CORROSION COMBAT

NACE INTERNATIONAL GATEWAY INDIA SECTION

May 2012, Vol.18, No.1

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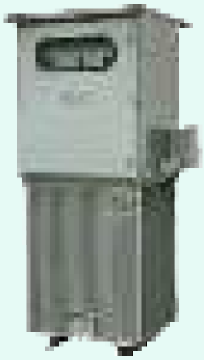

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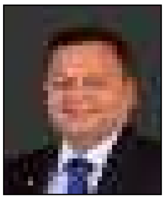
From the Desk of Vice President
NACE International



Greetings!!

I am indeed privileged and honoured to take over as Vice President of NACE International for 2012-13. Prior to this position, I had the great opportunity to represent our East Asian and Pacific Rim Area on the NACE International Board of Directors. Your encouragement and blessings during this period has been overwhelming for which I am forever grateful.

Over the past more than 15 years I have had the opportunity to work with several of you at India Section. Though I can't name all these wonderful people, I want to recognize Mr. Rajan Bahri, Mr. R P Nagar, Mr. K L Batra, Mr. Anand Kulkarni and Dr. Samir Degan who in reality share this special honour with me. We are a very cohesive team and I am forever indebted to them for always being there with me. This recognition is not just for me but for all of us at NACE International Gateway India Section.

An active participant in NACE India Section since 1994, I would like to commit myself to enhance the quality and range of the services provided by NACE International and activities in the field of corrosion awareness, protection and control of corrosion in India and globally.

Creating awareness for prevention of corrosion, increasing membership, organizing annual conferences / technology meets, developing new standards, educational and training programs are some of the steps that will help us to successfully comply with our mission of "Protecting People, Assets, and the Environment from the Effects of Corrosion".

This position is very important to me and I will put in my best efforts to further the cause of our glorious organization. Please feel free to advise me on what NACE International can do for you

Tushar Jhaveri
Vice President
NACE International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Editorial

Dear Friends,

A few months ago I got interior of my home painted. The job was done under “supply and apply” contract through the paint manufacturer. The applicators were thoroughly trained and meticulous in carrying the job. They were working with a study speed and were never in hurry to complete the work. The surface cleaning and application of different coats was done as per standard procedure. At the end of the day, it was a wonderful experience. It was a good mix of science and art. The paint manufacturer had made good use of chemistry to develop a good formulation. The applicators worked with the patience of an artist, being very careful with movement of their brush and roller. That was my experience of witnessing execution of a paint job for duration of 15 days.

How this story is related to corrosion? According to the Cost of Corrosion study organized by NACE in the USA during 1999 – 2001, application of paint constitutes about 88% of the cost of corrosion. That signifies importance of painting job. Only a well-executed paint job can be worth its money and provide durable protection against corrosion. The paint has to be applied very carefully, very patiently and very precisely. It needs not only a good paint chemistry, but skilled manpower as well. It may take some more time and costs a bit more. But with good workmanship, frequency of maintenance painting can be reduced significantly.

Many a times, when we visit a plant, paint failure on bolts, at edges of stiffeners and at the edges of an angle are common scenario. It gives an impression as if the whole of the plant has not been properly painted and needs re-painting. Also, these components support structure and their failures can jeopardize integrity of the structure. Stripe coat is answer to this problem. That is where precision and care is desired from applicator.

To sum up, a lot of expenditure on corrosion control is done by paint application. If done by trained and skilled hands, it will definitely benefit asset owner.

Cheers!

Dr Anil Bhardwaj
Editor Corrosion Combat

Z.R.C.
COLD GALVANIZING COMPOUND

Chrome free corrosion resistant organic-inorganic nano-hybrid Sol-gel coating

K. Rajesh Kumar
Scientist, NOVA Surface Care Center Pvt. Ltd
Research for Tomorrow's Technology - Value for Science

Abstract:

A chrome free corrosion resistant organic-inorganic nano-hybrid coating was developed on galvanized iron (GI) surface by sol-gel technique. The liquid sol was characterized by Fourier Transform Infra Red Spectroscopy (FTIR). Surface topography of the coated samples was analyzed by SEM. Thermal properties of silica sol powder were studied using Thermo Gravimetric Analysis (TGA) the corrosion resistance performance of sol-gel coated sample was evaluated by simulated corrosion tests. The sol-gel coated GI passed 1000 hours in salt spray and more than 2000 hours in water immersion tests. Apart from the excellent corrosion resistance, these coating shows excellent mechanical properties such as formability, flexibility and adhesion with the substrate.

Acknowledgments

The author thanks Dr. D. Sukul, Dept of Chemistry, NIT- Durgapur and Mr. Arun Kumar Singh, researcher TATA STEEL Ltd for their kind support.

Introduction:

Since the early 1900s, chromate conversion coatings have been used to improve corrosion resistance as well as paint adhesion of metal substrates. While traditional chromate-based conversion coatings are very efficient and offer many valuable coating properties, the chromates are toxic due to carcinogenic nature of hexavalent chromium. The environmental concerns dictate the elimination of current chromate-based surface treatment technologies and development of fundamentally new chromate-free coating systems that can provide long-term and environmentally benign corrosion protection. Therefore, the need exists for the development of low HAP, non-toxic and environmentally friendly coatings.

The organic-inorganic hybrid coatings produced through sol-gel method is considered as one of the advanced thin deposition techniques along with PVD, CVD, Sputtering and Plasma spray. Among them sol-gel method is found to be one of the best methods not only due to technical reasons but also because of ease of application and cost effectiveness against other deposition methods [1,2]. Sol-gel process has also emerged as a leading coating technology with variety of tailor-made functional properties. The organic-inorganic hybrid coating produced through sol-gel method has potential advantage of low curing temperature, dense, crack-free, flexible uniform barrier film; superior paint adhesion properties and coating thickness varying from 300 nm to 10 µm. The coating properties and applying conditions are favorable for its application on galvanized sheet (GI) to replace conventional post treatment processes such as chromating, phosphating and painting [3-7].

In the present work, an organic-inorganic nano-hybrid coating formulation was developed for Galvanized material. The coating formulation consisted of different inorganic and organic precursors. Sol-gel coated GI showed excellent corrosion resistance properties in various simulated corrosion test. This coating technology is environmental friendly and can very easily substitute carcinogenic chromes causing many health hazards. These coating also shows excellent, mechanical properties such as formability, flexibility, and adhesion with the substrate. Therefore, can easily consider used as a substitute to conventional passivation, organic coating system etc.

Materials

The commercially produced hot-dip galvanized steel sheet (GI) with 90 g/m^2 zinc coating and zero spangle surface appearance was used as the substrate. Silane precursors and ethanol was procured from sigma aldrich.

Sol synthesis:

Hybrid organic-inorganic nano-silica sol was prepared by addition of inorganic and organic precursors in a molar ratio of 3:1 in an acidic catalysis, using ethanol as the solvent. The sol was then continuously stirred till the phase separation disappeared and it became a transparent liquid sol.

Coating application:

The sol-gel film was applied on the GI samples by dip coating process at speed of 25 cm/min. The coated samples were kept at room temperature for 10 min followed by hot air oven drying at 80°C for an hour. The coated samples were preserved for four days before any testing to ensure extensive crosslink of the silane films with the substrate in ambient condition.

Methods and measurements

The FTIR analysis of sol was carried out by ThermoNicolet 6700 in the spectra range of 400 to 4000 cm^{-1} Attenuated Total Reflectance (ATR) method at 4 cm^{-1} resolution. Thermo gravimetric analysis (TGA) of silica sol powder was done at a heating rate of 10°C/min over the temperature range of ambient to 600°C in nitrogen atmosphere using DTG-60 Shimadzu, Japan. The surface morphology of the sol-gel coated substrates and sol were studied by Scanning Electron Microscopy (SEM) at an accelerated voltage of 15kV and 2.8A probe current with a working distance of 10mm using ZEISS Scanning electron microscope. The simulated corrosion studies such as Salt Spray Test (SST) and water immersion (WIT) were performed on both sol-gel coated GI as well as regular GI samples, to study the impact of corrosive atmosphere on coating degradation. Bend tests and impact test are a means of evaluating the flexibility of coated strip metal that is to be formed during a fabrication process was done as per standard. The Adhesion test was carried out by the cross cut Adhesion test method as per ASTM 3359. Detachment of the coating from substrate was observed by removal of a pressure sensitive tape placed on the scribed area and observing the degree of removed coating particles as per standard ASTM D 4145. Further scratches were observed with an optical microscope.

Result and Discussion:

FTIR spectrum of silica sol is given in Fig. 1. The peaks at 2974, 2927 and 1660 cm-1 are assigned to C-H stretching vibration of Si-O-$C_2H_{5,}$ while the peaks at 1167 and 1082 cm^{-1} are due to Si-O-C bond is due to hydrolysis and condensation of Si-O-C2H5 group in alkoxysilane and TEOS. The peak at 1048 is assigned to Si-O asymmetry stretching vibration of Si-O-Si and peaks at 910 and 880 cm-1 are due to H bonded Si-OH. The maximum peak at 790cm-1 is assigned to Si-O-Si symmetric vibration. The peak at 1270 and 540 cm-1 are due to epoxy breathing and PO_4^{3-} bending respectively, while the peak at 510 is due to the Si-O-Si bend. In addition, residue silanol Si-OH was still present in the film as broad bands appear at 3351cm^{-1}.

The sol was dispersed in alcohol and its particle size was measured by SEM. Fig. 2 is indicative of the particles obtained. It can be seen that the mean particle sizes varied

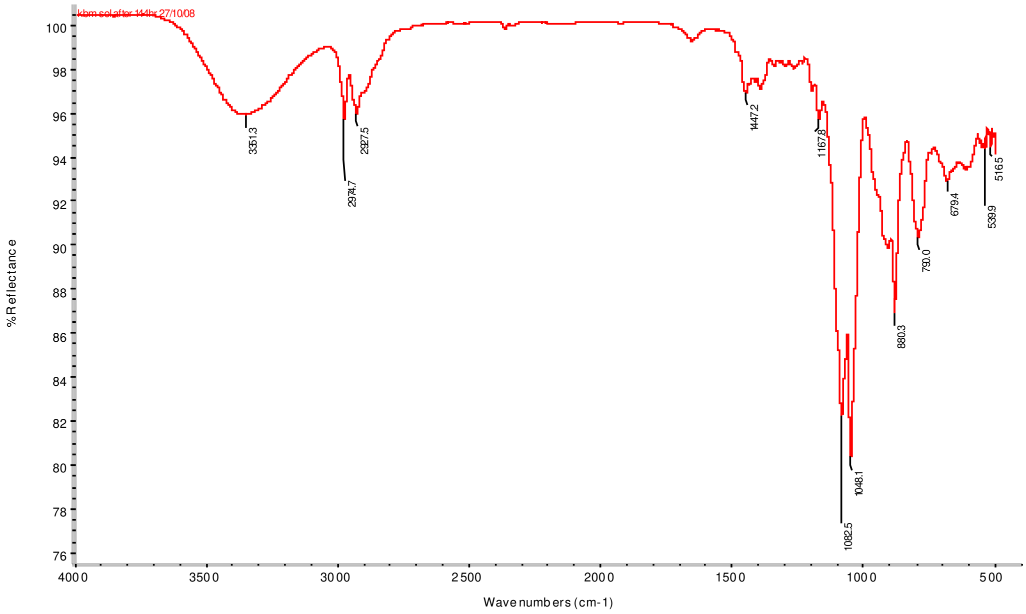


Fig. 1: FTIR spectra of Silica sol formulation.

between 20 to 35nm. The particles appear spherical and they exhibit interconnectivity with a string and branch-like morphology. The particles are prone to agglomeration, since even van der Waals' forces between particles of 1µm far exceed the weight of the individual particles and as such these powders are very cohesive.

The nano hybrid sol gel material was clearly found to experience a two-step weight loss procedure during the heat treatment in thermogravemtric test, as shown in Fig. 3. The First degradation stage with onset temperature at about 95°C was attributed due to water and solvent i.e. ethanol loss resulted from the further condensation reaction

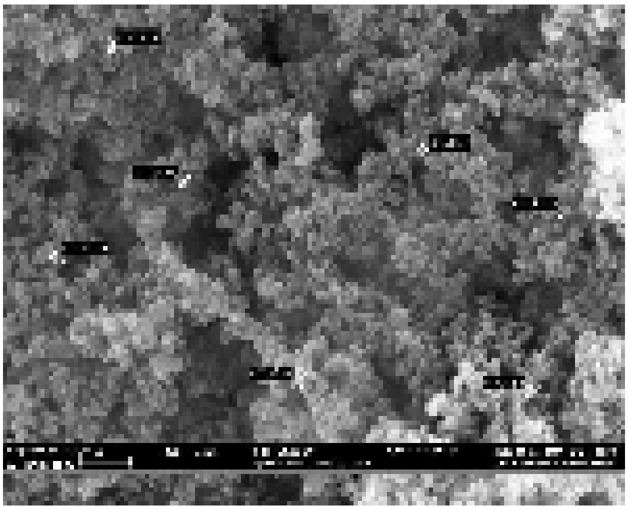


Fig. 2: Particle size measurement by SEM

between the Si-OH during the thermal treatment. It indicates that the condensation reactions between the Si-OH could be complete by heat-treating. The second degradation stage had a maximum decomposition rate between 350°C-650°C this is due to decomposition of the organic components in the hybrid material not bound to silicon- containing species [7,8].

Surface topography of the sol-gel coated samples were analyzed by SEM. Very smooth surface appeared on the sol-gel coated GI surface indicated that the coating is uniform, homogeneous, dense and crack-free in Figs. 5 (a). The EDX analysis indicated that sol-gel coated surface covered with Si and O as a main element as shown in Fig. 4(b) and 5(b). It is also observed that the sol-gel coating is well bounded and free from any form of defects such as blistering or crack.

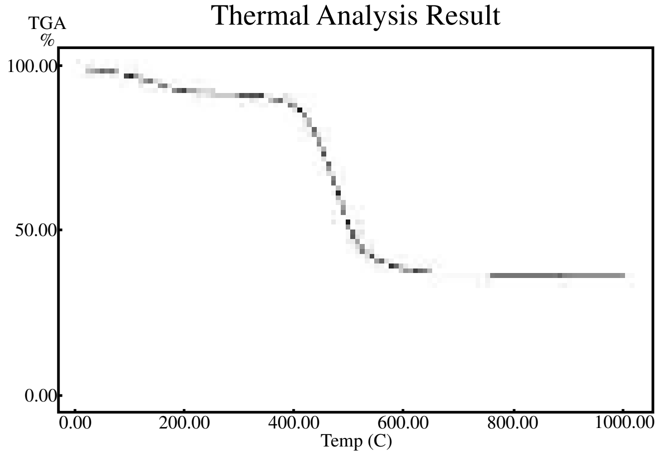
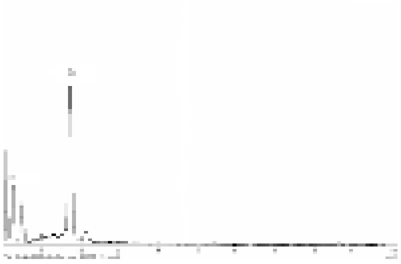


Fig. 3: TGA thermogram Curve of Hybrid Xerogel

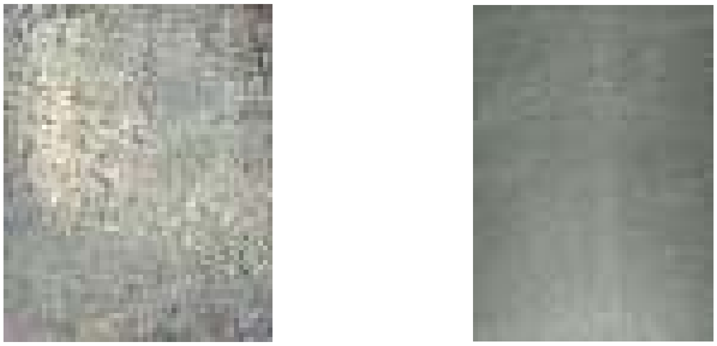
The photographs of the salt spray tested samples are given in Fig 6. It was observed that bare GI sample was covered with uniform white rust within a 72 hrs. However, the sol-gel coated sample did not show any corrosion sign even after 1000 hr indicates the better resistance of the coating to the chloride environment. The localized rupture of sol gel coated sample through pit formation presumably due to drop in hydrophobic character because of diffusion of corrosive species such as chlorine and oxygen to the GI

Fig. 5(a). SEM of Sol gel Coated sample



(b). EDS analysis of Sol gel Coated sample surface. This indicated that the sol-gel film gave the barrier protection to the metal surface. Its performance depends on the continuity, compactness and stability of the sol gel layer.

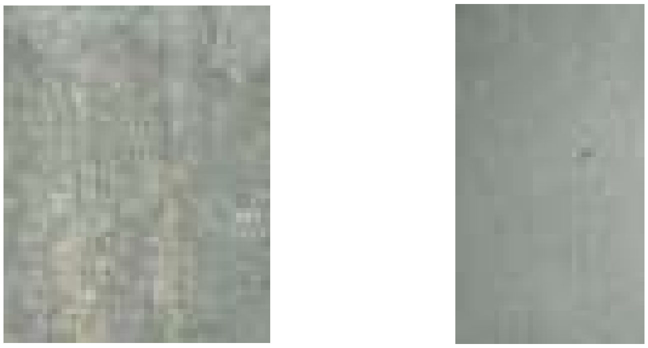
The GI and sol-gel coated sample resistance to water were evaluated as per ASTM D870 as shown in Fig. 7. A noticeable difference was observed between the GI and nano hybrid sample. The GI sample became fully white rusted only after 5 days where as no sign of white rust was on coated sheet even after 90 days of immersion. The bare surface was fully covered with the corrosion product and on the other hand there is no sign of corrosion on the coated sample. This is due to the dense and crack free character of the hybrid film.



Bare GI Sample After 72 hr   Sol-Gel Coated GI sample after 1000hr

Fig. 6: Photograph of the sample after Salt spray test

Flexibility of a coating also has a major contribution to coating adhesion. The T-bend was carried out by 0T bend test to measure the flexibility of the coating. There was no crack or delamination of the tested sample was observed. In impact test, coating was intact which indicate that the coating has strong adhesive bonding with the substrate. The sol-gel coated sample was tested for both direct and reverse impact test and no sign of damage to the film on either case. The impact resistance tested sample is shown in Fig. 8(a)



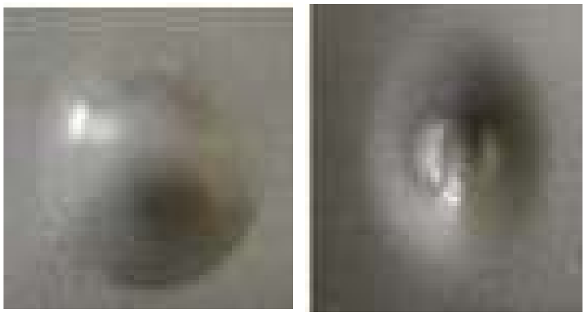
GI after 5 days   Sol gel coated GI after 90 days

Fig. 7: photograph of sol-gel coated GI samples before and after testing

where no cracking or debonding of the coating observed. It reveals that either in the tension or in compression the coating does not loose its adhesion. Thus, these coatings are very flexible and so can withstand the stresses during fabrication and forming. The cross-hatch test was done to characterize the adhesion between sol-gel coating and GI substrate. The nano hybrid coated sample showed no loss of film and therefore classified as 5B coating. No delamination or detachment of coatings at the edges and within the square lattice was observed when seen under optical microscope at magnification of 200 × (Fig. 8 (b)). The high flexibility of the coating is attributed to the inherent chemical structure of the hybrid material that led to good adhesion to the substrate.

Conclusion:

The present invention describes a sol-gel coating which after application on zinc and zinc alloy coated substrate enhanced the corrosion resistance properties of the substrate. The coatings can be applied on galvanized steel as well as mild steel with a coating thickness of only 8-10µm. With only 8-10µm of coating thickness, panel passed more than 1000 hrs in salt spray test and 2000 hrs in water immersion test, This coating technology is environmental friendly and can very easily substitute carcinogenic chromes causing many health hazards. Apart from the excellent corrosion resistance, these coating shows excellent, mechanical properties such as formability, flexibility, and adhesion with the substrate. These performances are difficult to achieve even using 75-100 µm coating thickness of conventional coatings thereby making sol-gel technology economically viable.



Reverse Direct

Fig. 8(a): Direct and Reverse Imapct test

Fig. 8 (b): Optical image of Cross cut

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A Report - NACE International Gateway India Section Honours Mr. Sudhir Vasudeva and Mr. Tushar Jhaveri

A get-together was organized by NACE International Gateway India Section on March 31, 2012 at Hotel Hyatt Regency, Sahar, Mumbai, to felicitate two great personalities who have been great supporters of NACE and an integral part of the growth of NACE in India.

The function started with a welcome address by Mr. K.L. Batra, Chariman – NACE International Gateway India Section.

Honour was bestowed on Mr. Sudhir Vasudeva, CMD, ONGC, for his ardent support to NACE International Gateway India Section in fighting against corrosion for the benefit of industry and country. Mr. Anand Kulkarni, Treasurer, NACE International Gateway India Section read a citation on a scroll which highlighted Mr. Vasudeva's ingenuity, determination and hard work. Mr Rajan Bahri, Trustee, NACE International Gateway India Section, presented the scroll to Mr. Vasudeva and also read poetry in his honour, which was enjoyed by Mr. Vasudeva and the gathering. In his speech, Mr. Vasudeva mentioned that he was well aware of the cost of corrosion to the country and the havoc it could play in his high risk oil and gas production industry. He was highly appreciative of NACE International Gateway India Section for its efforts and role in spreading the knowledge about corrosion and its control. He promised his support for all the programmes of NACE International Gateway India Section aimed at combating corrosion.

Mr. Tushar Jhaveri was felicitated for bringing great honours to NACE International Gateway India Section and to India. He has been elected Vice President of NACE International, Houston, USA. This is the first time an Indian has attained such laurels. He will be elevated to the post of President after serving the tenure of Vice President for one year. Mr. Bahri read poetry in his honour as well. In his brief speech, Mr Jhaveri expressed his commitment to the cause of fighting against corrosion and wished to bring more glory to this section.

CORCON 2012, which will be held at Hotel Grand Hyatt, Goa during September 26-29, 2012, was also launched. Speaking on the occasion, Mr. U.P.S. Madan, CMD, Maharashta Airport Development Corporation and one of the sponsors of CORCON 2012, said that he enjoyed being part of NACE International Gateway India Section and CORCON and shall extend his full support to the forth coming conference.

The brochure of CORCON 2012 was released by Mr. Vasudeva and Mr. U.P.S. Madan.

The vote of thanks was proposed by Dr. Samir Degan, Director, East Asia & Pacific Rim Area, NACE International.

Mr. Sudhir Vasudeva addressing the gathering

Dignitaries on the dias releasing CORCON brochure

NACE International Coating Inspector Programs

The **NACE Coating Inspector Program** (CIP) has set a single, global standard for inspections in the protective coatings industry since 1983 and is the world's most recognized and specified coating inspector certification program. Carrying the momentum of over 19,000 certified inspectors representing 119 counties, 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 program consists of three certification levels, ranging from entry level (CIP Level 1) to advanced coating inspection knowledge (CIP Level 3 Peer Review). It is designed to give the students a path for continued career-long professional development.

CIP Level 1 course provides students with knowledge of coating materials and techniques for surface preparation and application that prepares the student to perform basic coating inspections using nondestructive techniques and inspection instruments. CIP Level 2 course explains in-depth coverage of surface preparation, coating types, inspection criteria, lab testing, and failure modes for various coating including specialized coating and linings. CIP Level 3 candidates must demonstrate that they can apply the practical and theoretical knowledge of coatings they have learned throughout the CIP Level 1 and CIP Level 2 courses and from experiences faced on the job in real-life situations.

During the course Mr. Pete Engelbert has presented the coating Inspector Gage to Mr. Rob Freedman and Dr. Samir Degan. This Gage has been designed to aid you in routine inspection work by giving you a visual reference to several standards.

NACE International Gateway India Section (NIGIS) has successfully organized 64 Coating Inspector Program during last 5 years. NACE CIP training programs are the best and most comprehensive training programs in the industrial coating business. NIGIS organized following CIP courses during the period Jan - May 2012 in India.

Course No.	Course	Period	No. of Participants
1	CIP Level 1	09 - 14 January 2012	12
2	CIP Level 1	16 - 21 January 2012	26
3	CIP Level 2	23 - 28 January 2012	26
4	CIP Level 1	23 - 28 April 2012	18
5	CIP Level 1	30 April - 05 May 2012	21
6	CIP Level 2	07 - 12 May 2012	27

Photographs of CIP Courses

CIP Level -1 participants during 09 - 14 Jan 2012

CIP Level -1 participants during 30 - 05 May 2012

CIP Level -1 participants during 16 - 21 Jan 2012

CIP Level - 2 participants during 07 -12 May 2012

CIP Level- 2 participants during 23 - 28 Jan 2012

Pete Engelbert presenting the Coating inspector Guage to Rob Freedman & Dr. Samir Degan

CIP Level-1 participants during 23 - 28 Apr 2012

Participants during Lab Day

Non Intrusive Corrosion-Ersion Monitoring for Subsea Applications

SindreHalse Kristiansen, ClampOn, Geirnstanes, ClampOn

Abstract

The oil and gas industry has a need for reliable monitoring of changes in wall thickness both topside and subsea. It is important to detect and monitor the effect of corrosion and erosion as this may reduce the life-cycle cost and increase the lifetime of industrial infrastructure, ships, aircrafts, ground vehicles, pipelines, oil installations, etc. Even topside the conditions of operation can be extremely hostile, facing problems like surface roughness, fluid loading issues, temperature variations, and a host of other factors that make development of a robust wall thickness assessment tool a challenging task. Deploying a monitoring system subsea makes the application even more demanding when you have to take into account factors like high pressure and limited access. Over the last years ClampOn have offered a topside corrosion-erosion monitor (CEM) for monitoring changes in the wall thickness of such infrastructure. Major advantages of this technology have been its non-invasiveness, high repeatability, high coverage and the lack of any transducer movement, also making it an excellent candidate for subsea use. The measurement principle is based on dispersion of ultrasonic guided wave modes, and by using electromagnetism these waves can be transmitted through the pipe wall without the sensor being in direct contact with the metallic surface. It is installed on the outer pipe wall to produce real-time wall thickness information, not as a spot measurement, but as a unique average path-wall thickness. With several successful installations topside, the technology has now also been made available for subsea installation.

Introduction

There are many methods available to detect corrosion and erosion. In topside applications, the alternatives are both more reliable and more numerous. While in subsea applications, the environment is more hostile and accordingly detection will be a more challenging task. Pigable pipelines are normally inspected at regular intervals and tracking of pipeline integrity is in general not problematic. Some un-pigable pipelines can be inspected using cable-operated tools but such inspections are expensive and may require shut down of production. Subsea production templates, flow jumpers, manifolds and flow lines can today only be inspected by pre-installation of corrosion /erosion sensors or by use of Remotely Operated underwater Vehicles (ROV)-operated sensors.Current pre-installed sensor systems for monitoring pipeline integrity have proven to be of limited value to the operators. ROV-operated sensors only provide indicative and unreliable readings. A major challenge is that “hot-spots”, i.e. areas particularly susceptible to erosion/corrosion, are often detected after the template has been in operation for a while. Accordingly, the ability to retrofit a corrosion-erosion monitor on identified hot spots subsea is crucial. As an alternative, ClampOn have developed a CEM that uses dispersion of guided waves to track changes in pipe wall thickness. The transducers are fixed at pre-determined spots on the pipe outer wall to monitor the wall thickness loss in larger stretches of the pipe. The absence of any transducer movement or mechanical motion adds a high degree of robustness to the instrument. As it is permanently installed and needs no recalibration, it will be both more cost effective and reliable than other ROV-controlled methods.

Working Principle

The CEM is installed with transducers working in a pitch-catch mode of operation covering stretches of several meters, giving the average wall thickness between the transducers. The robust thickness assessment procedure involves a comprehensive analysis of the phase and group velocity dispersion characteristics of appropriate wave modes. The choice of modes for the analysis constitutes an important part of the design, as not all modes are equally sensitive to variations in wall thickness. Also, complications arising from mode overlapping and distortion have to be handled and overcome. Long term monitoring has to necessarily face the fact that there might exist local thickness variations that are a significant percentage of the average wall thickness. Most guided wave modes do not display the robustness required to smoothly integrate these changes into a quantitative, rather than qualitative, thickness assessment. The CEM system algorithm incorporates a patented use of so-called constant group velocity modes, or CGV modes, that provide maximum sensitivity to changes in wall thickness within the constraints imposed by the necessary robustness which the technique needs. In other words, the presence of highly localized damage and defects will be quantitatively incorporated into a robust "average thickness" measurement, with the use of an effective spectral and temporal dispersive analysis of the generated and received waveform. This CGV measurement is a relative measurement, meaning that the system needs an initial thickness value (measured during/prior to system installation), which it uses as a baseline reading, and calculates changes in average thickness from this initial value.

System Operation

Even though the most obvious application of a CEM is monitoring of pipe wall thickness, it can also find applications in several other areas such as tanks and separators. The CEM system is very flexible when it comes to system configuration. Typically, the system is set-up using between two and eight ultrasonic transducers and an electronics unit that handles all signal acquisition and processing. Two-and-two transducers operate consecutive in a pitch–catch mode of operation giving the average wall thickness of the area between the transducers. By choosing the transducer positions with care, normally unavailable areas can be monitored, e.g. buried parts of a pipeline. Most commonly, transducers will be placed on two rings around the pipe as illustrated in Figure 1, and set-up to monitor the area between the rings and, if possible, the area along the ring. Because of wave diffraction, the covered area stretches beyond the physical dimension of the transducers, also indicated in Figure1. Clearly, with the transducers being permanently installed, the coverage area of the system will be a certain fraction of the area over which the system is deployed. Typically, this fraction will be greater than 0.65, or 65%, and can reach 100% of a selected area.

When the transducers are set up to cover a pipe in such a way that several paths cross each other, i.e. monitors the same area, it is possible to extract additional information from the measurement data. Combining the wall thickness data with information on transducer setup a picture can be created showing the location of the damage and also give an estimate of the minimum wall thickness. Figure 2 show results from a demonstration using 16 transducers on plate. Both the maximum depth and the location of two defects were calculated and found to be in good agreement with actual data.

The instrument, topside, is usually hard wired to a power supply and a computer in a safe area. At many subsea locations it may not be applicable, or possible, to hard wire the instrument to existing infrastructure, and the only option will be to use a battery pack and an industrial computer with internal logging. A battery pack is usually designed to last 5 years and will then have to be replaced by a ROV to secure continued operation throughout the instrument lifetime. Data will be saved to internal memory and can be retrieved by an acoustic modem which allows for two way communication. The system is designed to be easily scalable for 8” to 24” pipe dimensions.

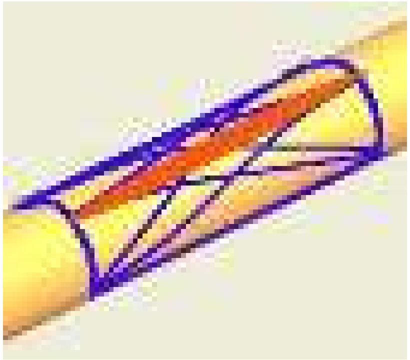
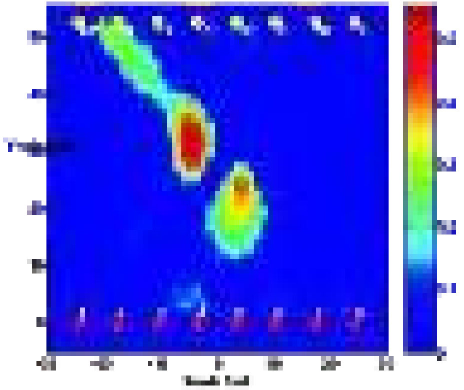


Figure 1 : An example of transducers set up with 6 sensors. Usually the transducers are installed on two "rings", and the area between the transducers is monitored. The red area indicates the size of the area monitored by one transducer pair.



Wall Thickness Loss [mm] - Maximum Depth 0.55714 mm; Average Depth 0.38684 mm

Figure 2 : Travel time tomography can provide additional information on systems where several transducers are covering the same area. These results are from a demonstration using 16 transducers to detect 2 damages, showing both localization and extent of damage.

Going Subsea

Even though the guided wave technique used by ClampOn's CEM system makes it a good candidate for subsea use, there will always be uncertainties when adapting a proven topside solution to the subsea environment. This being an instrument based on ultrasound means we also have to take into account changes in the acoustic premises, e.g. much better acoustic coupling between pipe wall and water than pipe wall and air. Another challenge is that access to the instrument after installation is limited for troubleshooting and repair. This can be both impractical and expensive. Keeping that in mind, many of the solutions selected for the subsea CEM are inspired by other well proven products. The electronics are based on the solution used for the topside CEM and the housing design is based on ClampOn's existing Deepwater model, rated to more than 3000 meters.

For existing non-pigable pipelines only ultrasonic spot measurement techniques are capable of ROV-installation. Based on knowledge and experience, the main reason for the problems encountered with these retrofitted systems is the piezoelectric transducers themselves. Lack of long term stability is the key issue. In order to maintain the repeatability of the system, frequent re-calibrations are needed. This is not suitable for long term subsea monitoring. In order to overcome this stability issue, electromagnetic acoustic transducers (EMATs) were developed. By transmitting a high-current pulse through the EMAT the waves can be transmitted and picked-up without the transducers being acoustically coupled to the pipe wall, making this a very stable solution that will not change over time. Actually, the transducers can have up to 3mm lift off from the steel wall, meaning it is possible to place them on the outside of pipe coating or painting. Both the EMATs and the electronics have for use subsea been made more powerful to give increased sensitivity and to make the system less vulnerable to installation deviation.

Much of the development work on the subsea CEM has been related to mechanical work, i.e. subsea clamp design and design of electronic housing etc. Two different solutions have been taken forward; one ROV-installable and one pre-installable solution. There will be no difference in the way they operate and they will give the same reliability and repeatability of measurement results. They differ in the way they are installed, with the ROV-installable being a fully ROV-installed system based on a clamp design.Both are made flexible and installation both in bends and straight sections is possible. As an example, consider the picture of the first subsea CEM with a ROV-clamp that was developed in cooperation with BP is shown in Figure3. In February 2012 the first subsea CEM was installed as the final part of the development process.

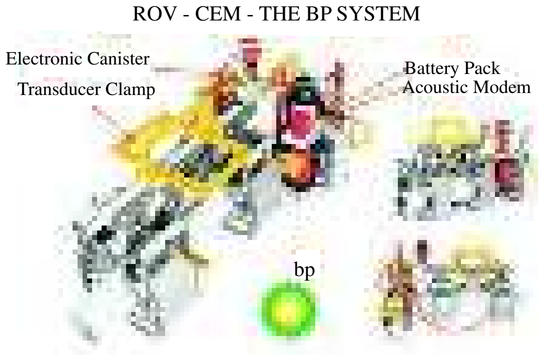


Figure 3: A ROV installable solution of ClampOn's subsea CEM used for the first project in cooperation with BP. The unit consists of a main clamp which holds the electronics unit and battery pack and a transducer clamp.

Conclusion

The CEM system was initially designed to provide an economical alternative to other ultrasonic-based systems and undesirable intrusive systems to get an estimate of the extent of corrosive and erosive damage in a structure. It has now also been taken forward for subsea use with the first unit installed in February 2012. It has been important to make the system flexible; both pre-installation topside and ROV installation is possible, giving the same functionality. It is also flexible with respect to positioning; it can be installed both in bends and on straight sections, and can be placed at remote locations as a standalone, self-powered unit.

Corrosion Basics

Coating Specifications

Regardless of the type of coating job, a proper specification is the key to its success. A specification that describes the materials needed, the objectives (s) of the coatings, the key procedures required, the appearance of the finished coating, and the inspection requirements, usually ensures a good coating job. A poor specification – one that is ambiguous, vague, lacks definition, or provides for a poor selection of materials – is an invitation to disagreements, possible lawsuits and, above all, early coating failure. Even good specifications are sometimes disregarded, forgotten, unread, or made available only to the job estimator and not to the rest of the job crew. Such circumstances are also an invitation to early coating failure and costly, continual maintenance.

A good specification should be a reliable guide for both the owner and the contractor of the coating crew and should be written to provide a clear understanding between the two parties. A good specification should and will invite cooperation between the owner and the contractor; thus it is more likely to result in a satisfactory job. On the other hand, some specification are written with an adverse relationship in mind, which can only lead to dissatisfaction of both parties and a poorer than ordinary chance for a satisfactory job. Dissatisfaction, arguments, hard feelings and, ultimately, legal action arise from the use of poor specifications.

To help corrosion engineers write good, sound specification, NACE has published “A Guide to the Preparation of Contract and Specification for the Application of Protective Coatings”. All parts of the document may not be applicable to any one specific job, and these parts may be eliminated or modified as desired. Even so, it should ensure that the content of the specification is as close to what is desired as possible.

Usually three, and perhaps four, entities are involved in a specification. They include the owner, possibly an engineering and design company, the manufacture for the product to be applied, and the contractor who will apply it. All of these people or companies should have a part in creating the specification. It is obvious that the owner is vitally interested in and ultimately responsible for the specification, either from within his own organization or from the outside, seeking the best possible advice from various sources (e.g., reliable engineering firms, coatings manufactures, and/or contractors).

Since an engineering firm usually is involved exclusively in new construction, it is often given primary responsibility for developing the specification for the owner. The coating manufacturer also has some involvement in specification development. It is the manufacturer's responsibility to provide the best information available on the use of the materials for the job that is contemplated. The manufacturer represents the most knowledgeable source of both material and application information for the materials; thus, the manufacturer should supply not only the typical data about a coating (e.g. percent of solids, drying time, etc.), but also practical information concerning the application of the specific material for the particular job. If the use of the coating being considered is questionable, then the manufacturer should step forward before the specification is written and recommend a better material.

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

Natural Gas Pipelines –
In-situ Coating on the Condensate Pipeline

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In the Natural Gas Distribution, often the temperature drops below the Dew Point of the Natural Gas normal range; this tends to form the condensation or even some cases severe ice formation on the Pipe OD that damages the Protective Coatings applied earlier resulting in the premature failure of the Coating. The technologies being specified on the particular application requires the parameters of working of Flexibility to take up the wide range of the temperatures that they are put to use.

Challenges in the Application:

Being the revenue generation business units of Oil & Gas, these assets cannot be taken for Shutdown nor feasible for isolation exclusively for the painting purpose alone. The selection of the Coating should take up the flexibility required for performing at these temperatures apart from selective reactions with the moisture after the curing of the paint film. Even the application is done in free & fair weather frame; ultimately the pipe has to be exposed to these variances in the various conditions. The wrong picking of the Coating cannot perform up to the designed life but leaves the Substrate exposed to atmospheric corrosion harming the life of pipe itself in the long run. Majority of the Coating technologies that are put to use are unable to stretch beyond elastic limits and in general fail to perform to the expectations.

Moisture Cure Urethanes – A Perfect Simple and Viable Solution:

In many cases, condensate will immediately form on the wet paint. When painting at the dew point, the cooling effect of the solvent evaporation will lower the immediate surface temperature enough to form condensate. In the described conditions, cure time can be as short as 4-8 hours. Single Component, moisture cured urethanes are now being used successfully where stability, intercoat adhesion and applicability under extreme conditions and low temperatures are required. Blending and catalyzing are not required for these coatings, which have the basis for specifications.

The longer life and corrosion resistance of these systems are proven by successful painting projects all over the world. But application restrictions, mixing errors and delays due to inclement field conditions are characteristic problems with these products. In most of the major maintenance areas of the world, this introduces delays in painting due to the coatings' restrictions against painting in humidities over 85 percent, or when the surface is within 3°C or 5°F of the dew point. In many other areas, stoppages occur because the temperature is below 5°C or 35-40 F. This is the lower limit for most popular plural component epoxy and inorganic coatings. While there is now cold-weather or surface-tolerant specialty primers, even these can cause delays or problems because not all components of the coating system are weather or moisture tolerant. Twenty-five years ago, the Germans attempted to solve these field painting problems with the development of specific moisture-cure urethane coatings. The original objective was to repaint off -shore oil platforms in the North Sea. The performance of these coatings was extraordinary, not only solving the application problems, but creating the most corrosion resistant systems known. They performed well even in 20-year salt water splash zones. These early coatings were effective but extremely difficult to consistently manufacture and only a few companies were able to master the manufacturing techniques or diversify from the original coatings.

By developing new manufacturing techniques, increasing the solids content, and improving even further the chemical resistance, formulators have produced single-component urethanes that have solved the inherent moisture-cure urethane problems, i.e. stability, intercoat adhesion, low-temperature and low humidity cure, and have created a new generic type of coating. These urethanes perform well in immersion, while traditional two-part urethanes are not generally recommended for Immersion.

All of these coatings will essentially cure under water, and hence are unaffected by high humidity and damp conditions. The formulations will cure down to -15°C (or -9°F). In as little as four hours and yield amazing resistance to corrosion. Typical-system resistance to ASTM salt-spray testing is in excess of 20,000 hours. The formulations can all be made to comply with VOC regulations and are in most cases much lower in monomeric isocyanate than typical two-component urethanes.

With these coatings there is no catalyzation or blending. Every inspector, project manager and applicator is given a signed certification that all coatings can be applied without regard for the humidity or dew point. Application can be done at temperatures down to -15°C. And every coating can be wetted or immersed after as little as 20 minutes. This allows coating application to continue any time the surface is not physically wet. In cases where the surface must be coated while wet, for example cold gas pipes with condensate, the surface can be towelled dry temporarily and immediately coated; Condensate may again form with no damage to the coating. The coatings are unaffected by sudden fog conditions and are designed for this use. Specifically, using moisture-cure urethanes with micaceous iron oxide on these surfaces allows application as above without delays for weather, but gives the added life due to the MIO. In addition to the facilities mentioned above, these single-packaged urethanes have been used successfully on spillway gates where their ability to withstand rapid immersion and their abrasion resistance have specified them; on natural gas pipelines and pumping stations where surfaces are constantly cold and wet; on radial gates and stopblocks; underground gas and water-metering stations; steel sheet pilings in Alaska where ice floes served as scaffolding; and on concrete bridge guard rails.

Summary

Advanced single-package, moisture cured urethane coatings, based on European technology, including the use of micaceous iron oxide in many coatings, have eliminated the uncertainties of many two-package versions when used on surfaces where application and service life are under wet and harsh conditions.

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Model: CD-295

CD Tester CD-295 complete unit consisting of:

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- User adjustable gain control for precision control
- Selection of channel via soft keypad operation
- Display unit indicate selected channel, voltage, current and time
- Indication of Test time and elapsed test time in hours
- 2 Acrylic glass test cups 80mm diameter
- 2 Platinum coated electrodes
- 2 Reference electrodes, calomel
- 1 Set connection cable
- Dimensions: 330 x 175 x 400mm
- Weight: 3.25 kg
- Power supply: 230 V/50 Hz, max. 30 W

Testing capabilities as per DIN 30 671, ASTM G8, ASTM G42, ASTM G95 and EN 12068 standards

Caltech Engineering Services
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A Report on NIGIS South Zone Student Section Induction Ceremony

A special function of NIGIS (South Zone) Induction Ceremony of Student Chapter was held on 13 Feb 2012, at Hotel GRT Radisson Mamallapuram.

Dr. U. Kamachi Mudali, President NIGIS (SZ) started the meeting by welcoming the students and EC members. First he introduced Dr. Samir Degan, Director, NACE International - East Asia & Pacific Rim Area (EAP Area), to the audience. He later highlighted the importance of student section and the motive of starting a student section.

In his address Dr. Samir Degan, gave a glimpse of NACE activities which was started in 1943 by 11 pipeline engineers in USA. Today NACE has 28,000 members in over 100 countries, of which 46% are from outside USA. In the recent years, the NACE East Asia & Pacific Rim Area has shown fastest growth. NACE International is a member driven society and through the membership has formed several technical groups, through which the NACE standards are written. NACE also provides a platform for exchange of information as well as organizes Corrosion Conferences around the world, where the students are also given a lot of support for participation. He also informed that NIGIS will provide support for students to participate in NACE Corrosion Conference in USA. CORCON is the yearly event NIGIS, Mumbai organizes. Dr. Samir also added that Mumbai, Shanghai, Kuala Lumpur, Western Australia and Chennai are the student section chapters of NACE International in the EAP Area.

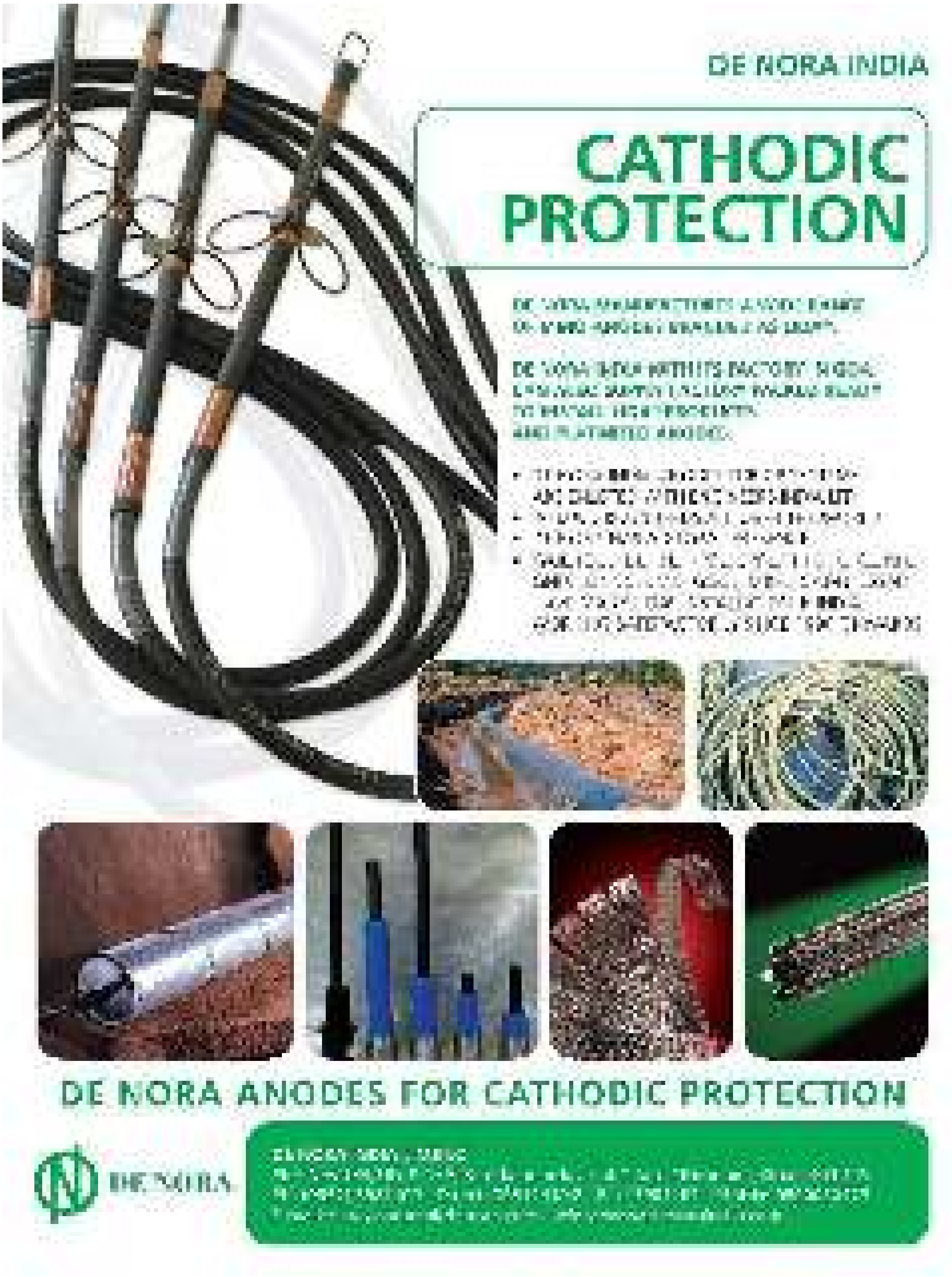
Later the students were inducted in to NIGIS by Dr. Samir Degan and on this memorable occasion the students were given the mementos.

The panel of senior colleagues of NIGIS; Prof. S.K.Seshadri, IIT Madras, Dr. U.Kamachi Mudali, Dr. T. S. Rao, Secretary, NIGIS(SZ), Dr. S. Rangarajan, Treasurer, NIGIS(SZ), Dr. N. Rajendran, Anna University and Dr. Oscar Martinez, Argentina spoke on the importance of corrosion science and technology and reiterated the importance of the research and the opportunities available. The students were advised to follow disciplined research practices and aim at achieving greater heights in their careers.

Dr. T. S. Rao, proposed vote of thanks and highlighted the generous support given by Dr. Samir Degan, in the organization of the function and for readily accepting our invitation to visit Chennai.

Samir Degan presenting Mementos to the Students

On the Dias (L to R) U. Kamachi Mudali, Samir Degan, T S Rao



A Report
Training Programme on Pipeline Corrosion

NACE International Gateway India Section (NIGIS) has organized educational & training programme on "Pipeline Corrosion" during the period 22-25 February, 2012 and 4 – 7 April, 2012 at Hotel Rodas, Mumbai.

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

The faculty includes professional experts from organizations and academic institutions such us Afcons Corrosion Protection Pvt. Ltd., Bhabha Atomic Research Centre, Bharat Petroleum Corporation Ltd., Berry Plastics Corrosion Protection Group, Corrosion Control Services (B) Ltd., Indian Institute of Technology Bombay, Oil and Natural Gas Corporation Ltd., Relene Petrochemical Pvt. Ltd. etc.

The participants appreciated the training programme and expressed their views as:

- "The programme was a unique experience and very nicely arranged and conducted"
- "I enhanced my knowledge with corrosion in Pipeline Corrosion & CP systems"
- "CP working and inspection, monitoring and controlling of corrosion are well taught"
- "Fulfilled my objective to attend the course as good knowledge about CP system given",
- "Thanks to NACE for conducting such useful programme"

Participants of 22- 25 February 2012
Training Programme

Participants of 4 – 7 April 2012
Training Programme

NACE International Certification CP Program

The Cathodic Protection Training and Certification Program (CP) of NACE International is a comprehensive program for professionals in any industry, including pipelines, bridges, tanks, well casings, the maritime and offshore industries, coated steel and concrete, and water and wastewater systems. The program is designed to give students a path for continued career-long professional development.

NACE International Gateway India Section conducted the first CP-1 Tester Training program during 23-28 Jan 2012 at Mumbai and there were 25 participants from across the globe and CP-2 Technician Training program was conducted during 30 Jan - 4 Feb 2012 at Mumbai, which was attended by 17 participants.

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 CP 1 - Cathodic Protection Tester course presents CP technology to students entering the cathodic protection industry and those who are responsible for observing, recording, 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.

NACE International Gateway India Section is again organizing CP 1 during 4 - 9 June 2012 & CP 2 during 11-16 June 2012 in Mumbai .

CP 1 Participants during 23-28 Jan 2012

CP 2 Participants during 30 Jan - 4 Feb 2012

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