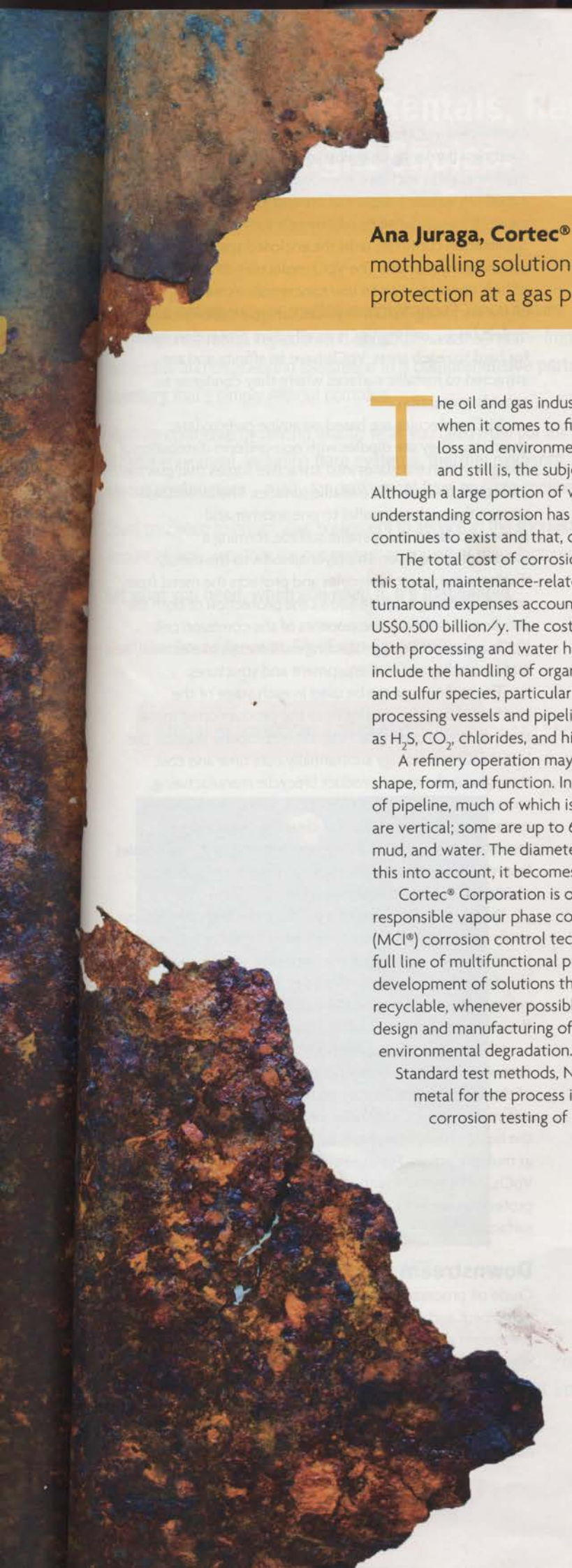
HYDROCARBON ENGINEERING

March 2016


CORROSION
CONTROL



Ana Juraga, Cortec® Corporation, USA, explains how a turnkey mothballing solution was used to ensure long term corrosion protection at a gas processing facility in Dubai.

The oil and gas industry has presented many different challenges to researchers when it comes to fighting the effects of corrosion, both in terms of economic loss and environmental safety. Corrosion in downstream operations has been, and still is, the subject of many studies, papers, courses and online forums. Although a large portion of what has been written shows that significant progress in understanding corrosion has been made, it also makes it clear that the problem continues to exist and that, quite possibly, is getting worse.

The total cost of corrosion control in refineries is estimated at US$3.692 billion/y. Of this total, maintenance-related expenses are estimated at US$1.767 billion/y, vessel turnaround expenses account for US$1.425 billion/y, and fouling costs are approximately US$0.500 billion/y. The costs associated with corrosion control in refineries include both processing and water handling. Corrosion-related issues regarding processing include the handling of organic acids (broadly referred to as napthenic acid corrosion) and sulfur species, particularly at elevated temperatures, as well as water carried over in processing vessels and pipelines. Water handling includes concerns with corrosives such as H_2S, CO_2, chlorides, and high levels of dissolved solids.

A refinery operation may have in excess of 3000 processing vessels of varying size, shape, form, and function. In addition, a typical refinery has about 3200 km (2000 miles) of pipeline, much of which is inaccessible. Some of these pipelines are horizontal; some are vertical; some are up to 61 m (200 ft) high; and some are buried under cement, soil, mud, and water. The diameters range from 10 cm (4 in.) up to 76 cm (30 in). Taking all of this into account, it becomes clear that corrosion is a complex problem.

Cortec® Corporation is one of the world leaders in innovative, environmentally responsible vapour phase corrosion inhibiting (VpCI®) and migratory corrosion inhibiting (MCI®) corrosion control technologies for various industries. The company produces a full line of multifunctional products and is highly commited to the continued development of solutions that are useful, non-hazardous to the environment and recyclable, whenever possible. Strong environmental concern is demonstrated in the design and manufacturing of products that protect materials of all kinds from environmental degradation. Most of the products conform to ASTM G 1 and ATMS G3 Standard test methods, NACE Standard TM-01-64 for laboratory corrosion testing of metal for the process industries, and NACE Standard TM 0169-95 for laboratory corrosion testing of metals.

Figure 1. View of the gas processing plant, Dubai.

Figure 2. The fin fans were coated with Cortec coatings and covered with anti-corrosion MilCorr® film.

Figure 3. Plant preservation.

Protective technology

VpCI technology is an innovative, environmentally safe, cost effective option for corrosion protection. The technology protects with a thin, mono-molecular protective barrier, which re-heals and self-replenishes and can be combined with other functional properties for added protective capabilities. VpCI forms a physical bond on the metal surface creating a barrier layer against aggressive ions, and protects multi-metals in enclosed environments. VpCI inhibitors have a medium vapour pressure of around 10^{-2} - 10^{-7} mmHg that causes it to vapourise or sublimate into the vapour phase. Sublimation continues until the enclosed space is saturated achieving equilibrium. The VpCI molecules diffuse from areas of high concentration to low concentration reaching all areas of the enclosure. VpCI molecules can go wherever oxygen molecules go, making VpCIs an effective protection method for hard to reach areas. VpCIs have an affinity and are attracted to metallic surfaces where they condense to provide protection.

VpCI molecules are based on amine carboxylate chemistry. They are dipoles with non-uniform distribution of charges, which translates into attractive forces that pull the molecules towards the metallic surfaces. The molecules arrange themselves parallel to one another and perpendicular to the metallic surface, forming a monomolecular layer. This layer adsorbs to the metal, displaces the water molecules and protects the metal from corrosion. Being a dipole allows the protection of both the anodic and cathodic components of the corrosion cell. VpCIs are effective at protecting multimetals in electrical, static, rotating and civil equipment and structures.

The technology can be used in each stage of the product's lifecycle, starting from the production of metal stock to actual use in the field. When properly applied, the VpCI/MCI technology substantially cuts time and cost throughout the entire product lifecycle: manufacturing, storage, shipping and field service. It also eliminates the extra processing steps, such as cleaning, degreasing, rust removal, pickling, sandblasting, and reprotecting, and enables less re-work, fewer rejects, improved quality, reduced rust claims and extended equipment life.

During manufacturing of a product, the technologies can easily integrate into a customer's fabrication and assembly process. While eliminating the corrosion of ferrous and non-ferrous metals, the technology can provide lubrication, enhance production speed, and prolonged tool life to help the customer produce high quality products.

Unlike conventional methods, such as filming amine corrosion inhibitors, operators can inject VpCIs into any part of the system, because they go to work immediately and are self-replenishing. Continuous, uninterrupted protection in the liquid phase, interphase, and vapour phase can be added at multiple points. For example, the automatic injection of VpCIs into a system, with no attendance operator, provides protection immediately, even on pre-rusted or scaled surfaces.

Downstream process systems

Crude oil processing equipment, pipes, pipelines, refinery equipment and systems, tankers and engines all need protection against pitting, corrosive gases and water intrusions. VpCI treatments can protect systems with a high ratio of residual water, as well as systems exposed to halogens, sulfide and hydrogen. These products are especially effective in low areas in the system where water collects causing extreme corrosive attack.

Equipment and pipeline failures in oil refining, gas processing and production facilities can create devastating delays. By reducing downtime and extending equipment life, this technology can improve downstream business operation effectiveness and efficiency. Furthermore, the products are useful as functional additives in finished petrochemical products, fuels and byproducts, offering corrosion protection enhancement, especially in moisture and corrosion prone products. They can also assist in the maintenance, repair and operations of downstream assets.

Figure 4. Equipment protected with MilCorr® film.

Figure 5. Insulated pipes being injected with VpCI® inhibitor.

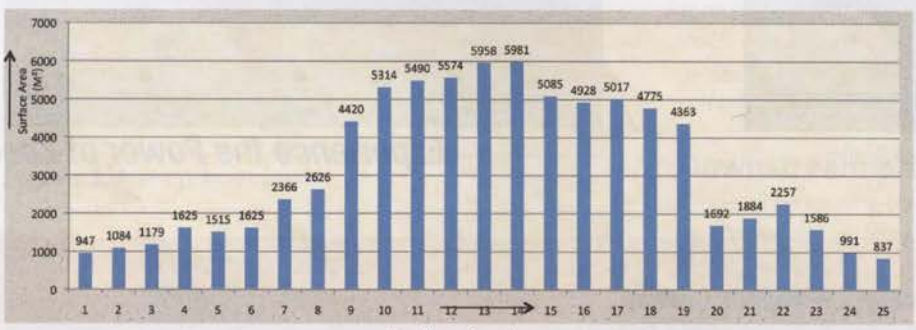


Figure 6. Weekly work progress from March 2012 - September 2012.

Case study: external mothballing of a gas plant

The customer for this project is one of the leading natural gas processing companies in Dubai. Dubai Petroleum supplied the feed for the customer's processing plant until 2011, when it stopped supply for various reasons, which led to the facility shutting down for an indefinite period. Cortec, its middle eastern distributor Kanoo Group, and the company discussed the possibilities of corrosion occurrences while the plant was shut down. Following a series of presentations, a turnkey mothballing solution for long term corrosion protection was chosen and the project began at the end of February 2012.

The total mothballing area was estimated at 80 000 m^2, which included around 30 000 m^2 of insulated pipes and columns. The corrosion under insulation (CUI) application, a major challenge, was achieved in the following way:

- The area of insulations to be protected were measured and volumes calculated.
- Half inch holes were drilled externally on the insulated surface at intervals of 1.5 m.
- VpCI-658 was injected at 0.5 l/m^3.
- The holes were sealed.
- The dimensions of the area preserved were recorded.
- Clearly visible UV stable labels were applied on the outside with equipment details, preservation date, next inspection date, next preservation date, etc.

The project also required the use of a number of other inhibitors, coatings, protectors and penetrants:

- A water-based vapour phase corrosion inhibitor coating, VpCI-391, was intended for medium to long term indoor/outdoor corrosion protection. Once dried, the inhibitor builds a non-tacky transparent film on the metal surface that provides salt, humidity, and UV resistance. Being a complex mixture of non-toxic organic inhibitors incorporated in a water-based acrylic polymer, the inhibitor offers corrosion protection that can compete with the most permanent coatings and primers.
- An oil-based package of corrosion inhibitors for lubricating oils, M-529, was used to provide corrosion protection during operating conditions and intermittent operation. M-529/M-529 L are very effective for mineral and synthetic based oils, including napthenic, iso-paraffinic and PAOs. M-529 L additionally contains an EP lubricity package and is recommended for lubriciating oil when EP lubricity is needed, such as gears or transmissions.
- A solvent-based coating for bear metal and outdoor protection, VpCI-368, was used to provide strong protection to metal substrates exposed to harsh

outdoor conditions. It leaves a firm, wax-like film that can be removed by mineral spirits or alkaline cleaners.

- Vapour phase corrosion inhibiting emitters, VpCI-105 and VpCI-111, were used to provide corrosion protection for metal components and parts enclosed in non-ventilated control boxes, cabinets, or tool boxes.
- A multifunctional outdoor cleaner/corrosion protector, ElectriCorr: VpCI-239, which forms a very thin film proven effective against aggressive conditions, including industrial, marine and tropical regions, was also used. It does not alter the electrical resistance or magnetic properties of metal substrates.
- A vapour phase corrosion inhibitor formulated with premium quality, severely hydrotreated base stock, Corlube VpCI Grease, was used to provide resistance to oxidation and good high temperature stability. VpCI CorrLube is suitable for both operating and lay-up conditions.
- Heavy duty film, MilCorr Film, provided a universal protection system with high ultraviolet (UV) light protection to maintain the integrity of the film itself as well as the parts packaged within.
- A VpCI film, VpCI-126 Blue, which combines the latest film technology with effective corrosion protection for all the metal products, was used to replace conventional rust preventatives, such as oils and desiccants, and eliminated all the degreasing or coating removal required in the past. It does not contain free amines, phosphates, or halogen-based materials, and is non-toxic and recyclable.
- A migratory corrosion inhibitor, VpCI-658, was used for corrosion under insulation (CUI). Formulated to provide rapid transport of VpCI throughout the insulating jacket, it can be applied by injection into the insulating jacket through either gravity feed or by using a portable injection pump.
- A VpCI super penatrant was used as a deep penetrating formulation to loosen frozen parts locked in rust. Its deep penetrating capabilities allow the user to go through as much as 0.5 in. (13 mm) of rust in 30 mins.
- Finally, a unique concentrated liquid formulation inhibitor for water cooling systems of pumps and compressors, VpCI-649, was used to protect ferrous and non-ferrous metals. The inhibitor is designed to provide long term protection in fresh water and glycol closed loop systems.

Conclusion

Cortec was selected for the turnkey mothballing project due to its product strength, technical expertise and support, and techno-commercial offerings. With the help of a skilled team and good project management, the entire project was completed in September 2012 (within seven months), which was much earlier than planned. Total man hours for the project reached 91 000, and there were no reported safety incidents. Personnel at all levels within the plant appreciated the efforts of the successful completion and expressed satisfaction in the way the project was conducted.