CORROSION COMBAT

January 2018

Quarterly Newsletter of NACE INTERNATIONAL GATEWAY INDIA SECTION

Worker safety at highly corrosive offshore platform

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Editorial

Hello Friends,

I wish each one of you a very happy new year 2018. May our efforts towards corrosion control meet higher levels of success! I wish that we our efforts of improving environment, raising levels of sustainability and making tomorrow better, would be intensified.

We always discuss about corrosion control and monitoring in terms of its impact on production loss, environment damage, safety, reliability, unplanned shut downs, operational integrity of plant etc. Corrosion cost is always highlighted to prompt management to take to remedial measures. But corrosion issues sometimes play a big role in adopting a business model and on profitability. Two examples are cited below in this regard.

Many high Total Acid Number (TAN) crude oils can be purchased at a substantial lower price as compared to conventional crude oils. Thus increasing refining margin and profits of a refinery. But these crude oils are more corrosive than the conventional crude oils. Therefore, two options are chosen.

(A) If it is a new refinery, corrosion resistant materials are selected in corrosion prone areas and the real time online corrosion monitoring is carried out by using non-intrusive tool, such as Field Signature Method (Electrical Signature Method) and Fixed UT probes on bends or other vulnerable locations.

(B) In older refineries, crude oils with different TAN values are blended such that corrosion rates are within the limits of efficacy of corrosion inhibitor and corrosion inhibitor as well as its dose is selected as per the requirement of corrosion rate resulting from the blend. Thus, by taking appropriate corrosion control measures, a refiner can increase its refining margin.

Deep water oil and gas production is highly cost intensive. In case of any failure of a down hole equipment or tubing during the tenancy of an oil and gas well, the repair cost through work over job will be enormous and can affect operational budget severely. Hence, material selection takes a conservative approach in such cases and takes into account worst case scenario of complete set of well conditions and nature of fluids produced. That pays rich dividend over life of the field / well.

The two examples amply demonstrate that expert inputs on material selection, corrosion inhibition and corrosion monitoring can improve profit margins of upstream as well as downstream oil and gas industry.

Anil Bhardwaj
Editor Corrosion Combat

Message

Dear NACE Members:

Greetings and wishing you all the very best for 2018.

During the past nine months of my term in the NACE executive office, I have had the privilege of meeting many members across the globe and also witnessing the goodwill that NACE shares among its peers globally. A majority of the travel is always in the fall, September to November, as most of our sections and areas schedule events half a year away from our main event CORROSION. Typically the travel is to conferences and in 2017 the events have been in Abu Dhabi, Dammam, Prague, Cartagena des Indias, Kuwait, Jakarta and Sydney.

Euro Corr which is run by the European Federation of Corrosion (EFC) was held this year in Prague, Czech Republic. The event was hosted by the Czech Corrosion Society and held in conjunction with the International Corrosion Congress. As a result, the attendance was significantly higher, with over 1400 attendees and 49 booths. The highlight of the event was an excellent plenary talk by Dr. John Scully, FNACE, and long time editor of NACE's Corrosion Journal. NACE and EFC share a very strong partnership and during course of the event, we had meetings with the corrosions societies of Poland, Croatia and Czech Republic. EFC has also recognised and supported NACE's European efforts by backing our first conference in Poland and the second conference, in association with the Milan Italy Section, in Genoa. Both events will be held in mid 2018.

In the West Asia and Africa Area, we had two excellent conferences in Dammam and Kuwait. In Dammam, the Materials Performance and Welding Technologies conference (MPWT) was held in partnership for the first time with the American Welding Society. MPWT 2017 had strong support from Saudi Aramco and SABIC, with a large presence from both organisations and was graced with the senior leadership from these organisations. In November, at the Kuwait Section's fourth annual conference, the Chief Executive of Kuwait Petroleum Company, Mr. Nizar Al Adsani, was the Chief Guest, and the event was supported by all the Kuwait Oil and Gas companies. The technical content of this event was excellent and the event well attended by professionals from around the region. In 2017, NACE also started working with CORRISA, the corrosion association in South Africa and also ran courses in Nigeria for the first time.

In October 2017, SLOM, the only marine terminal operators association in the world, held its annual event in Cartagena des Indias, Colombia. SLOM supports NACE's products and services and has evinced interest in expanding the relationship with NACE by recommending our education programs to their members and making it part of the self-regulation that they follow. The Oil Companies International Marine Forum (OCIMF) based in London, and a stakeholder like NACE at the International Maritime Organisation, is a strong supporter of SLOM and after discussions at Cartagena, is looking forward to working with NACE globally. This may lead to opportunities in our part of the world as well, providing additional opportunities with the maritime industry.

In November, NACE had a workshop on development of standards with the Indonesian Standards Organisation (BSN) in Jakarta, which was hosted by the Unites States Commercial Services. This event was a follow up commitment by NACE after NACE and BSN had signed an agreement for the adoption of NACE standards as Indonesian corrosion standards. The following standards will be the initial batch for adoption, NACE SP0775, NACE SP0575, NACE TM0169, NACE RP0395, NACE SP0169, NACE SP0106 and NACE TM0177. These standards will go through the normal adoption procedure of BSN and be ultimately translated into Bahasa Indonesia.

Corrosion and Prevention 2017, the Australasian Corrosion Association's (ACA) annual event was held in Sydney in November 2017 end. ACA shares an excellent relationship with NACE and the two organisations are building on the strong relationship with more cooperation in Government relations and education opportunities. ACA has dropped their CP course and runs NACE CP instead, and in future, NACE will be running ACA's concrete course and hot dip galvanising programs. NACE may soon run these programs in India as well. The event itself was well run at the Sydney convention centre and all technical programs were very well attended.

I am fortunate to have the support of the Past President and Vice President who took care of my absence at all the North American Area and Section events. Several of these events clashed with the events I attended, and program conflicts such as these will increase as the Areas and Sections around the globe ~~grow~~ become more active.

NACE is truly fortunate to have dynamic membership and strong external relationships, which keep the momentum of our mission moving ahead. As we gather more steam in 2018, I do hope that we in India also take our events and programs to a higher level with the wonderful commitment that we have from our committed members.

Wishing you all the very best for the New Year!

Dr. Samir Degan
President NACE International
2017-2018

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Condolence Message

We deeply regret the sad and sudden demise of Dr. Baldev Raj, Director, NIAS, Bengaluru, on 6th January 2018. Earlier, he served as Director of IGCAR. He was Founder President of the South Zone of NACE International Gateway India Section (NIGIS) and he had also served as President of several scientific societies such as Indian Institute of Metals (IIM), International Institute of Welding and Indian Society for Non-destructive Testing.

A scientist and an academician of great eminence, Dr Baldev Raj was also a torchbearer passionate about knowledge and the spread of education. With his genial and gracious personality, he endeared himself to students and professionals alike to whom he was an inspiring role model. As Chairman of CORCON 2005, the successful conference held in Chennai, Chairman of NIGIS Award Committee responsible for Corrosion Awareness Awards from 2007 to 2010 and as a visionary mentor to our governing board from time to time, Dr Baldev Raj was a pillar of strength for our section. He was conferred with the Life Time Achievement Award of NIGIS during CORCON 2013 in New Delhi for his enduring contribution to the area of corrosion science. Government of India awarded the "Padma Shri" to him in 2007 to honour him for his outstanding contributions to science, engineering and technology.

While his sudden passing is a great loss to our section and our nation, he will be always remembered for his humaneness, humility and zeal for learning and sharing knowledge, values that will be cherished by future generations.

His warm presence, cheerful smile and erudition will be greatly missed.

We mourn his sad demise and pray that the bereaved family gains the strength to bear this irreparable loss.

May his soul rest in peace!

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Efficient Cathodic Protection means Effective Corrosion Prevention

Our three tools to fight corrosion:
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Cathodic protection is required to maintain the integrity of a buried and submerged structure. As a buried structure is subjected to corrosive attack being in contact with soil, coating of the pipeline starts deteriorating. Cathodic protection is a method of corrosion control that is achieved by supplying an external direct current that neutralizes the natural corrosion current arising on the pipeline at coating defects.

For nearly three decades, Raychem RPG has been internationally recognized for designing and providing effective cathodic protection systems. Our team shares a high level of expertise about cathodic protection systems. We can offer superior technical support and assistance from the design stage through manufacturing and installation of CP system.

Raychem RPG has the experience & expertise of providing cathodic protection to plant piping network.

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- CP audit and consultancy
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- NACE Certified Coating Inspection & Coating Application
- In House Design Capabilities For CP Solutions For Marine And Offshore Facilities
- Customized Annual Maintenance Contract For Cathodic Protection Installations And TR Unit
- State Of Art Survey Equipments And CP Techniques To Carry Out Specialized Surveys Like CAT, DCVG, CIPL, AC/DC, Interference Etc.
- NACE Certified CP Specialists + NACE Certified CP Engineers

25 Years Of Experience In Active And Passive Corrosion Protection:

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- Coating Integrity Surveys 5000 + Kms
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- Consultancy On Rehabilitation Of CP Systems And Coating 1400 + Kms
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The Evolution of Worker Safety and the Next Step in the Journey

Matthew Boucher
Clock Spring, USA

ABSTRACT

Approximately 13 people die on the job in the United States each day from fatal injuries. Great strides have been made since 1970, when nearly 40 workers per day were killed on the job, but there is still room for improvement.

Safety standards have advanced, and worker deaths have trended downward, but job sites continue to be dangerous places. Regulations have greatly improved worker fatality rates, but guidelines and legislation can only go so far. More work needs to be done to protect workers' lives, and that work needs to take a different form. The criticality of these changes cannot be overstated because even a single death is one death too many.

INTRODUCTION

In 1970, President Richard Nixon signed the Williams-Steiger Occupational Safety and Health Act, federalizing worker safety issues and creating the United States Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH). OSHA, an agency of the United States Department of Labor, is responsible for assuring safe and healthful working conditions by setting and enforcing standards and by providing training, outreach, education and assistance. NIOSH is a part of the Center for Disease Control and Prevention within the United States Department of Health and Human Services and is responsible for conducting research and making recommendations for the prevention of work-related injuries and illnesses.

The passage of this act and the creation of these agencies were the result of a hard-fought legislative battle and a struggle on the part of many to address and remediate workplace hazards dating back to the 19th century.

While these advances in safety were groundbreaking, they have not eliminated worker fatalities. It is time to take the next step on the road to eliminating accidental deaths in the workplace.

From Indifference to Awareness

There is little data to measure worker safety before the 19th century, though we do know that pre-industrial laborers faced risks working in farms and fields. Industrialization and the introduction of the steam engine, which replaced animals, introduced different hazards, but whether these new technologies generally worsened the dangers of work is unclear.

The second industrial revolution, also known as the Technological Revolution, began in the United States shortly after the end of the US Civil War. While the first industrial revolution focused on textiles, coal and iron, the second industrial revolution saw the expansion of electricity, petroleum and steel.

Westward expansion spurred nationwide railroad construction, and as cities grew, they took on a different appearance. Buildings became taller, with Chicago's 138-foot tall Home Insurance Building, the tallest of its time, opening in 1884. Construction of this type required iron and steel, which were produced in huge volumes. During this time, there was extensive use of machinery in manufacturing, a great increase in the use of steam power, and widespread use of the telegraph. Petroleum expanded as a fuel, and the world saw the beginning of electrification. The introduction to the workplace of chemicals, large-scale industrial furnaces, extrusion methods, and machinery introduced hazards never previously encountered by workers. The net result was that workplace injuries and tragedies became commonplace.

The second American industrial revolution followed a different path from the parallel revolution going on in Great Britain. Owing to abundant natural resources and relatively higher wages, manufacturing in America encouraged the use of machines and processes that reduced the amount of labor required to produce goods. These developments occurred within a legal and regulatory climate that diminished employer's interest in safety. Consequently, Americans developed production methods that were both highly productive and often very dangerous.

Because companies bore no responsibility for the consequences of worker injuries and fatalities, they

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ALTA ALTENE main purpose is to grow further the reputation gained during the years and continue the development to the process of quality to meet the constantly changing market requirements. To choose ALTA ALTENE means to decide to have a partner sensitive to the changing requirements of the market and keeping constantly in step with the technological evolution.

ALTA ALTENE joined hands with multi-million dollar enterprise Raychem RPG to pursue the goal to further strengthen their presence in the oil, gas and hydro industry by offering world-renowned, highly efficient coating systems in India.

The partnership's main success and unique selling proposition is pairing the local presence with high-quality products manufactured in Italy.

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- Economical & Flexible Solution For The Protection Of Joints, Elbows, Flanges, Valves And Special Pipelines
- Systems Are Friendly For Environment And Safe For Human Health
- Systems Have Passed The Strictest Standards Of The Control Institutes Worldwide

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had no reason to be concerned about dangerous production methods. They pursued anything that would expedite production regardless of the physical consequences to employees. Injured workers or surviving heirs could sue employers for damages, but survey data suggest that these lawsuits were successful only about 50 percent of the time and resulted in awards equating to approximately six months of pay.

The most dangerous places for workers at the turn of the century were coal mines. Coal seams in England were deep, and the coal was expensive to produce. In America, coal was abundant and in many places was near the surface, which meant it could be mined less expensively. In Britain, rock held up the roof of the mine, and companies sought to exploit all of the coal in a relatively small space, working in concentrated areas that made worker supervision easier. American mines used coal pillars and wood beams to hold up the roofs, and workers were spread out across many rooms, which meant supervision was difficult. Blasting, a dangerous practice of using dynamite or other explosives to break rock, was routine. Since miners were paid by the ton, whenever safety interfered with productivity, safety took a back seat.

Legislating Safety

The 1907 Monongah, WV, mining disaster, in which 367 workers died as a result of an explosion, shocked the nation and led to the creation in 1910 of the U.S. Bureau of Mines to promote mine safety.

That same year, a journalist named William B Hard, published an article in "Everybody's Magazine" called "Making Steel and Killing Men." In the article, he estimated that every year, out of a workforce of 10,000 workers 1,200 were killed or seriously injured. He urged the steel industry to work to reduce its injury and casualty rate. In 1908, U.S. Steel formed a safety committee with a mandate from company president Elbert Gary to reduce the accident rate as much as possible. A highly successful "safety first" movement developed from this, spilling over into other industries and resulting in the creation of the National Safety Council in 1915.

The most important legislation came in 1908 when Congress passed a federal employers' liability law that applied to railroad workers in interstate projects. This made worker injuries and fatalities more expensive, and as a result, employers began to pay more attention to safety issues. Two years later in 1910, New York became the first state to pass a workmen's compensation law that, instead of requiring injured workers to prove employers we negligent, automatically compensated injuries at a fixed rate. Forty-four more states passed similar compensation laws between 1911 and 1921.

Significant increases in accident costs resulting from compensation laws and increased employer liability sparked the modern concern with safety and led to a long-term decline in worker related injuries and fatalities. Companies installed guards on open machine parts and machinery manufacturers developed safer designs. Management began identifying hazards, requiring PPE, and setting up safety departments and committees. The results were dramatic, reducing manufacturing injury rates by nearly 40 percent between 1926 and 1939.

Results since the 1970s have been even more impressive. Since 1970, fatalities in the workplace have dropped by 66 percent.

Making Strides toward Reducing Safety Incidents

A careful analysis of OSHA data reveals that the pipeline industry's strong focus on ensuring worker safety has resulted in remarkably few serious injuries each year. The data are not complete, but they provide a window to workplace hazards in the pipeline industry.

Nearly 60 percent of workers injured in the pipeline industry were involved in day-to-day pipeline operations, maintenance and repair. Almost half of the non-fatal injuries were the result of overexertion when lifting or moving heavy objects and nearly one-third were the result of slips and falls. More than half of the non-fatal injuries resulted in workers missing more than 21 days of work, with more than 40 percent of injured workers missing more than 31 days of work. Nearly all of the fatalities in the pipeline industry were the result of contact with motorized highway vehicles. The remainder were the result of being crushed by objects. This data does not include work in terminals and tank farms commonly associated with pipeline operations.

Most of the safety improvements made to date address these sorts of incidents, providing life-saving rules that include things like:

- Making sure not to override or defeat safety guards

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- Monitoring & Health Check-Up For Coating & CP System
- Coating Integrity Surveys Like CAT, DCVG, CIPL, ACVG, Soil Resistivity, Etc.
- AC/DC Interference Survey And Mitigation Interference Study Through Software Modelling
- Remote Monitoring & Control Of CP System
- Pipeline Coating Product And Its Application
- Cased Crossing Solutions By Casing Filling

We can evaluate the health of your pipelines or any other old metal structures exposed to corrosion and can recommend the customized solutions to enhance the life of the structures.

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- Securing work permits
- Tying off to fixed points when working at height
- Properly locking out and tagging out energy sources when working on equipment
- Not walking under suspended loads, etc.

While the guidelines exist, they are meaningless if there is no safety culture – a pervasive safety mindset that drives personal behavior.

Life Lesson - Brad Livingston's Safety Story

In examining how safety culture impacts workplace safety, it is helpful to look at the story of Brad Livingston, a retired laborer from Colorado Interstate Gas and professional safety speaker. In 1991, he was severely injured in a welding accident, and the person he was working with was killed when a series of gas storage tanks exploded. Brad now travels around the United States telling his story and encouraging improved safety consciousness.

Brad explains the ripple effect accidents have, using as an example the shortcuts he and his partner took when the accident he was injured in happened, describing the three or four minutes he and his coworker saved that resulted in Brad's two-year convalescence and permanent disfigurement and the death of his co-worker.

During his presentation, which is available on the Internet at www.bradlivingston.com, Brad explains the importance of following all the steps in the safety process and double and triple checking the hazards before carrying out dangerous work. Walking through the steps he and his coworker took on the day of the accident, he illustrates the dangers they faced when they decided to welded on the tanks that exploded, pointing out that before any work began, the tanks should have been emptied and rinsed and filled with water to prevent the explosion that severely injured Brad and took his coworker's life.

There are welding crews at this moment welding on or against live pipe. They are working with heavy equipment and lifting heavy objects over their heads and into ditches. They are taking risks that can cause pollutants to be released in the atmosphere, damage equipment and assets, and possibly result in the loss of life. Companies preach constant vigilance, but people still get hurt.

It is apparent when examining data from years for which complete OSHA data exist (2012, 2013, 2014) that safety advances have plateaued. Further gains will be difficult unless there is a step change in the way work is carried out and how safety is managed.

The Next Step

The disruptive change that is needed to improve worker safety is to increasingly employ ways of working that do not introduce hazards in the first place.

Options must be considered before hazards are introduced. For example, if it is possible to repair a pipe without welding it, then welding should not be done. If it is possible to repair a pipe without using heavy lifting equipment, then heavy equipment should be eliminated.

Lean principles, which are common in manufacturing environments, can help identify how and where to implement new methods and tools in pipeline maintenance and repair.

The goal of Lean management is to eliminate impediments so a process flows unimpeded by obstacles.

The first step in implementing Lean is to understand and then identify the eight forms of waste.

1. Transport, which refers to the movement of goods with machines or equipment
2. Inventory, which, in this case, means unnecessarily stocking repair products
3. Motion, which refers to the movement of people
4. Waiting, which is unproductive time
5. Overproduction, which creates unneeded products or components that introduce avoidable cost and take up space that could otherwise be used for something productive.
6. Overprocessing, which adds time to production without delivering value
7. Defect elimination, which removes the need to rework
8. Skills – Underutilizing capabilities, delegating tasks with inadequate training, in other words, safety

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VISCOTAQ® with its enhanced viscous elastic technology offers a unique waterproofing line of products to stop water infiltration at pipe casings, buildings, vaults, storm drains, sewer lines and more.

The philosophy behind the development of VISCOTAQ® is that - unlike other coatings - VISCOTAQ® always has a permanent and intimate contact with the surface of a substrate.

Qualities of VISCOTAQ®:

- Viscous-elastic amorphous a-polar polyolefin
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- Impermeable to moisture and gases
- Immediate adhesion to a substrate without primer
- Permanent wetting characteristics
- Becomes one continuous homogeneous impermeable layer
- Self-healing characteristics
- No curing time
- No problems with salts and osmosis
- 100% inert formulation

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Everything that has been done to date has focused on mitigating hazards, not removing them. The only way to make significant progress is by removing hazards in the workplace. Eliminating hazards means working in a different way.

Clock Spring is focused on removing the most hazardous variables in pipeline integrity operations – welding and lifting. While lifting introduces physical hazards, welding creates pollution as well. Developing products and procedures that circumvent hazards is a better solution than contending with hazards. Simply put, if it is not necessary to weld, a safety risk can be avoided. A solution that does not require welding clearly is a better choice.

The objective is to minimize sources of variance by reducing variables. That is a key design principle in product development and why Clock Spring products remain the easiest to install and offer the best long-term, validated performance in the industry.

The original Clock Spring product is a perfect example. It is a precured laminate composite repair sleeve that is manufactured inside an ISO 9001 certified facility, where manufacturing is quality controlled. Constructing the units in this environment eliminates many installation variables. The weight of the products allows workers to hand them down into a ditch, removing the need for heavy machinery and lifting straps. The installation process requires no welding. And the resulting repair is durable.

Building on the success of proven technology, the company is expanding its offerings, most recently introducing extended width Snap Wrap, which has the potential to revolutionize work on offshore platforms in one of the most corrosive naturally occurring environments.

Traditionally, when repairs are done on decks, rope access is required. Common repair methods take two to three days to execute – a long time to subject workers to exposure to the elements and on rope access.

The new composite solution takes a few hours, which is less tiring for workers and considerably less risky.

Conclusion

It is time for industry to take a different approach to safety with a focus on eliminating the need to perform activities that can result in injury. Research and development efforts should target lightweight products that do not require overhead lifting, and as far as is practical and possible, construction should avoid hot work. Eventually, innovation and creativity will produce solutions that no longer put workers in harm's way.

By looking at things from a different perspective, designing quality products, and following a safe and certifiable installation method that eliminates hazard risks, it is possible to become better stewards of assets as well as the environment.

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Author:

President and Chief Executive Officer of Clock Spring Matt Boucher understands the importance of asset integrity, maintenance, and reliability and has a career history of leveraging that knowledge to transform companies, managing growth and bringing process maturity to businesses. His more than two decades of operational, sales, and finance leadership experience with public and private companies includes private equity portfolio companies ranging from $10 million to $40 billion in revenue. He understands that people are a company's greatest asset and is passionate about building winning teams. Boucher, who joined Clock Spring in 2016, is an agent of change who understands that culture starts with leadership – finding ways to help organizations define desired behaviors and understanding the values that those behaviors imply. He holds an MBA from the University of Texas at Austin and a BS in Economics from Bentley University in Waltham, Mass. He is a Six Sigma Green Belt and is a member of the Interstate Natural Gas Foundation Board of Directors.
E-mail id:mboucher@clockspring.com

CORCON 2017 : International Corrosion Conference and Expo September 17-20, 2017

CORCON has earned a name for itself as a unique platform for exchange of information, and development of solutions on matters pertaining to corrosion.

"As one of the largest and most active sections of NACE International, the Gateway India Section's contribution towards generating awareness, and developing corrosion management strategies over time, is commendable. The annual CORCON has earned a name for itself as a unique platform for exchange of information, and development of solutions on matters pertaining to corrosion, said Vice Admiral Girish Luthra, Flag Officer Commanding-in-Chief, Western Naval Command. Speaking at CORCON 2017 as the Chief Guest at the inaugural function, he also brought out the various challenges faced by the Indian Navy in tackling corrosion, and the management strategies and practices in vogue. CORCON 2017 was held on September 17 – 20, 2017 at Hotel Sahara Star, Mumbai.

"As for various sectors of the industry, corrosion is also a phenomenon that has a very high bearing on asset management, in the Navy. We, therefore, acknowledge the initiatives taken by industry, and academia, to not only address the issues associated with corrosion, but also in making efforts to evolve solutions for practical applications and cost-saving. The Indian Navy has been associated with NACE for many years now, and has benefitted from the interactions and knowledge-base available with the organization," he emphasized.

"Over the years, CORCON has grown to become one of the world's largest corrosion events after CORROSION," said Dr Samir Degan, President (2017-2018), NACE International. "This success is due to the Gateway India Section team being a cohesive unit of committed and decision making individuals over the past 25 years."

Dr Samir Degan also highlighted before the delegates the various initiatives that keep Gateway India Section at the forefront. He said, "The India IMPACT Study is scheduled to be released in January 2018. We are now a key stakeholder in the National Mission on Corrosion Control Technologies and Standards as well as the Bureau of Corrosion Control. We have recognition from the Government with support from the Ministry of Chemicals and Fertilizers, besides key partnerships with the United States Commercial Services (USCS), Federation of Indian Petroleum Industry (FIPI), Federation of Indian Chambers of Commerce and Industry (FICCI) and Confederation of Indian Industry (CII). We are also setting up a training center in Mumbai in association with NACE HQ. With this strong partnership, we look forward to more initiatives with NACE such as IMPACT Plus, NACE International Institute Contractor Accreditation Program (NIICAP), and Master Painters Institute (MPI)."

"This year too, CORCON 2017 has received an overwhelming response from a large number of national and international eminent specialists across various industries, academia and R&D addressing on diverse topics pertaining to refinery, petrochemical, chemical, fertilizers, power plants, and utilities, etc.," said Mr N Manohar Rao, Chairman, CORCON 2017.

The technical program of this conference had over 160 paper presentations, 14 poster presentations, five plenary speakers, and 23 invited talks across 12 symposia and other topics besides four technical interactive forums. There was also an expo area with over 70 booths including an exclusive United States Pavilion, where throughout the day, one could see exhibitors and visitors busy in product demonstrations and animated business discussions.

An added attraction was the CP station that provided an insight to those who were new to methods / functionality of applying Cathodic Protection as an option to reduce corrosion especially in pipelines. The complimentary photograph at CORCON'S portrait station was also widely made use of and appreciated by the delegates.

CORCON 2017 had a day of special focus on corrosion in the oil and gas industry including plenary talks and 'Jung Se Jung' sessions. 'Jung Se Jung' was organized to take care of the focused requirement of a large number of delegates from oil and gas industry.

Amongst the major highlights was the workshop 'Empowering Women to Achieve their Ambition,' that attracted over 60 delegates. The workshop gave the participants an opportunity to enhance development and networking opportunities intended to inspire attendees to pursue leadership positions in the corrosion industry; provide personal and professional development and mentoring strategies through interactive activities; deliver ways to support and mentor others along the path to leadership success; and convey ideas about organizational preparedness and awareness of the need to have diverse leadership teams. The workshop was conducted by Elaine Bowman, Project Manager for the NACE Sponsored IMPACT Study, and a Past President of NACE International; Ms Helena Seelinger, Executive Director, NACE International Institute; and Ms Michelle Lau, NACE International Institute Certification Commission Chair.

The four-day conference was just not scientific and problem solving, brain-storming sessions, but also had its share of lighter moments. Day one, started off with a golf tournament at The Bombay Presidency Golf Club, which saw 120 participants, including many who had never played golf in their life. The energetic, melodious and soulful violin concert performance by Ms Sunita Khaund Bhuyan, on the second day, took delegates into a trance as she weaved her music through the various regions of India.

A glittering award winning function was the highlight of the third night. The NIGIS Corrosion Awareness Award Winners 2017 were Dr Sublime Ningshen, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam for Excellence in Corrosion Science and Technology in Research and Education; Mr Sahab Singh Gurjar, Cairn India Ltd., Ahmedabad for Excellence in Corrosion Science and Technology in Oil and Gas; Dr A. Ravi Shankar, IGCAR, Kalpakkam for Distinction in Corrosion Science and Technology in Research and Education; Mr Rukmangad Kondamgire, GSPL India Gasnet Ltd., Gandhinagar for Distinction in Corrosion Science and Technology in an Industrial Organization; Dr T. Siva, CSIR-Central Electrochemical Research Institute, Karaikudi, Student Award for Ph. D. Degree; Mr Sooraj Kumar, A. O., IIT Madras, Chennai, Student Award for M. Tech; and Dr N. Rajendran, Anna University, Chennai, Meritorious Contribution to Research and Education.

Mr Om Prakash Degan, Chairman, Osnar Group, was presented the Lifetime Achievement Award in appreciation of his excellent contribution to the development of NACE International Gateway India Section and his pioneering work in industrial paints and coating application in India.

The organizers of CORCON 2017 also placed on record the overwhelming support from the Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers, the Ministry of Shipping, Government of India, and support from partners: United State Commercial Service, Federation of Indian Petroleum Industry (FIPI), Federation of Indian Chambers of Commerce and Industry (FICCI), Confederation of Indian Industry (CII) and the Australian Corrosion Association, Inc., amongst others.

The dates for the next edition CORCON 2018 were also announced. The event is scheduled to be held September 30 – October 3, 2018, at Jaipur, Rajasthan.

Glimpses of CORCON 2017

N Manohar Rao, Chairman, CORCON 2017 warmly welcoming the fellow delegates

Vice Admiral Girish Luthra, Flag Officer Commanding-in-Chief, Western Naval Command delivering the inaugural speech

Dignitaries on the Dias releasing the CORCON 2017 Souvenir

Delegates during the inauguration session

Dr. U. Kamachi Mudali Chairman & Chief Executive Heavy Water Board, delivering the Plenary Talks

Dr. Anil Kakodkar, Former Chairman, Atomic Energy Commission interacts with conference Exhibitors

Glimpses of CORCON 2017

Dignitaries with winners of
Corrosion Awareness Award 2017

Panel Members of Technical Interactive Forum
"Corrosion in RCC Structures"

Cultural programme during the conference

Golf tournament organised for delegates at
The Bombay Presidency Golf Club

Workshop organised on 'Empowering Women to
achieve their Ambition"

Best Paper awards presented during the
Valedictory function

TINKER & RASOR

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NEW! Rechargeable Battery!

Four, independent channels with 200+ Megohm impedance and resolution down to the millivolt range. This instrument now includes a USB connector for simple and fast communication with Windows.

Test Stations
For Cathodic
Protection
Applications.

Tinker & Rasor test stations are made of tough polycarbonate materials with UV protection fade resistance. The Rapid Connect binding posts are plated for corrosion protection. Models include Removable covers, exposed terminals, At Grade and riser pipe is also available. Test Stations and riser pipes can be printed with identification information.

Reference Electrodes
Portable and Direct Burial

Tinker & Rasor manufactures a full line of reference electrodes:
Copper-Copper/Sulfate
Silver-Silver/Chloride
Portable
Direct Burial

Tinker & Rasor reference electrodes have replaceable parts, tips for soft soils, hard soils, models for concrete, sea water, and other unique features.

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Soil Resistivity Measurement

The Model SR-2 is an easy to use resistivity meter with a range of .1 ohm to 3 MegOhm.

- 4 Pin Wenner
- 3 Pin Fall of Potential
- 2 Pin
- Soilbox

MODEL CI-50
50 Amp Current Interrupter

The Model CI-50 has been completely redesigned. Now operating from "AA" batteries, a latching and locking lid and internal storage for the included cable, the CI-50 is a stand alone interrupter which can be easily programmed with .1 second timing resolution. Additional current interrupters available with GPS timing synchronization.

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Towards better quality control in Quenched and Self-Tempered (QST) or TMT steel reinforcing bars

Sooraj A. O. Nair and Radhakrishna G. Pillai
Indian Institute of Technology Madras

INTRODUCTION

Thermo Mechanically Treated (TMT) steel reinforcing bars (rebars) are commonly used in reinforced concrete construction site in many countries including India.These bars are manufactured by a special heat treatment process called quenching and self-tempering and are to be technically referred as QST steel rebars. This article is a concise version of a recent study on the microstructure, mechanical and corrosion characteristics of TMT/QST steel rebars (Nair 2017).

The dual steel phase distribution in QST steel bars

TMT/QST steel rebars constitute a dual phase distribution of two different types of steel microstructures. A typical cross-sectional phase distribution is given in Figure 1a. The hard 'tempered martensite' (TM) layer takes the periphery of the steel rebar around a soft 'ferrite-pearlite' (FP) core. TM primarily gives the strength whereas FP provides the ductility for these steel rebars. Unlike its predecessors like Cold-Twist Deformed (CTD) steel rebars and Mild Steel (MS) rebars, TMT/QST rebars hold good yield strength and ductility together.

Under good quality control of the quenching and self-temperingprocess, an ideal/adequate cross-sectional phase distribution (CSPD) is expected as in Figure 1a. This CSPD has a continuous, concentric, and uniform TMring around the FP core.However, it has been recently noticed that several rebars show inadequate CSPD with discontinuous TM in the periphery or eccentric FP core (non-uniform TM ring).

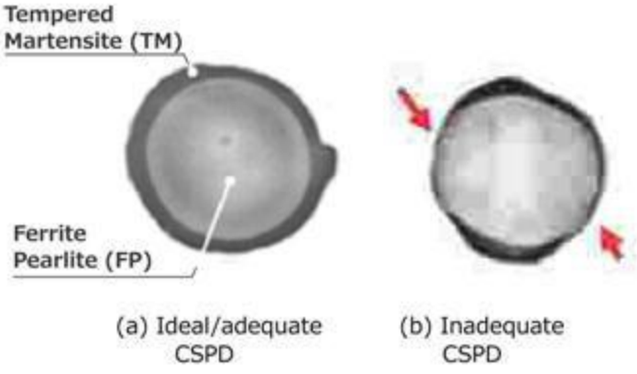

Figure 1: Cross-sectional phase distribution (CSPD) of TMT/QST steel reinforcing bars

The performance of an adequate and inadequate steel rebar in the corrosion resistance and mechanical response is of interest in this scenario.

What if the phase distribution is inadequate?

It is expected to have an adequate CSPD (or good quality) in rebars for regular construction applications. However, several rears collected from the Indian subcontinent has shown an inadequate (or poor quality) CSPD. A few of these cases are shown in Figure 2.This evaluation was focused on 8,12, and 16 mm bars and the results revealed that this issue is profound in 8 and 12 mm rebars.

Figure 2: Defective CSPD observed in several 8 and 12 mm rebars.

Why should we be concerned about rebars with an inadequate CSPD? A series of corrosion and mechanical tests have revealed that the defects reflect in the performance in the corrosion resistance and mechanical response of the TMT/QST steel bars. Defective rebars tend to have a relatively poor performance when compared to good quality rebars.

How could the quality affect the corrosion properties of steel?

Poor quality TMT/QST rebars could rust/corrode at an earlier stage than expected. This is attributed to the presence of FP at the periphery of PQ-QST rebars.

Research has found that the FP core can rust earlier than the peripheral TM. It has been experimentally proved that TM corrodes at a relatively higher concentration of chlorides (y%) than that of FP (x%), where y is nearly 20% higher than FP (See Figure 3a). This difference in the chloride threshold will result in poor quality rebars to rust (in pitting) earlier than good quality rebars.

Also, poor quality rebars are prone to bending cracks. This is crucial during bar-bending of these

rebars on site (See Figure 3b) especially in the case of over-bent rebars used as stirrups. Figure 4a shows multiple cracks on the longitudinal section of a poor-quality rebar under bending. A GQ-QST rebar with a complete TM ring on its periphery will bend without the formation of such cracks. In the presence of cracks, crevice corrosion could initiate and propagate even at a very low level of chlorides. This could result in subsequent weakening of these rebars and spalling of concrete.

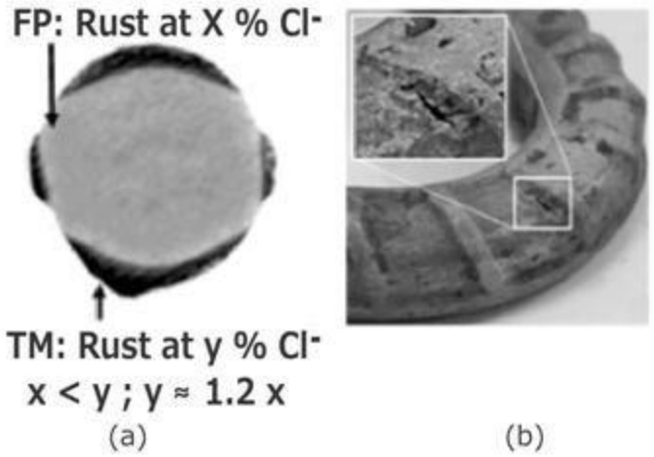

Figure 3: Effect of defects on the corrosion resistance a) pitting b) crevice

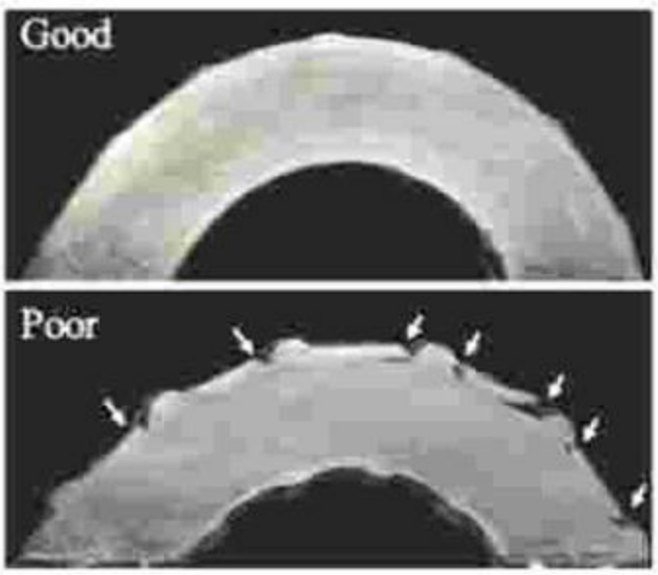

Figure 4: Longitudinal cross-section after bending good and poor quality rebars (machined and polished)

How could the quality affect the mechanical properties of steel?

The yield strength (and ultimate strength) for poor quality rebars exhibit a relatively higher scatter in data when compared to good quality steel rebars (See Figure 5).

This is because of the redistribution of FP and TM from the expected annular distribution of an ideal rebar (as shown in Figure 1a).The values are scattered due to the inadequate and variable CSPD across the length of different rebars. It has been found that for a single rebar length of 12 m, the CSPD varies across the length.

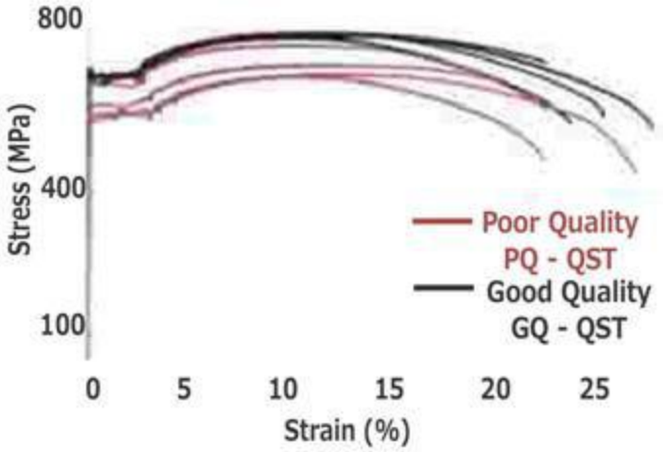

Figure 5: Comparison of stress-strain graphs in good and poor quality QST steel rebars

Is there a need for better quality control?

There exists poor quality control in the quenching and self-tempering process of QST/TMT steel rebars. It has been shown that the quality control could affect the performance of these steel rebars. Although this issue is not unknown in the industry, there is a lack of information on how to tackle this issue. Towards better quality control, a 'TM-ring' test setup, procedure and a 2-level acceptance criterion (Figure 6) were developed for site application based on the experimental observations (Nair and Pillai, 2017). The test procedure involves cutting a cross-sectional specimen in the presence of coolant and subjecting the cut (and polished) surface to standard 'nital' etchant. The cross-section will reveal the CSPD which could be visually evaluated or photographed for further analysis in a standard test setup and procedure.

The detailed 'TM-ring test' procedure to assess and classify the CSPD is published in Nair & Pillai (2017). Further details on the experimental test procedure and results from this research is available in the thesis by Nair (2017).

References

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REFERENCE CASES

	A				B				C				D			
L1	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	N	Y	N	N	N
L2	Y		Y		.				.				.			
	Accepted				Rejected				Rejected				Rejected			

LEVEL I (L1) ACCEPTANCE CRITERIA

No.	Question	Answer (circle one)
1.	Is a dark grey peripheral region and light grey core seen ?	Yes / No
2	Does the dark grey peripheral region form a continuous outer ring ?	Yes / No
3	Are the dark grey peripheral region and light grey core concentric?	Yes / No
4	Is the thickness of the dark grey peripheral region uniform?	Yes / No

Decision

If all the answers are **'Yes'.** then accept the rebar lot

If any one or more answers are **'No'** , then reject the rebar lot.

LEVEL 2 (L2) ACCEPTANCE CRITERIA

No.	Observations	in mm
1	Diameter of rebar, D	
2	Mesured thickness of TM, t_{TM}	

No.	Question	Answer (circle one)
1	$Ist_{TM} \geq 0.07$ D ?	Yes / No
2	$Ist_{TM} \leq 0.10$ D ?	Yes / No

Decision

If all the answers are **'Yes'**. then accept the rebar lot

If any one or more answers are **'No'** , then reject the rebar lot.

Authors:

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A Report - NACE International Certification Courses

For over 30 years, the NACE Coating Inspector Program has set the standard for inspections in the protective coatings industry and is the world's most recognized coating inspector certification program. CIP is the first international certification program designed to improve the overall quality of inspections performed, and it continues to provide the most complete training curriculum, producing top-notch inspectors for the industry.

CIP Level 1 course offers over 60 hours of instruction on the technical and practical fundamentals of coating inspection work for structural steel projects. This course provides students with knowledge of coating materials and techniques for surface preparation and application that prepares the student to perform basic coating inspections using non-destructive techniques and inspection instrumentation. Although specifically designed for coating inspector trainees, this course benefits anyone interested in gaining a better understanding of coatings application and inspection including project engineers, quality assurance managers, contractors, technical sales representatives, blasters, paint applicators, and maintenance personnel.

CIP Level 2 course focuses on advanced inspection techniques and specialized application methods for both steel and non-steel substrates, including concrete using both nondestructive and destructive techniques. Surface preparation, coating types, inspection criteria, lab testing, and failure modes for various coatings, including specialized coatings and linings are also covered. Classroom instruction is comprised of lectures, discussions, group exercises, and hands-on labs using destructive and nondestructive instruments and test methods. Students will also participate in case studies based on real-life situations and practices of a coatings inspector. The course concludes with both written and practical exams.

CIP Level 3 Peer Review examinations are conducted by contemporaries of the coating inspection industry and are experts in their field of work. There is no corresponding course work, only an oral assessment. Peer review examinations are conducted by contemporaries of the coating inspection industry and are experts in their field of work. There is no corresponding course work, only an oral assessment.

CP 1—Cathodic Protection Tester course provides theoretical knowledge and practical fundamentals for testing on both galvanic and impressed current CP systems.

CP 2—Cathodic Protection Technician course provides both theoretical knowledge and practical techniques for testing and evaluating data to determine the effectiveness of both galvanic and impressed current CP systems and to gather design data.

NIGIS organized following certification course during the year of 2017 in India.

Course No.	Course	Period	Venue	No. of Participants
1	CIP Level 1	30 Jan - 4 Feb 2017	Mumbai	19
2	CIP Level 2	06 - 11 Feb 2017	Mumbai	15
3	CP 2 Technician	06 - 10 March 2017	Noida	28
4	CIP Level 1	24 - 29 April 2017	Kochi	17
5	CIP Level 1	01 - 06 May 2017	Mumbai	25
6	CIP Level 2	08 - 13 May 2017	Mumbai	26
7	CP 2 Technician	23 - 27 May 2017	Mumbai	26
9	CP 3 Technologist	29 May - 3 June 2017	Mumbai	14
10	CIP Level 1	19 - 24 June 2017	Kolkata	10
11	CIP Level 1	26 June - 01 July 2017	Ahmedabad	18
12	CIP Level 1	03 July - 08 July 2017	Mumbai	24
13	Internal Corrosion For Pipeline	10 - 15 Sept 2017	Noida	26
14	CIP Peer Review	16 - 18 Sept 2017	Mumbai	20
15	CP 2 Technician	18 - 22 Sept 2017	Mumbai	16
16	CP 2 Technician	02 - 06 Oct 2017	Mumbai	20
17	CIP Level 1	02 - 07 Oct 2017	Mumbai	20
18	CIP Level 2	09 - 14 Oct 2017	Mumbai	20

Photographs of Certification Courses

CIP Level 1 participants during 24 - 29 April 2017

CIP Level 1 participants during 01 - 06 May 2017

CIP Level 1 participants during 03 - 08 July 2017

CIP Level 1 participants during 19 - 24 June 2017

Internal Corrosion For Pipeline participants during 10 - 15 Sept 2017

CP 2 participants during 02 - 06 Oct 2017

Nace International Institute Headquarters Report

Certification

September saw the addition of 347 new certifications and 894 renewals. The total active certifications remain steady at 55,390 which is slightly up from the previous month.

Current development activities remain focused on next generation CIP and CP exams.

As part of our goal in driving industry leadership, we have begun preparations in working towards achieving 17024 accreditation. To support this, we will be undergoing an ISO 17024 audit for the sole purpose of identifying our areas of strengths and weaknesses. This unofficial audit will help us to identify the areas which we need to focus on so that we can accredit our next generation CP and CIP level 3 certification which are currently targeted to launch in FY19.

Summary – Certification business remains stable and we are currently meeting all our monthly financial, development and grading targets.

NIICAP

Currently have five accredited contractors listed on the website:
http://www.niicap.net/accredited-contractors

One audit scheduled for the 28th of this month, this will be our 6th audited NIICAP Company. Two companies that have applied for NIICAP this month this will bring the total applications to 9.

The 7th NIICAP audit will be scheduled for the second week of December.

Currently, NIICAP has over 18 interested companies that are currently engaged with the program and we hope to have our 10th paid application in December.

Due to some political tension in the Middle East, contractors have asked for some more time before they commit, we recently resumed communication and hope to be back on track in that region by January.

We are now in communication with a few companies in India and we have two companies that have the application and said they are interested in applying.

Impact Portal

The project remains on target for a 1st December launch.

All remaining project work streams are progressing according to plan and will be ready for launch day. These work streams include:

- Portal UAT (User Acceptance Testing)
- Pilot Navigator training and certification – on schedule for November 28th

Over the last month we have been internally focused to ensure that all operational dependencies are ready for a December launch. We are happy to report that we have all elements in place to support the launch on December 1. In addition, we have recently added a Portal Administrator whose job role is key to ensuring that our customers and licensees are correctly administered and managed as they sign up and begin using IMPACT PLUS.

Summary – We are ready for launch on December 1 and we are excited at the new opportunity IMPACT PLUS brings to the overall NACE and NII product suite. This is a game changer and will open additional opportunities for all of NACE Products, Programs and Service offerings.

MPI LLC (Project Architect)

MPI is operationally stable and functioning in accordance to plan. This essentially means that financial processes and product streams are operating according to plan.

We have updated key contracts to reflect the new MPI. These contracts have been sent to existing MPI customers for signature. The contracts are key to MPI's operating model and include:

- Testing and Licensing agreements
- Logo license agreement

NACE and MPI finance teams are working closely to reconcile old and new MPI financials for reporting purposes. This task is 95% complete and preliminary financials indicate that we are within 5% of plan.

Headquarters Report

75th Anniversary

An artist has been selected to design and build a legacy art piece to commemorate NACE's 75-year history. The piece will be revealed in October 2018 during a reception at NACE HQ and will be displayed at CORROSION 2019. Afterward, it will then reside at NACE HQ or at the Elcometer Training Center.

Impact Study And Impact Plus

The first IMPACT PLUS Navigator training was held November 28 – 30. Seven candidates took the Navigator certification exam with a total of 12 people attending the training (we purposely did not schedule more than this number as this training was considered a pilot training). Two companies have committed as IMPACT PLUS licensees with three more committed to be licensed by the next Navigator training in February 2018. The IMPACT PLUS program had a soft launch on December 1.

Education

Education courses were held in three new markets:

- Internal Corrosion and CIP classes in Baku, Azerbaijan.
- Basic Corrosion class in Lagos, Nigeria partnering with the section.
- A public class, in Santa Cruz, Bolivia – CIP Level 1.

Attended the Western Area BOT meeting providing a presentation on partnering with NACE Education.

Global Operations

The first SPE / NACE joint workshop on "Corrosion Management for Upstream Oil and Gas Production Assets" was held at Kuala Lumpur, successfully filling 96% of the intended capacity, thanks to the well developed program. Representing NACE as co-chair of the planning committee was Dr. Carlos Palacios.

Certification chair, Michelle Lau, who was also an active member of the planning committee, presented IMPACT Plus. The workshop extended the NACE reach to non-members and the Upstream sector of the oil and gas industry.

A NACE member reception co-hosted with Korean Corrosion Experts Society (KOCES) was held in Busan, Korea with technical presentations to the audience of about 110 people. Toyoji Takeuchi, E A P area director, keynoted the event. Members showed strong interest in having a conference next year and initiated discussion of forming a member community.

Dr. Samir Degan, NACE president, led the NACE team at the Corrosion Standard Workshop in Jakarta, Indonesia. The workshop was the result of the collaboration between Indonesia Standard Agency(BSN), US Commercial Services and NACE. Samir, Michelle Lau, certification chair and Dr. Khlefa Esaklul, TCC chair, presented relevant topics to representatives from BSN, Ministry of Public Works and Housing, Ministry of Transportation, railway operations, gas companies and industries.

The LAA Board of Trustees took the opportunity during the PIMS Conference to hold a Strategic Planning session and developed three key strategic objectives for the Area.

Cairo Egypt section had its "Integrity Solutions and Advanced Techniques" seminar for some 150 members and professionals, delivering 6 papers ranging from pipeline to tank applications and from CP to coatings.

NACE education and certification programs were shared with some 1000 registrants at the Rio Pipeline 2017 in Rio de Janeiro, Brazil. Key organizations requesting follow-up meetings included Total, Braskem (largest polymer manufacturer in Brazil), Gerdau (steel manufacturer), Gas Natural Fanosa and Brazilian Navy Academy. The increase in foreign investment in the Brazilian oil industry will more than likely lead to an upsurge in the requirement of international recognized trainings and certifications.

Conferences & Exhibits

Conferences

PIMS was held in Lima, Peru. This was the first time for this event to be held in Peru. Below are the highlights:

- 190 total attendees for the 3rd installment of this event (27% more than the 2014 and 2015 events).
- 16 countries represented, 6 of which were outside of our Latin America Area.
- Jeff Didas, NACE vice president, presented NACE technical activities to a completely filled room.

Exhibits:

The Exhibits and Marketing Department sends out a Monthly Exhibitor Newsletter. This Newsletter contains important information for our C2018 exhibitors, as:

- How do I register my booth attendants?
- Where do I ship my booth?
- Where do I go to book my hotel accommodations?
- What sponsorship opportunities are available?

PUBLISHING

Books:
Publications signed a licensing agreement with Springer that will disseminate data from select NACE books to a large corrosion database that will be accessed by corrosion/coatings specialists around the world.

Materials Performance:

Conducted and received results for the 2017 MP readership survey, with a total of 452 responses. The editors use this information as a report card to ensure we are best serving our readers, and take the feedback into consideration when planning and preparing content.

A summary of results will be published in the February 2018 issue. Here are some highlights:

- 87% of readers always or occasionally apply information from MP to their work.
- 71% find the subject matter and technical quality very good, 26% find it average, 3% state it needs improvement.
- 65% find the readability very good, 33% find it average, 2% state it needs improvement.
- 89% find the length of the technical articles about right, the rest find them too long or too short.

Published the fall 2017 issue of Inspect This!

MARITIME

Delivered PSPC Review results to Tripartite. Updated GESAMP on the status of TM0112 revision and process for completion. GESAMP is the IMO sponsor of the Ballast Water Management Guide that refers to TM0112. Participated on American Association of Port Authorities webinar regarding mitigating damaging effects of corrosion at port facilities. Initiated discussion with Port of Alaska port director who is facing the need to replace all sheet pile infrastructure that make up the port within the next 10 years.

Established engagement opportunity with Oil Companies International Marine Forum (OCIMF) on corrosion in cargo and ballast tanks of oil tankers.

Identified engagement opportunity with International Association of Classification Societies (IACS) regarding creation of an IACS coating performance guideline for bulk carrier cargo tanks.

PUBLIC RELATIONS

Managed communications and public relations around the release of Economics of the Corrosion Industry: State of Ohio Report. Press release distribution was targeted to trade media and local media outlets. Social media outreach included general outreach to all NACE audiences and also targeted within Ohio and communities within 150 miles from the state. Currently working on follow up outreach with bylined articles for trade press and calls to local press to arrange interviews and/or other coverage.

GOVERNMENT RELATIONS

Participated in the Board Key Strategy Team 4 to update implementation plan and discuss future activities.
Led meeting with NACE Standards Department and the Pipeline and Hazardous Materials Safety Administration (PHMSA). Our meeting focused on increased communication and partnership on corrosion prevention policies.

Technical Activities:

Corrosion 2018 - Technical Content

- 39 technical symposia with 523 submitted draft papers. 2 symposia were removed from the schedule due to lack of submissions. Papers that were submitted were paired up with closely aligned symposia topics.
- Five (5) research in progress symposia being offered at C2018. As of 11/21/17 there are 21 submitted abstracts.
- The call for student poster abstracts opened on 21 August 2017.
- Now 11 Forums to be offered C2018, two more than what was offered at C2017. We gained a Forum with a recent submission from NIICAP.

Standards Initiatives

Work continued, new initiatives include:

- Mining - new STG approved
- Off-Shore Life Extension – data is being gathered, future technical meetings being planned
- Additive Manufacturing - NACE participating in ANSI/America Makes standards initiative
- Adoptions in India – meeting held with US Department of Commerce and next steps defined
- UK MoD standards migrations – Agreement being reviewed and next steps under development
- BSI reciprocal agreement – Agreement being reviewed for signature
- Maritime engineering aids – working its way through formal approval process
- ISO standard adoptions – working its way through formal approval process
- Prognostic Health Management (PHM) – Dialog with PHM continuing (also books, training/education)
- Construction – collaboration with MPI (NII affiliate) is ongoing

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NACE International Institute Acquires Canada's Master Painters Institute

NACE International Institute (NII), the leading advocate for corrosion control qualifications and solutions, has formally acquired Master Painters Institute (MPI) (Vancouver, British Columbia, Canada).

MPI is a leading North American certification organization for paint performance.

"Our organizations are a natural fit," says Chris Fowler, president of NII. "The NACE Institute will bring to MPI its resources in the areas of standards, training, and certification, which will benefit the quality of the commercial coatings profession while merging the coatings expertise of professionals on both the commercial and industrial side."

In this new partnership, NII and MPI will provide a single source for coatings information that meets business requirements for architectural and industrial coatings. The two groups plan to advance the quality of training and certification opportunities for commercial and industrial coatings professionals worldwide.

"There are many areas where NII and MPI activities intersect," says Davis Kyle, executive director of MPI. "Just this past April, an IHS Markit [London, United Kingdom] report found that 40% of the coatings industry is comprised of industrial coatings, while 45% is comprised of commercial coatings. These two market segments are only growing. Now is the time to partner with the NACE Institute."

The partnership will bring expanded resources from the NACE Institute to MPI, all while allowing MPI to continue operating its customer-focused operations in the same manner it has for years. The certification organization's products and services, including the MPI Approved Product Listing, product testing, training, and standards, will remain the same.

"MPI and the NACE International Institute share the same commitment to quality and professionalism," says Helena Seelinger, NII's executive director. "We are happy to be joining forces with MPI to support industry owners in their search for asset protection by qualified coatings products, while also bringing high-quality education and certification opportunities to our combined stakeholders. Demand for commercial coatings inspectors in Canada, the United States, and abroad is increasing, and NII and MPI are working together to cultivate qualified inspectors to meet these needs."

Based in Vancouver, MPI's employees will remain in their current roles to support the organization without changing its operations.

"The worldwide expertise of members in NACE and the NACE Institute is the stepping stone MPI needs to serve new areas globally," Kyle says. "We are looking forward to embarking on this new journey."

Source: NII, naceinstitute.org

Cathodic Protection Design Considerations for Multiple Well Casings

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Abstract

It is a challenging job to design a cathodic protection (CP) system for new well casings with good coating placed in vicinity of already existing bare (non-coated) well casings. Mainly due to considerations for current distribution between the former and the later as the both must be integrated to avoid interference. For a suitable design there are number of controlling factors that need to be taken into account such as well casing resistance remote to earth, backemf, flowline & trunckline resistances and negative cable resistance.

This paper presents various scenarios of multiple well casing CP system design.

- Design concept for dual bare well casings.
- Design concept for three or more bare well casings.
- Design concept for existing bare and new coated well casings.
  - ✓ Current distribution by controlling the negative cable resistance.
  - ✓ Current distribution by flow line / trunk line resistance.
- Design variable effecting the current distribution.
- Case study of multiple well casings.

Introduction

Designing of the cathodic protection (CP) system for a new well casing with good coating adjacent to an already existing well casing is challenging, especially when the existing well casing/casings are bare. One aspect of the corrosion control philosophy adopted for the new oil wells is to provide Fusion Bonded Epoxy (FBE) coats to well casings to minimize the CP current requirements. Use of the FBE coating reduces the required current and thus facilitates the use of a single CP power supply for multiple well casings. Also for engineering economy and for an integrated and effective cathodic protection system, the new well casing with good coating must be provided with the choice of single CP system.

There is a requirement for proper survey of the existing cathodic protection system of the well casing for creating a suitable design. It needs not to be emphasized that a person having broad experience in cathodic protection surveys is essential.

Design Approach

The cathodic protection system design for multiple well casings is to be prepared based on the consideration of following essential factors:

- ✓ Project specifications.
- ✓ Client's standards and referenced international standards.
- ✓ Plan drawings.
- ✓ Site survey for existing and proposed CP systems.
- ✓ Survey results.
- ✓ Engineering economy.
- ✓ Interference.
- ✓ Control of current for distribution to the wells through the use of negative cable connected to the wells.

Site Survey

A thorough study of layout drawings has a great importance for a detailed survey of the CP systems. The site data to be collected during the survey needs to be listed down. Following is the minimum data required to design the cathodic protection system:

- ✓ Existing cathodic protection station locations, rated and operating parameters.
- ✓ Current drawn by existing well casing/casings and flow line / lines by swain meter with current flow directions.
- ✓ Potential difference with polarity between existing casings incase existing casings are two or more.
- ✓ Distance from existing anode bed to new well casings and flow lines.
- ✓ Existing well casing to ground resistance.
- ✓ Existing flow line to ground resistance.
- ✓ Soil resistivity at existing anode bed locations.
- ✓ Soil resistivity at proposed new anode bed locations.
- ✓ Pipe-to-soil potential at nearest test station of existing flow line.

Design Parameters

A number of the following experience based field values and measured parameters are to be utilized to facilitated the design:

1.1 Current Requirement for a Bare Oil Well Casing:

The CP current required to cathodically protect a bare oil well / water injection well casing is to be 20 to 25 amperes in the onshore coastline area of Arabian Gulf. This criterion has been applied successfully for more than 25 years by operators in Middle – East based on their experience. The CP current requirement for bare oil well / water well injection casings for this design was set at 25 amperes and is sufficient to provide a conservative margin for variance in well completion characteristics.

1.2 Current Requirement for a Coated Oil Well or a Coated Water Injection Well Casing

The CP current required to cathodically protect a FBE coated oil well / water injection well casing is to be 2 to 4 amperes in the onshore coastline area of Arabian Gulf. This criterion has been applied successfully for more than 8 years by operators in Middle – East based on their experience. The CP current requirement for coated oil well / water well injection casings for this design was set at 3 amperes and is sufficient to provide a conservative margin for variance in well completion characteristics.

1.3 Current Requirement for a Bare Water Source Well:

A current of 6 amperes is required for the shallow water source wells, primarily to ensure that these well casings would not fail prematurely from interference currents produced by the nearby CP rectifiers. Complete external corrosion protection is not determined to be a high priority on these wells, but a current of 6 amperes is sufficient by the design to ensure acceptable longevity at least from the perspective of external corrosion failures.

1.4 Well Casing Resistance to Ground:

The current distribution to the wells will be controlled through the resistance of the negative return paths for the current, the effective resistance to ground of the respective types of well casings also needed to be determined. Field tests must be carried out on typical well types to establish the values to be used for these parameters. The field tests included casing-to-casing resistance substantiated by 3-Pin resistance measurements. Generally in the onshore coastline area of the Arabian Gulf, it was determined that 0.015 ohms would be used for bare well casings, and 0.07 ohms would be used as the resistance-to-ground of a coated well casing.

1.5 Anode Bed and Well Casing Back EMF:

The back emf generated by the half-cell potentials of the anode bed and the well casings is also required to develop a representative equivalent electrical circuit or design. To develop a representative equivalent electrical circuit for substantiating the design, the back emf appearing as half cell potentials of well casing and anode bed need to be taken into consideration.

We found that the nominal back emf sourced from a polarized well casing was -1.2 volts, and the nominal back emf sourced from a polarized anode bed was +0.8 volts with an overall effect as substantiated by measurements at a number of locations that resulted in an effective cumulative back emf of 2.0 volts, but for design considerations measurements must be taken at selection of representative wells to establish a reasonable approximation for these parameters.

Design Variables Effecting the Current Distribution

- ✓ Well casing resistance to remote earth
  - ➢ Bare casing
  - ➢ Coated casing
- ✓ Back emf
  - ➢ Bare casing
  - ➢ Coated Casing

- ✓ Flowline and trunkline resistances
  - ➢ Axial resistance (wall thickness, diameter and length of pipe)
  - ➢ Leakage resistance (coating quality, pipe diameter and length)
- ✓ Negative cable resistance
  - ➢ Only control variable in CP design
  - ➢ Size and length of cable

Design Concept

1.1 Design Concept for Dual Bare Well Casings

The well casing CP system started in mid 1980's in Middle East generally protected wells far from each other and protected one well and flow line with one CP system. During the early 1990's, with the increase in oil demand the number of oil wells increased in oil field and new wells drilled near the existing oil wells or both new wells drilled close to each other. The new and existing wells were bare. To avoid interference it was mandatory to provide integrated CP system for both wells. The resistance of well casing to ground was equal or near to equal for both the wells. The provision of isolation joint was not recommended in oil field for flow line and trunk line. The variable resistance in negative cable not recommended due to operations and HSE (Health, Safety and Environment) issues. Current distribution can be controlled by the resistance of negative cable from well to junction box. The location of negative junction box will be selected such a way that both the negative cables coming from the well is equal length and size. If required cable size will be adjusted for current distribution. Refer Figure – 1 for sketch of CP system.

1.1 Design Concept for Three or More Bare Well Casings

During the early 1990's increase in oil demand, number of new wells were drilled near the existing oil wells or new wells drilled close to each other. The new and existing wells were bare. To avoid interference it was mandatory to provide integrated CP system for all the wells. The resistance of well casing to ground fell equal or near to equal for both the wells. The provision of isolation joint was not recommended in oil field for flow line and trunk line. The resistance introduction to the negative cable was not recommended due to operations and HSE issues. The solution for current distribution can be by utilizing the resistance of negative cable from well to junction boxes. The location of negative junction box will be selected in such a way that all the negative cables coming from the well is of equal length and size. If length does not bring desired adjustment the cable size will be adjusted for current distribution. Refer Figure – 2 for sketch of CP system.

1.1 Design Concept for Existing bare and New Coated Well Casings

1.1.1 Current Distribution by Controlling the Negative Cable Resistance

An oil field with existing wells (some being more than 20 years old) distributed throughout is being further developed for crude oil production using a drilling philosophy that places multiple wells on a common drill site location (multi-well drill site) created in 2001 in Middle-East. The new wells for further development are directionally drilled to optimize production characteristics and minimize surface land usage, with typically 5 to 15 wells at each drill site. The well casings pass through the various corrosive formations of the soil strata. The cathodic protection (CP) current requirement of 20 to 25 amperes for a bare well casing in the this field, that was determined during the early 1980's, has been found to be effective in minimizing failures from external corrosion in corrosive formations.

One aspect of the corrosion control philosophy used for the new oil wells in the new development project was to utilize Fusion Bonded Epoxy (FBE) coated well casings to minimize the CP current requirements. Use of the FBE coating reduces the required current to less than 3 amperes per well and facilitates the use of a single CP power supply for each multi-well drill site.

The use of FBE coatings on the new well casings with a single CP power supply for each multi-well drill site provides significant economic and technical merits when compared to bare well casings. Without the FBE coating, most of the

multi-well drill sites would require multiple CP power supplies and increase in number of anodes proportional to the increase in the current requirement. Using a simple CP power supply with a single output; and avoiding electrical isolation, resistive control circuitry, and electronic control circuitry presents obvious advantage in equipment cost and maintenance. In addition, there is a reduced probability of deleterious DC interference when only one CP power supply is used and there is electrical continuity between all close proximity well casings.

To avoid interference isolation joint is not recommended. The current requirements for bare and coated wells are different. Bare and coated wells are interconnected by flow line. The casing to ground resistance is different for bare casing to ground and coated casing to ground. The back EMF for coated casing and bare casing is different. The only controllable variable to control the well casing current is negative cable resistance. The length is fixed based on cable route by adjusting cable size the current distribution of bare and coated casings can be controlled. The manual calculation is taking lots of time. It is recommended to use electric circuit software for fast and accurate calculations for complex circuits. Refer Figure – 3 for sketch of CP system.

The case study of this type of design is given below:

1.1.1 Current Distribution by Flow Line and Trunk line Resistance

CP system using current distribution for the well casing by flow line and trunk line resistance (Satellite System) started in mid 1980's in Middle East. The locations are usually 300Km to 400Km from shoreline of Arabian Gulf. There are typically ten to fifteen similar wells (bare casings) spaced 2 Km to 10 Km apart and are connected to flow line to a common processing facility. The current requirement is found to be 4 Amp for bare wells. The CP power supply was located at processing facility. There were no isolation joints. The current distribution dictated by resistance in respective flow line resulted in generally poor distribution ranging from 2 to 30 Amps to each casing.

Refer Figure – 4.1 for sketch of CP system.

The major re-development project was later initiated with several hundred distributed oil wells and peripheral water injection wells in 2008. All the new wells were coated with FBE coating. The current requirement for coated well is found to be 1 Amp. The CP system was provided with single dedicated power source for existing bare wells and centralized CP system that used trunk line and flow lines to distribute the current to new coated wells.

Case Study

This site is located 6 KM from Arabian Gulf coastline in eastern region of Saudi Arabia. The site is consisting of following:

- ✓ Four coated oil well casings (new)
- ✓ One bare oil well casing (old)
- ✓ One bare water supply well (shallow & small diameter)
- ✓ Three pipelines connected to the central manifold

Refer Finger – 5.1 for arrangement at referred site. The current requirement was as per Table - 1 for different type of wells.

Table – 1 Current Requirement

Structure	Design Target (Amps)	Operating Target (Amps)
Coated Casings	3 minimum	2 to 4
Bare Casings	25 minimum	20 to 25
H_2O Wells	<200mV to nearest well	<200mV to nearest well

The well casing resistance to remote earth is as below:

- ✓ Bare casing: 0.015 ohms
- ✓ Coated casing: 0.07 ohms
- ✓ Bare water supply casing: 0.05 ohms
- ✓ Coated pipeline: 0.055 ohms

The Back Electo-Motive Force (emf) is as below:

- ✓ Bare casing: 1.17 volts
- ✓ Coated casing: 1.20 volts
- ✓ Bare water supply casing: 1.15 volts
- ✓ Coated pipeline: 1.20 volts

The values of resistance to remote earth and back emf verified through simulation model.

- ✓ Current distribution
- ✓ Potential difference

The values of above fixed resistances, back emf and cable resistances inserted in electronic circuit software. Please refer Figure – 5.2 for results. As per theoretical design model current distribution found as per Table - 2.

Table – 2 Current Distribution as per Theoretical Model

Well Designation	Design Target (Amps Min.)	Operating Target (Amps)	Theoretical (Amps)
C1	5	2 to 4	5.118
B1	25	20 to 25	28.64
C2	5	2 to 4	5.311
C3	5	2 to 4	5.208
C4	5	2 to 4	5.147
B2	6	<200mV (H_2O Well)	9.6A (121mV)

The theoretical circuit used during design has been modified as per site parameters like back emf, water supply well resistance and foreign current from trunk line system. The results observed are very close to results obtained in commission. Refer Figure – 5.3 for results actual circuit and current flow. Refer Figure – 5.4 current distributions on site.

The theoretical model achieves adequate current to each well casing without the use of resistors or isolating equipments. The operating data is complicated by high current level supplied by connection of site to Trunk line system, but system still works effectively. The comparison of design and operating data shows differences are within tolerable levels and within targets.

Conclusion

A design with a focus on the negative circuit for current distribution with the use of a single CP power supply can be a cost effective alternative for cathodic protection of well casings for multi-well drill sites. Making use of an external coating system for the well casings enhances the savings (cost of coating included) and increases the number of wells that can be practically protected with a common rectifier.

Representative model development of an equivalent electrical circuit can be used to effectively design a single CP system for protection of a multi-well drill site without the necessity for electrical isolation or electronic current control. The use of widely available commercial electrical engineering software makes optimization of the design both rapid and accurate.

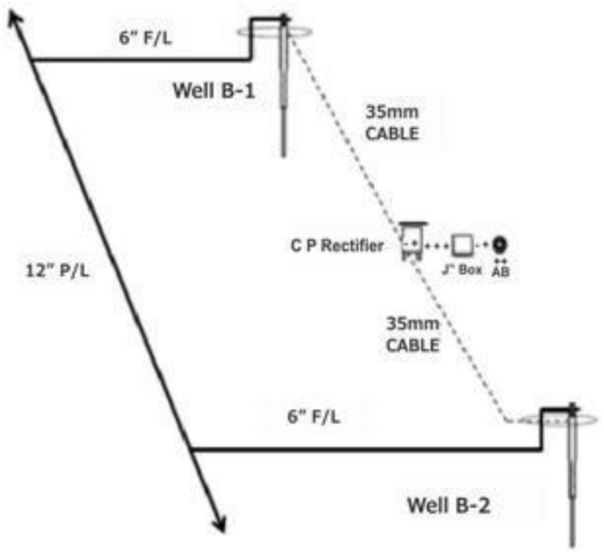

Figure – 1 CP system for Duel Bare Well Casings

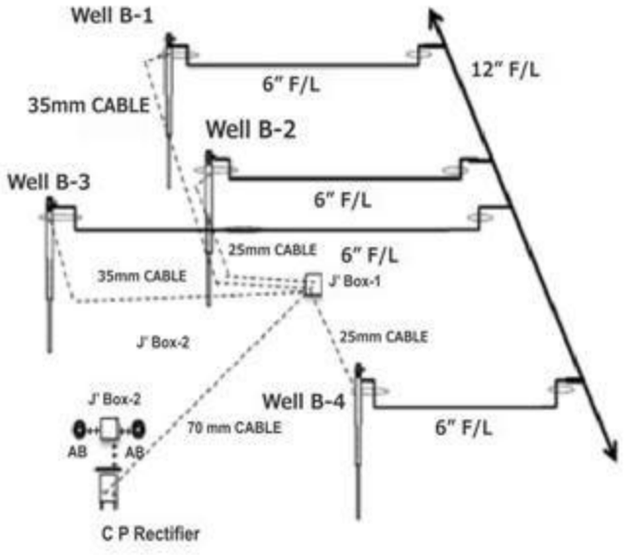

Figure – 2 CP system for Multiple Bare Well Casings

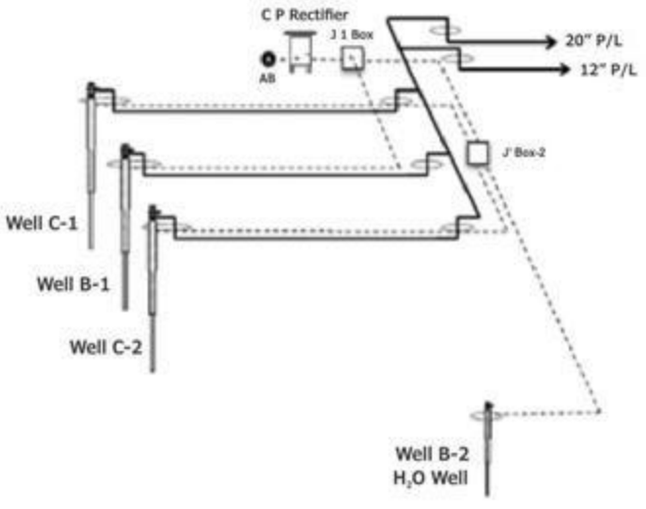

Figure – 3 CP system for Multiple Bare Well Casings

The commissioning results as listed in below tables.

Table – 3 Commissioning Results – Well Current

Pre-commissioning Form for Multi Well Cathodic Protection Site										
Field:					**Site Name:**					
Date:	4-Jan-09	Measurement Taken By (Print Name):								
TR Unit	**Rating**				**Operating Output**				**Total Current Measured at Site**	
	30 Volts	100 Amps			10 Volts		38 Amps		57.34 Amp	
Well Casing Current Measurement										
Well or P/L Number	**Well or Pipeline Type**	**Min Amps Commission**	**Amps Returning Thru F/L (1)**				**Mult**		**Amps In Cable(1)**	**Amps Up Casing (=$Amps_{F/L}$ + $Amps_{Cable}$)**
			(AmpsF/L with Swain Meter)				**0.6**			
i.e. XYZ-123	**i.e. Bare Oil Well**		**0°**	**90°**	**180°**	**270°**	**AVG**	**Actual**	**(Amps Cable)**	
C1	Coated Oil Well	3	6	6.2	5.8	5.8	5.95	3.39	2.1	5.49
B1	Bare Oil Well	25	16.7	16.6	16.8	16.6	16.7	9.5	22.5	32.00
C2	Coated Oil Well	3	3.5	3.3	2.8	0	2.4	1.37	4.2	5.57
C3	Coated Oil Well	3	5.5	5.6	6.1	6.5	5.93	3.38	2.9	6.28
C4	Coated Oil Well	3	2.4	2.4	2.4	2.6	2.45	1.4	2.4	3.80
B2	Bare Water Supply	6					4.2	4.2		4.20
8" Lateral			5.8	5.8	5.9	6	5.88	3.35		
20" Lateral							14.3	14.3		
4" to Scraper			2.5	2.6	2.8	2.9	2.7	1.54		
Note 1: Current flowing away from well is +ve; current flowing toward well is -ve.										

Table – 3 Commissioning Results – Negative JB Current

Negative Junction Box - Current Measurement							
Box Descrip.:	CPJB-05		Box Descrip.:	CPJB-04	Box Descrip.:		
Cable Descrip.	Size	Amps(2)	Cable Descrip.	Amps in Cable	Cable Descrip.	Amps in Cable	
C-1	16	2.00	To TR	38			
C-2	16	4.00	B-1	22.5			
C-3	16	3.00	To CPJB-05	15.4			
C-4	16	2.20					
H_2O Well	35	4.20					
Note 2: Current flowing toward rectifier is +ve; current flowing away from rectifier is -ve.							

Potential Difference Between Wells			Notes or Comments
+ve Terminal of Meter to Well Number	-ve Terminal of Meter to Well Number	Potential Difference in millivolts	1
			2
C-4	C-3	-4.2	
C-3	C-2	8.9	3
C-2	B-1	-25.6	
B-1	C-1	18.1	4
H_2O Well	C-4	-168	
			5

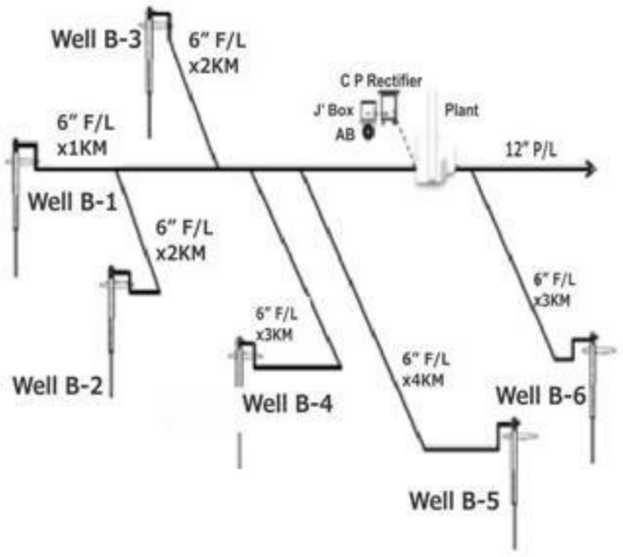

Figure – 4.1 CP system for Multiple Bare Well Casings Current Controlled by Flowline – Poor Current Distribution

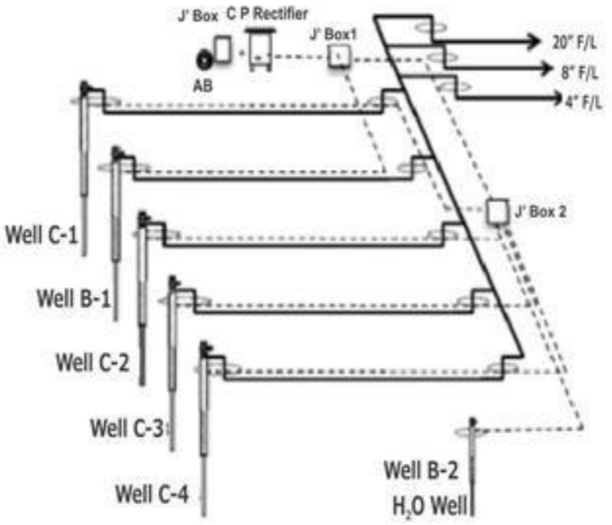

Figure – 5.1 Case Study of CP system for Multiple Bare & Coated Well Casings Site Arrangement

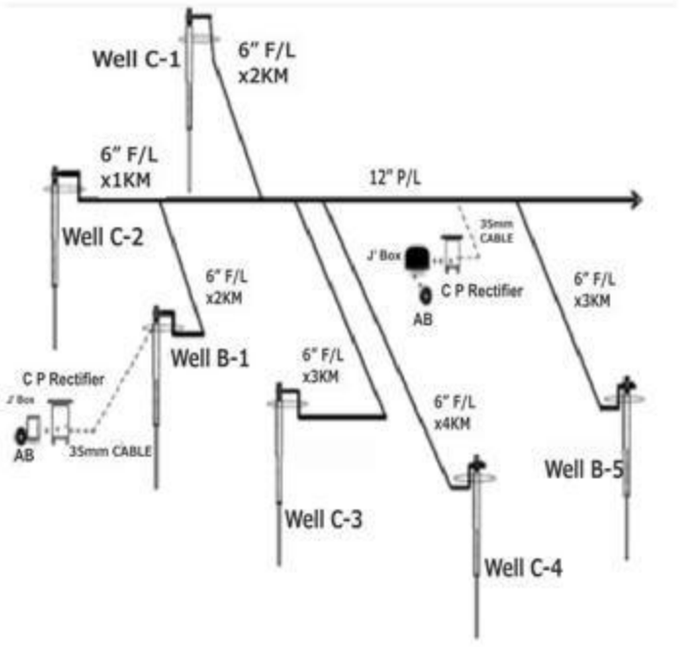

Figure – 4.2 CP system for Multiple Bare & Coated Well Casings Cuurent Controlled by Flowline – Good Current Distribution (Bare well provide with dedicated CP System)

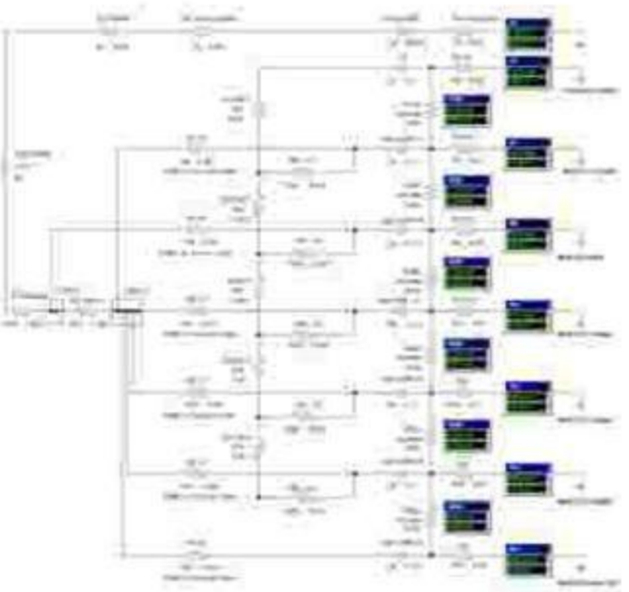

Figure – 5.2 Case Study of CP system for Multiple Bare & Coated Well Casings,Theoritical Design Model

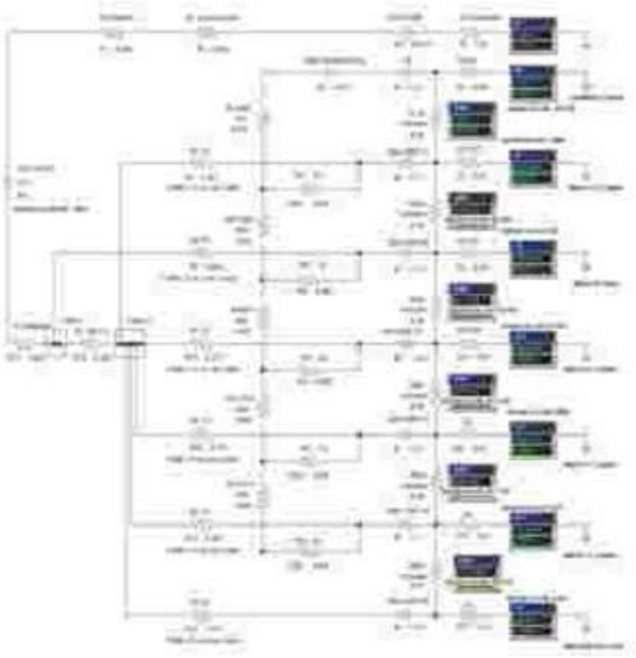

Figure – 5.3 Case Study of CP system for Multiple Bare & Coated Well Casings, Theoritical Design Model (Modified to include current from Trunkline System)

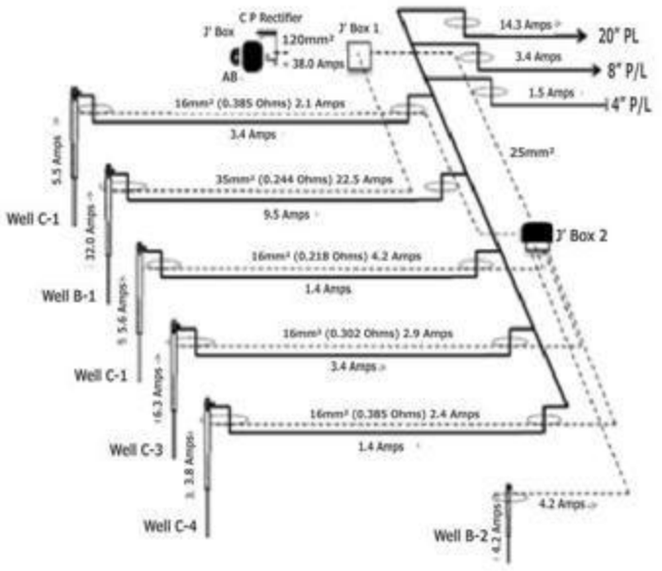

Figure – 5.4 Case Study of CP system for Multiple Bare & Coated Well Casings Current Distribution

Acknowledgments

The author wish to express their thanks to the Directors of Corrosion Protection Specialist Pvt. Ltd., entire team of Abdulla Fouad Impalloy Ltd. Co.(AFIC), Cathodic Protection and Coatings Unit of Consulting Service Department of Saudi Aramco for their guidance, Mr. Darrell R. Catte – Cathodic Protection Consultant (Canada), Zakum Development Company (ZADCO – Abu Dhabi) and Abu Dhabi Company for Onshore Oil Operations (ADCO – Abu Dhabi).

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Mr. Pankaj Panchal is Electrical Engineer. He has 20+ years of experience in Cathodic Protection and Corrosion control systems including Survey, Design, Engineering, Project Management, analysis, inspection and troubleshooting in the Corrosion Industries. He is NACE Certified Corrosion Specialist and Cathodic Protection Specialist. He is NACE Instructor for CP-1,CP-2, CP-3 and CP-4 courses.

He is having cathodic protection systems and corrosion control system survey, design, projects, operation and maintenance experience for :

- Onshore :Pipelines, Plants, Well Casings, Tanks Bottom, Tank Internals & Process Vessels.
- Offshore :Platforms, Pipelines, Well Casings& Jetties.
- AC / DC Interference study and mitigation.
- Integrity Management.

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- PERMANENT REF. CELL (Cu-CuSo4)
- KIRK CELL
- TEST STATION (TLP)
- JUNCTION BOX (AJB / CJB)
- CANNISTERS
- ELECTROLYTE (KOH)
- EASY KIT FOR CP MONITORING

SURVEY :

- CIPL
- DCVG / A-FRAME
- CAT
- AC / DC INTERFERENCE
- SOIL RESISTIVITY
- SOIL (PH) - ANALYSIS

INSTALLATION :

- PCP
- TCP

E-PIPE ASSIST
(A VERSATILE HIGH IMPEDANCE DATA LOGGER)

- RECORD STORAGE UPTO 6 LAC READINGS
- TLP DATABASE STORAGE OF 6000 TLP WITH TYPE & LOCATION
- 2 DAYS BACKUP 5000 MAh BATTERY
- MODES : MANUAL + AUTOMATIC
- RECORDING OF ALL TYPES OF TLP DATA
- **TYPE-1:** (TYPE- A / B), **TYPE-2**: (TYPE- IJ / 6L), **TYPE-3:** (TYPE- C), **TYPE-4:** (TYPE- VC),**TYPE-5**: (TYPE- N), **TYPE-6:** (TYPE- E),**TYPE-7**: (TYPE- M), **TYPE-8:** (TYPE- CORROSION COUPON) **TYPE-9** – (TYPE- ER PROBE) MANUAL ENTRY
- AUTO SMS WHILE READING
- GPS TRACKING
- SOLAR INTERFACE
- SOFTWARE ASSISTED FOR DIRECT REPORTING
- 24 HR DATA LOGGING AC + DC TOGETHER

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A Report - Pipeline Corrosion

NACE International Gateway India Section (NIGIS) organized an educational & training programme on "Pipeline Corrosion" during the period 04 – 16 December 2017 at Hotel Rodas, Powai, Mumbai.

Corrosion of most common engineering materials at near-ambient temperatures occurs in water - containing environments and is electrochemical in nature. The corrosion process involves the removal of electrons (oxidation) of the metal and the consumption of those electrons by some other reduction reaction, such as oxygen or water reduction. The electrochemical nature of the corrosion process provides opportunities to detect and mitigate corrosion of underground structures. The principal methods for mitigating corrosion on underground pipelines are coatings and cathodic protection (CP).

Pipeline Corrosion Training Programme covers various aspects of corrosion of pipelines and methods for prevention and control of their corrosion. The topics coved during the programme were Pipeline Integrity & Corrosion – An overview, Pipeline Corrosion & its Prevention / Control, Galvanic Anode & Impressed Current Cathodic Protection Systems, Pipeline Internal Corrosion and Prevention, Intelligent Pigging, Pipeline Risk Analysis / Assessment, Pipeline Installation, Security Management, Maintenance and Repairs, External Pipeline Corrosion Protection Monitoring & Health Assessment Surveys, Selection & Application of Corrosion Protection Coatings, Case Studies: Coating / Cathodic Protection / Electrical Interferences, Plant pipe Corrosion Case Studies.

This programme is pertinent to pipeline industry which is apparent from the response received from oil companies and industries that have extensive pipe installations

Faculty included eminent professionals from industry and academia and faculty as well as course content received appreciation from participants. Participants are from companies ABSIV (India) Pvt. Ltd, Pyramid Technical Services Pvt. Ltd, BPCL, HPCL, IOCL, MRPL, MGL, RGPL, Demech Chemical Products Pvt Ltd, RGTIL, RIL, STP Limited, Tata Power, Tata Pigments Ltd.who all appreciated the program.

Participants during Training Session

Open Forum Discussions during Valedictory function

Group Photo of Pipeline Corrosion Training Program

Corrosion Basics : Hydrogen Damage*

HYDROGEN IS A FACTOR IN MANY CRACKING SITUATIONS and can result from many causes. Corrosion product hydrogen, hydrogen from overzealous catholic protection, hydrogen from picking operations, or hydrogen from welding with damp electrodes can be sources of trouble.

As an interstitial element in the body centered cubic (bcc) ferrite lattice, hydrogen can contribute to a number of mechanical problems for steels. Any interstitial solute can cause an increase in the brittle to ductile transition temperature. This will make the steel inherently brittle up to a somewhat higher temperature than would the otherwise be the case.

Delayed fracture is the main manifestation of hydrogen damage. The typical test for this is to have a notched tensile specimen loaded to some fairly high percentage of its notched ultimate tensile strength (UTS). In the presence of a damaging amount of hydrogen, sudden failure would occur after the load had been applied for some time - usually a few hours. The process of fracture is time sensitive and seems to require time for hydrogen to diffuse to sites where it can contribute to crack growth.

Welding with damp electrodes is a typical means of ingress for hydrogen.

The reaction

$$Fe + H_2O - FeO + 2H$$

is responsible. Atomic hydrogen can dissolve in many solid metals, including α iron.

However, if the workpiece is not under load, some fraction of the contained hydrogen is able to diffuse harmlessly away and eventually escape. After ~ 48 h at ambient temperature, the tendency to hydrogen damage is reduced. Some fraction of the hydrogen is taken up irreversibly, however, and will never diffuse out. Shorter times at higher temperatures will be equally effective in removing that part of the hydrogen which is removable.

Hydrogen cracking was observed often in high-strength steel undercarriages for commercial airliners in the early 1950s. The hydrogen probably originated from cleaning and plating techniques used in the application of cadmium plating which was specified for corrosion resistance to the undercarriages. Fortunately, none of these failures occurred on landing, despite the fact that landing conditions correspond to maximum stressing. Typically, the classic type of delayed failure occurs after the aircraft has been standing for some time at the gate.

Hydrogen damage can be expected in any steel for which the UTS exceeds ~ 100,000 psi. Lower strength materials are affected more rarely. Zinc plated wood screws, particularly in the heavier gages, are prone to hydrogen damage. The hydrogen results from poor picking and plating techniques, such as trying to obtain bright plating on an excessively large barrel load. Any other operation likely to increase hydrogen over voltage will also increase the possibility for hydrogen damage. Mistreated screws, 3 to 4 in. (8 to 10 cm) in length, can fail in brittle fashion in the time required to secure them with a hand-operated screwdriver. Unfortunately, it is no longer possible to purchase unplated screws.

Detection of hydrogen damage is difficult. The delayed fracture test is tedious and time consuming. For applications in aircraft, etc; it is customary to call up detailed specifications for finishing and plating operations and to bake or boil the work produced. This seems to be an effective procedure.

The hydrogen content of steel produced in the mill in periods of high indoor humidity, as in summer heat waves, poses an interesting problem. With processes such as ladle degassing becoming more common, such concerns will become less important in the future.

* Adapted from Corrosion Basics – An introduction, National Association of Corrosion Engineers

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