects as the communication evolves and when requested by the prospect:

1. Tim Whited NACE paper with tan floor scan data
2. VTTI T-204 case history
3. VTTI T-206 case history
4. ORPIC T-3114 case history
5. API TR 655
6. API 2610
- 7.

3.3. Corrosion Prospects:

LinkedIn

You can start by identifying the target facility or company that you want to approach. Visit their LinkedIn page. Select people tab and filter by country to narrow down your selection. In the search field type cathodic protection and choose the most senior person from the list. Once selected, you can send him the following connection request message.

- Hello Mr. John, I work with corrosion engineers to help them in mitigating and monitoring soil-side corrosion on storage tank bottoms using vapor phase corrosion inhibitors. It would be great to connect with you!

Phone call:

You can use the following script if you have the telephone of the prospect which you could have got from the prospect themselves over LinkedIn or through a referral from an existing client or from a colleague.

Salesperson: Hello am I speaking to Mr. John? This is Eric from Cortec Middle East. Our company is specialized in controlling and monitoring soil-side corrosion on storage tank bottoms using vapor phase corrosion inhibitor technology. "I have personally" "or We have" worked with corrosion engineers to help them reduce soil-side corrosion on storage tank bottoms by up to 90% and continuously monitor it using electrical resistance probes.

Salesperson: Corrosion engineers utilize our technology to overcome the limitation of cathodic protection in providing protection in the areas where it loses contact with the sand such as air gap areas and on tanks that are not being able to achieve the protection criteria.

Salesperson: Which tanks at your facility that you believe we can take as an example to demonstrate how we can help you with our solution?

Salesperson: we have published several NACE technical papers on succesful field applications for our technology. Please share with me your email address to send you couple of papers for your review.

Salesperson: I also would like to arrange for a meeting with you in person or online to share with you and your team in more detail how we can work with you to improve the protection of your tanks against soil side corrosion. When is a good date and time next week to setup the meeting?

Email:

The following email template can be used to send an introductory email to a cathodic protection engineer who you have got their email either after connecting on LinkedIn or through a referral from an existing client or from a colleague. You could mention how you got their email address to create an immediate connection with the recipient. In case you got the email through one of the email finder apps you can simply start your email directly.

Dear Mr. John,

Cortec Middle East is a solution provider specialized in supplementing Cathodic Protection (CP) systems performance for mitigating soil side corrosion on storage tank bottoms using Vapor phase Corrosion Inhibitor (VpCI) technology.

With more than 200 succesful applications in the region, our company has worked with CP engineers to help them achieve, but not limited to, the following objectives:

1. Overcome limitations of cathodic protection systems in areas where the tank floor loses contact with the sand pad such as in gap areas, and around the annular plates where they are resting on ring wall which shields the cathodic protection current.
2. Avoid costly retrofits when CP systems are not achieving the protection criteria.
3. Provide professional assessment for the performance of a tank CP system.

I am happy to share with you several NACE technical papers on succesful field applications upon your request.

In this regard, I would like us to arrange for a meeting with you in person or online to share with you and your team in more detail how we can work with you to improve the protection of your tanks against soil side corrosion. Would Monday or Wednesday next week at 3 pm be suitable for you? If not, please suggest a date and time to arrange for the meeting.

Regards,

3.4. Management and operations Prospects:

LinkedIn

You can start by identifying the target facility or company that you want to approach. Visit their LinkedIn page. Select people tab and filter by country to narrow down your selection. In the search field type cathodic protection and choose the most senior person from the list. Once selected, you can send him the following connection request message.

- Hello Mr. John, I work with facility managers to help them save up to 30% of storage tanks OPEX using vapor phase corrosion inhibitors technology, It would be great to connect with you!
- Hello Mr. John, I work with operations managers to help them save up to 30% of storage tanks OPEX and keep the tanks in operation for extended periods using vapor phase corrosion inhibitors technology, It would be great to connect with you!

If the prospect accepts your connection, you can share with him short messages on LinkedIn to develop the relationship further, gauge level of interest and secure an email address, or appointment.

- Thank you for accepting my connection! We have successfully implemented our technology on more than 650 tanks globally which resulted in tremendous savings for tank operators. A major refinery in the Arabian Peninsula used our technology to save more than USD 13,000,000 on 21 tanks. They published their experience in a NACE paper. I am attaching it for your reference.

If you see that the prospect has read your message but did not reply to you, you can send him a follow up message as follows:

- Hello John, I hope you found time to go through the technical paper. If not, I am happy to save you the time and share with you all the necessary details over phone, or in a short presentation for you and your team. Would next Monday at 11:00 am be a good time for you?

Phone call:

You can use the following script if you have the telephone of the prospect which you could have got from the prospect themselves over LinkedIn or through a referral from an existing client or from a colleague.

Salesperson: Hello am I speaking to Mr. John? This is Eric from Cortec Middle East. Our company is specialized in mitigating soil side corrosion on storage tank bottoms using vapor phase corrosion inhibitor technology.

Salesperson: I have personally worked with operations teams at different facilities to help them defer scheduled inspections for some tanks and extend next inspection interval for other tanks, which resulted in tremendous savings on their CAPEX and OPEX. For example, A major refinery Oman used our technology to save more than USD 13,000,000 on 21 tanks. They published their experience in a NACE paper. Would you like me to share a copy of the NACE paper by email after our call? *If yes*, please share with me your email address.

Salesperson: How many tanks will be coming out of service for inspection in the next 6 to 12 months? Are you interested in looking into a solution to help you defer the inspection on one of the tanks for a year or two? *or*

Salesperson: Do you have any tank that is out of service that you would like to extend its next inspection interval to more than what you usually target, to show you how much savings you can make by implementing our technology? *If yes*, please share with me your email address to send you the required documents.

Salesperson: I would like to arrange for a meeting with you in person or online to share with you and your team in more detail how we can work with you to improve the protection of your tanks against soil side corrosion. When is a good date and time next week to setup the meeting?

Email:

The following email template can be used to send an introductory email to a cathodic protection engineer who you have got their email either after connecting on LinkedIn or through a referral from an existing client or from a colleague. You could mention how you got their email address to create an immediate connection with the recipient. In case you got the email through one of the email finder apps you can simply start your email directly.

Subject: Maximize the in-service time of storage tanks using VpCI technology

Subject: Reduce storage tank OPEX by 30% using VpCI technology

Subject: Defer scheduled out of service tank inspection using VpCI technology

Dear Mr. John,

Cortec Middle East is a solution provider specialized in supplementing Cathodic Protection (CP) systems performance for mitigating soil side corrosion on storage tank bottoms using Vapor phase Corrosion Inhibitor (VpCI) technology.

With more than 200 succesful applications in the region, we have worked with operations teams to help them achieve not less than 30% reduction on storage tanks OPEX by:

- Increase remaining life of existing bottom plates up to 10 years.
- Extend next inspection interval by up to 5 years.
- Defer a scheduled T&I for up to 3 years.
- Develop an economic and effective repair plan.

I am happy to share with you several NACE technical papers on succesful field applications upon your request.

In this regard, I would like us to arrange for a meeting with you in person or online to share with you and your team in more detail how we can work with you and help you reduce storage tank OPEX in your facility. Would Monday or Wednesday next week at 3 pm be suitable for you? If not, please suggest a date and time to arrange for the meeting.

Regards,

4. Presenting:

4.1. Management and operations:

When presenting to people from management and operations our focus should be on their pain and gain points, such as cost savings related to OPEX and CAPEX, quick installation, no delays on tank box up etc..

CorroLogic AST Solution helps operations and management to reduce OPEX by 30% during the tank life cycle through one or more of the following options:

1. Deferment of scheduled out-of-service tank inspection: it is not unusual for operations to prefer to keep one or more of the tanks that are due for inspection in service. We can help you achieve this objective by working with the inspection team to review historical inspection data for the subject tank and conduct a risk assesment study and evaluate the possibility of deferring the scheduled inspection without compromising the safety and integrity of the tank.
2. Extend next inspection interval: for tanks that are currently out-of-service or planned to be out of service, implementing CorroLogic AST solution can help operations increase the next inspection interval of storage tanks. Construction and inspection data can be used to conduct Risk Based Inspection (RBI) study to evaluate the maximum inspection interval that can be achieved upon implementing CorroLogic AST solution.
3. Prepare effective tank floor repair plan: Using risk assesment approach can help us review and optimize the tank floor repair plan in cooperation with the inspection and integrity team.
4. Reduce repair requirements in future out of service inspections.
5. Increase remaining life of bottom plates: CorroLogic AST solution reduces soil-side corrosion and hence plate thickness reduction rate which results in extending the service life the tank floor and increases Return On Investment (ROI)

To demonstrate how CorroLogic AST Solution can help extend the next inspection interval and associated cost savings. Let us look at a case study for a crude oil tank in a major refinery in one of the GCC. It is a 75 meter in diameter constructed in 2000 on clean sand pad with concreter ring wall, HDPE liner and protected with impressed current cathodic protection system. In 2012, the cathodic protection system stopped working leaving the tank floor without corrosion control solution.

In 2020, the tank was taken out of service for inpsection. Magnetic Flux Leakage (MFL) floor scan revealed active general and localized soil-side corrosion with plate thickness reduction up to 68% and remaining life less than 2 years in some plates.

A repair plan was prepared by the inspection to include placing 60 welded-on patch plates and replace 4 plates.

We worked with the inspection team to conduct risk assessment study where the damage factor was determined, and next inspection interval was calculated to be 6.5 years.

To help the tank owner assess the value of our solution, a cost benefit analysis was done. Cost of out of service tank inspection can be divided into direct and indirect costs.

Tank inspection cost, excluding repair works, is estimated at USD 950,000, with tank cleaning and loss of production during downtime contributing to more than 85% of the inspection cost.

Beside the patch repair scenario, another three repair scenarios were considered, which is full bottom replacement, full bottom and cathodic protection replacement and patch repair combined with injection of CorroLogic AST solution. To evaluate the return on investment, we divide the total cost of repair scenario over the next inspection interval and the remaining life achieved from the repair scenario. In the case of patch repair, the cost per year of inspection interval is USD 9,250, compared to USD 225,000 and USD 148,000 for full bottom replacement and full bottom replacement plus installation of new cathodic protection system, respectively. The cost of patch repair plus CorroLogic AST solution scenario is USD 13,500 per year of inspection interval. With extra USD 5,000 investment per year, a total saving of more than USD 1,000,000 over the next 15 years is obtained.

4.2. Integrity & Inspection:

CorroLogic AST Solution helps integrity and inspection teams to

1. Reduce the probability of failure and switch from time-based inspection to risk-based inspection.
2. Empower inspection and integrity teams to evaluate and satisfy safely operations' request to defer a scheduled inspection for one or more of the tanks which usually results in tremendous savings generate revenue for the facility.
3. Extend next inspection interval: for tanks that are currently out-of-service or planned to be out of service, implementing CorroLogic AST solution can help inspection and integrity teams to increase the next inspection interval of storage tanks. Construction and inspection data can be used to conduct Risk Based Inspection (RBI) study to evaluate the maximum inspection interval that can be achieved upon implementing CorroLogic AST solution.
4. Prepare effective tank floor repair plan: Using risk assessment approach, we can work with you to review and optimize the tank floor repair plan.

To demonstrate the effect CorroLogic AST solution on the tank integrity and inspection results, tank floor scan data was compared before and after application of CorroLogic AST solution. The first case study is for a tank in storage terminal in the GCC. It is 38 meter in diameter tank, constructed in 2010 on a cursed stone ring wall, clean sand and HDPE release preventive barrier. The tank leaked after 6 years from construction date and had to be taken out of service for inspection and repair. In 2020, the tank owner needed to change the service of the tank and took this as an opportunity to check the floor status after implementing CorroLogic AST solution in 2016.

The tank floor condition in 2016 revealed severe soil-side corrosion up to 1.17 mm/yr, with several plates with through holes and more than 80 locations having less than 6mm thickness.

Based on the inspection activities, a repair plan was prepared to fully replace the annular plates, replace 30 sketch plates, place 58 welded-on patch plates and inject CorroLogic Powder. Based on a risk assessment study, the soil-side corrosion rate was calculated to be 0.24 mm/year in the unrepaired areas and the next inspection interval less than 9 years, without the effect of CorroLogic AST solution.

After four years, the tank floor was scanned and showed 86% reduction in the corrosion rate. No repair was required in 2020 and the tank was boxed up with more than 10 years next inspection interval.

The second case study is for a 29 meter in diameter sour water tank in a refinery in Oman. The tank was constructed in 2005 on a concrete ring wall with clean sand, cathodic protection, and HDPE release preventive barrier. The tank leaked in 2010 and was taken out of service for inspection and repair. After 3 years, the tank leaked and was taken again out of service. In 2013 the tank owner has decided to go through complete tank rebottoming, but the operations were looking for a way to help them postpone this decision to during the scheduled inspection in 2019. To achieve this objective, CorroLogic AST solution was considered.

The main findings from the inspection in 2013 are the following:

1. More than 40% plate thickness loss in 28 out of 40 membrane plates
2. 5 annular plates with perforations out of the 16 plates
3. Repair plan was made but could give them up to 3 years only for next inspection interval.
4. CorroLogic AST solution was implemented to extend the next inspection interval to 2019, until the tank floor gets replaced.

After injection of CorroLogic Powder the tank was boxed up and opened in 2019. Since the main objective of the tank owner was to avoid any tank leak with minimal repair for the next 6 years was achieved and decision to replace the entire tank floor in 2019 was taken in 2013, the tank owner opted to scan only 40% of the tank area and proceed with floor replacement. The scanned area showed 43% reduction in the corrosion.

A more comprehensive case study was done on 12 tanks which had new floors between year 2006 and 2011 and published in Corrosion 2020 conference. Five tanks were protected with Vapor phase corrosion inhibitors and 7 tanks were protected with cathodic protection.

The tanks were later inspected as per the T&I schedule after 7 to 10 years from new floor installations. The MFL floor scan data findings are summarized in a graph that plots the total number of corrosion indications per the magnitude of corrosion rate. The blue data is for the CP protected tanks and the yellow data for VpCI protected tanks. Vapor phase corrosion inhibitors have shown very good long-term performance.

4.3. Cathodic Protection

Cathodic protection is a well-established technology in the industry and considered the main soil-side corrosion mitigation method used in this region and north America. It is a very effective system under the right conditions. When the tank floor is in direct contact with a conductive sand pad, cathodic protection can completely mitigate soil-side corrosion.

However, the tank floor- to -soil interface is complex and usually involves challenging details such as the presence of air gaps due to buckling up of the bottom plates due or settlement in the foundation. The presence of air gaps prevents cathodic protection current from reaching to the metal surface. With time the sand gets dry, and its resistivity increases which reduces the cathodic protection current that can reach to the surface of the bottom plates and polarize the surface and achieve the protection criteria. The use of shielding material such as asphalt, oily or bituminous sand renders the CP system partially effective.

The VpCI working mechanism where it can diffuse through sand and space and form a protective layer on the metal surface, enables VpCI to play a role in complimenting cathodic protection system where it fails.

A logical approach would be to combine both technologies to enhance protection against soil-side corrosion. In the areas where tank floor is in direct contact with conductive tank pad, cathodic protection will provide full protection. In areas where cathodic protection cannot reach, VpCI provides protection. But are both systems compatible? Both effect the electrochemistry at the tank floor surface. Are these effects complementary or competitive?

CorroLogic Products have been tested in house and in third-party labs to verify compatibility of VpCI with the impressed current cathodic protection system components such as MMO anodes, titanium conductors, and preeminent reference electrodes which all showed no negative impact on the performance of these components.

Several studies have been conducted to answer this question. In a research work published in Corrosion 2016 conference, six lab scale tanks were constructed to simulate actual tank construction with HDPE liner, ICCP system and ER probes.

Three tanks had their CP system off and the other three tanks on. The tanks with off CP system showed an average corrosion rate of 13 mpy, while CP protected tanks showed an average corrosion rate of 3 mpy, which clearly shows the effect of CP system. In the second phase of the research, all the 6 tanks were injected with VpCI liquid. Corrosion rate of non-CP protected tanks went down to an average of 3 mpy and to 0.3 mpy in CP protected tanks. The results indicated maximum protection is achieved by combining both systems.

In 2017 we published a paper that investigated the impact and interactions between VpCI and impressed current cathodic protection system from the angle of effect of VpCI on polarization and cathodic protection current. To answer this enquiry, we devised a differential oxygen concentration cell as depicted on the slide. In the experiment we were monitoring three parameters, potential, corrosion current and cathodic protection current as shown in the graph. The experiment showed that the VpCI chemistry that was used worked as a cathodic polarizer and resulted in reducing the cathodic protection current required to bring corrosion rate to zero by 40%.

In a sequel study we did in 2018, we used the same setup, but we tested another 2 different chemistries, and the conclusion was that not all VpCI chemistries are compatible with cathodic protection systems. Where one of the chemistries worked as a cathodic depolarizer.