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April 2014, Vol. 20 No.1

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Letters to the editor are always welcome. We invite your suggestions, comments and views on the Newsletter as well as articles for publications. To publish your article, submit it to rishikesh@naceindia.org

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Message

It truly has been a pleasure and honor to serve as President of NACE International for 2013-14.

It was a very hectic and exciting year as I and other members of the NACE leadership traveled the world to meet with thousands of members, other corrosion organizations and NACE staff as we worked together in our common goals to protect people, assets, and the environment from the detrimental effects of corrosion. At the beginning of my term last March I hoped to see additional membership growth in the year ahead, and in particular more involvement in global activities. NACE membership has grown by more than 10% since then—to nearly 34,000—with 46% of members based outside the United States.

As set forth in the NACE 2013-2017 Strategic Plan, the organization is committed to globalization of its activities and resources. NACE now has offices in Malaysia, Brazil, China, India, and Saudi Arabia, in addition to the Houston, Texas-based headquarters. Other international activities include expansion of our world-renowned education and training programs, conferences and seminars on leading corrosion topics, partnerships with other corrosion entities, section and student section development, and translations of technical resources such as standards, reports, books, course materials, and Web site pages.

A major highlight this year was the opening of NACE's first education and training center outside of the United States in Dubai, where the entire suite of NACE courses will be offered. The center is expected to serve more than 1,000 students each year by providing courses on general corrosion, coatings, cathodic protection, internal corrosion for pipelines, pipeline integrity management, and more.

To further strengthen NACE's global presence and provide current data on corrosion-related expenditures, the NACE Board of Directors authorized a new cost of corrosion study to determine the financial and societal impact of corrosion on industry sectors including infrastructure, manufacturing, utilities, transportation, and government. The two-year study, led by NACE with participation from industry partners worldwide, is now underway. We are very fortunate that our Past President Elaine Bowman has accepted to associate with this important endeavor as our Project Manager. The study will integrate research based on international, regional, and academic participation and will focus on economic data to provide statistics and models that asset owners can use to implement asset preservation, management, and/or replacement. This study is titled The IMPACT Study and will also include data from India. I am very pleased that our Section is keenly involved to support this important initiative.

I humbly thank all our section members for all their support and inspiration during my Presidency year and acknowledge that I could contribute only because of your commitment and passion for our association. Across NACE International, we are recognized as one of the most vibrant and active sections only due to the tireless efforts and dedication of our members.

I look forward to you continuing contribution and the coming year is going to be very exciting and challenging with all the activities planned by our Section.

Tushar Jhaveri
President, NACE International
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Message

Dear Members:

NACE International Gateway India Section's premiere event CORCON will be held in Mumbai from 12th to 15th November 2014. This year we plan to have a wider participation from across academia and industry, as well as participation from overseas.

I am pleased to inform you that the U.S. Department of Commercial Services has granted Trade Fair Certification to CORCON 2014. This program is a cooperative arrangement between private trade show organisers and the U.S. government to increase U.S. exports and expand U.S. participation in overseas trade shows. This certification signals official U.S. Government support to CORCON to potential exhibitors and visitors, to the Indian government and business community leaders, and to foreign buyers/attendees – thus encouraging their support and participation. The program also standardises, leverages, coordinates, and initiates US Department of Commerce support domestically and worldwide; unifies U.S. participation, and institutionalises NIGIS and US Commercial Services responsibilities.

This year we also have the support of the Federation of Indian Chambers of Commerce and Industry (FICCI). Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialisation, and its emergence as one of the most rapidly growing global economies. FICCI has contributed to this historical process by encouraging debate, articulating the private sector's views and influencing policy. A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry. FICCI draws its membership from the corporate sector, both private and public, including SMEs and MNCs; FICCI enjoys an indirect membership of over 2,50,000 companies from various regional chambers of commerce. As of January 2014, NACE International Gateway India Section is also a member of FICCI.

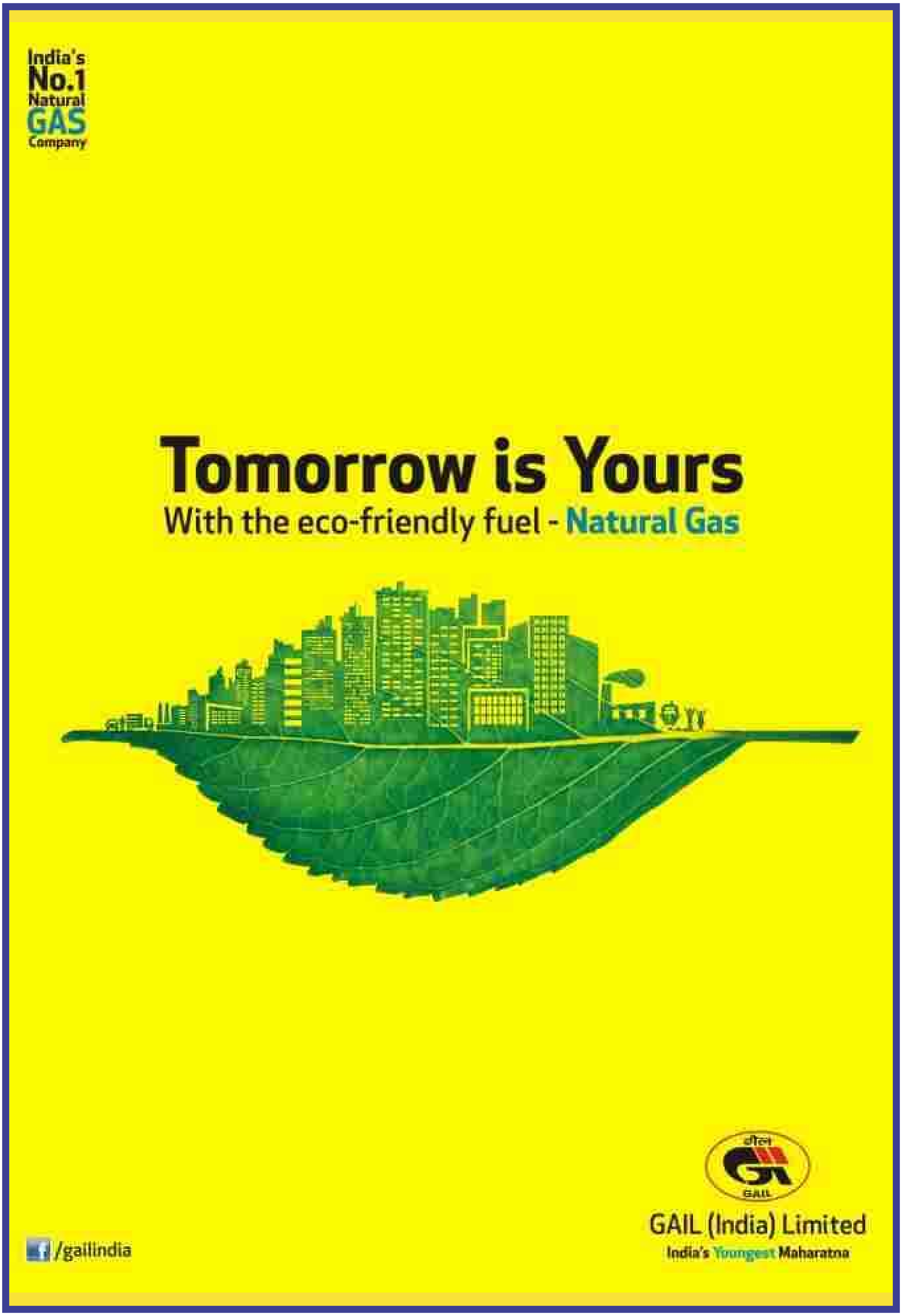
With the cost of corrosion world wide being over US$ one trillion today, we at NACE International believe that at least a third of this cost can be saved by using available practices and technologies in our routine working environments. Further costs can be reduced by incorporating corrosion prevention technologies and practices in the design stage of the asset. Towards achieving this end, it is imperative to promote interactions between people and organisations working in the field of corrosion. CORCON 2014 will provide an ideal platform for these interactions and also spread the awareness of the scourge of corrosion.

The CORCON organising committee is planning a mega event and we are confident that the delegates will find participating in CORCON 2014 much more rewarding.

Your involvement at this premier event is essential for the success of CORCON 2014. Please support us to accomplish our NACE International mission "Protecting people, assets and the environment from the effects of corrosion".

Be part of CORCON 2014 and let us save our people, assets and the environment from corrosion for the common good. We look forward to your participation at CORCON 2014.

Dr. Samir Degan
Chairman NIGIS & CORCON 2014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Editorial

Dear Friends,

There was an underground pipeline network in a Gas Processing Complex. It was cathodically protected. Since inception, a section of this pipeline network was under-protected. In spite of increase in current from existing TR units, installation of new TR units and laying horizontal anode bed, the requisite protection level could not be attained. A detailed survey revealed that a portion of the underground pipeline was bare, which was draining current. Till the problem was diagnosed, a good sum was spent on gratuitous measures.

A pipeline meant to transport refined products failed within a few months. The pipeline had railway traction in parallel and current picked up from one substation drained elsewhere and resulted in leaks at those drain points. This stray current was not considered in CP design. There is a view that this may be a reason for frequent failure water pipelines in Mumbai (needs detailed investigations before concluding).

Premature leakage in pipelines has also been reported when they were idle for a few weeks or months either after hydrotest or during service life. Such failures are due either to oxygen corrosion or MIC or under-deposit corrosion.

A 161 km section of 36” dia, uncoated pipelines was completely immersed in seawater for 3 months. 157,000 kg of debris was removed during pigging cleaning.

In a condensate refinery, anodes were installed for protection of bottom of storage tanks. There was a gap of 3 years between installation and commissioning of CP system. Leaks were reported in tank bottoms when commissioning of the plant commenced.

Coating damage and inadequate cathodic protection caused the corrosion that left holes in the hull of a brand-new $500 million Coast Guard cutter Stratton in the USA.

Bottom line of all these stories is – *A Stitch in Time Saves Nine.*

Anil Bhardwaj
Editor Corrosion Combat

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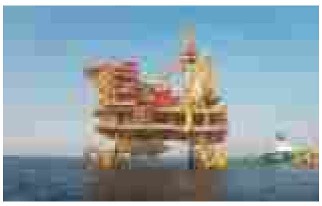

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The 5-M Methodology to Control Internal Corrosion of the Oil Transmission Pipelines

Sankara Papavinasam
CorrMagnet Consulting Inc. Ontario, Canada

Introduction

Oil transmission pipelines provide link between production facilities and refineries. Their safety and reliability are extensively being scrutinized by regulators, public, environmental groups, and media[1-5]. Some stakeholders - based on information from internet - are concerned that the internal corrosion risk of oil transmission pipelines is very high.

In order to provide confidence to the stakeholders the corrosion professionals must:

- ensure that the risk due to internal corrosion of oil transmission pipelines is low and
- demonstrate that the oil transmission pipelines are continued to be operated at that low risk level.

This short technical paper describes the 5-M methodology to achieve both of the above objectives. It should be noted that this paper only presents a birds-eye view. Technical book and courses are available to systematically implement this methodology[6].

5-M Methodology

The oil and gas industry is striving to reach "zero failure". The overall objective of the 5-M methodology is to help the industry to attain this goal. The 5-M methodology consists of five individual elements : modeling, mitigation, monitoring, maintenance and management.

This paper describes application of the 5-M methodology to control internal corrosion of the oil transmission pipelines.

Modeling

Primary function of modeling is to predict if a given material is susceptible to a particular type of corrosion in a given environment and to estimate the rate at which the material would corrode in that given environment. This prediction may be based on laboratory experiments and/or based on field experience. Modelling helps the corrosion professionals to establish corrosion allowance (i.e., material wall thickness) and to decide if additional corrosion control strategies are required.

In order to predict the susceptibility of oil transmission pipelines two parameters are essential:

- locations where water may accumulate (without water corrosion does not take place)
- pitting corrosion rate in those locations where water accumulates.

An oil-transmission pipeline is defined as the one packed with oil and with less volume of basic sediment and water (BS&W). Regulations and best practices in many parts of the world require that BS&W value is kept low. For example, the BS&W value in oil transmission pipeline is typically less than 0.5 % in Canada and less than 1.0 % in USA.

Obviously the number of locations for water accumulation is low if the BS&W is low. NACE SP0208, "Internal Corrosion Direct Assessment Methodology for Liquid Petroleum Pipelines" provides several models to predict locations of water accumulation in oil transmission pipelines.

Because of their non-polar nature, crude oils cannot dissolve ionic water. However, at low concentrations of water (such as found in the oil transmission pipelines), crude oil can form emulsion with water. There are two kinds of emulsion: water-in-oil and oil-in-water.

- In water-in-oil emulsion, the non-ionic (non-conducting) oil is the continuous phase in which the ionic water is dispersed. Therefore, corrosion does not occur in the presence of water-in-oil emulsion.

- In oil-in-water emulsion, the ionic (conducting) water is the continuous phase in which the non-ionic oil is dispersed. Therefore, corrosion occurs in the presence of oil-in-water emulsion.


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Based on extensive field experience it is established that a minimum flow rate of 1 to 3m/s is required to maintain the water-in-oil emulsion and to minimize formation of oil-in-water emulsion (or free water). However the type of emulsion and its stability depends on the type of crude oil, composition of water, operating pressure, pipeline profile, temperature, and flow rate.

The percentage ratio of water and oil at which water-in-oil emulsion inverts into oil-in-water is known as the "emulsion inversion point (EIP)". ASTM G205, "Standard Guide for Determining Corrosivity of Crude Oils" provides methodologies to determine the type of emulsion and EIP under pipeline operating conditions.

The susceptibility to corrosion in the presence of oil-in-water emulsion (or free water) depends on the wettability:

- when the oil phase preferentially wets the surface (oil-wet), corrosion does not take place
- when the water phase preferentially wets the surface (water-wet), corrosion takes place; and
- when no phase preferentially wets the surface (mixed-wet), corrosion may or may not take place.

ASTM G205 provides methodologies to determine the wettability under pipeline operating conditions.

In the presence of oil-in-water emulsion (or free water) on a water-wet surface, corrosion will take place. The crude oil phase surrounding the water phase may influence corrosion by partitioning water-soluble species:

- If the water soluble species are corrosive in nature, the corrosivity of the water phase would be more than that observed without oil phase.
- If water soluble species are inhibitive in nature, the corrosivity of the water phase would be less than that observed without oil phase.

The corrosion takes place is not uniform, but localized pitting corrosion. The localized pitting corrosion rate depends on several parameters including compositions of material (e.g., carbon steel), crude oil, water, gas, and solid; temperature; pressure, flow rate, and presence of microbes. A field-validated model is available to predict localized pitting corrosion rates based on readily available field operating parameters[7].

Mitigation

The objective of Step 2 – Mitigation - is to develop a mitigation strategy if Step 1 (model) predicts internal pitting corrosion rate is high, i.e., at this pitting corrosion rate the minimum thickness of material used as corrosion allowance is inadequate.

Cleaning the pipeline using pigs followed by addition of corrosion inhibitors is the most common and the most cost-effective method to mitigate internal pitting corrosion of oil transmission pipelines.

Recently several standards have been developed to evaluate corrosion inhibitors:

- ASTM G202, "Standard Test Method for Using Atmospheric Pressure Rotating Cage"
- ASTM G184, "Standard Practice for Evaluating and Qualifying Oil Field and Refinery Inhibitors Using Rotating Cage"
- ASTM G185, "Standard Practice for Evaluating and Qualifying Oil Field and Refinery Inhibitors Using Rotating Cylinder Electrode"
- ASTM G208, "Standard Practice for Evaluating and Qualifying Oil Field and Refinery Inhibitors Using Jet Impingement Apparatus"

Using these standards most appropriate corrosion inhibitors can be selected. An appropriate inhibitor for a particular application should not only have higher inhibitory efficiency but also have other suitable properties. These properties are known as secondary corrosion inhibitor properties. They include water/oil partitioning, solubility, emulsification tendency, foam tendency, thermal stability, toxicity, and compatibility with other additives and materials. ASTM G170, "Standard Guide for Evaluating and Qualifying Oil Field and Refinery Corrosion Inhibitors in the Laboratory" provides methodologies to evaluate these secondary inhibitor properties.

Experience indicates that an integrated program with both batch and continuous treatments ensures successful application and

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maintenance of an inhibitor film. Thus for best protection the inhibitor application is carried out in three steps:

1. Batch treatment at a higher concentration of inhibitor over a short time span to establish initial inhibitor film on the surface
2. Continuous application at medium concentration to ensure integrity of the inhibitor film on the surface
3. Continuous application at a lower concentration to maintain the inhibitor film on the surface.

Whatever may be the inhibitor application methodology, it is important that the inhibitor is available 100% of time. If the inhibitor is not available 100% of the time, the corrosion rate fluctuates between the uninhibited and inhibited corrosion rate.

For practical reasons, the inhibitor need not be available 100% of the time because of the persistency of corrosion inhibitor, i.e., the duration for which the inhibitor film is present on the surface without damage. If the events that make inhibitors not available can be corrected within the duration of the film persistency of corrosion inhibitors, they can be considered as non-events. For example, if the inhibitor persistency is 10 hours and if a failed inhibitor injection pump is repaired and back on service within 10 hours such an event is considered as insignificant.

Monitoring

The objective of Step 3 - Monitoring - is to ensure that the pipeline is performing in the way the model (Step 1) predicts and that the mitigation strategy (Step 2) is adequate.

Corrosion monitoring may occur in three stages:

- In the laboratory at the design stage to evaluate the suitability of a given material in the anticipated environment. (This activity is normally carried out in the "modeling" step).
- In the field during operation the oil transmission pipeline in monitored to determine the actual corrosion rate and to optimize pigging frequency, corrosion inhibitor dosage, and inhibitor application frequency.
- In the field during operation the oil transmission pipeline is inspected to ensure that the material is continued to be safe under the field operating environment, i.e., to ensure that the corrosion allowance thickness has not exceeded.

NACE Standard report 3T199, "Techniques for Monitoring Corrosion and Related Parameters in Field Applications"describes more than 40 different internal corrosion monitoring techniques. A recent survey provides feedback on various monitoring techniques currently being used in the oil transmission pipelines[8].

Maintenance

All strategies (selection of appropriate materials that can withstand corrosion in a given environment, development of appropriate model to predict the behaviour of the system, implementation of mitigation strategies to control corrosion, and monitoring of system to ensure that the corrosion of the system is under control) would fail if a good maintenance strategy was not developed and implemented. A comprehensive and effective program requires maintenance of five interdependent entities:

- Equipment
- Workforce
- Data
- Communication, and
- Associated activities.

Management

Corporate management implements top-down approach (risk-avoidance, goal-based, financial-oriented) to minimize the risk from corrosion. On the other hand, corrosion professional estimates risk in bottom-up approach (field-experience, fact-based, technical-oriented). Corrosion management provides vital and seamless link between top-down corporate management approach and bottom-up corrosion professional approach. In a way, the corrosion management is a combination of art and science to balance financial and technical requirements.

Corrosion management is thus a systematic, proactive, continuous, ongoing, technically sound, and financially viable process of ensuring that the people, infrastructure, and

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environment are safe from corrosion. The activities of corrosion management include:

- Evaluation and quantification of corrosion risks during design, construction, operation, shutdown, and abandonment stages, and identification of factors causing, influencing, and accelerating these corrosion risks.

- Establishment and implementation of organizational structure, resources, responsibilities, best practices, procedures, and processes to mitigate and monitor corrosion risks.

- Maintenance and dissemination of corporate strategy, regulatory requirements, finance, information affecting corrosion, and records of corrosion control activities.

- Review the success of implementation of corrosion control strategies and identify opportunities for further correction and improvement.

Implementation of 5-M Methodology to Control Internal Corrosion

All 5 elements must be implemented to effectively control internal corrosion of oil transmission pipelines. In order to facilitate the implementation of the 5-M methodology a 100-point scoring system has been developed.

Ideally the risk from internal corrosion becomes zero when the score reaches 100. Practically, depending on the status of the oil transmission pipelines one or two elements may be avoided, i.e., the risk from internal corrosion is kept low even when the score does not reach 100.

As illustrated in Table 1, for pipeline A implementation of three of the five elements is sufficient to reduce the risk from internal corrosion to a low level. On the other hand, for pipeline B implementation of three of the five elements may not be sufficient to reduce the risk from internal corrosion. By adequately implementing additional elements the risk of pipeline B can be reduced.

Table 1: Illustration for implementing 5-M methodology to control in internal corrosion

5-M element	Pipeline A		Pipeline B	
	Conditions	5-M element score	Conditions	5-M element score
Model	• Operates at less than 0.5% BS&W • Locations for water accumulation established and drippers are placed to drain any accumulated water • Water-in-oil emulsion • Oil-wet • Inhibitory oil	20/20	• Operates at less than 5% BS&W • Locations for water accumulation established • Oil-in-water emulsion • Wettability and inhibitory nature of oil not known	15/20
Mitigation	Not implemented	0/20	• Batch inhibitor treatment	20/20
Monitoring	Not implemented	0/20		0/20
Maintenance	• Drippers are regularly drained to remove water	20/20		0/20
Management	• Activities for internal corrosion control strategies implemented • The corrosion control strategies periodically reviewed and corrections, if necessary, are implemented	20/20	• Activities for internal corrosion control strategies implemented	15/20
Corrosion risk	• Low	60/100	• Likely high	50/100

Summary

1. Regulatory, public, environmentalists, and media attention on the operation of oil transmission pipelines is at a higher level.
2. It is not only important to keep the risk due to internal corrosion at a low level, but also important to demonstrate that the risk is kept at low level. The 5-M methodology has been developed to achieve both these objectives.
3. The five elements of the 5-M methodology are: modelling, mitigation, monitoring, maintenance, and management.
4. A scoring system has also been developed to effectively and economically implement the 5-M methodology and to choose appropriate cost-effective solutions to reduce internal corrosion risk.

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6. S. Papavinasam, "Corrosion Control in the Oil and Gas Industry", Gulf Professional Publishing (Imprint of Elsevier) [In print, publication anticipated in Fall 2013].
7. S. Papavinasam, A. Doiron, and T. Panneerselvam, "Integration of Localized Internal Pitting Corrosion and Flow Models", CORROSION 2012, Paper #23794, NACE International, Houston, TX (2012).
8. S. Papavinasam, A. Doiron, and R.W. Revie, "Industry Survey on Techniques to Monitor Internal Corrosion", Materials Performance, 51(2), 2012, p.34.

Author:

Sankara Papavinasm over the past two decades (President of CorrMagnet Consulting Inc.) who is a Fellow of NACE and ASTM International, has led industry R&D projects of total value exceeding $ 10MM, developed two software products to predict internal corrosion of oil and gas transmission pipelines, published more than 100 papers, obtained two patents, led the development of 6 ASTM standards, contributed to the development of 4 NACE standards, appeared in front of the Canadian Senate Committee to explain internal corrosion control practices in oil transmission pipelines, presented at the National Academy of Sciences, Washington DC on crude oil corrosivity and its inhibitory nature under pipeline operating condition, gave several media interviews, and organized various conferences, seminars, workshops, and sessions. He is currently leading NACE TG 447 to develop a start-of-the-art standard report on the selection of flow and internal corrosion models (one key component of this report is a table listing all key constituents affecting internal corrosion of oil and gas transmission pipelines) and writing a book entitled: "Corrosion Control in the Oil and Gas Industry", (Elsevier Publishing, 2013). Dr. Papavinasam also led a Pipeline Research Council International (PRCI) co-funded project: "Determine inhibitory and/or corrosive properties of condensate". The results from this project were used to develop ASTM G205 which is currently being used to evaluate corrosivity of crude oils under pipeline operating conditions. E-mail: spapavin@corrmagnet.com

Caltech Engineering Services offers new gelled permanent Copper Copper-Sulphate reference cell to measure electrical potentials for corrosion engineers. This electrode is recommended for measurement of electric potentials of test stations contact points for surveying purpose for buried pipelines, tanks & underground structures.

Features: Rugged ultraviolet and chemically resistant inert ceramic tubing. Continuous moisture retaining capability with preheated uniform, controlled ceramic porosity. Especially gel surrounding with copper wire reduces electrical resistance and no requirement of moistening. Excellent shelf life and highest sensing area allows measurements with stability.

Long Life: Designed for 25 years long life reference cell. Does not dry out in low humidity/ heat. Suitable for most of the environments. Identified with Sr. Number.

Applications: Direct burial underground reference cell in soil or costal area with or without chlorides are supplied with 30 feet (10 mts) 4mm sq. insulated copper wire is used to connect the test station and reference cell. Additional cable length can be supplied as per customer need.

Dimensions: 60mm OD x 400mm long (2.36” dia x 16” long)
48 Oz (1350 gms)

Stability: ± 5mv

Temperature: -15 to 90º C

Report on
CORCON 2013 – Corrosion Conference and Expo
30 September – 3 October 2013

Every year corrosion researchers, scientists, academics, and professionals attend the CORCON conference and expo in India to deliberate and learn the latest on corrosion control system design, technology application and asset maintenance to prevent corrosion failures and losses. More than 700 people attended CORCON 2013, the 21st annual conference and expo held on September 30 to October 3 at the Lalit Hotel in New Delhi. Organized by the NACE International Gateway India Section (NIGIS), the event featured plenary lectures from leading corrosion experts, symposia on 14 topics with over 26 sessions, a poster presentation of technical papers, and six Technical Interactive Forums (TIFs). Speakers from industry and academia presented a total of 156 keynote, invited, and contributory talks covering contemporary issues, developments, technology and innovative practices.

Praful Patel, honourable minister of Heavy Industries and Public Enterprises in the Government of India, gave the inaugural speech at the conference. In his address, he said, "Corrosion is something we all recognize, but some do not want to acknowledge or take action on it. Corrosion affects the environment and even human lives if not taken care of, especially in sectors like marine, refineries and automobiles. There are many corrosion mitigating materials available now that were not available in earlier times. Research and development activities play a vital role in developing new technologies and it should be a continuous endeavour on the part of the industry to adopt better corrosion control and mitigation measures in order to save huge direct and indirect corrosion-related expenditures."

NACE President Tushar Jhaveri, said, "There is a lot of new infrastructure being developed all around the world. It is essential that corrosion prevention measures are considered right at the planning stage itself. The cost of corrosion is as high as 3% of a country's GDP. In some countries like ours, it could be as high as 4 to 5% of the GDP. Unfortunately, corrosion prevention is not given the attention it requires, except in high-risk areas like oil and gas pipelines, nuclear power, thermal power etc." He continued, "I anticipate continued growth and progress in our industry as we encourage new developments in corrosion control, support important initiatives, expand our global presence and increase awareness about thecritical need for corrosion control systems in every country and industry. Participation in NACE activities has been increasing significantly through the years. The importance of our mission to protect people, assets, and the environment from the effects of corrosion is also very critical to our industry and country as a whole. We need to convince all stakeholders, including our government, that controlling corrosion not only saves money, but also saves lives."

B.Narayan, Group President of Reliance Industries, urged that corrosion must be fought on a war footing. He further said that war destroys, disease destroys, and corrosion destroys. Therefore, corrosion must be taken seriously, more so in India where awareness is lacking as compared to other advanced countries.

During his address, NACE Director and CORCON Chairman Samir Degan said, CORCON 2013 has received overwhelming response from a large number of eminent specialists across industry, R&D, and academia addressing such diverse topics as corrosion in refinery, petrochemical, chemical, and fertilizer industries; power plants and utilities; military and aerospace systems; marine and offshore systems; concrete corrosion; coatings and linings; cathodic and anodic protection; materialsand composites; internal corrosion of pipelines; residual life assessment in industries; and others. This conference will spread awareness about the menace of corrosion and the delegates will find the experience very rewarding."

The CORCON 2013 Expo had 65 booths including a USA pavilion with several new participants. Delegates Australia, China, Denmark, Japan, Switzerland, the United Kingdom, and the United States also attended the conference and expo.

Every year, the NIGIS Corrosion Awareness Awards are presented at CORCON to honour and respect individuals and institutions for their contributions to corrosion awareness and developments in the field of corrosion science and technology in India, and to commemorate the Corrosion Awareness Day that has been held since 1995. The section has so far honoured 90 scientists, teachers, engineers, and professionals; 33 students; and 20 public and private sector laboratories. In 2013, these awards were presented to the following individuals:

- Excellence in Corrosion Science and Technology award for an individual involved in research and education: Mumtaz Ahmad Quraishi, IIT (BHU), Varanasi
- Excellence in Corrosion Science and Technology award for a person working in the oil and gas sector: S.K. Srivastava, IEOT, ONGC, Navi Mumbai
- Distinction in Corrosion Science & Technology award for a person working in an industrial organization: Ashish Khera, Allied Engineers, New Delhi
- Distinction in Corrosion Science and Technology award for a person involved in research and education: M. Kiran Kumar, BARC, Mumbai
- Meritorious Contribution award for a person involved in research and development: R Venkatesan, National Institute of Ocean Technology, Chennai
- Meritorious Contribution award for a person working in an industrial organization: P M Fanse, Consultant, Vadodara
- NIGIS Award for Excellent Laboratory to Welspun Corp Ltd., Mumbai

The receipts of Student Award for the Ph.D. and M Tech degrees completed in 2012- 2013 were Geogy Jiju Abraham, IIT Bombay, Mumbai and Mohammad Umar Farooq Khan, IIT Bombay, Mumbai respectively.

The Lifetime Achievement Award for a distinguished senior citizen for his contributions to the activities for the growth and development of NACE International and NIGIS, corrosion science and technology, and corrosion awareness in India was presented to Dr. Baldev Raj, who served has the Director of the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam.

On the last day, 3rd October, best technical oral and poster papers, best stalls at the expo were honoured and winners of these awards were :

Technical Sessions	Paper and Author
Cathodic Protection	AC & DC Interference and Mitigation measures taken in East West Gas Pipeline of RGTIL Alok Gurtu & Venkateshwara Reddy, RGTIL, Navi Mumbai
Coatings & Linings	Use of Atlas cell test methodology to test selective linings for high temperature crude oil storage. Surojit B Mukherjee, Akzo Nobel, United Kingdom
Corrosion in Military & Aerospace Systems	Correlation studies between the surface hierarchy of super hydrophobic surfaces and mechanical properties of PU based composite materials for ship hull applications Comd B. Sabarish, DIAT, Pune
Corrosion in Refineries, Petrochemicals, Chemicals and Fertiliser Industries	Corrosion Threats to Refineries and Some Good Practices to Mitigate Them S K Bagchi, Oil Industry Safety Directorate, Noida
	Failure analysis of a Crude Column Overhead Exchanger Akhil Jaithlya, Mahendra Kumar Rastogi & Narendra Pandey, BORL, Bina
Internal Corrosion of Pipeline	Internal Corrosion in Cross Country Crude Oil Pipelines Sanal S, Mohamed Babu M A & Arun K Soman, BPCL-Kochi Refinery, Kochi
Marine and Offshore Corrosion	Thermal Spray Aluminum Coating for Splash Zone D. Nage, Larsen & Toubro, Mumbai

Technical Sessions	Paper and Author
Materials & Composites	Challenging Repairs completed to pipelines using composite sleeves James Knights, Clock Spring Company, Great Britain
Microbial Corrosion and Inhibitors	Biodegradable Acid Corrosion Inhibitor for Filter Cake Removal System Garima Misra, Halliburton, Pune
Power Plants and Utilities	The oxidation behavior of aluminum coated T-91 alloy steel in high temperature steam. K B Gaonkar, K Singh, Sunil Kumar B, Vivekan and Kain, B Paul and N Krishnamurthy, BARC, Mumbai
Reinforced Concrete	Assessment of Chloride Induced Corrosion of Steel in Concrete Using Half-Cell Potential and Resistivity Methods Bhaskar Sangoju, B H Bharatkumar, CSIR-SERC, Chennai and Ravindra Gettu, IIT Madras, Chennai
Research in Progress	An environment friendly coating for Galvanised Steel Akshya Kumar Guin, Manish Bhadu, Kedar Bhave & Mohua Sinhababu, Tata Steel Ltd, Jamshedpur
Residual Life Assessment	Fitness for Service Assessment of a Multilayered Hydrogen Storage Bullet with Defects Satya Pal Singh, Sova Bhattacharya, Kannan C, Brijesh Kumar, Rajagopal S & Malhotra R K, IOCL, Faridabad
Student Session	Pitting and exfoliation corrosion of retrogressed and re-aged AA7085 sheet Ajay Krishnan, & V S Raja,IIT Bombay, Riya Agrawal, VNIT, Nagpur and A K Mukhopadhyay, DMRL, Hyderabad

The following posters were awarded :

Winner	High temperature corrosion behaviour of Cr_3C_2-NiCr coating in molten salt environment under cyclic condition at 900˚C Deepa Mudgal, Surendra Singh & Satya Prakash, IIT Roorkee
1st Runner up	Electrochemical Impedance Study of High Nitrogen, Nickel and Manganese free Austenitic Stainless Steel in Artificial Physiological Solutions S.B. Arya, NITK Surathkal and V S Raja & A N Tiwari, IIT Bombay
2nd Runner up	Evaluation of Corrosion Resistance of Weathering and Carbon Steel Exposed in Industrial-Marine-Urban Environment P Dhaiveegan, N Rajendran, Anna University, N Elangovan, A M Jain College and T Nishimura, NIMS, Japan

The following exhibition stalls were adjudged as best in various categories:

12 Sqm – Winner	Winoa Abrasives India Private Ltd.
12 Sqm – Runner	Tinker & Rasor
9 Sqm – Winner	Hi-Temp Coatings Technology
9 Sqm – Runner	Denso GmbH

CORCON 2014 will be held in Hotel Hyatt, Santacruz (E), Mumbai, India, November 12 to 15, 2014.

Glimpses of CORCON 2013

Honourable Minister Shri Praful Patel lighting the lamp to inaugurate the conference.

John McCaslin from the U.S. Department of Commercial Services cuts the ceremonial ribbon to the USA pavilion in the exhibition hall

Dr. Samir Degan, Chairman CORCON & NIGIS, addressing the delegates during his inaugural address

R D Goyal, Director (Projects) Gail (India) Ltd. visiting the exhibition premises of the conference.

Dignitaries in the Dias releasing the CORCON 2013 Technical Proceeding

Delegates during the inauguration session

Glimpses of CORCON 2013

CORCON dignitaries,
NACE International directors, and
staff pose at the podium

Panel Members during
Technical Interactive Forum:
Regulations and Standards in Pipelines

Neil G. Thompson,
Det Norske Veritas (USA), Inc.,
USA delivering Keynote talk

NACE President Tushar Jhaveri (right) presents
the Lifetime Achievement Award for 2013
to Baldev Raj on behalf of NIGIS

Cultural programme during the conference

Certificates for best paper awards being
presented by Dr. Samir Degan
during valedictory function

UNITED STATES DEPARTMENT OF COMMERCE
International Trade Administration
Washington, D.C. 20230

Mr. Bob Chalker, Executive Director
NACE International
1440 South Creek Drive
Houston, Texas 77084

Dear Mr. Chalker,

The U.S. Department of Commerce is pleased to grant Trade Fair Certification to **NACE International, to** organize the official **United States Pavilion** at the **CORCON** 2014 to be held in Mumbai, India, November 12-15, 2014.

Through Certification, the Commercial Service of the Department of Commerce recognizes your professional capability to organize a United States Pavilion and endorses the event as an excellent opportunity to showcase U.S. products and services. Your Project Officer, **Kevin Haley**, will coordinate Commerce Department support for the event and will provide outreach and promotional efforts to help expand U.S. exhibitor participation.

Trade Fair Certification is based on NACE International operating a U.S. Pavilion at CORCON 2014 for exhibitors of U.S. products. The U.S. Pavilion should not be co-branded with any other country or market, unless approved in writing by the TFC Program Manager. An EXCEL spreadsheet of U.S. exhibitors is due 30 days prior to the event for pre-show distribution and end-user contact. All goods displayed in the U.S. pavilion or under Trade Fair Certification auspices by U.S. firms or their local representatives must be marketed under an American brand name and must have at least 51% U.S. content.

Your payment of a non-refundable certification fee of $2,000 will signify your agreement to comply with the procedures and requirements of the Trade Fair Certification Program as published in the Federal Register notice of April 30, 1993. The fee will be used to provide you with promotional support and on-site assistance specifically related to this certified event. **Certification becomes effective upon receipt of your payment.**

We accept payment by check or credit card. If paying by check, please make the check payable to the U.S. Department of Commerce. Please **FEDEX/UPS** your check, together with a signed copy of the **Participation Agreement to**:

Kevin Haley
U.S. Department of Commerce
Ronald Reagan Building, Suite M800
1300 Pennsylvania Avenue NW
Washington, D.C. 20004

Our decision to endorse **CORCON 2014** is based on **NACE International** previous success in providing opportunities for U.S. exhibitors to explore world markets.

Sincerely,

Kevin Haley for

Michael K. Thompson
Program Manager
Trade Fair Certification

A Report - Workshop on Corrosion

NACE International Gateway India Section (NIGIS) and US Commercial Services (USCS) jointly organized Corrosion Workshop with Kanara Chambers Of Commerce, (KCCI), Mangalore. Present were – Minister Commercial Services Mr John M McCaslin, US Embassy from Delhi; Mr Jim, Senior Consular USCS Chennai and Mr Amin Kanara, President Chambers of Commerce, Board Members of KCCI; Ms Mehnaz Senior Officer from US Trade Department (USTDA); Dr Samir Degan Chairman NIGIS & Area Director NACE International; Mr Upadhyay, Chairman MRPL; Senior Government officials and representatives from the industry and academia like Mangalore Chemicals & Fertilizers, Mangalore Port Trust; NIT, Suratkal.

The Cooperation with USCS is expected to will give a great outreach globally to NIGIS. NIGIS has similar sensitizing sessions on corrosion issues faced by industry planned across all 12 American Business Corners in India. More such Business Corners are coming up in Ludhiana and Vizag. After this alliance with USCS, increased participation of US Companies is expected at CORCON 2014 at Mumbai in November.

The USCS is having Corrosion as nationwide priority and running many parallel programs. The IVLP program (International Visitor Leadership Program) in the area of corrosion is to take a fully sponsored delegation to US to promote exchange of information and best practices. This will have local involvement of NIST, NACE & ANSI as well.

US Commercial Services is also looking at a major standards event in India towards April-May 2014 with focus on Corrosion Standards involving BIS, ANSI and industry.

Dignitaries in the dias during inauguration of the workshop.

Corrosion Awareness Session in Progress at ABC Mangalore, KCCI

Announcement

We are pleased to inform you that NACE International Gateway India Section is a member of The Federation of Indian Chambers of Commerce and Industry(FICCI) as of January 2014.

About FICCI:

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialization, and its emergence as one of the most rapidly growing global economies. FICCI has contributed to this historical process by encouraging debate, articulating the private sector's views and influencing policy. A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry. FICCI draws its membership from the corporate sector, both private and public, including SMEs and MNCs; FICCI enjoys an indirect membership of over 2,50,000 companies from various regional chambers of commerce.

FICCI *Industry's voice for Policy Change*

Federation of Indian Chambers of Commerce and Industry

NACE INTERNATIONAL CERTIFICATION COURSES

NACE International Gateway India Section regularly organises certification courses "Coating Inspector Program" Level I, II & Peer Review of NACE International. NACE CIP training programs are the best and most comprehensive training programs in the industrial coating business. The CIP certification is recognised worldwide and has been approved as a requirement for coating inspectors by the International Maritime Organization (IMO).

CIP continues to initiate today's coatings professionals into the world of corrosion control by protective coatings, inspection of those coatings, and coatings project awareness, resulting in billions of dollars saved by reducing costly mistakes.

The majority of coating failures are caused by faulty surface preparation, application technique, or selection of the wrong coating for the intended service environment. Inspectors ensure proper surface preparation and application by verifying that the material is properly applied via measurements and testes during application and on the finished (cured) coating. Proper installation of a protective coating system allows the system to achieve its designed service life along with the associated economic value and benefit.

Rework and replacement is expensive and can be avoided with effective quality control by a trained coating inspector. The inspector's role is vital for any coatings job so that problems can be identified before the project moves on to the next step. This reduces the potential for coatings failures that can result in costly repairs, downtime, environmental issues and health hazards.

NIGIS is organising first time PCS Level 1 and PCS Level 2 during 7 – 12 July 2014 in India. PCS 1 Basic Principles provides an introduction of coatings and linings used to control corrosion as well as the economic benefits of managing them. This course defines and examines common coatings used for corrosion control and addresses when, how and why they should be used while PCS 2 Advanced provides advanced-level technology topics related to protective coatings.

NIGIS organized following certification course during the period October – February 2014 in India.

Course No.	Course	Period	Venue	No. of Participants
1	CIP Level 1	7 – 12 October 2013	New Delhi	15
2	CIP Level 1	14 – 19 October 2013	Mumbai	27
3	CIP Level 2	21 – 26 October 2013	Mumbai	17
4	CIP Level 1	2 – 7 December 2013	Mumbai	26
5	CIP Level 2	9 – 14 December 2013	Mumbai	16
6	CIP Level 1	27 Jan to 1 Feb 2014	Mumbai	24
7	CIP Level 2	3 – 8 February 2014	Mumbai	19
8	CIP Level 1	10 – 15 February 2014	Vadodara	16

Photographs of CIP Courses

CIP Level 1 participants during 7 – 12 October 2013

CIP Level 1 participants during 27 Jan to 1 Feb 2014

CIP Level 1 participants during 14 – 19 October 2013

CIP Level 2 participants during 3 – 8 February 2014

CIP Level 2 participants during 21 – 26 October 2013

CIP Level 1 participants during 10 – 15 February 2014

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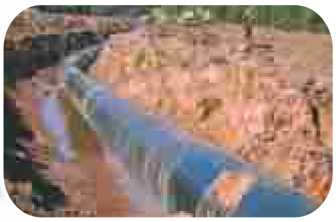

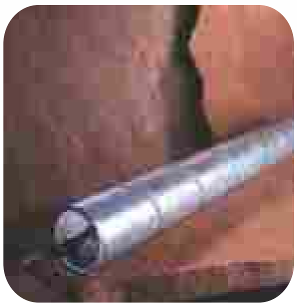


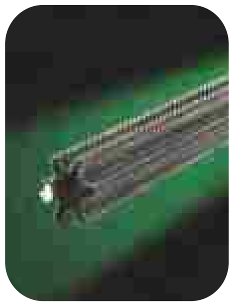

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Atmospheric Corrosion Studies on Painted & Bare Constructional Steels

Dr Jayanta Kr Saha
Institute for Steel Development & Growth, Kolkata

Introduction :

Mild steel (MS) has got versatile application as structural steel for construction. But this is very much prone to corrosion in industrial and marine environments in presence of harmful pollutants and other industrial effluents in addition to normal humid atmosphere. MS corrodes relatively faster and leads to colossal loss in every year and to reduce this loss some kind of protection in the form of paints and coatings is always used. Addition of small % of elements like Cu, Cr, P etc. in mild steel known as weathering steel (WS) considerably improves its corrosion resistance in industrial and rural atmosphere. While the organic coatings are invariably applied to MS structures, WS is used with or without coatings. Engineers and scientists all over the world are concerned for much in depth research works at surface engineering of atmospheric degradation of MS and WS as well as improved formulation of organic paints. Both painted and bare steel panels were deployed at different climatic zones of the country. Endeavours have been made for better understanding of the degradation process through various AC/DC electrochemical test methods and surface characterization through electron microscopy.

Experiments :

Two types of hot rolled structural steel sheets (5 mm thick) were taken for the experiments. These were plain carbon steel (MS) and weathering steel (WS). MS conforming to standard [1] is the most common structural steel and WS conforming to standard [2] exhibits increased atmospheric corrosion resistance compared to MS due to its chemical composition as shown in table 1.

Paint systems used for experiments was zinc phosphate primer (50% Zn as compound) with micaceous iron oxide (MIO) as intermediate coat followed by polyurethane (PU) as top coat denoted as ZP. Test panels are deployed for exposure based on manufacturers' catalogues and standards [3]. The details of paint system used is shown in table 2.

Aqueous solutions were used to simulate specific conditions to carry out electrochemical tests using Gamry Potentiostat on field exposed panels. The test electrolytes are to simulate the atmospheric conditions in the laboratory at 25±3ºC, neutral salt solution (3.5% NaCl, pH~6.7) and weakly alkaline solution (0.1M Na_2SO_4 + 0.1N NaCl, pH ~ 8.5) to get chloride and sulphate ions in the environment for carrying out tests. Electrolyte used in SAEJ 2334 test was used to determine corrosion performance for coating system as this solution shows a high degree of correlation with field service conditions [4].

Panels were deployed at three sites like Digha denoted as P1, Chennai denoted as P2 and Jamshedpur denoted as P3. The exposure sites selected are : normal marine environment P1 characterized by proximity to ocean with salt laden air and less polluted marine environment,

Table 1: Chemical Composition of Steels

Steels	C	Mn	Cu	Cr	Ni	Si	S	P
MS	0.17	0.76	0.01	0.03	0.01	0.01	0.01	0.01
WS	0.09	0.38	0.35	0.45	0.27	0.41	0.01	0.11

Table 2: Paint Systems with Coating Thickness

System	Coat Name	Description	Coats	DFT (µm)
ZP	Primer Coat	Epoxy Zinc Phosphate	1x75	250
	Intermediate Coat	High Build Epoxy MIO	1x125	
	Top Coat	Aliphatic Acrylic PU	1x50	

P2 characterized by more SO_4^{2-} with less salt laden air and a polluted industrial environment, P3 characterized by high SO_4^{2-} with little salinity selected as per standard [5]. The meteorological data of the sites are given in table 3.

Results:

Corrosion Rate: The exposed bare MS and WS panels were drawn from the sites for corrosion rate determination at different time interval. Corrosion products were removed by pickling solution and the respective corrosion rates calculated by adopting standards [6&7] and the values are given in table 4.

Fig.1 Painted Panels at Exposure Site

Table 3: Meteorological Data of Exposure Sites

Exposure Site Details	Digha (P1)	Chennai (P2)	Jamshedpur (P3)
Altitude (Ft)	SL	20	1590
Distance from Sea (km)	0.1	1.5	200
Av. Temp (°C) (min-max)	25 (21-28)	32 (30-35)	27 (8-47)
Av. RH (%) (min-max)	63 (49-89)	66 (30-100)	80 (33-98)
Av. Rainfall (mm)	1782	1084	905
Salinity (mg) NaCl/100 cm^2/day	0.83	0.42	Trace
SO_2 (mg)/100 cm^2/day	Trace	16.5	22

Table 4: Corrosion Rate (μm/y) of MS and WS Exposed at Sites

Exposure months	Digha (P1)		Chennai (P2)		Jamshedpur (P3)	
	MS	WS	MS	WS	MS	WS
18	24.1	20.2	19.5	13.4	13.6	10.3
30	24.2	19.1	18.3	13.2	12.4	9.4
42	26.4	18.2	17.4	12.1	12.3	9.5

DC Corrosion: Polarisation tests were carried on bare MS and WS drawn from P1, P2 and P3 after 42 month atmospheric exposure in 3.5% NaCl solution and the corrosion rate (I_{corr}) is given in table 4.

Table 4: Corrosion Rate in 3.5% NaCl Exposed for 42 month of MS and WS

Sites	Panels	I_{corr} (μA/cm²)	E_{corr} (mV)
P1	MS	63.80	-701.8
	WS	103.3	-643.9
P2	MS	45.32	-725.9
	WS	45.52	-656.2
P3	MS	30.77	-637.5
	WS	27.89	-524.9

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An international offshore oil field services provider

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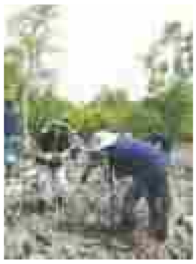


Bumi Armada is a Malaysia-based international offshore oil field services provider with presence in over 10 countries around the world and is listed on the Bursa Malaysia. With a fleet of over 40 OSVs, we are Malaysia's largest owner and operator of offshore support vessels and the fifth largest owner and operator of Floating Production Storage and offloading (FPSO) vessels in the world.

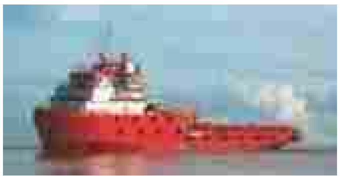
Of our three operating FPSOs, two are located offshore Nigeria – Armada Perkasa and Armada Perdana, and the other, Armada TGT 1, offshore Vietnam. Two FPSOs, one each for India and Australia, and currently under conversion at the yard. Our company has a derrick lay barge, Armada Installer in the Caspian Sea and a newly acquired SURF vessel, Armada Hawk.

With more than 600 shore-based employees and access to over 1, 400 crew from more than 20 nationalities, we currently serve clients in Asia, Africa and Latin America.

Bumi Armada is a socially responsible company that has a firm commitment to local content, wherever we operate, through the creation of jobs, provision of training and tapping into local resources.

We have made a conscious effort to conduct and manage our business operations in a responsible manner with safety, reliability, good corporate governance and transparency as our overriding principles.

This philosophy has helped us to deliver on our promises – on time, within budget and most importantly of all, safely. We attribute our success to the trust our clients have in our brand. This trust has kept us "Knots Ahead of the Rest."


EIS on Bare Panels: EIS was carried out in 0.1M Na_2SO_4 + 0.1N NaCl solution on uncoated MS and WS drawn from sites after 42 month atmospheric exposure. The results presented are an average of three tests for each panel. Data obtained from impedance Plots of MS & WS exposed for 42 month are given in table 5.

EIS on Coated Panels: EIS was carried out in 3.5% NaCl solution exposed for 936 h on coated ZP+MS and ZP+WS drawn from P1, P2 and P3 after 42 month of atmospheric exposure. Data obtained from impedance plots of coated ZP + MS & ZP + WS for P1, P2 and P3 are given in table 6.

Rust Characterization by Raman Spectroscopy: Rust phases of uncoated MS and WS panels were identified through Raman spectroscopy after 18 month and 42 month atmospheric exposure for all the places P1, P2 and P3. Raman shift values are given in table no 7, 8 & 9 respectively.

Table 5: EIS in 0.1M Na_2SO_4 + 0.1N NaCl on MS and WS Exposed for 42 month

Sites	Panels	R_u ohm cm²	R_p ohm cm²	R_{po} ohm cm²	C_c F/cm²	C_f F/cm²	Fit
P1	MS	2.39×10^{-3}	6.63×10^{6}	13.64×10^{3}	20.84×10^{-9}	2.86×10^{-6}	REAP
	WS	4.0×10^{-3}	2.66×10^{6}	19.21×10^{2}	1.06×10^{-6}	50.76×10^{-11}	REAP
P2	MS	1.11×10^{-3}	3.95×10^{5}	55.61×10^{3}	28.00×10^{-8}	8.30×10^{-6}	REAP
	WS	2.5×10^{-3}	2.48×10^{7}	1.52×10^{3}	1.43×10^{-6}	20.84×10^{-11}	REAP
P3	MS	6.52×10^{-3}	6.66×10^{2}	26.75×10^{4}	13.91×10^{-5}	42.12×10^{-12}	REAP
	WS	1.44×10^{-3}	9.56×10^{5}	4.92×10^{4}	77.73×10^{-12}	16.55×10^{-11}	REAP

Table 6: EIS parameters of ZP+MS and ZP+WS in 3.5% NaCl Solution after Exposed for 42 month

Sites	Panels	R_u ohm cm²	R_p ohm cm²	R_{po} ohm	C_c F/cm²	C_f F/cm²	Fit
P1	ZP+MS	20.09×10^{-2}	46.18×10^{4}	9.39×10^{2}	3.45×10^{-8}	10.64×10^{-4}	REAP
	ZP+WS	10.89×10^{-3}	25.76×10^{4}	9.03	19.17×10^{-8}	58.33×10^{-3}	REAP
P2	ZP+MS	77.35×10^{-3}	12.25×10^{4}	23.68×10^{4}	71.54×10^{-12}	4.71×10^{-9}	REAP
	ZP+WS	34.60×10^{-2}	80.54×10^{6}	24.22×10^{6}	22.20×10^{-12}	16.30×10^{-11}	REAP
P3	ZP+MS	96.73×10^{-3}	2.59×10^{3}	59.42×10^{3}	2.11×10^{-9}	2.58×10^{-6}	REAP
	ZP+WS	1.02×10^{-3}	16.34×10^{3}	31.85×10^{7}	2.42×10^{-11}	11.37×10^{-6}	REAP

C_f: Double layer capacitance

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A a

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Table 7 Phases by Raman Exposed after 18 month and 42 month at P1 of MS and WS

18 month					42 month			
Panel	Raman Shift cm^{-1}	Phase	Published Raman shift cm^{-1}	Ref				
MS	1307.28							
	251.12							
	221.48							
	375.33							
	695.92							
WS	265.37							
	392.92							
	241.60							
	1292.10							
	491.01							

Discussions:

Corrosion Rate: During the first 18 m of exposure the corrosion rate of uncoated MS and WS panels at P1 is higher with respect to P2 and P3. This is due to the variation of relative humidity is maximum at P1 and most importantly is due to the presence of high content of chloride ions at P1. For WS at P2 and P3 corrosion rate progressively decreases with time due to the availability of SO_2 compared to P1. At all sites corrosion of MS was found to be higher than WS. MS recorded highest corrosion rate at P1 followed by P2 and P3. Higher corrosion rate of MS is due to formation of non protective rust layer developed. Rusting on MS is proceeding at a comparatively higher rate.

Lower corrosion rate on WS at P2 and P3 appears primarily due to availability of SO_2 in the environment. Formation of continuous rust product causes a reduction in oxygen supply to diffuse through rust deposits and reduces the corrosion rate.

After 42 month exposure the corrosion rate is stabilized at P2 and P3 but it continued at P1 on WS. These phenomena may be primarily due the atmospheric pollution and meteorological conditions. The corrosion rate on WS is lower due to presence of SO_2 at P2 and P3 and the steady state corrosion rate on WS (<12 μm/y) is achieved at SO_2 (20-50 μg/100 cm²) which is in accordance with the findings of Knotkova [16] who reported that SO_2 played an important role for lowering corrosion rate on WS.

WS does not perform well at P1 due to presence of Chloride ions and recorded higher corrosion rate. The alloying elements perhaps makes it more vulnerable. Similar findings for WS has been reported by Madlangbayan et al. [17]. The corrosion rate of WS is found lower than MS for all the environments and shows stable corrosion rate at P2 and P3.

DC Measurement: Corrosion rate of exposed panels after 42 month exposure, data obtained from the polarization diagrams in 3.5% NaCl solution was found to be of the order of 10^{-6} A/cm² for MS and WS at all sites. Such low Icorr may be due to the formation of compact rusts layers which are not allowing electrolytes to go in except the holidays exposed on the surface. Ecorr values for both the materials were noblest at P3.

AC Impedance: EIS carried out in 0.1N NaCl + 0.1M Na_2SO_4 solution on bare WS panels exposed for 42 month at P2 recorded lower coating capacitance (Cc:28.00×10^{-8}) & double layer capacitance (Cf:$20.8.4 \times 10^{-11}$) and higher polariasation resistance (Rp:2.48×10^{7}) & pore resistance (Rpo:1.52×10^{3}). Identical trend is found at P3 with lower Cc (77.73×10^{-12}) & Cf (16.55×10^{-11}) and higher Rp (9.56×10^{5}) & Rpo (4.92×10^{4}) with respect to exposure at P1 with higher Cc (1.06×10^{-6}) & Cf (50.76×10^{-11}) and lower Rp (2.66×10^{6}) & Rpo(19.21×10^{2}). Similar trend was also noticed for MS. Rust coatings formed showed REAP model fit and typical electrical equivalent representative circuit. Warburg diffusion (Wd) is visible on WS for all the sites as per Nyquist plots and predominant at P3. Phase angles are varying on WS at P1 (-350), P2 (-210) and higher at P3 (-550). For MS phase angles are at P1 (-310), P2 (-180) and P3 (-180) which indicates none of the interfaces showing ideal capacitive behaviour. Both Nyquist and Bode plots fit well at low to medium frequencies. In Nyquist plot of WS, Z_{img} increases at lower frequencies with respect to MS and Wd is found in WS. Presence of Wd indicates diffusion barrier to the flow of corrosive ions. Kihira et al [18] and Nishimura et.al [19] earlier reported same findings under such condition where the impedance increased and capacitance decreased on WS. Formation of compact adherent corrosion products seems to be the reason for higher values on WS at P2 and P3.

EIS of coated panels exposed to 42 month was done in slightly stronger corrosive media (3.5% NaCl). At P1 as per table ZP+MS show higher Rp(46.18×10^{6}) & Rpo(9.39×10^{2}) as compared to ZP+WS which shows lower Rp(25.76×10^{4}) & Rpo(9.03) indicating higher degradation rate, though double layer capacitance (Cf:$>10^{-3}$) developed at P1 and Cc ($>10^{-8}$) reduced resulting in higher corrosion rate. Rpo drops at P1 due to the penetration of electrolyte through the coating to the substrate. ZP+WS at both P2, P3 is having higher Rp & Rpo($>10^{6}$). This is possibly due to the formation of protective passive layer on WS substrate. The appearance of second time constant at P2 and P3 indicates the damage of barrier properties of paint film by the formation of double layer capacitance. REAP model fit is found suitable. All these corroborate the corrosion rate data as obtained show the impedance plots of ZP+MS for P2 and P3 respectively. After 42 month exposure, Rp has

come down to 10^3 from 10^8 due to degradation of surface with prolonged exposure.

Raman Spectroscopy: After 18 m exposure at P1 as per table Raman spectroscopy detected major peaks

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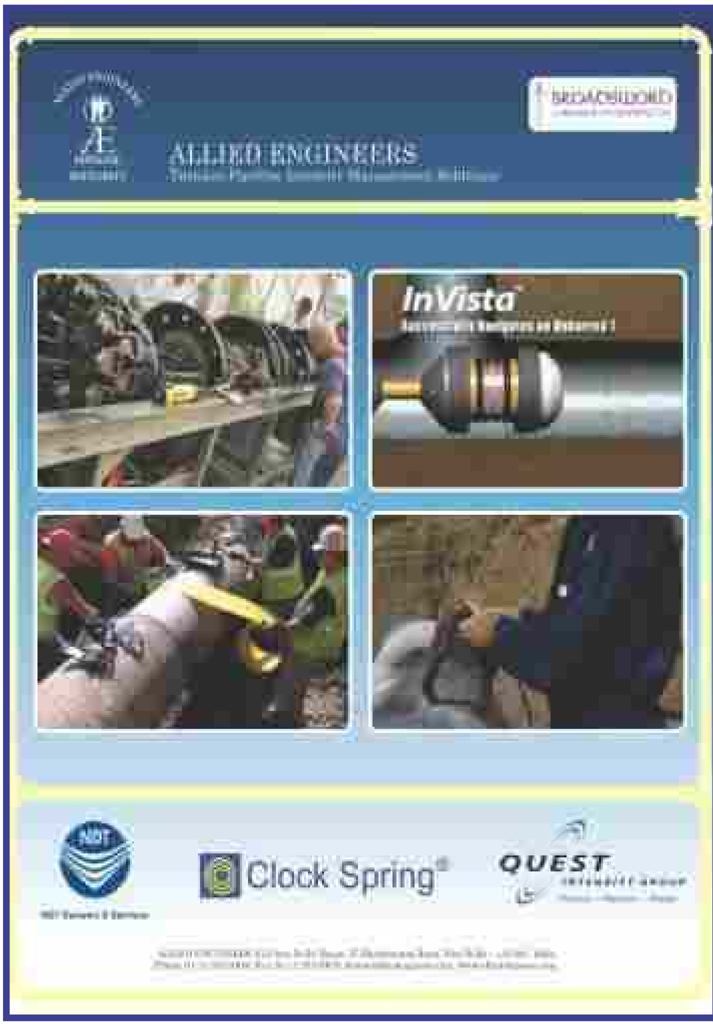

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capacitors. Corrosion occurring at the metal surface has a polarization resistance related to the corrosion rate, and an electric double layer that also behaves as a capacitor. Rusting does not occur until the polarisation resistance fall below 10^6 ohm.cm^2.

The studies revealed that WS exhibited more pitting than on MS and deterioration of coated panels was highest at P1. Chloride ions accelerated corrosion at P1 and corrosion rate on WS is almost equal with MS. WS showed compact protective oxide film at P3 and its corrosion rate was found lower than MS for all the environments. Stable corrosion rate was found at P2 and P3 on WS and presence of SO_2 helped to prevent deterioration of weathering steels at these two sites. Performance of scribed coated panels with MS substrate was inferior with respect to WS substrate. Rust morphologies on MS showed lot of voids and micro cracks at all sites but compact, acicular oxides were formed on WS at P2 and P3 sites.

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"Studies on Influence of alloy microstructure and superficial coating of reactive oxides on the high temperature corrosion behaviour of 2.25 Cr-1Mo and 9Cr-1Mo steels in SO_2+O_2 atmospheres"

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National Institute of Technology, Durgapur, India

Introduction:

The high temperature corrosion of Metals and alloys in multi component gaseous atmospheres has been the subject-of several studies because of its practical importance in many industrial applications. Combustion gases of fossil fuels usually contain Oxygen, Sulfur, Carbon, Nitrogen and alkali metals (Na, K). The corrosion chemistry of metals and alloys exposed to multicomponent environments is complex, and present understanding of such complex processes is very limited.

One of the most usual environments in which it is possible to find oxygenated sulfur compounds such as SO_2 and SO_3 is in conventional fossil-fuel-burning power plants. In this case, combustion of the flammable material (generally coal) is accomplished in an excess of air, to assure reaction with the oxygen to form SO_2 (O_2+½S_2= SO_2) and SO_3 (SO_2 +½S_2= SO_3) in an oxidizing atmosphere. Sulfidation in oxidizing atmospheres is frequently accelerated by the presence of other impurities like Sodium, Potassium and Chlorides. PerKofstad in his study of corrosion at high temperature, reviews the behaviour of pure metal and binary alloys in SO_2 and SO_2 + O_2 atmospheres. The metals and alloys exposed at high temperature generally develop corrosion products in the form of oxides and / or sulfides. The kinetics of the SO_2 +½ O_2= SO_3 is relatively slow without catalysts. Most of the tests were conducted in conjunction with Pt- catalysts to obtain an equilibrium SO_3 partial pressure. SO_3 is an important reactant in the corrosion reaction involving SO_2 gas. Corrosion rate was found to be dependent on the ratio of SO_2 : O_2. When the ratio is 2:1, which gives the highest partial pressure of SO_3. The corrosion reaction is also temperature dependent. Corrosion rate in SO_2 atmosphere normally increased with increasing temperature until a maximum is reached. Further increases in temperature results in a reduced corrosion rate .

In the majority of conventional high temperature alloy, Chromium is an important alloying element which is expected to form Cr_2O_3 Scales, thereby providing corrosion protection. However, the ability of these scales to prevent rapid attack by contaminants, particularly sulfur is limited.

Aim and objectives of the present work:

Metallurgical Structure of metals and alloys greatly influence the ultimate characteristics of the scale formed in high temperature. Alloy microstructure can play a role in oxidation behaviour finds references in the past literatures.

Thermo mechanical treatments that alloys experience during fabrication (e.g. forging, hot rolling) and welding and in high temperature service, or those given to improve their mechanical properties, can bring about alterations in their microstructures. These alterations may include precipitation of beneficial elements (e.g. Cr) as secondary phases or change in grain size that can influence the corrosion resistance of the alloys. Klueh and king have observed the importance of microstructure dependent environmental effect on the mechanical properties (e.g. creep fracture) of the "Chrome-Moly" Steels.

Realizing the importance of structure property correlation, the present investigation have been carried out to understand the influence of a few common variation in alloy microstructure on high temperature corrosion behaviour of two commercial varieties of ferritic steels, namely, 2.25Cr-1Mo Steel and 9 Cr-1Mo Steel in SO_2-O_2 environments (SO_2:O_2 ratio of 2:1) at 1 atm pressure.

Microstructural variations chosen for the present study are as follows:

(I) Those caused due to TIG-Welding of these steels. Weldments consist of microstructurally different regions, viz, Base metal, Heat affected zone (HAZ) and weld metal.

(ii) Variation in grain size of the alloy.

(iii) Those caused due to variation of cold deformation of the alloy.

Finally, an attempt was made to improve the corrosion resistance of ferritic steel at high temperature in SO_2+O_2 environment by superficial coating of reactive oxides (like CeO_2, $Y2O_3$).

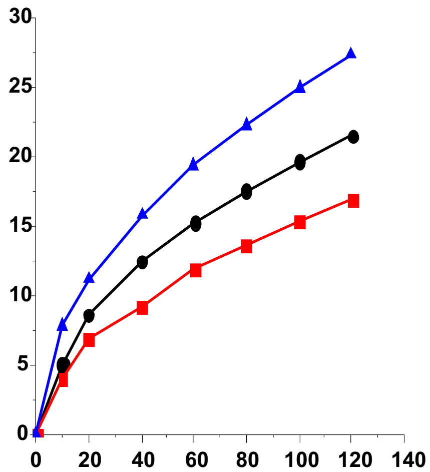
Experimental Set-up:

The experimental set up consists of horizontal tube furnace, where SO_2 and O_2 cylinders are connected for creating The environment. All the tests were carried out in isothermal conditions. The samples were exposed to a flowing mixed gas of SO_2 and O_2 for different duration in a horizontal quartz tube furnace. The SO_2 + O_2 gas mixtures were prepared with the use of calibrated flow meters before entering the horizontal tube furnace. The gases were dried over P_2O_5. The total flow rate of the gas mixtures entering the furnace was approximately 80 ml/min. The total pressure of the flowing gas was maintained at 1 atm in all the cases.

As it is well known that the equilibrium of the reaction $SO_2 + ½ O_2 = SO_3$ is slowly established, a Pt-catalyst was used to ensure rapid equilibration. The catalyst was made from pt-mesh in the form a small bucket in which the specimen was placed inside the furnace and the weight change of the specimens were measured by means of a digital electronic balance with an accuracy of ± 0.01mg.

Material used:

Two types of 'chrome- moly' ferritic steels (2.25 Cr-1Mo and 9Cr-1Mo steels) in the form of plates were used for the present study.



Results and Discussion:

The welding was performed by Auto TIG welding machine (Model: Auto-TIG 3000PC). The microstructural variations have been observed during TIG welding of 2.25Cr-1Mo and 9Cr-1Mo steels. The transverse section of the weldments were cut and polished and then etched with 2% nital for 20 seconds before they were examined by optical microscope. Microstructurally different regions, viz. base metal (BM), heat affected zone (HAZ) and weld metal (WM) were identified. Using a diamond-coated wafering blade, specimens from weld metal, HAZ and base metal were cut out from the weldments.

Studies on TEM micrographs shows the secondary carbides precipitates mainly $Cr_{23}C_6$ at the grain boundaries of the HAZ of 2.25Cr-1Mo steel. However, secondary phases present in the base metal and weld metal zone are MO_2C and Fe_3C. Here chromium carbide precipitates has not been observed.

The reaction kinetics of the three regions at 773K and 973 K for 2.25 Cr-1Mo steel are shown respectively in Fig.1 and Fig.2. The similar kinetic plots for 9Cr-1Mo steel at 973K is represented in Fig.3.

Morphological variation, if any between the scales developed over the base metal, HAZ and weld metal were examined by Scanning electron microscope (SEM).The surfaces and cross-sections of the exposed specimens were also examined by the energy dispersive analysis of X-rays (EDX).

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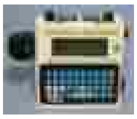
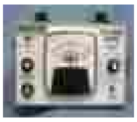
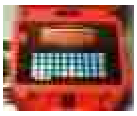
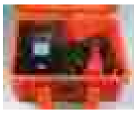
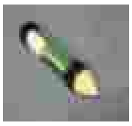
 CIPL / DCVG Survey Instrument	 Analog DCVG Instrument	 Stationary Data Logger
 GPS Current Interrupters	 Portable Reference Cell	 Portable Emergency Light
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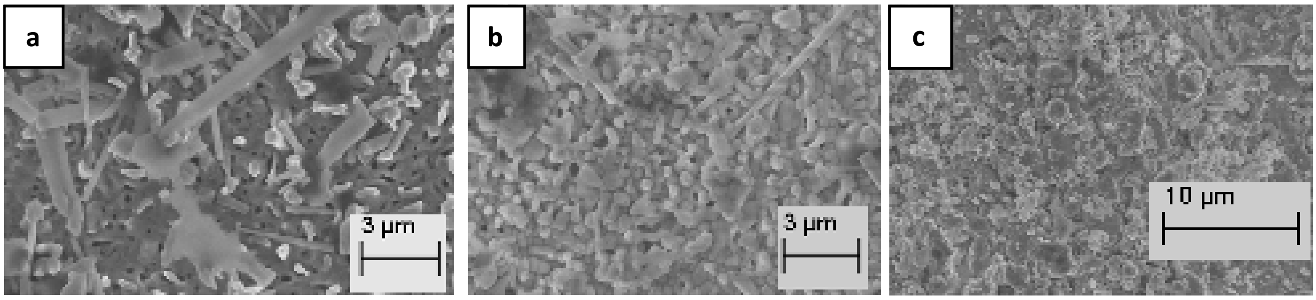


Fig 4: The top scale morphology of three region of the weldments of 9 Cr 1Mo steel (a) Weld metal (b) HAZ and (c) Base Metal

Here, HAZ develops thicker scale (182 μm) than those of the base metal (75μm) and weld metal (60μm). The higher corrosion rate of HAZ and formation of thicker scale over it could be attributed to (i) preferential grain boundary attack by inward diffusion of S^{-2} and O^{-2} ions and (ii) the absence of protective inner scale of the Cr-rich oxide due to non availability of the free Cr from the alloy as a result of carbide formation in this region (HAZ) which was identified by the TEM analysis. In the absence of the protective scale, the major oxide formed over HAZ is the Fe_3O_4 an oxide with higher Fe content.

HAZ shows a greater tendency for spallation of scale during cooling to room temperature. This could be due to the presence of MOO_3 in the inner scale of HAZ, whose Pilling- Bedworth ratio is very high (PBR=3.4), which is highly non protective scale. Formation of the protective inner scale Cr_2O_3 (PBR=2.07) over the weld metal and the base metal impedes the outward diffusion of Fe and hence, scale thickness decreases with time. The major phase identified is Fe_2O_3, an oxide with lower Fe content.

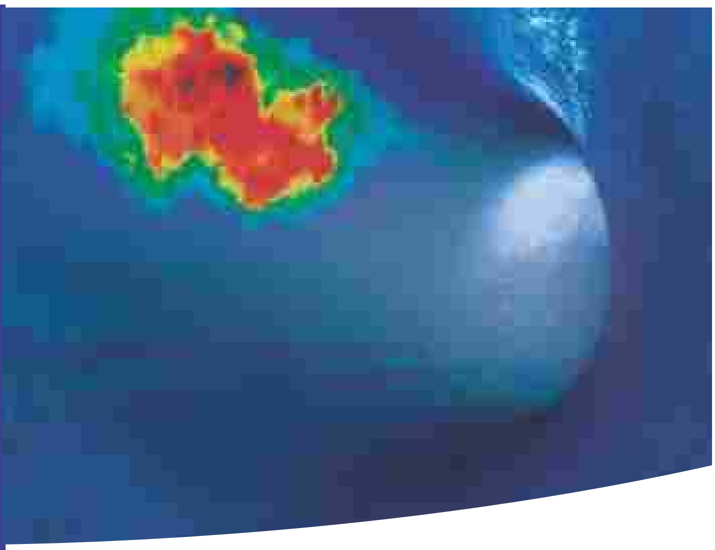
However, in 9Cr-1Mo steel the kinetic behavior has changed due to increase in chromium content of the steel. Here the weld metal corrodes at the higher rate and develops a thicker scale than other regions of the weldment. This could be attributed to the least protective inner scale with minimum Cr content, due to the thermal cycles (during welding) favourable for forming delta ferrite, Cr-rich secondary phases resulting in the trapping of the Cr in this region.

The improvement corrosion resistance of other regions of the weldment can be attributed to different thermal cycles (not so severe like weld metal zone) experienced by those regions (BM and HAZ) during welding and also possible to have free Cr-in these regions to form protective scale (Cr_2O_3).

In order to get varying grain sizes, 2.25 Cr-1Mo steel specimens were subjected to annealing treatments of different time-temperature combination in sealed tube. Corrosion study was conducted in SO_2+O_2 atmosphere at 823K and 923K for 8 hrs. The parabolic rate constant value increases more than three times in case of 18 μm grain size specimen compare to that of 72 μm grain size specimen.

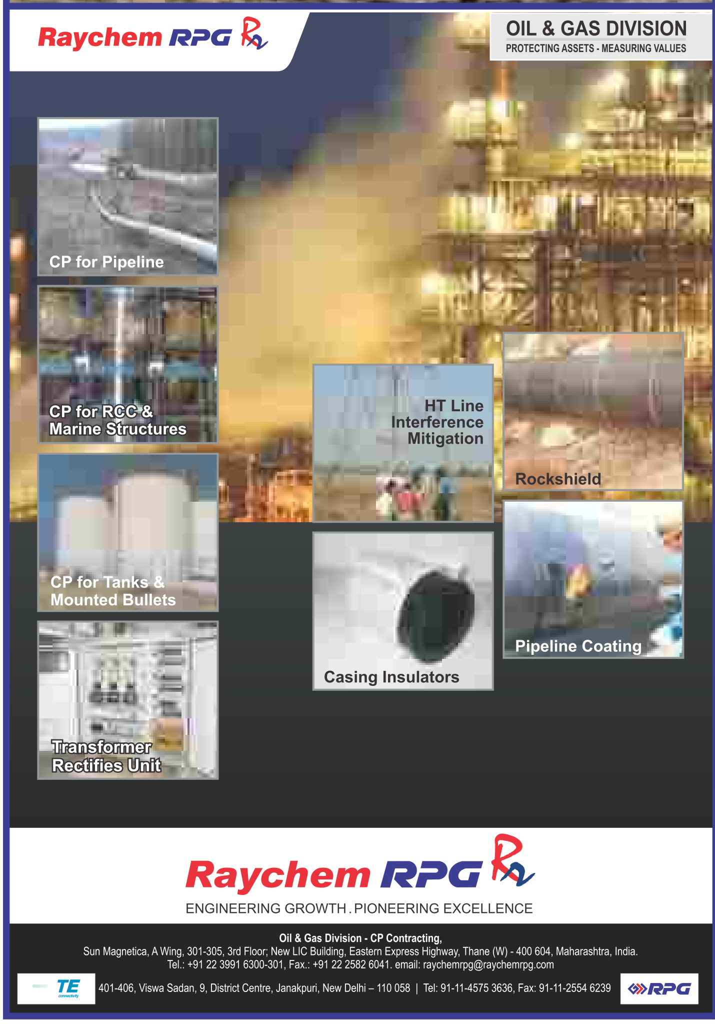
It is quite evident that finer the grains, the larger is the grain- boundary area and faster would be the corrosion of the alloy through a predominant attack along the grain boundaries. On the other hand, in case of an alloy with low Cr-content, like 2.25Cr-1Mo steel, irrespective of its grain size, grain boundary diffusion of Cr in 8 hours, would never be sufficient to effect lateral growth of Cr_2O_3 to form a continuous layer of the protective oxide, rather the grain boundaries act merely as the sites for enhanced progress of oxygen/ sulfur leading to internal oxidation/ sulfidation of the alloy. Hence it can be concluded that the corrosion increases with the grain size of the alloy, owing to decrease in grain boundaries of the alloys. The fine grained alloy resulting thicker scale is accompanied by cracking and spallation during cooling after exposure.

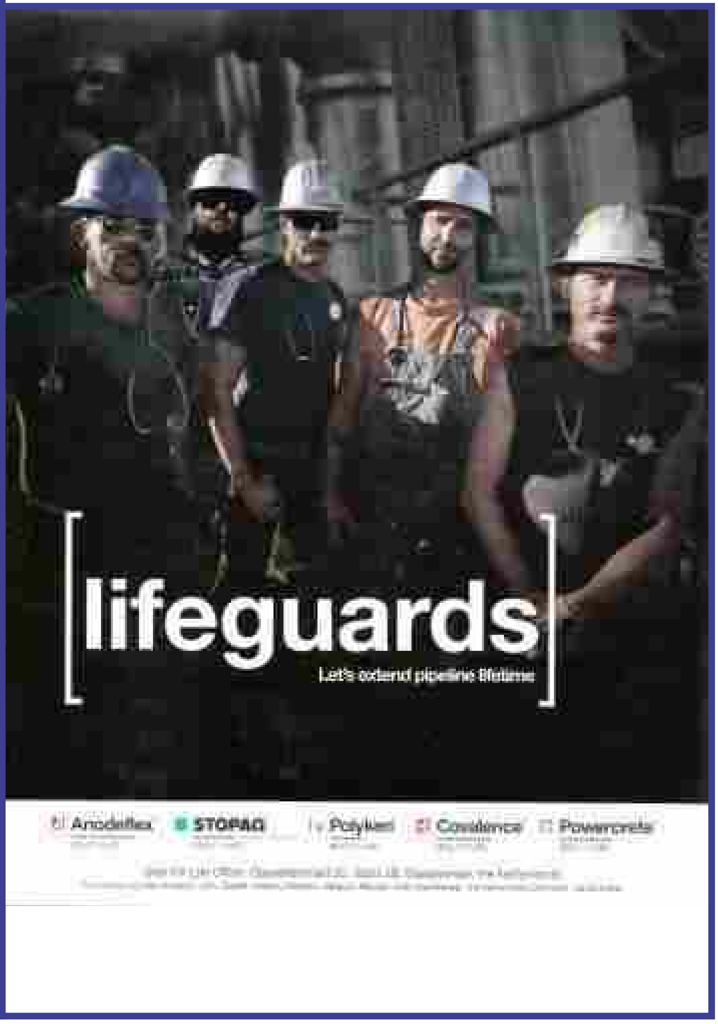
The experiment was also conducted to study the influence of cold work on the corrosion behavior of 2.25Cr-1Mo steel in So_2+O_2 atmosphere. The rectangular specimens are given different percentage of deformation by stepped cold rolling by laboratory scale two high cold rolling mill. The experimental results of the corrosion study of deformed alloy at 823K and 923 K for 24 hours have been presented in Fig.5. It was observed that the corrosion kinetics increases with increasing degree of cold working upto 50.45% deformation. Cold working higher than 50.45% shows decrease in corrosion rate.



Focusing on the future is a key component of successful asset management. Quest Integrity Group has invested heavily in advancing NDT technology to capture high quality, repeatable data with 100% coverage. Paired with our advanced engineering assessment capabilities, clients take full advantage of the comprehensive data gathered by our proprietary inspection tools.

The result - we provide actionable information





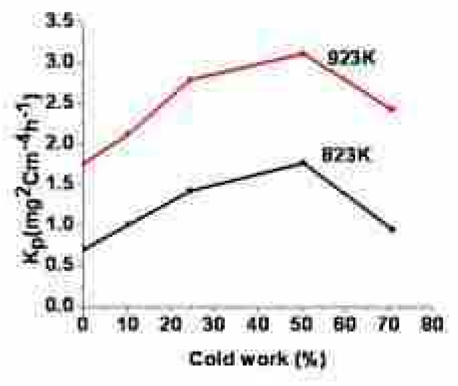
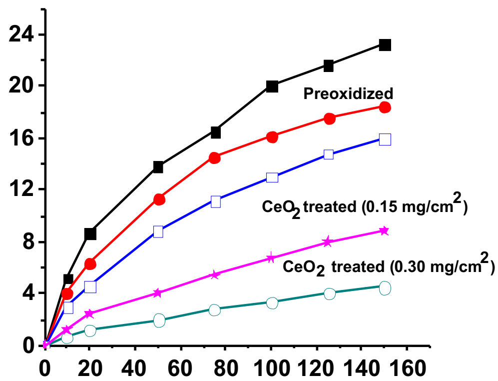


Fig 5: Parabolic rate constant at different percentage of cold work

Due to cold work the concentration of defects in the alloy is increased in the oxide/ sulfide layer (Corrosion product). This may results in an increased amount of defect too, creating easy diffusion paths in the oxide layer itself and as a consequence a faster corrosion rate is observed up to 50.45% cold deformation. Actually, the mechanism proposed that cold working provides sinks for cation vacancies (V''_M) flowing in ward to the oxide/alloy interface thereby minimizing interfacial detachment. Otherwise, the pores and voids at the oxide / alloy interface slows the corrosion rate by impeding the metal transfer from the substrate.

For samples of cold working higher than 50.45%, recrystallization took place, which causes a reduction in the dislocation density and the formation of very small stain free new grains. Here, also due to higher cold deformation some Cr-will diffuse out of the matrix, leading to Cr-concentration within the inner-Oxide/Sulfide layer. This also reduces the outward iron diffusion and the inward oxygen/sulfur diffusion, thereby prevent the corrosion process. Finally, to prevent the high temperature



corrosion of 2.25 Cr-1 Mo steel in SO_2+O_2 environments, the pre-corrosion treatment like pre-oxidation and superficial coatings of CeO2 and Y_2O_3 oxides were conducted. The experimental results are presented in Fig.6 and Fig.7 for CeO_2 and Y_2O_3 coatings respectively. It can be concluded that the CeO_2 and Y_2O_3 coated alloy improve the corrosion resistance at high temperature in SO_2+O_2 environments to a greater extent, compared to un-coated and pre-oxides specimen owing to improvement in scale adherence of the alloy. To extend the life time of the scale, reactive oxide coating is always beneficial for low alloy steel because of their good Pilling Bedoworth ratio (PBR/CeO_2=1.09 and PBR/Y_2O_3=1.13).

Authors:

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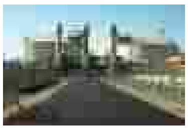
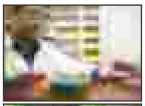
SHELL IN INDIA

Royal Dutch Shell is one of the most diversified international oil company in India's energy sector with nearly US$1 billion invested. It is a major private sector supplier of crude products and chemicals to India. With over 3000 staff in India, Shell has a significant Technology center, a financial business services center and operates an LNG receiving and re-gasification terminal. It also has a downstream business marketing fuels, lubricants and speciality products.

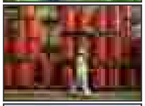




Our current business activities



R & D : Third Shell Global Centre for Innovation & Technology in Bangalore, the other two being in Houston and Amsterdam. Centre delivers high-end technical studies, projects and services for Shell worldwide, the region and India. Services span upstream, downstream, chemicals, gas and refinery operations & laboratories for downstream operations.

GAS: HaziraLNG PvtLtd (HLPL): Joint Venture between Shell (74%) and Total (26%) HaziraLNG receiving and re-gasification terminal Capacity 5 million tonnes of LNG per annum HaziraPorts PvtLtd. – (HPPL) Bulk container port operational since 2012



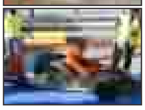
FINANCIAL BUSINESS SERVICES : Commenced Chennai-based financial operations since mid-2008 and now has a headcount of over 1800. Center provides a wide range of finance, accounting and other business and customer services to Shell operating companies globally

LUBRICANTS : A state-of-the-art lube-oil blending plant at Taloja, outside Mumbai, considered to be among the finest blending plants in Asia -manufacturing a range of branded lubricants such as Helix, Advance and Rimula, focused on the automotive and industrial sector

BITUMEN: High capacity plant 70,000 MTPA at Uluberia, West Bengal producing a range of Bitumen Specialty products such as Bitumen emulsions, Crumb Rubber Modified Bitumen (CRMB) and Polymer Modified Bitumen (PMB).

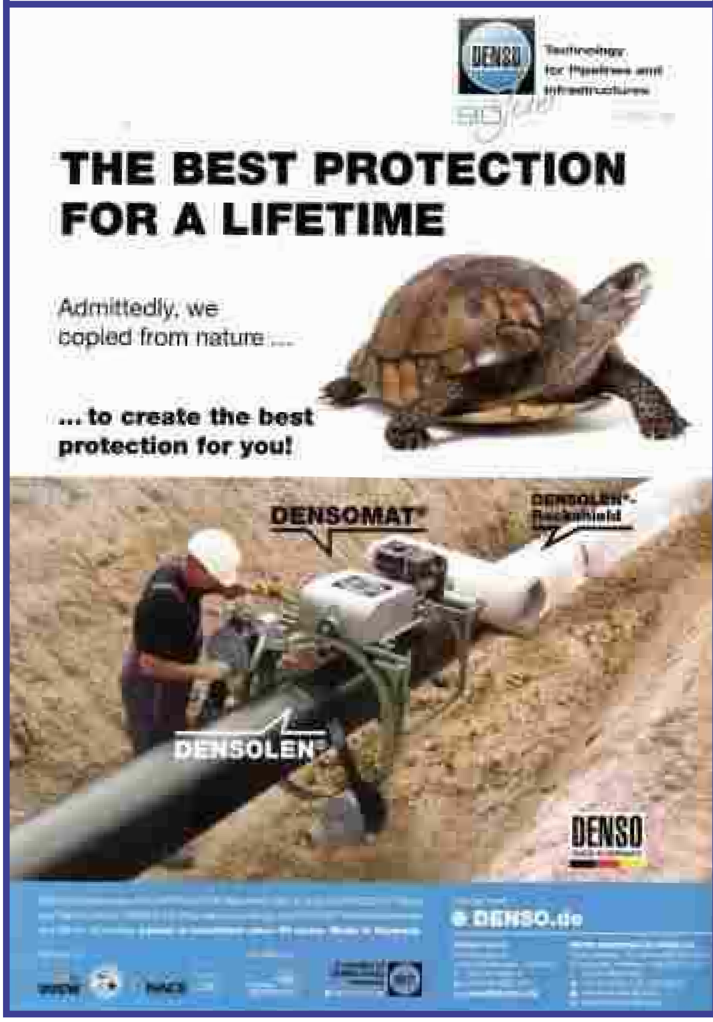
RETAIL: Only international company to be granted Government of India approval to retail fuel in India till date. License for 2000 fuel retail stations.

MARINE : Provides fuels, lubricants and related technical services to the shipping industry.



AVIATION : Joint Venture between Shell and MRPL serving a network of 12 airports.

LICENSING : Technical Services Agreement with major companies.



CORSYM'14

CORSYM'14 the International Corrosion Prevention Symposium for Research Scholars was held at Victor Menezes Convention Center, Indian Institute of Technology, Bombay (IIT Bombay) on 20th and 21st Feb 2014. This event was organized and sponsored essentially by NACE India section, NACE EAP rim area and co-sponsored by DST, DRDO, CSIR, BRNS and Outokumpo. The symposium was well supported by Department of Metallurgical Engineering & Materials Science, Indian Institute of Technology, Bombay.

CORSYM'14 had 2 essential distinguishing features which make it even more special than CORSYM'13. The first one was that it included a 2 day workshop which provided the participants hands on experience in various electrochemical DC and AC techniques for Corrosion analysis. The second one was the participation of students all across Asia in the symposium and special lectures by experts from five different countries.

The response to the workshop was truly overwhelming. Out of only from prospective participants and due to logistics constraints it was only possible to have about 50 participants for the workshop. The Participants included undergraduate and postgraduate students as well as faculty from the universities and colleges all across India and they were 42 in number. These participants were exposed to DC polarization and AC impedance techniques through lectures by Prof V.S. Raja (IIT Bombay) and Prof. Nick Birbilis (Monash University, Australia) and later given hands-on training by a group of enthusiastic research-volunteers of Aqueous Corrosion Laboratory of IITB Bombay.

The symposium was also met with tremendous response from students in India and abroad. Over 100 abstracts for oral and poster presentations were received and presented. The symposium included 4 plenary and 4 keynote lectures on different aspects of corrosion by eminent experts of Corrosion Science from India and abroad. The plenary and keynote speakers included Prof. T. Shoji from Tohoku University, Japan, Prof Wan Ta Tsai and Prof Huang from Taiwan, Prof Nick Birbilis from Monash University, Australia, Prof. K A Natrajan from IISc Bangalore, Dr Vivekananand Kain from BARC, Dr. Daniel Blackwood from National University of Singapore and Dr Kamachi Mudali from IGCAR Kalpakkam,.

Prof. Subhasis Choudhary- Deputy Director, Academic & Infrastructural affairs IIT Bombay, was the chief guest to inaugurate the conference. Dr. Samir Degan, Area Director NACE EAP, Mr. Tushar Jhaveri, President NACE International Prof. Raja, Chair CORSYM'14 and Mr. Ajay Krishnan - Convener CORSYM'14 addressed the student delegates.

CORSYM 14 concluded with a one day Mumbai Darshan trip on 22nd Feb for interested participants which was sponsored by CORSYM-2014.

Dignitaries on the dias releasing the symposium proceeding

Participants during the symposium.

International Corrosion Awareness Day April 24th, 2014. Function at Federation House, FICCI, New Delhi

The International Corrosion Awareness Day was celebrated at Federation House, FICCI, New Delhi on 24th April with over 110 participants from industry, academia and government.

Important guests present were the Joint Secretary Dr. A.J.V. Prasad, Ministry of Chemicals, Government of India; Mr John McCaslin, Minister Counselor, United States Department of Commerce; Former Chairmans of ONGC Mr. S. Vasudeva and Mr. S.K. Manglik; Former Chairman of GAIL India Limited, Mr. C.R.Prasad; Director (R&D) Indian Oil Corporation Limited, Dr R.K. Malhotra; Director General Petrotech, Mr. Ashok Anand; Director Petrotech and Former Director (R&D) IOCL, Mr. Anand Kumar; Mr A. Prasad, Director General FICCI; Mr. Vinay Mathur, Dy Secretary General, FICCI; Mr. P.S. Singh, Head, Chemicals and Petrochemicals, FICCI.

Leadership from NACE included Ms. Elaine Bowman, Past President NACE International; Mr. Tushar Jhaveri, Immediate Past President NACE International; Dr. Samir Degan, Chairman NIGIS; Mr. Anand Kulkarni; Mr. Manohar Rao; Ms. Helena Seelinger; Mr Narendra Kumar; Dr. Kamachi Mudali and Dr. Anil Bhardwaj.

Highlights of the day were –

- The Impact Study was announced by Past President Elaine Bowman and an overview was given to delegates present.
- NIGIS / FICCI MoU signed earlier announced. FICCI, established in 1927, is the largest industry association and industry policy influencer in India.
- The MoA between NIGIS and United States Department of Commerce was signed. It was exchanged by Mr John M McCaslin, Minister Counsellor and Dr Samir Degan, Chairman NIGIS.
- FICCI announced their support to IMPACT study in INDIA.
- The Ministry of Chemicals, Government of India will also extend support along with FICCI as shared by the Joint Secretary (Chemicals) Dr. A.J.V. Prasad.

Memorandum of Agreement between NIGIS and USCS exchanged

NACE members & staff along with FICCI staff at International Corrosion Awareness Day

Elaine Bowman presenting the IMPACT Study to the Audience

Corrosion Basics: Marine Environments*

Marine atmospheres are severely corrosive environments. The degree of severity, however, depends on several variables. Humidity in a marine atmosphere is generally high, but the temperature is variable, depending on climate (tropical, temperate, or arctic) and amount of sunlight. Chloride content is also variable, depending on the distance from the shoreline.

Three primary areas for corrosion of marine structures can be isolated. The first is the submerged area where corrosion is relatively uniform from the mean low-tide area downward. At greater depths, there is often a large quantity of soluble oxygen in the water, which means corrosion can readily occur. Tabel 1 shows factors that influence corrosion of steel in seawater.

The second area is the tidal or splash zone. This is an area of maximum corrosion because it is alternatively exposed to seawater and air with maximum oxygen content in the strong electrolyte. The third area is that above the splash zone. It is less corrosive than the splash zone but is a very strong atmospheric corrosion area, often characterized by large tubercles of rust and deep pits.

TABLE 1 – Corrosion Factors for Carbon Steel Immersed in Seawater

Factor in Seawater	Effect on Iron and Steel
Chloride ion	Highly corrosive to ferrous metals. Carbon Steel and common ferrous metals cannot be passivated. (Sea salt is 55% chloride)
Electrical conductivity	High conductivity makes it possible for anodes and cathodes to operate over long distance; thus, corrosion possibilities are increased and total attack may be much greater than that for the same structure in freshwater.
Oxygen	Steel corrosion, for the most part, is cathodically controlled. Oxygen, by depolarizing the cathode, facilitates the attack; thus, high oxygen content increases corrosiveness.
Velocity	Corrosion rate is increased, especially in turbulent flow. Moving seawater can destroy rust barrier and provide more oxygen. Impingement attack tends to promote rapid penetration. Cavitation damage exposes a fresh steel surface to further corrosion.
Temperature	Increasing ambient temperature tends to accelerate attack. Heated seawater may deposit protective scale or lose its oxygen; either or both action tend to reduce attack.
Biofouling	Hard –shell animal fouling tends to reduce attack by restricting access of oxygen. Bacteria participate in the corrosion reaction in some cases.
Stress	Cyclic stress sometimes accelerates failure of corroding steel member. Tensile stresses near yield also promote failure in special situations.
Pollution	Sulfides, which are normally present in polluted seawater, greatly accelerate attack on steel. However, the low oxygen content of polluted waters could favor reduced corrosion.
Silt and suspended sediment	Erosion of the steel surface by suspended matter in the flowing seawater greatly increases the tendency to corrode.
Film formation	A coating of rust, or rust and mineral scale (calcium and magnesium salts), interferes with the diffusion of oxygen to the cathode surface, thus slowing attack.

* Adapted from Corrosion Basics - An Introduction, National Association of Corrosion Engineers

NACE International Certification Cathodic Protection(CP) Program

NACE International Gateway India Section organised certification courses on Cathodic Protection Tester, Cathodic Protection Technician and Cathodic Protection Technologist.

The CP program includes four certification courses and moves from entry level (CP 1) to the most knowledgeable and experienced specialist level (CP 4). Each CP course is an independent component of the program and has a different skill and education level for entry, taking into account the student's work experience, and mathematics and science background. The NACE Cathodic Protection (CP) Training and Certification Program is a comprehensive program designed for individuals working in the field of cathodic protection from the beginner to the specialist.

The CP 1 - Cathodic Protection Tester course presents CP technology to students entering the cathodic protection industry and responsible for gathering and/or recording data for CP systems or measuring the effectiveness of CP systems.

The CP 2 - Cathodic Protection Technician course provides intermediate-level training in Corrosion Theory and CP concepts, Types of CP Systems, AC and DC stray current interference, Field measurement techniques and CP Record keeping. This course is for students with a working knowledge of cathodic protection or for those who have extensive cathodic protection field experience with a technical background.

The CP 3 - Cathodic Protection Technologist Course builds on the technology presented in the CP – 2 Cathodic Protection Technician course.

The CP 4 - Cathodic Protection Specialist Course focuses on the principles and procedures for CP design on a variety of structures for both galvanic and impressed current systems.

NIGIS organized following certification course during the month of Feb 2014 in Mumbai, India.

Course No.	Course	Period	No. of Participants
1.	Cathodic Protection Tester (CP-1)	10 - 15 Feb 2014	12
2.	Cathodic Protection Technician (CP-2)	17 – 22 Feb 2014	19

CP Level 1 participants from 10 - 15 Feb 2014

CP Level 2 participants from 17 - 22 Feb 2014