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Cathodic Protection & Monitoring/Coating Applicators
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- Painting Inspector Levels 1, 2 & 3
- Pipeline Coatings Inspector Level 2
- Cathodic protection of re-inforced concrete structures Levels 1 & 2
- Insulation Inspector Level 2
- Hot Dip Galvanising Inspector
- Fire Proofing Inspector Level 2
- Cathodic protection of buried and submerged structures Levels 1 & 2

For further information or administrative details, costs and bookings for courses and examinations or detailed information packages free of charge, please contact:

Martin Dawson or David Betts on:
Tel: +44 (0)1709 560459  Fax: +44 (0)1709 557705
Email: enquiries@ruanetpo.com
Internet: www.argyllruane.com

Technical and eligibility enquiries can be made direct to Dave Griffiths the ICorr Scheme Manager on:
Tel: +44 (0)1709 550999

Ruane & T P O’Neill Argyll-Ruane Ltd.
Meadowbank Road, Rotherham S61 2NF, United Kingdom

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March/April 2012

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Things seem to have become really busy lately. As I foretold in my last article I attended the AGM of the Midland Branch when Ross Fielding handed over the Chairmanship to Jim Preston. Ross has done a superb job breathing life back into the Midland Branch and all his hard work is really appreciated. After the AGM there were very interesting and informative presentations on Surface Analysis and Glass Flake coatings which made a useful half day meeting. Again it was held in the Chamberlain Room of the Birmingham Council Chambers overlooking Victoria Square and Andrew Gormley’s statue ‘Iron Man’. The statue cast in Willenhall, represents the traditional skills of Birmingham and the Black Country however I have my doubts that it will endure as long as the Delhi Pillar but I would like to be around to see! At the recent meeting of the Council and Trustees of the Institute I was able to show mock ups of the new website which received positive reactions and now hopefully we can move forward with a test site to debug before going live. Whilst on the subject of IT we now have our own Linkedin group and hopefully this will become a valuable resource for both networking between members and sharing knowledge and solutions to corrosion related problems. Please join up! Jonathan Philips who set it up is writing a note elsewhere in this edition of Corrosion Management with guidance on how to join for any of you who are unfamiliar with the site, we need to get it used as much as possible.

I recently took part in Assessment Interviews for two candidates for Chartered Engineer and was most impressed by the rigour of the process not only were there senior assessors from ICorr and the Society of Environmental Engineers (our partner and the registered body for this) but also a very experienced representative of the Engineering Council to oversee the process and ensure that we were setting the right standards. Whilst on the subject of chartered status I did complete my application for Chartered Scientist and I wait with trepidation for the outcome. More on this as it unfolds.

The recent General Meeting of the Science Council was focused on young people and how to make science and technology more appealing to students whilst at school and before career paths are considered and become fixed. This is a very important issue if this country is to thrive in an increasingly competitive and global economy we need many more young people following Scientific and Technological careers.

THE PAST, PRESENT AND FUTURE

50 years ago a young, earnest, fresh-faced post-doc arrived in Manchester for an interview. He had come from Cambridge where he had got a Ph.D. from the Department of Metallurgy working with T.P. Hoar on the corrosion of aluminium. His face dropped when he saw the University building it was an old cotton mill surrounded by back-to-back houses and cobbled streets. The mill was a temporary building and due to be demolished within 10 years. It leaked from the outside and leaked from the inside. This young man’s name was Graham Wood. He was appointed to carry out his own research into the corrosion of aluminium but also to create a Masters course in corrosion science. Now this Masters course is 50 years old and it’s now Prof Graham Wood, F.R.S.

40 years ago John Dawson was working in the corrosion group in chemical engineering and his job was also twofold Firstly to pursue his own research but also to create the one week course in corrosion engineering biased towards the process industry. Indeed John is still teaching on this course.

30 years ago I was given a task of organising this short-course and this year we have changed its emphasis towards the oil and gas industry and we are convinced that this new venture will be equally successful. Details of this new course can be found on the University of Manchester, School of Materials website under “corrosion short course”.

These courses have changed, developed and been modified during the years as science and technology have changed, but their continuing success is a clear indication of their relevance not only for today but for the future.

The old mill was never demolished. It still with us today; it is still leaky from the outside and still leaky from the inside and my office got flooded two weeks ago.

David Scantlebury
Professor of Corrosion Science and Engineering

The latest copy of ICATS News can be found in this edition of Corrosion Management. This is the first copy since the re branding of ICATS has taken place and I hope it is of some interest to you. Future copies of ICATS News will be available to download from the website www.icats-training.org. We are planning three editions a year and would welcome contributions from ICATS member companies or individuals who have experience with ICATS that they feel may interest others.

Please feel free to contact me in Northampton.

David Eyre
ICATS Coordinator
ICorr has just launched its own LinkedIn group for members and those interested in the Institute’s activities. LinkedIn is the world’s largest professional network with over 120 million members and growing rapidly. It enables you to connect to your trusted contacts and helps you exchange knowledge, ideas, and opportunities with a broader network of professionals. The ICorr group will enable members to keep up to date with all the latest news and events on a platform they are already using rather than having to specifically go to the website. In addition it will provide a forum for discussion and debate enabling you to share ideas and best practice.

The LinkedIn group is connected with the website so all the latest news will be fed to the linked page. In the fullness of time we will also be connecting the ICorr forum, the conferences and events section and the Jobs section so no matter what your preferred platform you can be kept up to date.

If you are unfamiliar with LinkedIn but would like to register and Join the ICorr Group go to www.linkedin.com where you will find all the information you need.

For those of you familiar with LinkedIn simply go to the groups option in the main menu, select groups directory and search for ‘institute of corrosion’. We would encourage as many members as possible to connect with the group as the busier it gets the more benefit everyone will gain from it.

If anyone has any questions, suggestions or comments then you can contact me at jonathan@squareone.co.uk or on 0114 2730132.

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**MEMBERSHIP SUBSCRIPTION RATES 2012/2013**

<table>
<thead>
<tr>
<th>MEMBERSHIP CATEGORIES</th>
<th>ANNUAL RATE from 1 July 2012</th>
<th>REGISTRATION FEES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Member</td>
<td>*Free</td>
<td>£68.00</td>
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<td></td>
<td>*Free</td>
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<tr>
<td>Technician</td>
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<td>Professional Fellow</td>
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<tr>
<td>Sustaining Membership</td>
<td>The annual rate from 1st July 2012 is £345.00 (plus VAT)</td>
<td>£15.00</td>
</tr>
<tr>
<td>&quot;GOLD&quot; Sustaining Membership</td>
<td>The annual rate from 1st July 2012 is £665.00 (plus VAT)</td>
<td>£15.00</td>
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**NEW APPLICANTS**

All new applications for Ordinary membership must be accompanied by a payment of £83.00. The applicant will immediately be admitted into the Institute as an Ordinary Member.

**STUDENTS**

*Applications should be accompanied by proof that you are a student to qualify for free membership.

**JANUARY - MARCH APPLICATIONS**

Applications submitted between 1st January and 31st March (ie. in the second half of the subscription year) need submit only half the annual rate plus the full Registration fee of £15 (ie. £49.00 for Ordinary Members).

**APRIL – JUNE APPLICATIONS**

Applications during April, May and June will be treated as being made on 1st July 2012.

**PAYMENTS**

Applicants are requested to make payment ONLY in £GBP. If you would like to pay in Euro’s please contact ICorr Head Office. Payment may also be made by credit card for £GBP only in which case a surcharge of £3.00 per payment is made to cover substantial increases in bank charges. Overseas members who wish to receive the Institute’s journal Corrosion Management by air mail should add £20.00 to their subscription payment.

**GRADE TRANSFER**

Applications for transfer to a higher grade should be made on the Professional Membership Application Transfer Form and be accompanied by a payment of £43.00, being £15.00 administration fee plus the £28.00 difference between Ordinary and Professional Membership or £25.00. being £15.00 administration fee plus the £10.00 difference between Ordinary and Technician Membership.
LONDON BRANCH NEWS

Soho – Sex, Drugs & Rock n’ Roll

London Branch Sustaining Members
Sponsored Evening
Thursday 3rd May 2012
SOHO WALKING TOUR

This year, our Blue Badge Tourist Guide, Ingrid Wallenborg, will lead a fascinating and educational gentle stroll through Soho. This will conclude with a walk from Regent Street to the Naval Club where the traditional hot chili and rice will be awaiting us.

This walk should appeal to all as it contains a good variety of vice, spiced up by an ethnic setting. You will of course hear of the 'King of Soho' and the scandalous nude dancing girls and the fortune that Levi’s jeans can bring. The stroll takes us past the ‘pub’ that ran out of champagne and the former home of the controversial author whose world famous books very few have actually read. If ever there was a melting pot it is here where every kind of language [and not just Cantonese] can be heard – and gender seen! – and many of the world’s most famous pop stars started out sometimes by simply helping out in the record store of some friends.

We will as usual include a stop for refreshments ‘en route’.

As this is a sponsored evening, there will be no charge, and all ICorr members with their family or friends are most welcome. Meet at 17.30 at Piccadilly Circus, in front of the Criterion Restaurant, as we did last year.

This Guided Tour will take place whatever the weather conditions.

John T O’Shea,
Deputy Chairman, London Branch Committee

PRESENTATION ON ‘INTEGRITY & CORROSION MANAGEMENT’

An attendance of 30 at the London Branch meeting on February 9th were given a presentation on ‘Integrity and corrosion management’ by Jeremy Ludlow of Wood Group Integrity Management. Mr Ludlow said that risk assessment with corrosion problems is an important aspect and that there is a need to consider the entire engineering life cycle to safeguard the owner’s investment. Inspection, monitoring, maintenance and repairs have to be considered, and other important factors are duty of care for the environment as well as personal and legal requirements and it is vital to assess the probability of failure.

MARCH MEETING

At the close of the London Branch AGM on March 8th, Chairman Andy Taylor presented pairs of glasses engraved with the ICorr logo in presentation boxes as long service awards to David Dore (15+ years), Brian Coldie (14+ years), Derek Hoskins (20+ years), Trevor Osborne (15+ years) and John O’Shea (25+ years). In addition, John O’Shea was presented with a Past President’s Medal in recognition of his tenure as ICorr President 2000 – 2002. Andy then gave a technical presentation about the Buncefield fuel depot explosion on 11th December 2005; it resulted in the largest peace time fire in Europe just 40km from London - the explosion was even heard in Holland. The event injured 43 people but fortunately there were no fatalities, although things might have been different had it occurred on a Monday. The effects were devastating as illustrated with graphic images, with about 2,000 people being removed for safe keeping and the M1 was closed. There was a serious disruption to fuel supplies including those to Heathrow Airport. As a fuel tank was being filled, it overflowed with no knowledge of that happening on site because a float switch failed. The resulting explosion was measured at 6 on the Richter scale and it took four days to extinguish the fire.
I mentioned the Hammersmith flyover in my last TT and particularly assessing the risk of its collapse. This excited some interest most notably from correspondent Mick Ogden who has some indirect association with this flyover and its repair. Quoting him: "Regarding the risk associated with the Hammersmith flyover a great deal of engineering has taken place and is currently being carried out by some very skilled people. I would think if the original design calculations were reviewed and based on the known corrosion of the pre-tensioned wires it would have been pretty straightforward to work out the risk of collapse of the flyover". This is reassuring and was confirmed when the flyover problem was discussed in the 23rd February issue of NCE (New Civil Engineer). In the latter article it was stated that "detailed analysis including endoscopic and radiographic surveys of the reinforcement together with computer modelling gave TfL the confidence to allow one lane to reopen to light traffic in each direction in early January". Also that "Engineers, after investigating a range of options, are installing new high strength cables on the six most damaged spans". It is interesting too that emergency surgery using hydro demolition has had to be employed. (hydro-blasting is more familiar to DJM as an effective way of removing old coatings and indeed preparing a metal surface for painting). In relation to risk Mick states "My world is welded steel cross country gas pipelines. These are generally designed for 40 years. Recently the owners have undertaken detailed risk assessments and decided to increase the pressure and increase the life of these pipelines. He goes on "I have done a lot of work on the effects of HVAC power lines to buried steel pipelines, these power lines induce hundreds of amps into the pipelines, I have had the electric shocks from them and had the tingling sensation from standing underneath power lines. The effects of these powerlines on the general public have been studied over many years and no adverse affects have been identified, however their proximity to housing is controlled". With this last example it is useful to have someone talking from the sharp end! Picking up on the inspection aspect, corrosionists like ourselves have a key part to play in helping to design effective inspection regimes and also monitoring methods. In the case of the Hammersmith flyover it was only when acoustic emission indicated that, due to corrosion, wire breaks were occurring on a daily basis that people started to sit up and take notice. This is one of a range of techniques available eg resistance wires, coupons and electrochemical methods like LPR and EIS; the latter two being useful for monitoring under well controlled immersion conditions. In the concrete field, potential mapping and LPR are both popular.

I discussed these electrochemical methods 5 years ago in a TT (Jan/Feb 07). But an upcoming method that did not get much mention then is the Electrochemical Noise Method (ENM). This is something of a hobby horse of mine in its application to anti-corrosive organic coatings. It also has
Jim Britton has worked in the offshore corrosion field since 1972. He was educated in the UK, began his offshore career in the UK North Sea, and is founder and Chief Executive Officer (CEO) of Deepwater Corrosion Services. Jim has published dozens of technical papers and articles on offshore corrosion-related issues and holds several patents for technology associated with corrosion and asset integrity management. For the last 15 years, he has focused his efforts on asset life extension methodologies and cathodic protection retrofit technology. With such extensive experience, Jim provides an excellent perspective on corrosion and asset integrity management. ICorr Aberdeen branch committee members Kevin Paterson and Eugene Ogoshi met with him to discuss the role of corrosion professionals in asset integrity management.

Q. Could you please tell us of your professional background?

A. After I left high school, I worked at a local metallographic laboratory as a technical assistant. They sponsored me on a day-release programme where I obtained my National Diploma. I started out in corrosion in 1972 and moved into the offshore industry following my metallurgical apprenticeship. From that time, I performed various corrosion-related projects around the world and moved to the United States in 1982. I formed Deepwater Corrosion Services in 1986, which focuses primarily on providing corrosion control solutions and technologies for the oil and gas industry.

Q. Looking back at your long and distinguished career, is there a reason you chose corrosion as a profession?

A. Yes there is. As I mentioned earlier, my career started as a metallographic assistant and I worked in a corrosion-related failure investigation project. In doing this work, I had the opportunity to work with some corrosion engineers and this inspired me to follow a career in corrosion. I looked for an opportunity to get out of the laboratory and get into a more practical field environment. I would say that an early exposure to material and corrosion science attracted me to corrosion as a profession.

Q. Can you describe what a typical day in your professional life would look like?

A. Unfortunately, since I am the CEO of Deepwater, the first half of the day is usually taken up by business-related meetings that are not very interesting from a corrosion viewpoint. However, I make a conscious effort to ensure that I get involved in the corrosion-technology aspects of Deepwater’s work. I get involved in global projects at a high level, checking project progress and consulting with my lead engineers around the world on corrosion issues. I must say that this is the aspect of my work that I really enjoy. If I am really lucky, I will attend our regular product development and improvement committee meetings that focus on new technology development, research and development activities and other technology improvement discussions. Being in the oil and gas business, most of my time is spent either overseas, in aeroplanes or sitting at airports.
Q. Corrosion control and asset integrity management are certainly discrete concepts but are very much related. How would you explain both concepts?

A. For offshore assets, corrosion is not the only threat, but it is a significant and major threat to asset integrity. Asset integrity management from my point of view is the intelligent deployment of initially front-end risk-based inspection and monitoring coupled with well-thought-out application of the various corrosion control techniques.

Q. What do you consider the main components of a good asset integrity management system? What are the key benefits of implementing an asset integrity management system?

A. Starting with the second question, the key benefits are to ensure Health, Safety and Environment (HSE) compliance and to keep the asset stakeholders happy by operating a profitable venture. Downtime and catastrophic failure are certainly unacceptable in today’s business, so integrity risks to the asset must be well-managed. The most important aspect of a successful asset integrity management programme starts with an intelligent risk-based inspection programme. Unfortunately, many of these programmes are not well thought out and are very often wasteful and not focused on the key corrosion threats. Another key point is to get senior management to support the programme. If senior management supports an asset integrity management system, it is more likely to succeed. Thirdly, it is vital that the practitioners are competent. If you have unqualified personnel involved in any aspect of the programme, it will be a weak link and risk will be elevated. So in summary, senior management support, good programmes and good people are the main factors to consider when developing asset integrity management systems.

Q. Experts have always emphasised the importance of reviewing asset integrity management systems regularly to ensure they remain fit for their purpose. Why do you think this is important?

A. It is absolutely critical to do this for some reasons that I will pick on although there are probably more. The first is the dynamic nature of corrosion risk as the asset ages. There will be changes in corrosion models, reservoir corrosivity, constituents and other parameters, so the model and risk for corrosion damage are continually varying. Therefore, as the asset ages, there is a changing criticality that must be continually reviewed. Another reason to continually review the system is to ensure you get the loop effect of feeding results from integrity activities into the decision-making process to ensure intelligent changes are made to the system. Another obvious reason to review is the development of new technology. There is a regular introduction of better ways of doing everything in integrity management, such as new inspection tools, new subsea equipment, new materials, new ways of producing oil and gas — especially in the subsea industry — and deep-water sectors. So what worked well in the beginning of the field life may be inappropriate further into the asset’s service life. Finally, the review of the system is consistent with HSE requirements that are placed on oil and gas companies.

Q. It is no secret that oil and gas assets are increasingly required to function beyond their original design life. There is now a need to perform life-extension studies to prove these assets can continue in service. What do you think is the primary role of the corrosion professional in this process?

A. I think the primary role of the corrosion professional is to provide advice to the stakeholders and asset owners on the threat that specific types of corrosion damage pose to the integrity of their asset. Not all corrosion elevates risk, so corrosion professionals should be able to advise on where risk-increasing corrosion mechanisms exist and how their effects are. Also, the corrosion engineer must interact effectively with other disciplines to understand how other relevant parameters can affect corrosion. For example, a change in fatigue life could reduce the tolerance of an asset to corrosion. In this case, the structural and corrosion engineers must combine their individual expertise to ensure that adequate assessments are made to quantify and control the combined risk of fatigue and corrosion.

Q. What are the main challenges facing the UK upstream oil and gas sector as most assets approach the end of their service life?

A. I think there are two major challenges that are specifically brought about by aging infrastructure. First is finding the monetary capital to decommission the asset. Another challenge to the industry is maintaining the asset’s integrity and fitness for purpose on a very tight budget. There are many more challenges but I think these are the key challenges the industry faces and will continue to face in the future.

Q. The interview will not be complete without a question relating to cathodic protection because you have done a lot of work in developing cathodic protection retrofit technologies. From your point of view, do you think there is a good understanding of cathodic protection in the industry? What are the common mistakes in its application?

A. I am amazed at the amount of fundamental ignorance that pervades the industry when it comes to cathodic protection. There are a lot of misconceptions, but I will mention the two most common. The first is the insistence by some engineers that cathodic protection is a line of sight wave phenomenon rather than an electrochemical mechanism, thus the classic misconception arises that if an anode cannot “see” the structure then cathodic protection cannot be achieved. The second common mistake is the lack of appreciation for the fundamental principle of cathodic protection, such as the crowding up of sacrificial anode arrays onto skids with a complete disregard of mutual interference effects, and this has led to high profile deployment of anodes that have been massively under-protective. I think there is a need for more awareness of the fundamentals of cathodic protection in the industry.

Q. Do you have any advice for the corrosion professionals joining the oil and gas industry (especially in the North Sea)? What prospects do you see for the future of the industry?

A. I would say to any young professional that corrosion is a good profession which is still under-populated, and I would recommend it as a career choice. Corrosion is not confined to the oil and gas sector and indeed, in the offshore sector, it is branching into other areas such as renewables. I would, however, advise any entry level or graduate corrosion professional to get a job where they can get practical field exposure to corrosion because this will positively develop a fundamental knowledge of corrosion and enhance career opportunities in the future. Corrosion in the oil and gas industry has a very good prospect, but one must be willing to travel regularly and/or possibly relocate because it is essentially a mobile industry.

The members of the Aberdeen branch committee would like to thank Jim Britton for his contribution to our interview series. We would also like to commend him for his continued commitment to the development of corrosion technologies and his support for our branch activities. This interview has been conducted by the Institute of Corrosion (ICorr) Aberdeen branch committee. More information about branch activities can be obtained from the ICorr Aberdeen branch secretary, Frances Blackburn, ICorrABZ@gmail.com. Alternatively, a calendar of local events of interest to corrosion professionals in the Aberdeen area and the opportunity to sign up for the branch’s mailing list is available at https://sites.google.com/site/icorrabz/home.
The first meeting of 2012 was held on the 24th of January at the Palm Court hotel in Aberdeen. Dr David Baxter of Atkins Oil and Gas delivered his presentation on “Corrosion Fatigue of Subsea Pipelines” to forty nine (49) members in attendance.

Dr Baxter started his presentation by explaining the concept of fatigue and corrosion. He explained some fatigue related problems and threats pipelines faced such as Vortex Induced Vibration (VIV) loading, thermal cycling/buckling etc. He explained the synergistic effect of both damage mechanisms and described how this could lead to significant failure in practice especially in the welded joints of pipelines. David mentioned the two main approaches used for fatigue design i.e. the S-N approach and Fracture mechanism approach. For the S-N approach, he mentioned that magnitude of stress (y-axis) versus number of cycles (x-axis) curves where derived from testing and adopted by various design codes for example BS 7608, BS5400 and DNV RP C203. He noted that beyond the use of design codes, the assessments were left to knowledge and experience of the assessor. He added that fracture mechanics approach considered the amount of time it took for defects to grow and was a more complex assessment than the S-N approach.

He showed the negative effects of sour environment with graphical illustrations of test results. “The results show a notable reduction in S-N fatigue life due to contact with sour environment,” Dr Baxter explained. He also illustrated a marked increase in crack growth rate from fracture mechanics testing and the effects of other key parameters. David discussed the results from the SAFEBUCK JIP and other project specific modelling. Results showed a negative influence of the environment on fatigue resistant properties of materials. Generating data at low frequency and the time dependence of S-N experiments were highlighted as some of the challenges the team faced during fatigue testing.

He ended his talk by drawing conclusions from test results, modelling and experience. Among other findings, he noted that seawater and sour conditions had a dramatic effect in reducing fatigue life. He added that lateral buckling and cyclic loading frequency were also important design parameters to consider.

The negative effect of CP overprotection of pipelines and industry preference of the two different approaches to fatigue design featured in an interactive question and answer session that followed immediately after the presentation.

The ICorr branch chairman thanked the speaker for his presentation and urged new/intending members to contact the committee members for more information on ICorr. PET booklets, Corrosion Management magazines and continuous professional development certificates were distributed to members immediately after the meeting.

More information about the Aberdeen branch activities can be got from the ICorr Aberdeen branch Secretary, Frances Blackburn, ICorrABZ@gmail.com. Alternatively, a calendar of local events of interest to corrosion professionals in the Aberdeen area and the opportunity to sign up to the branch mailing list is available at https://sites.google.com/site/icorrabz/home.
On the 28th February 2012 the Aberdeen branch meeting was held at the Palm Court hotel. The guest speaker was John Thirkettle who is a corrosion consultant of forty-eight (48) years work experience. John explained the concept of Corrosion Under Insulation (CUI) with illustrative photographs showing its insidious nature. He noted that although the concept has been known for a while, professionals were still looking for a practical solution after years of research. He mentioned that the reason was that initial research was conducted in a disorganised way without enough communication between various research groups. He explained how major changes the oil and gas industry in the 1970’s brought about new insulation systems and with it some problems, which only came to light about twenty (20) years later. He explained how the Forum has used proactive workshops to share knowledge, experience and information on CUI, reminiscing on the early days of the UK CUI Forum.

John described the structure of the UK CUI Industrial forum, its members, achievement over the last few years and its affiliations. He outlined the major workshop themes, which the forum had organised including CUI detection systems, long range ultrasonic testing, thermally sprayed aluminium (TSA), insulation systems, cladding and protective coating systems. He went into some detail of the application of technologies such as the hydrotector and long range UT for CUI detection and their limitations. He noted the successes in the application of thermally sprayed aluminium (TSA) illustrating its application technique with photographs. He also touched on the benefits of applying the Pinovo surface preparation technology, which featured in the branch’s October 2011 meeting, and explained how this technology can be used to make the TSA application process more effective and cheaper. He covered new technologies like the aerogel blanket and its application.

John Thirkettle went on to explain the Forum’s contribution to the European Federation of Corrosion (EFC) document number 55, which is a standard CUI guidance document and discussed its content. He outlined current initiatives of the Forum, which included a training and certification scheme for insulation applicators and inspectors. Questions from the audience were on the application of drain plugs as an effective CUI mitigation technique and how to use the EFC 55 guidance document. Members of the audience provided useful insight into historical practices of CUI and how this could lead to problems in the future as the Q&A session evolved into an open technical discussion.

The ICorr branch chairman thanked the speaker for his presentation and urged new/intending members to contact the committee members for more information on ICorr. PET booklets, Corrosion Management magazines and continuous professional development certificates were distributed to members immediately after the meeting.

More information about the Aberdeen branch activities can be got from the ICorr Aberdeen branch Secretary, Frances Blackburn, ICorrABZ@gmail.com. Alternatively, a calendar of local events of interest to corrosion professionals in the Aberdeen area and the opportunity to sign up to the branch mailing list is available at https://sites.google.com/site/icorrabz/home.
Rectifier Technologies, a leading Designer and Manufacturer of Impressed Current Cathodic Protection Power Supplies utilizing high efficiency Switch Mode technology, has pleasure in releasing the latest addition to its family of Rectifiers.

The RTD CP500 Power Supply is a Switched Mode Supply (SMR) module designed to provide up to 500 watts of output power. It is designed to be used in conjunction with corrosion protection equipment and can interface with a wide range of CP systems. The Module can be used as a stand alone unit or as part of a bank of modules for greater power. The CP500 is small and efficient and has a built in supervisory system which allows it to interface with external communications.

The Input is Universal, single phase, 85 – 264v AC with efficiency greater than 90% and power factor better than 98% with AC ripple on the DC line less than 1% at full load. It can operate in constant voltage, constant current or automatic modes. It has inbuilt interrupt facilities and USB interface for communications link to a PC and an interface for GPS option. Facility is provided for connection to a reference cell or external cell module.

Operating Temperature Range is -20°C to 50°C.

Used in conjunction with this Rectifier is a Programmer Module designed for initial setup via a CAN BUS interface. The Programmer can be used as a removable module, for system inspection only, or as a fixed module for use with a backplane. When fitted to a backplane the programmer can be used for continuous system monitoring and control. It features an alphanumeric display and two simple user controls.

Amongst other functions the Programmer is utilised to set Interrupter timings and GPS Synchronization, zone control and remote comms options. Once the parameters have been set they are loaded into the rectifier and will remain as fixed settings unless reprogrammed.

Setting the Programmer is simple. The rotary encoder scrolls round the internal modes allowing the operator to easily update any system variables. The digital alphanumeric display ensures that user information can be read accurately, even in low light conditions.

The mechanical format can be Stand alone Rectifier (Minimum format) - Stand alone with full Side plane mounting Programmer (single pluggable connection between Rectifier and Programmer) – Stand alone with parallel modules (single programmer, offering current sharing between modules) – Magazine system with parallel modules (single programmer, offering current sharing between modules).

All options can be supplied either Wall or Cabinet mounted.

For more information contact: Rectifier Technologies Ltd., Sturmer Road, Haverhill, Suffolk, CB9 7UU, England.
T: +44 (0) 1440 706777  F: +44 (0) 1440 762810  www.rtuk.co.uk
GPL Civil Engineering Limited is a unique and professional company that prides itself on the ability to deliver a quality service to all its clients within the Rail, Civil, Utility and Building Industries. This commitment and ability to develop has led to the formation of GPL Special Projects Ltd. With surface preparation and coatings application at its core GPL Special Projects Ltd can boast 30+ years combined experience through qualified staff and fully trained operatives in the protective coatings industry and can deliver numerous niche services as highlighted below:

- Surface preparation including shot blasting
- Protective coating systems
- Waterproofing – Stirling Lloyd Hytec Approved Applicator
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- Concrete repairs
- Decorative coatings
- Tank linings

GPL are proud of the investments made in personnel and service provision, with a busy training regime that identifies the requirements of individuals and provides them with an ongoing development and education process. The GPL company ethos is to provide a quality product, produced in accordance with all Environmental and Health and Safety responsibilities, within the designated timescale to the satisfaction of the client. GPL believe in working closely with clients to provide professional assistance and advice on many construction processes from the initial planning of the works through to the development of work plans and methodology and then undertaking applications.

GPL are not afraid of adopting new and innovative processes and at all times remain flexible and capable of adapting working practices to suit differing ambient conditions together with programme restraints and environmentally sensitive situations.

GPL Special Projects Ltd now hold the following accreditations:
- Sector scheme 19a Highways
- Link Up
- ICATS registered
- Stirling Lloyd Hytec approved Applicator status

### Mount Sion Footbridge Refurbishment, Radcliffe

**Client:** Bury Council  
**Start Date:** March 2012  
**Duration:** 8 weeks  
**Value:** £130,000

GPL Special Projects have recently procured its first direct contract for Bury Council and will soon commence works to refurbish an existing steel footbridge over the River Irwell in Radcliffe near Manchester.

The works comprise surface preparation using both shot blasting and hand preparation techniques; replacement of a number of items of steelwork including parapets, priming of the substructure and superstructure before finally re-painting. The work will be carefully undertaken to ensure the integrity of existing services and asbestos pipework. All works will be completed from a fully encapsulated scaffold structure spanning the River Irwell with maximum care being taken to ensure that works progress in a safe and environmentally sensitive manner.

For more information please visit www.gplcivils.co.uk or contact: Mr Ben Jones, Special Projects Director  Tel: 0161 7457888
One of Belfast’s road bridges is about to emerge from major refurbishment, a challenging job completed against tight deadlines. The coating contractors are RHINOCEROS, a quickly growing infrastructure maintenance company based in London.

2012 is a special year for Belfast: not only is it the Titanic Centenary year, but also the Queen’s Diamond Jubilee. A landmark common to both is the Queen Elizabeth II Bridge. The bridge was opened by the Queen in 1967, and spans the River Lagan just a seagull’s hop from the Harland and Wolff yard which launched the most famous ship in history. The massive shipyard gantries are now sadly quiet, but the Queen Elizabeth II Bridge is busier than ever. The Department for Regional Development Northern Ireland decided late last year to give it a proper refurbishment as part of the Belfast City’s preparations for 2012.

The contract was always going to present special problems, and RHINOCEROS sent an experienced Contract Manager, Bill Prendergast, to inspect the Bridge and prepare their plan. Time was already tight – the deadline was April 2012 and the contract was only awarded in December 2011. Inspections revealed extensive corrosion and failure of existing coatings, most visibly on the parapets and handrails. The beams underneath were worse: pigeons had deposited up to 7” of guano throughout the structure, and the existing chlorinated rubber coatings were severely damaged.

Refurbishing any transport infrastructure can be a logistical headache. The Bridge had to be kept open to road and foot traffic throughout the operation, and there were plenty of minor inconveniences, such as a one-way system which meant a City centre detour to move supplies and plant from one end of the Bridge to the other. On top of that, work was to start in February, when cold and damp could be expected to be at their worst.

RHINOCEROS built its early reputation on graffiti removal and anti-graffiti coatings, but are now just as likely to be seen tackling large infrastructure maintenance projects all over the country, and beyond. Lateral thinking and problem-solving approach has won the RHINOCEROS team friends in many maintenance departments. Bill cut his teeth in the Southampton marine industry and works both as a Contractors Manager and as a Paint Inspector with ICORR Level 3 accreditation. His team are all ICATS accredited, or working hard to complete their ICATS training under Bill’s active supervision.

Concrete refurbishment was being done concurrently by Graham Structural Solutions of Belfast, and they planned to control the temperature and humidity at levels which would allow painting by installing a Wacker Neuson ground heater. This powerful US built heater is designed for thawing out frozen ground and heating very large buildings. Calculations showed the device could heat the entire structure by 1 degree C in 24 hours, so less than a week would be needed to take it from 0 degrees C to a workable 5 degrees Celsius. In fact, Bill says the heating was so efficient that his workmen were able to do most of their work at a comfortable 15 degrees C.

The bridge had previously been painted with up to 6 coats of chlorinated rubber. Consultations between RHINOCEROS, Belfast’s Road Agency and Mike Taylor of PPG/ Sigma resulted in a specification for 40% blast cleaning to SA 2.5, with the remainder of the structure being sweep blasted to remove only the top chlorinated rubber.

Mike Taylor says “From experience with Highways Agency bridges, over-coating these types of systems can be fraught with difficulty. Applying an epoxy system such as HA115, HA116, HA168, over the physical drying chlorinated rubber systems has led to experiences of cracking, delamination and crazing.

Success is measured on the long term adhesion of the coatings to all the different surfaces of the structure. External areas on outer beams that are subject to sun and temperature rises and falls are far more difficult to coat successfully because of the difference in thermal characteristics of the chlorinated rubber compared with the epoxy. The chlorinated rubber will expand and contract with temperature whereas the epoxy is more rigid and if applied over the chlorinated rubber is likely to crack.

Experience from other Highways Agency bridges has shown that on outer beams the best option is to remove the existing chlorinated rubber system by abrasive blast cleaning and apply a new epoxy system. The under deck areas, where the existing chlorinated rubber system is more sheltered from the temperature fluctuations, can possibly be treated with an epoxy system. It has been found that spot priming with HA Item 115 and then applying HA Item 112 and HA Item 168 can be successful. HA Item 112 is preferred because from experience it is more flexible than HA Item 116 and therefore less prone to cracking because of the micaceous iron oxide pigmentation. It has also been found that the chlorinated rubber systems can have a powdery surface and this is best removed by slight sweep blasting before over coating with the epoxy system.”

The choice of abrasive was also critical. Gerry Bourke of Scangrit said Olivine was the preferred option when blasting above rivers: “Olivine AF530 and Olivine AF5 20 will achieve “Medium” blast profiles on mild steel as defined by BS EN ISO 8503-1:1995. A medium blast profile is defined as being between 50 and 70 microns and up to 85 micron.

“In an independent Testing of Expendable Abrasives conducted by PERA on behalf of Scangrit, Olivine AF530 achieved a blast profile of 52.9um and Olivine AF520 achieved a blast profile of 68.5um. The tests were conducted with a compressor rated at 350cfm at 100psi delivery pressure. The blast nozzle was a venturi type having a nozzle bore of 3/8”. Pressure measured in the grit delivery hose, behind the blast nozzle, was 60psi.”
RHINOCEROS Manager Duncan J MacLean says Olivine also has the advantage of being a natural mineral - in the event of a spill or a tear in the containment sheeting no environmental contamination would be caused. "In practice this has proved to be a smart move. The men like it and say they never want to go back to using copper slag. It has proved to be highly efficient in removing the 6 coats of chlorinated rubber. The AF530 or medium grit has proved to be ideal for sweep blasting the chlorinated rubber. The AF520, a coarser grade, has produced a profile which exceeds that required by the paint and has satisfied the client that his paint is going to stick to the bridge for a very long time!"

After heating the area, it took over 100 tons of Olivine for blast cleaning, the waste having to be vacuum cleaned off the Terram protective sheeting and hauled up to the road surface in large buckets.

The first coating of Sigma 690 was applied by airless spray to a depth of 150 microns. A stripe coat over joints and rivets followed, using Sigma Micaceous Iron Oxide (MIO) to 75 microns. This was covered with a further full sprayed coat of MIO to 150 microns, and finally a top coat of Sigma 550 to 50 microns, in Belfast signature colour Neptune.

The parapets and handrails were taken to bare metal SA 2.5, then coated with Sigma 456, a further spray coating of Sigma 456 and a top coating of Sigma 550 in Blueberry and Turquoise.

The Titanic continues to generate controversy; latest theories suggest its hull failure might have been quickened due to excessive sulphur content in the steel. But above water level Belfast is about to unveil a very attractive example of the best modern refurbishment techniques.

**HANKINSON PAINTING GROUP**

**HANKINSON RESTORE ANCIENT STRUCTURE**

The Blasting Division of Hankinson Painting Group were recently involved in the restoration of the main span of Powick New Bridge, a Grade II listed structure which carries the A449 over the River Teme, approximately 2 miles South West of the City of Worcester. The bridge was built in 1837 and consists of two side spans and one main span – the main span taking the road across the river.

The main span (approximately 21 metres in length) consists of 7 No cast iron arch ribs and deck plates supported on sandstone abutments. Access to the structure was carried out using a fully encapsulated hung scaffold. Due to the environmentally sensitive location (river and flood plain) of the bridge no scaffold could be erected from ground level.

Treatment of the structure consisted of full fresh water wash down followed by abrasive blasting of the cast iron using Garnet media (approximately 16 tonne). This was then followed by applying a 5-coat epoxy paint system (approximately 950 litres in total) provided by Hempel Paints and a compatible metal filler (approx. 60 litres) to all blow holes (honeycomb-which is common in cast iron steelwork). All joints/interfaces were treated using a compatible polysulphide sealant. External side elevations of the Main Span were then picked out in various colours, which were chosen by the client.

Once all works were completed the scaffold was dismantled and all contact points were prepared and treated by specialist rope access operatives.

Although not a requirement of the contract, all procedures were carried out in accordance with the National Highways Sector Scheme for Corrosion Protection of Ferrous Materials by Industrial Coatings (NHSS19A) and all operatives were ICATS accredited.

Operations Manager, Frank Kershaw commented “The works to the Grade II listed structure required not only the ability to perform technically challenging operations but also for our operatives to incorporate their artistic skills to complete the works to the crest heraldry. I would like to take this opportunity to commend the labour force who worked on the scheme”.

All waste generated from the works was collected and securely stored prior to removal to a suitably licenced waste transfer facility in accordance with the Company’s ISO14001 procedures.

The contract has recently been shortlisted in the Industrial Category of the Painting & Decorating Association Premier Trophy Awards.

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**Main Supplier Details:-**

**Item:** Protective Coatings  
**Supplier:** Hempel Paints  
**Materials:**  
Item 115 - Hempadur Mastic 8588E - 19910  
Item 116 (Stripe) - Hempadur Mastic 8588E  
Item 116 - Hempadur Mastic 8588E - 17050  
Item 116 (Stripe) - Hempadur Mastic 8588E  
Item 169 - Hempathane Topcoat 5521E – 12-8-21  
**Special/Other Products Used:-**  
**Item:** Metal Filler  
**Supplier:** Hempel Paints  
**Material:** Hempel ProFiller 35370  
**Item:** Polysulphide Sealant  
**Supplier:** Adshead Ratcliffe  
**Material:** Arbokol 1000

For more information please contact: Central House, Lyng Lane, West Bromwich, West Midlands B70 7RW  
Telephone: 0870 789 2020  
email: sales@hankinson.co.uk  
website: www.hankinson.co.uk
MPM North West Ltd is a family business, owned by the Hawkins family, based at Maryport Marina in West Cumbria. The core business is boatbuilding, repair and maintenance and, over the years, the company has gained great experience in the application of coatings to cope with the most extreme environments. It was this experience along with specialist knowledge of rigging systems, that allowed MPM North West to win the contract to repair and repaint Blackpool Tower.

The job started in 2008 on an eight year contract, now slightly less due to the period of accelerated works in 2011 to get the new Tower Eye attraction ready to open for Merlin Entertainments who are the operators of Blackpool Tower for the Tower’s owners Blackpool Council.

MPM North West took possession of the site as Principle Contractors and established a CDM regime which they manage from their offices which they established at the 80 foot, rooftop, level. Workshop and welfare facilities were set up too along with a small tower crane which was cantilevered from a custom built base platform attached to the north western Tower leg.

To access all parts of the Tower structure MPMNW install scaffold decks sequentially with the scaffold components being delivered early morning at the base of the Tower from where they are hoisted to rooftop level by the tower crane. From there MPMNW use the same lifts as the public to transfer the scaffold and blasting then commences. The water blasting is carried out using Jetstream Europe twin gun machines with Barracuda rotating heads made by Stoneage Waterblast Tools working at a pressure of around 32,000 PSI. Operators have to undergo safety training and must wear protective body armour and steel reinforced wellingtons to protect them from the force of the water.

The stripped bare steelwork is immediately coated with a single application of weldable primer using airless spray equipment, by Graco, at an operating pressure of 6,800 PSI. Inspections are then carried out by BWB Structural Engineers and MPMNW to evaluate the degree of corrosion sustained by the plates, bars, rolled sections and the millions of fixings, rivets and bolts, which make up the tower. Those corroded steel components with degradation in excess of 20% are removed and replaced with new steel.

MPMNW collaborated with Amtec Consultants Ltd and the technical staff of Hempel’s Paints to developed the new coating system for the Tower; Hempel was founded in 1915 in Denmark so that company’s history is nearly as old at the Tower itself which opened in 1894. Three coats are applied, two coats of two pack epoxy paint, and a top coat of two pack polyurethane giving a minimum of 300 microns DFT. The top coat is red and cannot be changed without listed building consent as the Tower is a Grade One listed building. Interestingly, this colour has changed once when permission was granted for the Tower to be painted gold for its centenary celebrations.

The paint is being spray, brush and roller applied to suit the particular access issues throughout the complex steelwork structure. At laminar joints where there is a risk of insufficient paint penetration all joints are caulked with Sikaflex prior to the completion of the coating system and potential water traps are prevented by the judicious application of the same product. Preparations and coatings are inspected by MPMNW’s Inspector with auditing services provided by Amtec Consultants Ltd.

The existing paint being removed from the Tower is lead based so all waste is treated as hazardous and is collected and contained within sealed drums. These are removed down to rooftop level for storage prior to craning off for transport and disposal at licensed sites under Environment Agency approved procedures. Stringent PPE routines are practiced by MPMNW’s employees and the health of workers is monitored by regular blood tests.

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Tower Facts

- Opened on 14th May 1894
- 118 years old this year
- 518 feet 9 inches high 158 metres
- Grade on listed building
- Member of the Wold federation of Great Towers
- Cost of building £290,000
- 2,500 tons of steel
- 93 tons of cast iron
- Original admission 6d plus 6d to go to top
- The Circus is positioned at the base of the Tower between the four legs
- The Circus ring when flooded can hold 42,000 gallons of water
- The present Ballroom was designed by Frank Matcham
- The ballroom floor measures 120 feet x 102 feet comprising of 30,602 blocks of Mahogany, Oak and Walnut
Galvanizing has long been used within the construction industry to protect steel from corrosion, not only because of its ease of application, cost effectiveness and long-term durability, but because of its inherently sustainable qualities. Ongoing technological advances and new product developments have made galvanizing an increasingly environmentally-friendly finish, one which can be incorporated into a variety of construction projects, both large and small-scale. Trevor Beech of Wedge Group Galvanizing, the UK's largest hot-dip galvanizing organisation, outlines some of the key benefits of galvanizing and its sustainable qualities, as well as highlighting a newly developed paint which has been produced specifically for use with galvanized steel.

"Steel is a vital raw material in the construction process, but it is highly prone to corrosion. In fact, figures suggest that approximately 4% of the world's GDP is lost each year due to corrosion, with one tonne of steel turning to rust every 90 seconds – for every two tonnes of new steel produced, one is made simply to replace metal lost due to rust.

The process of galvanizing involves clean steel being dipped into molten zinc at temperatures up to 450˚C, where a series of zinc-iron alloy layers are formed to create a protective coating which can provide up to 60 years of maintenance-free life.

As a process, galvanizing results in minimal waste, as any zinc that doesn’t instantly form a coating on the metal, remains in the galvanizing bath and is subsequently reused. Indeed, zinc’s non-ferrous characteristics enable it to be recycled again and again without any loss of its physical or chemical properties. Of course, galvanizing really comes into its own as a sustainable finish because of its one-off nature – the process only needs to be carried out at the beginning of the construction project, but result in an effective and long-lasting protection against corrosion. There's no need for the process to be repeated, and there's no requirement for time and cost-intensive maintenance. At end of life the galvanized products can also be removed, re-galvanized and re-used, as well as being easily recycled with scrap created in the steel production process.

The industry has also taken significant steps over the past few years to enhance the process to reduce its overall environmental impact, moves which Wedge Group has helped to lead the way. As a company, we have implemented a number of highly-innovative elements to reduce waste and improve energy efficiency. For example, we have introduced sophisticated rainwater harvesting and sustainable drainage systems at the majority of our 14 plants across the UK, which has minimised the reliance on mains supply.

Once steelwork has been galvanized, there can be a requirement to add colour to the finish, perhaps to complement a company's existing branding. This can lead to major issues with adhesion, as most types of paint simply cannot bond adequately to the surface. To ensure that the paint remains on the surface of the steel, the paint must be compatible with the galvanized coating, a combination that will provide unparalleled corrosion protection.

Wedge Group Galvanizing is currently the sole UK distributor of Galvacoat, a two-component polyurethane-based paint system which has been specifically designed for use on galvanized steel. Galvanizing provides an ideal primer for the paint, which is available in all RAL and BS colours at different levels of gloss, allowing the end contractor a huge degree of design freedom. Once applied to galvanized steel via its one coat system, Galvacoat can last for a minimum of 8-10 years, eliminating the need for repeated on-site maintenance and replacement costs. It has already proven to be a popular solution for specialist signage manufacturer ASG, who recently used the paint on steel gantries installed on the forecourts of every Tesco petrol station in the UK."
INFLUENCE OF CORROSION ON DESIGN OF MARINE STRUCTURES

Ali Sarandily, Technical Director, Ports & Marine, AECOM Perth, Western Australia AUSTRALIA.

ABSTRACT

This paper is about a study which show how a design life of 50 years for steel marine structures in a severe marine environment in terms of corrosion can be achieved. The study has looked at:
- Selection of material and form of construction
- Corrosion rates in various zones
- Influence of marine environment on corrosion and mechanism of corrosion; and

1. Understanding of the mechanisms of corrosion and corrosion issues relating to design is the first and most important step in corrosion control;
2. The occurrence of corrosion in marine structures is as simple as:
   A + B = C
   Where:
   A: Aggressive Marine Environment;
   B: Bad Design/detailing; and
   C: Concentrated Corrosion

The common factor in all the above is the "prevent the formation of corrosion cell principle" which relies on the designer having an understanding and awareness of the mechanism of corrosion and corrosion cell formation. The designer must consider the "prevent the formation of corrosion cell principle" while formulating steel design details for marine structures.

KEY WORDS

Uniform and concentrated corrosion, durability of marine structures, and marine environment.

1.0 INTRODUCTION

When it comes to corrosion and durability of marine structures, there is a belief among maritime engineers that corrosion will not occur and marine structures normally remain durable if they are fully protected by cathodic protection or if the steel structure has sufficient corrosion protective coating.

This may be true for uniform and general corrosion which occurs in a homogenous material and a member with no difference in electrical potential between any points on the surface. However, the corrosion rate accelerates and becomes more concentrated due to bad design or material choice or a combination of the two, where cathodic protection will not be effective.

This occurs because normally engineers design the structures and refer to relevant "codes of Practices" to cover the corrosion by ignoring the principles and basis of corrosion and how and why it occurs. The objective of this paper is to look at:
- A case study to understand the material choice and form of design that is intended to achieve the design life of the structure;
- The basis and forms of corrosion and factors that affect the corrosivity; and
- Provide a general awareness that engineers could follow to minimize the effect of corrosion in marine structures by adopting "prevent the formation of corrosion cell principle".

Corrosion occurs on unprotected steel structures in any location, and varies in intensity depending on local variables but it is the localized and aggressive corrosion in the marine environment that if it is not dealt with, may cause the marine structure to fail. The localised corrosion can occur when:

- Dissimilar metals are in contact or joined together; or
- A detail exists that allows penetration, retention or trapping of moisture or water; or
- A steel member is constantly exposed to wetting and drying conditions

Many mistakenly believe that application of a coating system or cathodic protection will eliminate corrosion but the coating system hasn’t prevented the corrosion of Delta Pier in and below the Splash Zone where the bond between the flame sprayed thermoplastic coating and the steel sheet pile has failed and re-exposed the structure to the corrosive environment.

Engineers often apply time-honored methods to protect maritime structures against corrosion with little or no understanding of the principles behind them. The goal of this paper is to encourage engineers to think more about the root cause of the various types of corrosion in marine structures and apply the "prevent the formation of corrosion cell principle" to overcome the occurrence of corrosion.

The majority of marine structures are made of carbon steel members or carbon steel (i.e. steel reinforcement) embedded in concrete members or a combination of the two. They are subjected to harsh environmental conditions and loads. The common approach is to design the structure to resist the environmental loads (i.e. ocean wave, current and tidal actions etc.) but the design for durability comes into 2nd place, and if it is overlooked, this may lead to catastrophic consequences.

There are many different technical reasons for Marine Structures to fail and failure is normally a consequence of a combination of different factors. However failure due to corrosion could occur if the concentrated corrosion coincides with the highly stressed bending zone of structural members.

There has been no reported catastrophic failure due to corrosion in operational marine structures but following highlights the failure of Bridge structures due to Accelerated Low Water Corrosion (ALWC) of piles.

An engineering report, investigating the collapse of a Northern Territory bridge, found that two steel piles of the Adelaide River Bridge were completely corroded through the base. This was believed to be caused by a number of factors, including a sulphate reducing bacteria which had attacked the steel pile and which had not previously been known to exist in tropical conditions.

For many marine steel structures the issue of corrosion is one of uniform or concentrated corrosion and the design life of marine structures is normally 50 years and the need to design, detail and construct a durable and a functional structure, requires a detailed understanding of:
- material selection and form of design and its fabrication;
the surrounding environment and its effect on durability of the structure; and

basis and mechanism of corrosion and how and when it occurs.

All of the above are required so that the intended design life can be achieved by providing a design solution to corrosion problems in the marine environment.

The reason for selecting this case study is that the author was responsible for the design and design management of this marine structure and ensured that the durability of structure was addressed at the design stage and not at the maintenance stage which is normally too late and not cost effective.

2.0 CASE STUDY

2.1 Harriet and Nelson Point Jetties in Port Hedland, Australia

Harriet and Nelson Point loading Jetties are located at Port Hedland (approximately 1600 Km from Perth), in Western Australia where two new berths will be located at each jetty with capacity to accommodate Cape Class vessels to a maximum of 250,000 DWT (Dead Weight Tonne) at each berth. The length of each jetty is 865m and the width is approximately 30m (Figure 1). The requirement was to design an economical width is approximately 30m (Figure 1). The length of each jetty is 865m and the width is approximately 30m (Figure 1). The requirement was to design an economical

2.1.1 Selection of Material and Form of Construction

The question of material selection and form of construction is crucial for the long term corrosion prevention of jetty structures as it is required to withstand the extreme load combinations while allowing uninterrupted loading of iron ore to continue. Therefore, a suitable material needs to be robust to transfer the applied load to the foundations as well as retaining service life for 50 years in corrosive marine environment with minimum preventive measure without significant maintenance work.

There is really no simple rule for choice of material in the design of marine structures, it is normally based on the Company or designer’s experience on similar projects and:

Cost and their availability;

Design parameters;

Service life;

Short fabrication and installation time;

Applied load; and

Seabed condition

The Norsok Standard M-001 which is commonly used for material selection, recommends that the choice of material shall be such that, general, pitting and crevice corrosions can cost effectively be prevented. This is true but the fabrication method and the corrosion rate of the material are equally important as they both influence the corrosion.

The construction material for this type of structure is usually a combination of carbon steel and reinforced concrete members. The most common Jetty construction consists of circular carbon steel piles supporting a concrete or steel frame deck system and in Western Australia the general approach for the construction is a modular construction with limited site works. This is to prefabricate offsite a complete section and then transport to site by heavy lift ship or semi-submersible vessel for final installation. The reason being that modular construction provides "high quality" product and fewer defects as it will be carried out under a controlled environment.

The construction material for marine structures differs from country to country. For example the author has experienced that concrete marine structures are more commonly used in Hong Kong and Persian Gulf countries than in United Kingdom and Australia and the reason behind this is purely economics but the marine environment of these countries can also be more polluted so corrosion prevention of steel structures in polluted marine environments is not very cost effective.

2.1.1.1 Choice of Carbon Steel as a Construction Material for main framing and substructure

Carbon steel has been chosen for the main framing of superstructures and substructures of this marine structure. The key driver for use of carbon steel for the main framing and substructure is its versatility to be fabricated in a form of module offsite and inspected for any defects during fabrication including welds before installation. This is to identify and eliminate the sources of corrosion hot spots as well as structural defects. Any defects during fabrication or service life due to corrosion either in the member or joints will later have a detrimental affect on stability of the structure or operation of the facilities.

2.1.1.2 Modular Construction

Modular construction techniques commonly used in the oil and gas industry for decades are now being successfully applied to some of the other large maritime projects undertaken in Australia. After fabrication offshore, wharf modules are normally transported by heavy lift ship to the site, transferred onto their final positions by the ship's Cranes. Figure 2 below shows an example of box girder beams where the weld details can easily be inspected before assembly.

The initial motivation for using modular construction was because of over-riding requirements for speed of construction and site safety when working over water, improved quality, and for an early return of investment. The same conclusion was also echoed in the 4th International Modular Construction & Pre-Assembled Fabrications Conference, recently held in Perth, but they also stated that the modular construction also provided high quality and few defected products with lower cost which is critical for achieving the intended design life of the structure.

It has also been proven that use of offsite fabrication is very effective in terms of function, quality, time, cost and operative safety.
2.1.1.3 Corrosion Rate Classification for Carbon Steel

When a designer is selecting a construction material, the corrosion rate figures for the material must be known so that the designer can determine how much sacrificial corrosion allowance is required when a preventive measure to corrosion is designed. Different materials have varying corrosion rates depending on specific environments.

Table 25 in BS6349 "Code of Practice for Maritime Structures" (table 1 below) provides corrosion rates for unprotected structural steels in temperate climate in mm/side/year.

Hong Kong Port Works manual\(^1\) follows BS6349\(^2\) with the exception that the corrosion in splash and below seabed zones are 0.5 and 0.04 mm per year respectively.

2.1.2 Influence of Marine Environment on Corrosion

Davis et al states that Marine Environmental conditions do influence the corrosion of marine structures, and there is quite often a definite relationship between the corrosion rate and the protective current density required to prevent corrosion\(^4\). For example a cathodic protection system designed for an offshore platform or drilling rig in the Gulf of Mexico may not operate with the desired results in the North Sea area. A cathodic protection system designed for corrosion prevention on a structure in open sea water would not perform satisfactorily for the same structure in brackish water (i.e. mixtures of fresh and salt waters found in tidal bays and estuaries) or polluted waters. Therefore in order to understand how the marine environment may influence corrosion, it is important to have an understanding of the environment of the structure and whether it will have an additional affect on the corrosivity of the structures as seawater becomes more corrosive due to its higher conductivity and chloride ion content compared to say Brackish waters\(^15\).

There is also a degree of agreement that the corrosion of carbon steel and its severity in the marine environment depends on many parameters including temperature, dissolved oxygen content, salinity, water chemistry, pH, biofouling, fluid velocity and surface roughness, but the current velocity and temperature variations particularly affect the corrosion rate. For example some work has shown that the corrosion rate of carbon steel is linear up to water velocity of 2 m/s and non linear between 2 and 6 m/s by using an experimental method of holding a carbon steel pipe 150mm long by 12.5mm to 50mm diameter in a recirculating system with seawater at 23°C. There is a monotonic decrease in the rate as water velocity increases further while others\(^19\) report that their field test data shows that the current velocity increases the corrosion rate of carbon steel under tidal conditions non linearly up to maximum current velocity of 1 m/s where 1 m/s was the peak current velocity of the test field location. However, the comparison results show that the overall corrosion loss in both cases are similar so the overall design approach will not be affected.

As a general principle the corrosion rate also increases with temperature but other variables such as oxygen concentration and biological activity must also be considered\(^17\).

2.1.3 Basis and Mechanism of Corrosion in Carbon Steel and how it relates to preventive measures

Corrosion manifests itself in many ways so an understanding of the basis and mechanism of corrosion and how and when it occurs will allow the designer to provide a design solution to corrosion problems in marine environment in order to achieve the intended design life of the structure.

Unlike the Oil and Gas industry, a corrosion engineer is not usually part of the design team of marine structures except for design of cathodic protection systems where a corrosion engineer is employed. Hence the whole design process is designed and managed by a maritime engineer often with little knowledge of basis of corrosion except that of code requirements. Zaki Ahmad states that it is important the designer have an understanding and awareness of "corrosion" problems and more often, more attention is paid to selection of "corrosion" resistant materials for specific environment, and a minimal consideration is given to design and detailing.

Therefore in order to understand the requirements for corrosion protection and to make an appropriate judgement on the corrosion and corrosion prevention of marine structures we need to have an appreciation of

<table>
<thead>
<tr>
<th>Factors</th>
<th>Average (mm/side/year)</th>
<th>Upper limit values (mm/side/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric zone – above splash zone and where direct wave or spray impingement is infrequent (i.e. in the dry)</td>
<td>0.04</td>
<td>0.10</td>
</tr>
<tr>
<td>Splash zone – above mean high water spring level</td>
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<td>0.17</td>
</tr>
<tr>
<td>Tidal zone – between mean high water and mean low water spring level</td>
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<td>0.10</td>
</tr>
<tr>
<td>Intertidal low water zone – between low water spring and 0.5m below lowest astronomical tide</td>
<td>0.08</td>
<td>0.17</td>
</tr>
<tr>
<td>Continuous immersed zone – from 0.5m below lowest astronomical tide to seabed level</td>
<td>0.04</td>
<td>0.13</td>
</tr>
<tr>
<td>Below seabed level</td>
<td>-</td>
<td>0.015 max.</td>
</tr>
</tbody>
</table>

Table 1: Corrosion rates of carbon steel in marine environment as per BS6349 table 25
how the corrosion cells are created which lead to corrosion. 21

A basic corrosion cell consists of:
- Anode site, where corrosion occurs and from which current flows;
- Cathode site, where no corrosion occurs and to which current flows;
- Electrolyte, a medium capable of conducting electric current by ionic current flow (i.e. water, or saturated concrete);
- Metallic path, connection between the anode and cathode, which allows current return and completes the circuit.

and they are all required for corrosion to occur. The driving force behind corrosion is a corrosion cell that is electrochemical in nature; that is, involves chemical reactions and the transport of electrons. The driving force behind the corrosion cell is a potential or voltage difference between the anode and cathode, which leads to corrosion to occur.

The corrosion cell (i.e. potential difference) can be created if:
- Unprotected steel surface is in contact with electrolyte which could be either a film of moisture or seawater;
- Dissimilar metals are in contact or joined together;
- A detail exists that allows penetration, retention or trapping of moisture or water; and
- Steel member is constantly exposed to wetting and drying conditions.

The above are some examples of the corrosion cell creators in their simplest form and if the formation of corrosion cell is prevented, then corrosion can be prevented and the intended design life of the marine structure can be achieved. We name this approach “prevent the formation of corrosion cell principle”. In order to accomplish this, the designer must have an understanding and awareness of corrosion cell formation during the design and detailing process of the structure. We will explore this in some detail to understand the mechanism and formation of the corrosion cell and how it can be prevented.

2.1.3.1 Unprotected steel surface in contact with electrolyte

Atmospheric zone adjacent to jetty is laden with wind-swept fine particles of sea salt (i.e. sodium chloride) that is highly corrosive and deposits on nuts and bolting and surface of the structure surfaces 22 & 23. The sodium chloride could be dispersed either as liquid aerosol or dry particles 24, and it will provide catalyst for corrosion which is known to occur at relative humidity as low as 35% 25.

When the unprotected steel surface is contact with an electrolyte such as seawater or a film of moisture containing dissolved salts, an electrochemical process occurs which leads to corrosion 26. All metals in contact with an electrolyte have an electrochemical potential that is specific for the metal/electrolyte combination. Different metals have different potentials in a specific electrolyte. At the surface of one metal in an electrolyte, there are anodic and cathodic areas, which have small differences in potential. They form active electrochemical cells in which current flows from the anodic areas into the electrolyte, and from the electrolyte into the cathodic areas.

The prime example of this scenario is the primary and secondary steel members of a jetty structure and if it is left unprotected, or badly protected, cell corrosion will be created on its surface which will lead to corrosion. Hence to prevent the creation of the corrosion cells, all the primary and secondary members as shown in Figure 2 are coated with an anti-corrosion system to prevent the creation of the corrosion cells.

2.1.3.2 Dissimilar metals are in contact or joined together

Although dissimilar metals such as stainless steel anchor bolts aren’t encouraged for use in marine environment, there are places that stainless steel anchor bolts are used due to their higher yield strength. Where there are stainless steel anchor bolts in concrete, there is possibility of corrosion of the bolts, base plate or embedded carbon steel reinforcement and it is a concern for the designers as cathodic protection. Therefore proper detailing of the holding down bolts by understanding the corrosion mechanism is the key for the preventing corrosion in the structure.

Due to the nature of this Jetty Structure and its design all these details are in the atmospheric zone of the structure and figures 3 and 4 provide two examples of stainless steel holding bolts.

2.1.3.3 A detail that allows penetration, retention or trapping of moisture or water

Good design detailing is the first and most important step in corrosion control and improper detailing will create a corrosion cell in maritime structures that will lead to corrosion. The codes for steel structures provide general guidance on use of structural steel and good detailing but do not provide an in depth knowledge of the subject. BS EN ISO 12944-3 guidance for the prevention of corrosion by good design 22 detailing states that “the design of a structure can affect the durability of any protective coating applied..."
to it. Detailing is important to ensure that the protective treatment can be applied to all surfaces. Narrow gaps, difficult to reach corners, and hidden surfaces should be avoided whenever possible. Details that could potentially trap moisture and debris, which would accelerate corrosion, should also be avoided”.

Clause 59 of BS 6349: Part 11 provides general guidance on the use of structural steel and other metals in marine structures and the important points to note are as follows:

- Fabrication details should be kept as simple as possible and should be designed to avoid corrosion and facilitate maintenance;
- Tolerances for on-site connections should be generous because of the difficulties associated with working in a marine environment;
- As much prefabrication as possible should be undertaken, taking advantage of mechanised welding and early painting under factory-controlled conditions; and
- Maintenance strategy is developed to ensure that periodic inspection is carried out to enable corroded or other deteriorated members to be identified and dealt with at an early stage before it affects the integrity of the structure.

Penetration, retention or entrapment of moisture or water can be the result of many scenarios. Examples are provided in figures 5, 6 and 7 where water will be trapped and corrosion will commence by forming a corrosion cell if good design detailing is not carried out.

Example 1: Figure 5 shows a typical gusset free weld connection for a truss where the designer has only shown the weld lengths to resist the applied load but the joint as it is shown is prone to crevice corrosion as the connection has not been sealed by the weld. The solution is to fillet weld the remaining part in order to seal the joint all around.

Example 2: Figure 6 shows a typical detail of a berthing dolphin where a reinforced concrete pile cap is supported by piles. Possible crevice corrosion may occur at the point of encapsulation where steel is capped by concrete as there is no bond between them and the members are constantly exposed to wetting and drying conditions. The solution is either to coat the outer surface of steel pile right to the top and 50mm return inside the pile or adopt the reinforced concrete insitu fill option to the top 2 to 3m of pile and make the section of the pile sacrificial. Possible crevice corrosion between steel pile and concrete cap.

Example 3: Figure 7 shows a bolted connection of a module to its base plate on site. Possible crevice corrosion may occur between the base plates or bolts and base plates. The solution is to use a:

- Membrane between the coated base plates so that the gap between the steel plates is sealed; and
- Non metallic and heat and UV resistant washers in the bolts so that the gaps between the bolts and the base plates are sealed.

By sealing the gaps the penetration, retention or trapping of moisture or water can be prevented, hence the creation of a corrosion cell.

2.1.3.4 Steel Members constantly exposed to wetting and drying conditions

Exposing the steel members to constant wetting and drying condition (i.e. splash zone) will result in formation of corrosion cells that lead to aggressive and localised corrosion and has been the subject of intense study in recent years.

Corrosion in the splash zone normally encompasses several exposure zones of differing aggressivity and the corrosion performance of marine structures in these zones requires specific consideration when designing the marine structures. The classification of the zones is shown in figure 8 and they are:

- Atmospheric Zone: The atmospheric zone is located above the splash zones where the area is exposed to salt laden atmosphere;
Splash Zone: The splash zone is located between the tidal and marine atmospheric zones (i.e. above mean high-water);

Tidal and Low Water Zones: Tidal zone lies between the mean low water and mean high-water tides.

Submerged Zone: This is the zone that lies between the seabed level (including scouring zone) and 600mm -700mm below the mean low water; and

Below the seabed level: Where structure is below the seabed-level.

2.1.3.4.1 Corrosion in Atmospheric Zone

This is the area between the top of the structure and the splash zone. The corrosion of an unprotected steel structures in this zone is generally less than in the splash zone (Figure 8) but it is still significant. The corrosion and degree of severity in the atmospheric zone depends on several variables such as humidity, temperature, chloride content, wind and sunlight. For example saline particles in the atmospheric zone accelerate metallic corrosion process as chloride increases the solubility of the corrosion products. It is also reported that marine chloride dissolved in the layer of moisture also raises the conductivity of the electrolyte layer on the metal and tends to destroy the passive film existing on the metallic surface. Recent study has also demonstrated that bacteria are involved in the longer term corrosion of mild steel in the atmospheric zone.

2.1.3.4.2 Corrosion in Splash Zone and Below Waterline

A common localised and aggressive type of corrosion that occurs in splash zone and below waterline is defined as Accelerated Low Water Corrosion (ALWA) and its existences wasn’t widely recognised until 1980s. ALWA (Figure 8) is aggressive and localised and occurs on the surface of steel maritime structures in the tidal zones.

The detailed mechanism of ALWC is still not very clear and continues to be a matter of some debate but it is said it is to be one form of Microbiologically Influenced Corrosion (MIC) also known as microbial corrosion or biological corrosion. It is the deterioration of metals as a result of the metabolic activity of microorganisms.

It has been reported that when metal is first immersed in seawater, a thin biological slime fouling layer tends to develop in a matter of hours, which itself may influence the subsequent settlement of micro and macro fouling organisms. Following the micro- or macro fouling organisms attachment, large differences in oxygen concentration or pH changes can be created on metal surfaces which results in localised corrosion.

In general the intensity of corrosion of an unprotected steel structure in seawater varies markedly with position relative to the mean high and low tide level as shown in figure 8. It states that the splash zone is the most severely attacked region due to continuous contact with highly aerated sea water and the erosive effects of spray, waves and tidal actions.

Corrosion in the tidal zone (i.e. between MLW and MHW) is usually slow and uniform. The area tends to accumulate dense barnacle growths with filamentous green seaweeds. The marine growth does not corrode the material but makes the carbon steel more noble.

Corrosion in the Low water zone is relatively severe due to differential aeration at the uppermost point of continuous steel immersion, where electrolyte is permanent and oxygen levels peak, as well as that the low water zone is acting anodic relative to the tidal zone.

The area approximately 500mm below mean low water, where severe corrosion rates are often experienced is subject to Accelerated Low Water Corrosion (ALWC) and PIANC summaries the corrosion mechanism of ALWC by stating that ALWC occurs in the presence of sulphates in marine environments, which are converted by sulphate-reducing bacteria (SRB) into hydrogen sulphide (H2S) that causes direct anaerobic corrosion of steel surfaces. The H2S generated in this metabolic process also serves as a food source for...
Corrosion in the immersed zone is relatively slow and uniform (Figure 8) and in many cases the structure could be passivated by corrosion by-products or marine growth. Exception can occur at bed level, where concentrated corrosion caused by differential oxygen cells, by scouring that exposes clean steel or the presence of soil-borne SRB\(^1\).

Where the structure is below the seabed-level very little corrosion occurs as there is no oxygen and the rate given for the corrosion below seabed level is 0.05mm per year\(^13\). However if there is coarse granular material where oxygen traces are present, corrosion will occur but it is slow and uniform except if the soil is acidic or contains SRB.

2.1.3.4.3 Immersed and Embedded Zones

Corrosion in the immersed zone is relatively slow and uniform. The presence of oxygen and the rate given for the corrosion below seabed level is 0.05mm per year\(^13\). However, if there is coarse granular material where oxygen traces are present, corrosion will occur but it is slow and uniform except if the soil is acidic or contains SRB.

2.1.4 Methods for Control and Prevention of Corrosion in Marine Steel Structures

When it comes to design of preventive measures for corrosion of carbon steel in marine environment, there is no clear cut approach in corrosion industry to overcome the corrosion. How much protection is required is still debatable, the reason being that the corrosion of steel in marine environments, sometimes difficult to relate to field conditions and hence not easily transportable to other situations\(^56\). Hence the designer normally relies on operators own guidelines (based on their operational and maintenance experiences) or various specialist publications that provide guide lines for corrosion protection\(^19\). On major resources projects the 1st author has followed the operator’s more strenuous guideline on the corrosion protection rather than the code of practice (Figure 9). The following corrosion protection coating system was applied from -2mCD to top of piles, and all primary and secondary steelwork for marine structure in Port Hedland:

- Prime Coat of Intergard 269;
- Top coat of Interzone 954 applied by airless spray, two coats (wet on dry), tinted for visual differentiation;
- Total topcoat of DFT 500 microns; and
- Colour N35 light grey as a final topcoat for piles.

Impressed current cathodic protection is also installed on piles to minimise maintenance and disruption of jetty loading operations during its design life\(^40\).

ALWA is a concern for designers because the corrosion rates can be at least a factor of 10 times faster than average level corrosion resulting in a potential failure in less than 10 years\(^19\) and a novel form of naturally occurring coating that could mitigate the corrosion damage to existing structures called "LATreat" has recently been proposed\(^29\). In brief, this is a three stage protection on an existing structure:

- The first stage of the three-step process involves surface cleaning and removal of deposits via an applied voltage to the structure. Through this step, hydrogen is evolved from the surface – this helps to dislodge and remove the corrosion and associated biofilm;
- The second phase involves a voltage reversal, where chlorine is directly generated on the surface by-product of salt water electrolysis. Once the chlorine has reached a significant concentration (a few parts per million), it kills local bacteria and other microbial agents by sterilisation. It is said that it is a similar process to the chlorination of swimming pools – i.e. direct electrolysis of salt solution to produce chlorine; and
- In stage three, the applied voltage polarity is reversed again, reverting to the initial phase. The current flow, however, is controlled to a much lower value and is pulsed on and off. Instead of hydrogen, water is reduced directly by electrolysis and produces alkali locally at the structure surface.

It is reported that if the pH is altered and raised (such as by the production of alkali), the solubility of calcium carbonate (as seawater is a dilute solution of CO\(_2\) in the form of calcium bicarbonate) reduces and a film of calcium carbonate is deposited. The coating, consisting of calcium carbonate and magnesium hydroxide is deposited by a similar mechanism, as it is naturally layered by the pulsed nature of the current.

Due to all the uncertainty that surrounds the following precautions should be followed as part of the design in order to achieve the intended design life:

- Use of a heavier section
- Use of high yield steel at mild steel stress levels
- Application of Coating System; and
- Application of Cathodic Protection; or
- Combination of all above

Although all the above can be used separately or in combination to prevent general corrosion\(^1\) \& \(^41\) the only preventive action that will delay or minimise localised corrosion is the "Design for durability and good detailing".

2.1.5 What is design for durability

By understanding the corrosion mechanism (as also outlined above), the design for durability and good detailing stands at the core of corrosion control of the marine steel structure. The aim in the design should be to prevent the formation of corrosion cells
which are the catalyst for commencement of corrosion. For example if we can eliminate the formation of the electrolyte on the structures, then the commencement of corrosion will be delayed. This means that the structural detailing should be in such a way:

- To maintain adequate space between components to facilitate corrosion protection painting system to be applied;
- To avoid formation of pools of water in parts of the structure at all time;
- To ensure good drainage of water on steel members at all time;
- To fully seal hollow sections;
- To avoid placing steel members so they are inaccessible for inspection; and
- To insulate two metals from each other if two different metals are used in the design.

Hence eliminating the formation of corrosion cells. The design should be based on the "eliminate the corrosion cells principle".

The following are some examples of structural details based on idea of "eliminate the corrosion cells principle":

**Example 1**

The design was such that the top of the pile as shown in Figure 10 was sloped, hence the sea water would have been pooled and corrosion cell. The detail was modified by welding an additional plate (see Figure 10) to provide a sloped drainage system to eliminate the creation of corrosion cells in that area.

**Example 2**

Figure 11 shows detailing that provides good drainage and adequate space between components to facilitate corrosion protection painting or galvanising;

**Example 3**

The detailing of the catwalk bottom nodes at an LNG/LPG jetty (i.e. bottom structural chords intersect) was such that ponding would have occurred. Hence "Megapoxy P1" was used (Figure 12) to eliminate the ponding hence elimination of corrosion cells.

"Megapoxy P1" is a two component high strength epoxy paste based on DGEBA epoxy resin and carbonate free filler. Easy to use, this product sets after mixing with excellent properties for a wide range of applications such as metal to metal bonding.

3.0 CONCLUSION

This study has looked at a case study to show how a design life of 50 years for steel marine structures in a severe marine environment in terms of corrosion can be achieved. The study has shown that, corrosion affecting the durability of marine structures is rather a complex phenomenon and there is no single approach to the corrosion prevention of marine structures. An effective approach to corrosion prevention is a combination of the following:

1. Understanding of mechanism of corrosion and corrosion issues;
2. In the case of carbon steel marine structures:
   - good detailing;
   - offsite fabrication with good quality control; and
   - application of an appropriate coating system that forms an impregnating type barrier against the passage of seawater to the surface of the carbon steel structure.

The common factor in all the above is the "prevent the formation of corrosion cells principle" which relies on the designer having an understanding and awareness of the mechanism of corrosion and corrosion cell formation. The designer must consider the "prevent the formation of corrosion cells principle". 
principle” while formulating carbon steel design details for marine structures.

The study has also concluded that:

- Understanding of the mechanisms of corrosion and corrosion issues relating to design detailing is the first and most important step in corrosion control;
- The occurrence of corrosion in marine structures is as simple as:

\[ A + B = C \]

Where:
- A: Aggressive Marine Environment;
- B: Bad Design/detailing; and
- C: Concentrated Corrosion

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Specialist anti-corrosion and sealing products manufacturer Winn & Coales (Denso) Ltd announce that in April 2012 they are launching a new flexible rubber bitumen sealing strip system for jointing precast concrete units. The system comprises both a sealing strip and primer called Densostrip and Densostrip Primer respectively.

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Densostrip should be available from all of the normal trade outlets from April onwards.

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# ICATS Registered Companies

ICATS Registered Companies with Qualified Applicators

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Address</th>
<th>Telephone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Integrated Services Ltd</td>
<td>Unit 3, Waterton Buildings, Moor Road, Waterton Industrial Estate, Bridgend, CF31 3TR</td>
<td>01646 654054</td>
</tr>
<tr>
<td>Alltask Limited</td>
<td>Alltask House, Commissioners Road, Strood, Kent, ME2 4E</td>
<td>01634 298000</td>
</tr>
<tr>
<td>Alfred Bagnall &amp; Sons</td>
<td>6 Manor Lane, Shipley, West Yorkshire, BD18 3RD</td>
<td>01302 853259</td>
</tr>
<tr>
<td>APB Construction (UK)</td>
<td>Unit 3, Bramley Way, Hellaby Industrial Estate, Hellaby, Rotherham, S. Yorkshire, S66 8Q8</td>
<td>01709 541000</td>
</tr>
<tr>
<td>APB Group Limited</td>
<td>Ryandra House, Ryandra Business Park, Brookhouse Way, Cheadle, Staffs, ST10 1SR</td>
<td>01538 755377</td>
</tr>
<tr>
<td>Armourcote Surface Technology Plc</td>
<td>15/17 Colvilles Place, Kelvin Industrial Estate, East Kilbride, Scotland, G75 0PZ</td>
<td>01355 248223</td>
</tr>
<tr>
<td>Austin Hayes Ltd</td>
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<td>0113 250 2255</td>
</tr>
<tr>
<td>Beaver Limited</td>
<td>Little Coldharbour farm, Tong Lane, Lamberhurst, Kent, TN3 8AD, UK</td>
<td>01892 890045</td>
</tr>
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<td>Briton Fabricators Ltd</td>
<td>Watnall Road, Hucknall, Notts, NG15 6EP</td>
<td>0115 963 2901</td>
</tr>
<tr>
<td>Cape Industrial Services</td>
<td>Cape House, 3 Red Hall Avenue, Paragon Business Village, Wakefield, WF 1 2UL</td>
<td>01224 215800</td>
</tr>
<tr>
<td>Cleveland Bridge UK Ltd</td>
<td>Cleveland House, Yarm Road, Darlington, DL1 4DE</td>
<td>01325 502345</td>
</tr>
<tr>
<td>Coating Services Ltd</td>
<td>Partington Street, Mumps Bridge, Oldham, OL1 3RJ, UK</td>
<td>0161 665 1998</td>
</tr>
<tr>
<td>Collins Engineering Railway Contracts</td>
<td>Salcombe Road, Meadow Lane Industrial Estate, Alfreton, Derbyshire, DE55 7RG</td>
<td>01773 833255</td>
</tr>
<tr>
<td>Community Clean</td>
<td>11 Old Forge Road, Ferndown Industrial Estate, Ferndown, Wimborne, Dorset, BH21 7RR, UK</td>
<td>01425 6850133</td>
</tr>
<tr>
<td>Corrocoat</td>
<td>Forster Street, Leeds, LS10 1PW</td>
<td>01132760760</td>
</tr>
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<td>Denholm Industrial</td>
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<td>0141 445 3939</td>
</tr>
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<td>Dyer &amp; Butler Ltd (Rail)</td>
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<td>02380 667549</td>
</tr>
<tr>
<td>ENC (Yorkshire) Ltd</td>
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</tr>
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<td>E &amp; P Painting Contractors</td>
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</tr>
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<td>F A Clover &amp; Son Ltd</td>
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<td>Forth Estuary Transport Authority</td>
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</tr>
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<td>GABRE (UK) Ltd</td>
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<td>02882 897950</td>
</tr>
<tr>
<td>H&amp;H Painting Contractors Ltd</td>
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<td>07937 382619</td>
</tr>
<tr>
<td>HarSCO Infrastructure Services Ltd</td>
<td>Unit 3 Manby Road, South Killingholme, Immingham, North Lincolnshire, DN40 3DX</td>
<td>01469 553800</td>
</tr>
<tr>
<td>Harrisons Engineering Lancashire Ltd</td>
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</tr>
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</tr>
<tr>
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</tr>
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<td>Hi-Tech Surface Treatment Ltd</td>
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<td>Hunter Steel Coatings Ltd</td>
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<td>Hyspec Services Ltd</td>
<td>Unit 3 Meadowfield Industrial Estate, Cowdenbeath Road, Burntisland, Fife, KY3 0LH</td>
<td>01392 674661</td>
</tr>
<tr>
<td>Industrial Coating Services</td>
<td>5 Danesbury Crescent, Kingstanding, Birmingham, B44 OQP</td>
<td>0121 384 2266</td>
</tr>
<tr>
<td>Company Name</td>
<td>Address</td>
<td>Phone Number</td>
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</tr>
<tr>
<td>Industrial Painting</td>
<td>48-49 RCM Business Centres, Sandbeds Trading Estate, Dewsbury Road, Ossett, WF5 9ND</td>
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<td>International Energy Services Ltd</td>
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<td>Jack Tighe Coatings</td>
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<td>Jack Tighe Ltd</td>
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</tr>
<tr>
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<td>Lanarkshire Welding Co.</td>
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<td>Maclean &amp; Speirs Blasting Ltd</td>
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<td>01505 324777</td>
</tr>
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<td>MCL Coatings Ltd</td>
<td>Pickering Road, Halebank Industrial Estate, Widnes, Cheshire, W5B 8XW</td>
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<tr>
<td>N L Williams Group Ltd</td>
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<td>01634 256969</td>
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<td>T I Protective Coatings</td>
<td>Unit 6, Lodge Bank, Crown Lane, Horwich, Bolton, Lancs, BL6 SHU</td>
<td>01204 468080</td>
</tr>
<tr>
<td>TEMA Engineering Ltd</td>
<td>5-6 Curran Road, Cardiff, CF10 5DF, UK</td>
<td>020920 344556</td>
</tr>
<tr>
<td>ThyssenKrupp Palmers Ltd</td>
<td>1120 Elliot Court, Herald Avenue, Coventry Business Park, Coventry, CV5 6UB</td>
<td>02476 710294</td>
</tr>
<tr>
<td>Vale Protective Coatings Ltd</td>
<td>Building 152 – Langar North Industrial Estate, Harby Road, Langar, NG13 9HY</td>
<td>01949 869784</td>
</tr>
<tr>
<td>Walker Construction (UK) Ltd</td>
<td>Park Farm Road, Folkestone, Kent, CT19 5DY</td>
<td>01303 851111</td>
</tr>
<tr>
<td>Wardle Painters Ltd</td>
<td>Unit S, Wimbborne Building, Atlantic Way, Barry Docks, Glamorgan, CF63 3RA, UK</td>
<td>01446 748620</td>
</tr>
<tr>
<td>W G Beaumont &amp; Son</td>
<td>Beaumont House, 8 Bernard Road, Romford RM7 0HX</td>
<td>01708 749202</td>
</tr>
<tr>
<td>Company Name</td>
<td>Address</td>
<td>Telephone Number</td>
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<tr>
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</tr>
<tr>
<td>William Hare Ltd</td>
<td>Brandleholme House, Brandleholme Road, Burys, Lancs, BL8 1JJ, UK</td>
<td>T: 0161 609 0000</td>
</tr>
<tr>
<td>Barrier Ltd</td>
<td>Stephenson Street, Wallsend, Tyne &amp; Wear, NE28 6UE, UK</td>
<td>T: 0191 262 0510</td>
</tr>
<tr>
<td>BSM Consulting</td>
<td>11 Kingsmead, Nailsea BS48 2XH</td>
<td>T: 01275 854708</td>
</tr>
<tr>
<td>BAM Nuttall Ltd</td>
<td>St James House, Knoll Road, Camberley GU11 3XW</td>
<td>T: 0782 5798440</td>
</tr>
<tr>
<td>Celtic Specialist Treatments Ltd</td>
<td>Rosedale, Carelicken Lane, Langstone Newport, Gwent, NP18 2JZ</td>
<td>T: 01633 400194</td>
</tr>
<tr>
<td>Coastground Ltd</td>
<td>Morton Peto Road, Capton Hall Industrial, Great Yarmouth, Norfolk, NR31 OLT</td>
<td>T: 01493 650455</td>
</tr>
<tr>
<td>D&amp;D Rail Ltd</td>
<td>Time House, Time Square, Basildon Essex SS14 1DJ</td>
<td>T: 01268 520000</td>
</tr>
<tr>
<td>DRH Coatings Ltd</td>
<td>Suite 5, 3 Shawcross Industrial Estate, Ackworth Road, Portsmouth PO3 5JP</td>
<td>T: 023 9266 6165</td>
</tr>
<tr>
<td>EMS Services Ltd</td>
<td>Tank Farm Road, Llandarcy, SA10 6EN</td>
<td>T: 0800 8400564</td>
</tr>
<tr>
<td>Excel Contractors Ltd</td>
<td>11a West End Road, Bitterne, Southampton SO18 6TE</td>
<td>T: 02380 444420</td>
</tr>
<tr>
<td>Forward Protective</td>
<td>Vernon Street, Shirebrook, Mansfield Notts, NG20 8SS</td>
<td>T: 01623 748323</td>
</tr>
<tr>
<td>Gallidris Construction Ltd</td>
<td>Gallidris House, Pavillion Business Centre, Kinetic Crescent, Innova Science Park, Enfield BN3 7FJ</td>
<td>T: 01992 763000</td>
</tr>
<tr>
<td>G &amp; W Burton Ltd</td>
<td>New Court, Wooddalling, Norwich, Norfolk, NR11 6SA</td>
<td>T: 01263 584203</td>
</tr>
<tr>
<td>Hempel UK Ltd</td>
<td>Llantarnam Park, Cwmbran, Gwent, NP44 3XF</td>
<td>T: 01633 874024</td>
</tr>
<tr>
<td>IDL Fabrications Limited</td>
<td>Crabtree Lane, Clayton, Manchester, M11 4GU</td>
<td>T: 0161 2306666</td>
</tr>
<tr>
<td>Interkey Services Ltd</td>
<td>2 Princenwood Road, Corby, Northamptonshire, NN17 4AP</td>
<td>T: 01536 266607</td>
</tr>
<tr>
<td>Leighs Paints</td>
<td>Tower Works, Kestor Street, Bolton, Lancs. BL2 2AL</td>
<td>T: 0161 2306666</td>
</tr>
<tr>
<td>Malakoff Limited</td>
<td>North Ness, Lerwick, Shetland, ZE1 0LZ, UK</td>
<td>T: 01595 695544</td>
</tr>
<tr>
<td>Matthew James Services</td>
<td>Unit 4, Shibdon Business, Cowen Road Blaydon, Newcastle-Upon-Tyne, NE21 STX</td>
<td>T: 0191 414 5700</td>
</tr>
<tr>
<td>NSG UK Ltd</td>
<td>Fourth Avenue, Deeside Industrial Park, Deeside, Flintshire CH5 2NR</td>
<td>T: 01244 833138</td>
</tr>
<tr>
<td>Over Rail Services Ltd</td>
<td>Unit 10 Millhead Way, Purdys Industrial Estate, Rochford, Essex, SS4 1ND</td>
<td>T: 07976372866</td>
</tr>
<tr>
<td>Paint Inspection Ltd</td>
<td>Trafalgar House, 223 Southampton Road, Portchester, PO6 4PY</td>
<td>T: 0845 4638680</td>
</tr>
<tr>
<td>Possilpark Shotblasting Co Ltd</td>
<td>Dalmarnock Works, 73 Dunn Street, Glasgow, G40 3PE</td>
<td>T: 0141 556 6221</td>
</tr>
<tr>
<td>Radleigh Metal Coatings Ltd</td>
<td>Unit 30 Central Trading Estate, Cable Street, Wolverhampton, WV2 2HX</td>
<td>T: 01902 870606</td>
</tr>
<tr>
<td>R.L.P. Painting</td>
<td>Heathfield House, Old Bawtry Road, Finningley, Doncaster, DN9 3DD, UK</td>
<td>T: 01302 772222</td>
</tr>
<tr>
<td>Tinsley Special Products</td>
<td>Enterprise House, Durham Lane, Eaglescliffe, Stockton-on-Tees TS16 0PS</td>
<td>T: 01642 784279</td>
</tr>
</tbody>
</table>
DIARY DATES 2011/2012

12th April 2012
London Branch joint meeting with NACE, Speaker: David Harvey on 'Cathodic protection of complex structures'.
Meet at Naval Club, 38 Hill Street, London W1 17.30 for 18.15 start.

17th April 2012
Al-Zn-In Sacrificial Anodes Manufacture and Specification.
Dr Nigel Owen (Aberdeen Foundries Ltd).
Contact: Aberdeen Branch for further details.

26th April 2012
CED Working Day and Symposium on Microbial Corrosion
The Corrosion Engineering Division will be running a Spring Working Day on Thursday 26th April 2012 at the National Motorcycle Museum Conference Centre, Birmingham. The theme for the meeting will be 'Microbial Corrosion'. Please contact Nick Smart, CED chair, at nick.smart@serco.com. Further information will be posted on the Institute’s web site in due course.

3rd May 2012
London Branch Sustaining Members Sponsored Evening
Blue Badge Guided Tour of Soho.
Free to all members, family and friends.
Meet at 17.30 at Piccadilly Circus, in front of the Criterion Restaurant, as we did last year.

15th May 2012
Corrosion Fatigue Developments
Environment assisted cracking remains a major challenge across a wide range of industry and business sectors. Corrosion Fatigue is of particular significance with implications for both design and the safe and economic operation of components and structures. In this seminar, leading researchers and engineers will highlight progress in characterisation of corrosion-fatigue crack development and in life prediction for critical applications.
Contact: Registration is on-line at www.fesi.org.uk and then click on the link.
Venue: National Physical Laboratory, Teddington, UK, TW11 0LW.

22nd May 2012
Joint NACE Meeting.
Contact: Aberdeen Branch for further details.

19th June 2012
London Branch Golf Day
Silvermere Golf Club, Surrey
Contact Derek Hoskins at: dhoskins@waitrose.com

TBC – November 2012
Corrosion of Infrastructure ’Present Knowledge and Future Solutions’.
Venue: Institute of Materials, Minerals and Mining
1 Carlton House Terrace, London SW1Y 5DB
Further information along with a registration form is available to download at www.icorr.org in the conferences and events section. You can also contact Prof. Robert Akid robert.akid@manchester.ac.uk or Prof. Paul Lambert paul.lambert@mottmac.com

Diary Dates 2011/2012 continues...