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First let me wish you all a Happy New Year; 2011 was challenging for many businesses and I hope that 2012 will be better for all our membership. Now into my second year as your President I look forward to the challenge of moving the Institute forward and developing the initiatives which have developed during my first year. As I have stated before most of these are dependent on your contributions. We do not have a vast technical staff able to develop training programs write standards or produce state of the art updates on the various technologies that make up corrosion and its prevention. We rely on the input from the many members who contribute mainly time along with expertise to make the Institute what it is.

On holiday in India before Christmas I managed to achieve a long held ambition that of seeing the Delhi Pillar. Seven metres tall and weighing more than 6 tonnes it was produced by forge welding sixteen hundred years ago (although there are some authorities who suggest that it may be considerably older) and owes its corrosion resistance to the high levels of phosphorous in its composition. The pillar is now fenced to protect it from damage by tourists and therefore I was unable to test the popular tradition that it was considered good luck if one could stand with one’s back to the pillar and make one’s hands meet behind it. I have long been fascinated by the history of metallurgy and India offers many avenues for research for example wootz steel, the raw material for the best blades from Damascus and Toledo in the middle ages.

The Annual General Meeting of the Institute was held on Thursday 12th January before a London Branch meeting the minutes of the last meeting were confirmed. I gave a short report on the activities of the past year and Dr Tony Collins our Treasurer gave an explanation of the accounts. Trustees and members of Council were re-elected unopposed and George Winning was elected to join Council. The meeting took a little over half an hour and we were then treated to a fascinating insight into the issues marine coatings by Dr. Raouf Kattan.

My diary for February includes meetings of ICorr Council the Science Council and the Midlands Branch AGM but now I really must get on with completing my application for Chartered Scientist.

140 members and guests attended London Branch’s 22nd Christmas Luncheon at the Royal Overseas League in London on 1st December. The very well received guest speaker was Garry Richardson, sports presenter and interviewer for the BBC. His entertaining and humorous presentation included examples of commenting gaffs – not only by himself but by others too. He mentioned his famous interview with then U.S. President Bill Clinton in the Royal Box during a rain delay at Wimbledon. He is seen here signing autographs.
Welcome to our 134 new members, who joined in 2011 together with the congratulations of the Institute for all the members who have attained professional status in 2011.

In 2011 the following members were awarded Professional Status:

**Technician**
- Philip P Mathew
- Tahir Mehmood
- Anil Mathew
- Paul Burn
- Mark Smith
- Philip Manallo
- Stephen George Sisson
- John Blackburn

**Professional**
- Murali Narayana Embran
- Makanjuola Oki
- Robert A Burn
- Basanta Kumar Lenka
- Kuppili Prabhakara Rao
- Simon Peter Filmore
- Rajiv Assi
- Alireza Aghasadeghi
- David Dingwall
- Mohammed Arif
- Bill CRM
- Mahmoud Said Hanafy
- Arwind Kumar Dubey
- Rudi Merola
- Patrick Indravarman V Rabindran
- Michael James Nixon
- Ahmed Fathi Eid
- Ryan Wrench
- Christopher David Wozencroft
- Cristiano Padovani
- Eugene Ogosi
- Anthony Robert Foster
- Peter Frank Bullick
- Earl Lee Toups II
- Martin Yeardley
- Mohammed Javeed Shaikh
- Abirami Krishnan Gunasekaran
- Wasim Idris Baig
- Robert Grainger
- Matthew Allen
- Khun Nay Win
- B Palanivel
- Imran Ashraf
- Aftab Fakruddin Khan
- Veluppillai Vijayaraghavan
- Alberto Adacer Hallig
- Muhammad Mozammul
- Shibu Abraham

**Fellow**
- Winston William Shim
- Andrew Lyon Taylor
- Joseph Stuart Jones
- Roderick Michael Callon
- Douglas John Mills
- Asok Thomas Mathew

London Branch’s first meeting of the year at the Naval Club in January was well attended with just over 30 present. Speaker was Dr Raouf Kattan of Safinah Ltd., and his subject: Marine Coatings. Raouf indicated the common problem that whilst there may be a general knowledge of corrosion, there is often a seemingly apathetic attitude to actually putting money forward to combat it – after all - coatings are usually a tiny fraction of the total cost of projects. He emphasised that the cost of repairs can be huge when compared to applying an adequate coating in the first place and there was also the all too common problem of neglect, when properly coated surfaces might be damaged by careless activity. There was emphasis on choosing the correct design and in particular the difficult problem caused by sharp edges and inaccessibility. He included some excellent illustrations in his often humorous presentation and concluded about the vital importance of precise contracts and specifications, the ploy being to minimise risks by identifying as many relevant parameters as possible.

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’. The programme will start with a plenary lecture about Microbial Corrosion, given by Dr. Jim Stott, a Senior Consultant in the Production Chemistry Team at Intertek-CAPCIS Limited. This will be followed by a series of talks on the subject of microbial corrosion relating to the various working groups of the Corrosion Engineering Division.

This working day will be a good opportunity to network with other corrosion professionals from different industry sectors and to discuss some of the latest developments in the field of microbial corrosion and corrosion engineering. If you are interested in giving a presentation at the working day 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. Entry to the museum will be available at the end of the working day at a reduced rate.
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For further information contact:
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M.P. Ryan Ltd. has over 27 years of experience in the Asset Management and Integrity Services sector. Our business has developed to become a leading Irish company offering Pipeline Maintenance and Integrity Management Services.

Our clients include private and semi state companies in the Energy and Utilities industries in Ireland. We specialise in Electrical and Instrumentation Maintenance and Corrosion Prevention solutions.

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- DCVG Survey
- C.I.P. Surveys
- Cathodic Protection equipment and supplies

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For further information contact: Gravel Walk House, Clonmel, Co. Tipperary, Ireland Tel: +353 6123487
MPM North West Ltd have extensive experience in the specification and application of coatings to cope with the most extreme environments from Victorian Piers to the Houses of Parliament and boats to Blackpool Tower. Currently we are halfway through a 9 year contract to repair and restore the tower. MPM has engineered and implemented all the pre-requisite tasks on site and utilizes an UHP system to remove existing coatings.

The exposed steelwork is inspected to evaluate the degree of corrosion sustained by the plates, bars, rolled sections and the millions of fixings, rivets and bolts and those corroded steel components with excessive degradation are replaced with new steel.

A new paint system was developed with Hempels Paints and this is 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, joints are caulked with Sikaflex prior to the completion of the coating system and potential water traps are prevented by the application of the same product.

Fully sheeted scaffold is erected sequentially to provide safe and contained access and all risings are removed and disposed of to suit EA procedures.

For further information contact:
MPM North West Ltd., Marine Road, Maryport, Cumbria, CA15 8AY   Tel: 01900 810299   E.mail: mikej@mpmnw.co.uk   www.mpmarine.co.uk

Paint Inspection Ltd pride themselves at being on the forefront of coatings technology, by having both ICorr and NACE qualified inspectors we are able to cover all areas of inspection work within the industry, and by utilising new technology our turnaround speed and accuracy is industry leading. Our flexible approach also means we can react well to individual clients needs from small one off inspections to large scale project management including 24 hour support. Our team are all dedicated specialist and have either ICorr level 2 or 3 qualifications, other certifications include PTS, LUL entry permit, Confined Space to name but a few. We will also provide technical support when required for any coating or testing queries.

For further information visit: Trafalgar Wharf, 223 Southampton Road, Portchester, Hampshire, PO6 4PY  www.paint-inspection.co.uk

As a special service for the EFC Member Societies and their individual members, a link to EUROCORR proceedings from previous conferences has been made available. Currently this covers the conferences from 2003 to 2010. This link can be found in the members restricted area of the Icorr web site. See page 17 for more information on this subject.
ICORR ABERDEEN BRANCH MEETING NOVEMBER 2011-
PIPELINE INTEGRITY MANAGEMENT, NO GUARANTEES?

On the 29th of November, the Aberdeen branch held the last branch meeting of 2011 at the Palm Court hotel in Aberdeen. Although it was a cold night, the turnout was impressive with 57 members in attendance. The speaker of the night was Dr Jonathan Marsh of Wood Group Integrity Management (WGIM), a seasoned professional who has authored/co-authored over forty (40) academic publications relating to corrosion, materials, pipeline integrity, future life prediction etc and has a wealth of experience in corrosion science and engineering.

Dr Jonathan Marsh started his presentation by explaining the concept of integrity management assurance and concluded his introduction expertly with a warning to the audience that even if steps have been taken to mitigate and inspect for corrosion/other defects this was not a guarantee that failure had been averted. He noted that in his experience corrosion had surprisingly been observed in apparently benign conditions. He explained the life cycle of pipelines, explaining the importance of inspection post commissioning and outlined various non-destructive inspection techniques (NDT) such as CVI, UT, TOFD, LRUT, Radiography, thermographic techniques explaining their main applications and limitations. He focused on the types of inline inspection (ILI) techniques used for pipeline systems and listed variables that defined the tool’s probability of detection (PoD) explaining that defects can be missed during inline inspection runs. He noted that results acquired from ILI could vary significantly from results obtained from corrosion prediction and monitoring models/tools. He went on to outline various techniques of mitigating internal corrosion in practice such as application of corrosion inhibitors, biocides, oxygen scavengers, H2S scavengers etc.

Dr Marsh explained that every inspection technique had limitations and explained that inspection of subsea pipelines can be expensive sometimes exceeding the alternative of complete pipeline replacement. He explained the difference in three popular methods applied for defect assessments (DNV-RP-F101, ASME B31G and RSTRENG). He noted that each method took into account safety factors and discussed the degree of variance in conservativeness for each method. He went on to narrate three (3) project experiences where corrosion damage had been observed or damage had resulted unexpectedly even when recent assessment by ILI/defect assessment results and that of corrosion prediction models had been used to establish that the risk of failure was low.

He concluded his talk by advising that all systems including assets constructed with corrosion resistant alloys (CRA) should be inspected emphasizing that CRA should not be considered immune to corrosion. He went on to re-state that ILI was a good technique for inspecting pipelines but in practice the inspection tool may not pick up all defects especially at welds. Finally, he noted that there was always a risk that corrosion/defects could be missed during inspection of pipelines.

Questions from the audience after the presentation were related to UT/MFL principles, defect assessment codes, usage of various types of ILI tools, defect detection capability etc. Other questions were on corrosion prediction models, defect growth postulation, chemical analysis, microbial issues and cost implication queries. Branch members used the opportunity to share experience on project references used and suggested the possible negative effects of poor fabrication techniques and preferential weld corrosion issues as the session wound up.

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 www.sites.google.com/site/icorrabz/home.
Technical Topics No.35:
ASSESSMENT OF RISK AND SCIENTIFIC FREEDOM
by Technical Secretary, Douglas J Mills

As many readers will know, ICorr is a member of this Parliamentary and Scientific committee. As well as technical meetings attended by parliamentarians and others, this body holds high profile social events with invited speakers. So back in November the President and immediate Past President went along to the annual lunch, held at the Palace of Westminster. Although I did not attend that, I have been to a couple of the recent technical meetings, both held in Portcullis House (there is normally some social time at the end of these meetings which is useful for networking). Anyway in this TT I thought I would give you a taste of some of the matters raised in these two “debates”. The first meeting took the topic of Scientific Freedom - is it the Elixir of Civilisation? The main point being made was that since the mid 90s, government money to support science has been given out on the basis of competitive tender (although a high malafetin’ term is used – peer review). And very often, the money is given to those projects which have the perceived highest impact. The time when this started (1993) coincided with a reduction in the UK’s production of really top quality science e.g. fewer Nobel prize winners. Considering a few of the doyens in our own field eg Sam Hoar, Jack Mayne and particularly Ulick R Evans, the father of corrosion science, like most of the people researching in Universities at that time, they investigated what interested them (”Research is what I do when I don’t know what I’m doing”(!) ) Would scientists like them have made the discoveries that they did, if support for their work had been tied to potential “impacts”?. Of course we cannot be sure, and certainly the speaker from the EPSRC did not believe it had been proved that scientific freedom is now negated by the way that grant money is distributed. What is undeniable though is that academics have much less time for thinking than they once did. That is true also for technical people working in industry. Work life is more pressured across the board and although there might be a perceived increase in productivity, there is very likely to be a downside in terms of creativity. Moving onto the other debate, this was bit more “down to earth” on The Assessment of Risk. It was pointed out that there is not a great deal of understanding of risk among the general public and this is not helped by the way that the popular press sensationalize things. Although many people can work out the odds, and hence the potential winnings, on the three horse accumulator, when it comes to a rational assessment of the risks associated with living under or close to a power line, they are much less able to . They just can’t think straight on any emotive issue This is even more so in the case of nuclear power. Regarding the latter it is not just people but governments who are prone to act irrationality. For example the recent decision of Germany to ban all nuclear power was an (over?) reaction to the wholly extraordinary events in Japan a bit under a year ago. Although the Tsunami killed 23,000 people and devastated hundreds of square kilometres, there were actually no deaths at all as a result of the nuclear accident at Fukushima. It has been calculated that the extra risk of getting cancer due to the radiation that the fire-fighters (the people most at risk) were exposed to was equivalent to the extra risk of a white van driver being hurt in an accident over his lifetime compared with a normal driver (up from 25% to 26%). The debate also highlighted the fact that the terms “risk free” or “100% safe” are meaningless. All one can do with any activity is minimize the risks to an acceptable level (but that level is often difficult to define). A speaker from the Insurance industry suggested that the whole industry was much more precise now than it was used to be, thanks to modelling and mathematics. But a model is not fool-proof and predictions should not be made based on a model alone. Moving from this debate to a recent “concrete” example of risk related to our own field of corrosion, there has been the shutting of the 50-year-old Hammersmith flyover, the main road carrying the A4 into London, on 23rd December. I drove over it the previous weekend! An Evening Standard report on this stated that steel cables that hold the 900-metre-long concrete structure together had been corroded by salt water from grit laid during successive winters. Some cables (wires?) had snapped and a spokesman said “the bridge could collapse”. He added: “weight restrictions and limited hours will be considered”. Chris Burgoyne, a reader in concrete structures at Cambridge University had said “The fact that there is so much corrosion is quite surprising and worrying”. So how is the risk assessed in this case? Was/is a mathematical model used/ being used? We do not know. But I think as a driver I would rather be safe than sorry. One other piece of not exactly infrastructure but undoubtedly a big structure that reputedly has corrosion problems is the London Eye (see photo).This was designed for a short (1 or 2 year) life and the galvanised steel cables used were hence coated with quite a thin layer of zinc. It has now been operating for ten years. And not surprisingly the galvanising is beginning to fail. Like the flyover, this is not easy to fix. So one might conclude than in our field, when designing, it is much better to pay out a bit more at the start and hence reduce the subsequent risk of failure. Talking of corrosion of Infrastructure there is interesting ICorr meeting coming up on 18th April on this topic at the Institute of Materials which I hope to attend. As usual any comments on this TT please send to: Douglas@harrbridge.freeserve.co.uk
This year Cathelco will be launching a new generation of ICCP anodes to protect the hulls of ships against corrosion.

The company, based in Chesterfield, are world leading manufacturers of impressed current cathodic protection (ICCP) systems for ships and offshore structures.

“C-Max anodes have a number of features which enhance performance and make them easier to install”, said Robert Field, technical manager at Cathelco.

One of the principal advantages is that the anodes are diver changeable. This is increasingly important as the shipping industry looks to longer periods between drydocking and there is a need to install or replace anodes at sea.

The anodes are significantly lighter than their predecessors and are installed using self-snapping torque nuts. These are double headed so that when the first section snaps off, the lower head can be used to remove the anode at a later date.

In the case of linear anodes, current is emitted from one or more tubular elements which are made from titanium with a mixed metal oxide coating. These are mounted on an integral backing shield made from strong, but lightweight ABS plastic. There are also disc anodes designed with a rubber over-moulding to create a tight seal with the hull.

A large vessel such as an oil tanker or bulk carrier would be equipped with a ‘forward’ and ‘aft’ system. Both ICCP systems would consist of an arrangement of reference electrodes and anodes connected to control panels.

In operation, the reference electrodes measure the electrical potential at the hull/seawater interface and send a signal to the control panel which automatically raises or lowers the output to the anodes. In this way, the hull receives the optimum level of corrosion protection at all times.

Typically, disc anodes would be used in pairs, port and starboard, for the forward system. This is because their circular shape reduces the risk of physical damage and helps to maintain the flow dynamics at the bow of the vessel. Their low profile also avoids the problem of rubbing by anchor chains.

The ‘aft’ system would generally employ pairs of linear anodes which have outputs of up to 300 amps. Higher anode output is required at the stern of the vessel where there is greater turbulence from the propellers and air is drawn into the seawater increasing rates of corrosion.

“The C-Max anode range is result of a comprehensive programme of research and development. The anodes have been trialled
using our test tank facilities in Chesterfield which enables us to measure their performance at different levels of salinity”, Robert Field explained.

Having successfully established themselves in the seawater pipework anti-fouling system market, Cathelco diversified into ICCP systems in 1992.

Since then, C-Shield systems have been installed on thousands of commercial and naval vessels.

In addition to commercial vessels, the systems are supplied for the growing number of FPSOs and FSOs which are used to exploit offshore oil fields in the North Sea, Arctic Circle, Brazil and the Middle East to name but a few.

In the naval sector, Cathelco serve more than 40 navies worldwide and have supplied equipment for major projects such as FREMM (multi-purpose frigates), BAM (Buque de Accion Maritima) as well as experimental fast craft for the US Navy.

“Today, control panels with the option of monitoring the performance of ICCP systems and recording data for analysis by our corrosion engineers are becoming increasingly important to customers”, Robert Field concluded.

Looking to the future, Cathelco will be combining their new anode range with ever more sophisticated software for controlling and monitoring ICCP systems, with the principal aim of reducing hull maintenance costs.

For further information contact:
Cathelco Ltd, Marine House, Dunston Rd, Chesterfield S41 8NY, United Kingdom
Tel: +44 (0)1246 457900
Fax: +44 (0)1246 457901
Email: sales@cathelco.com
Web: www.cathelco.com
Billingham Forum is Tees Active’s latest re-development. Tees Active is one of the new breed of charitable leisure management organisations operating in the UK. Set up with the intention of taking on the management of facilities provided by Stockton-on-Tees Borough Council, the organisation works very closely with the council as its main funding partner.

Billingham Forum swimming pool was to undergo a full refurbishment as part of the re-development. Corrosion Control Services Limited (CCSL) were appointed by Morgan Ashurst to complete a condition survey. Evidence of spalling concrete and corroded reinforcement was noted.

CCSL worked in collaboration with their sister company Freyssinet Limited and proposed a solution of concrete repair to service voids surrounding the pool, and the installation of cathodic protection (CP) system, as concrete repairs alone were considered inadequate to provide the clients desired 20-year design life. Mott McDonald were commissioned to design a suitable system and worked in conjunction with Freyssinet to develop a suitable economic solution to the corrosion problem.

Due to the service voids status as a confined space it was necessary to minimise any dust producing activities such as chasing of concrete, which may normally be associated with concrete repair and cathodic protection. Concrete repairs were carried out by Freyssinet operatives in October/November 2010. Repairs were specified and completed in full accordance with the relevant sections of EN 1504 Products and Systems for the Protection and Repair of Concrete Structures – definitions, requirements, quality control and evaluation of conformity.

The CP works were carried out over a 6 week period up to commissioning. Freyssinet installed a Protector Cassette anode system within the service voids at a spacing defined by the Mott McDonald design which minimised the cost and confined space risks associated with the structure. The system was commissioned in May 2011 and is performing to the full requirements of BS EN 12696:2000 Cathodic Protection of Steel in Concrete.

The doors to the Forum re-opened on Friday 3rd June. Thousands of visitors came to view the new surroundings and enjoy the activities on offer including in addition to the 25 metre pool, an Ice Arena, Activ8 gym, spinning studio, play barn and bowls club.

For further information contact:
Corrosion Control Services Ltd.
Tel: 01952 201901
Fax: 01952 201753
The AC5/AC7 site is located to the north of Birmingham, below the Gravelly Hill Interchange. Following structural assessment by the Highways Agency in 2008, the existing half joint between support structures AC5 and AC7 was deemed sub-standard and required emergency temporary support. The Amey design team developed a permanent solution and Freyssinet Limited was appointed to carry out concrete repairs and cathodic protection as the specialist contractor within the Highways Agency Area 9 &10 CMF.

Construction of the new support structure and repair of the existing deck had to be undertaken concurrently in order to achieve the programmed completion date. Freyssinet accessed the existing deck soffit from a scaffold system whilst Osborne Limited undertook the construction of new concrete piers directly below.

The concrete surfaces of the deck soffit and half joint were repaired in sequence in order to maintain structural integrity, by avoiding removal of too much structural concrete during each stage. Both flowable repair materials and sprayed concrete methods were used; repair materials placed in each stage had to reach a specified strength before the next stage commenced.

Freyssinet worked closely with Amey to develop a suitable method of undertaking flowable concrete repairs to the suspended span and cantilever span elements of the deck. There were concerns during design stage that, with limited access, it would be difficult to repair the deck soffit without compromising structural integrity. Extensive research and trials with a new pump by Freyssinet proved successful. This innovative system provided benefit to the works and proved to be a cost effective way of reducing construction time and manual handling associated with traditional methods. Amey are looking to adopt this method for future schemes in Area 9.

During the repairs process concrete was removed by Freyssinet’s in-house hydro-demolition team, accredited by the Water Jetting Association. Following hydro-demolition, an inspection of the existing reinforcement was undertaken. Where corrosion was present it was necessary to undertake structural reinforcement welding. Once concrete repairs were completed, a Cathodic Protection mesh and overlay system was installed. Freyssinet undertook the installation and commissioning with their in-house CP team Corrosion Control Service Limited (CCSL).

Following completion of the new reinforced concrete support structure by Osborne, it was necessary to transfer the loads from the temporary support into the new structure. Freyssinet supplied and installed the bearing assemblies for the new support structure and transferred the load during a night closure of the AC slip road. A programme of load checks were then undertaken.

As a consequence of dedicated teamwork, a spirit of working towards a common goal, and the availability of Freyssinet’s in-house expertise, the works were completed on time and within budget, to the satisfaction of the Amey and the client.

For further information contact:
Corrosion Control Services Ltd.
Tel: 01952 201901
Fax: 01952 201753
A NEW STANDARD IN POWER SUPPLIES FOR THE CATHODIC PROTECTION (CP) INDUSTRY – BAC CORROSION CONTROL LTD’S INNOVATIVE SWITCH-MODE POWER SUPPLY UNITS.

In 2006, BAC Corrosion Control Ltd (BAC) began to investigate the possibility of applying SMPS technology to impressed current cathodic protection (ICCP) systems. Such systems have been in use for some time within the concrete CP market, being used to protect steel reinforcements in places as far afield as Saudi Arabia.

In 2010, BAC were approached by the UK’s high pressure gas network operator, National Grid, to supply replacement power supplies across Great Britain’s high pressure natural gas pipeline network. National Grid had a need to replace outdated oil cooled, pole mounted units which had begun to pose health, safety and environmental issues which needed to be resolved in the new design. The major considerations for meeting the needs of National Grid were broken into two categories: commercial and technical. Commercially the new units had to be competitively priced whilst technically innovative in design and acceptable to National Grid, meeting their specific requirements and quality standards.

New SMPS technologies
SMPS bring a range of complex technologies together to form a single unit, resulting in advantages over more traditional transformer rectifiers. The way a SMPS unit works is thus - the 115V or 230VAC voltage is rectified and smoothed by diodes and capacitors resulting in a high tension DC voltage. The DC is then switched on and off at high frequency (typically switching at 30kHz to 500kHz) creating a crude AC waveform which is passed across a much smaller ferrite transformer. This voltage is then converted into the DC output voltage by another set of diodes, capacitors and inductors. Corrections to the output voltage due to load or input changes are achieved by adjusting the pulse width of the high frequency waveform.

Control and regulation of the output is achieved by controlling the percentage of time the switching elements are switched on during each cycle. BAC SMPS units contain a microcontroller to achieve this, allowing the user to digitally set the parameters via a keypad and display. This is an improvement on older potentiometer systems that could change the set point due to the temperature of the potentiometer changing.

Advantages of the new units
- A smaller, more compact size reducing both weight and space requirements
- Very low AC ripple on the DC output
- Highly efficient design
- Accurate digital control throughout the full range of rated output
- Precise control at low output power
- No on site portable appliance testing (PAT) is required
If failure in units occur, replacement units can be easily installed with little downtime or inconvenience.

No need for personnel to work at height using ladders on units mounted on poles as units are usually situated in roadside glassfibre reinforced plastic (GRP) cabinets.

No risk of contaminating the surrounding land following oil leaks from old units.

No Polychlorinated Biphenyls (PCB’s) - a persistent organic pollutant found in oil cooled units.

Added flexibility if needed depending on customer specifications.

Tony Gerrard, Managing Director at BAC said, “SMPS units have a lot of advantages over conventional units. This mainly relates to the much faster switching frequencies used in the design where the high frequency means that inductive components reduce in size dramatically reducing the overall size and weight of the unit. This also enables us to offer units with very low AC ripple on the output. High AC ripple has been of concern in the industry since AC induced ripple was identified as a problem. With ever increasing electricity costs, the running cost of the unit has become ever more important. The advanced topology of the units means they are very efficient, giving the SMPS units a clear edge in the market place.”

National Grid project

During negotiations with National Grid, BAC took on the task of reviewing the existing units and producing a turn key solution for the entire TR network. From the beginning, National Grid had a clear vision of what the new system would be capable of, and it was BAC that provided the technical expertise needed to turn these ideas into reality.

It was after thorough consultation with National Grid, that the SMPS technology was identified as the most suitable to meet their needs. With the accurate control of output even at low power a standard sized SMPS unit capable of achieving a 48V 20A DC was selected for the entire network. The specification continued to develop; as the new technology opened new avenues of possibilities such as directly interfacing with National Grid’s remote monitoring system to allow synchronous switching of outputs across multiple units without the need of expensive and bulky switching components.

Both BAC and National Grid identified several features which have been incorporated into the final design such as:

- Local control using digital keypad
- Integrated 4-20mA transducers for current, voltage and remote monitoring with the fitting of a free issue National Grid specified text based unit
- Direct interface to National Grid’s preferred remote monitoring device, allowing the output to be synchronously switched
- Electrically safe DC chamber to protect operatives working on the units – one of the key driving forces behind the project.

Once all the detail had been added to the SMPS specification, BAC’s attention turned to the roadside kiosk. The original units required yearly portable appliance testing, something which was both costly and impractical. BAC redesigned the roadside kiosk rationalising the design so as to maximize the benefits offered by the new smaller power supply. The completed roadside kiosk design incorporated an IP54 seal, and all the necessary ancillaries making it suitable for deployment in all areas of the UK.

In 2010 BAC secured the first part of this prestigious contract with National Grid to manufacture an initial 151 SMPS units at an initial rate of 16 units per month.

The replacement of the existing National Grid units with the new SMPS type is a reasonably long process due to the re-connection of the AC power supplies to the units. These are being installed with ‘smart’ meters as opposed to the original un-metered supplies which will in turn reduce overall installation and running cost.

During this period of finalising the installations, a complete unit has been installed outside at BAC’s headquarters in Telford, UK, and has now been on test for over a year. Regular inspection and receipt of monitoring text messages has shown that the unit has continuously operated to its design specification, and to date no issues have arisen. As National Grid units come on line, the results for this will augment the positive feedback of the test unit installed at BAC.

For further information contact:

Tel: 01952 290321   www.bacgroup.com
As the technology of pipeline coatings has advanced further and further, the current requirements to Cathodically protect a pipeline are decreasing. From the field applied Asphalt Mastic, and Coal-Tar Enamel of the 1970’s, through to the factory applied three layer coatings of today, the current densities required have dropped significantly as the table below demonstrates.

![Figure 1: Typical pipeline current requirements over service life](image)

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 10</th>
<th>Year 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Mastic</td>
<td>151A</td>
<td>565A</td>
<td>942A</td>
</tr>
<tr>
<td>Fusion Bonded Epoxy</td>
<td>0.19A</td>
<td>0.57A</td>
<td>0.75A</td>
</tr>
</tbody>
</table>

Over a 100km length, 600mm diameter pipeline with a surface area of 188,496m², this can have a dramatic effect on the total current requirements of the pipeline and in hand the technology required to provide the power.

Cathodic Protection Co Limited have recently commissioned a project to protect 2 pipelines in South Europe, one 2km in length, installed in 2005 with a Coal Tar Epoxy coating, and the other 11km in length, installed in 2010 with a Fusion Bonded Epoxy coating. The shorter pipeline is entirely buried on land however the longer pipeline is split between seabed and land. The installation was made more complex by the requirement for automatic potential control, and also the variation of current requirements relative to the immersed pipeline due to tidal changes.

A traditional transformer rectifier (TR) utilising phase angle control of a thyristor operates by determining the point on the sine wave at which the thyristor will fire, thus giving the level of DC output required. This control allows smooth infinite adjustment between 3% and 100% of the rated output. However many design specifications lead to a current output so far in excess of the actual requirements that the initial power required for protection sits in the lower 3% of the power band of the transformer rectifier.

Upon commissioning, the total current requirements for both pipelines was 0.73A at low tide and 1.24A at high tide, which equated to 0.73% and 1.24% of the rated TR output. Due to the low output relative to the TR rating, problems were experienced with the automatic control, resulting in an unstable output from the TR. Pipeline potential fluctuated between over protection and under protection. Further testing confirmed that the TR performed satisfactorily within its rated operating range, and for this application a modification to the unit would be required.

CPC were further commissioned at this point to remedy these issues. Our solution was a simple modification which provided a selectable 10A output. This would then bring the required power well into the control zone at 7.3% and 12.4% and still keep the 100A capacity in case this is ever needed. These works were carried out within the original enclosure at the customer’s site by our technical services team with minimal disruption.

Routine maintenance on the site then required disconnection of part of the older pipeline which further lowered the current requirements. At this point instability was again noted on the output of the TR. Upon investigation it was found that the AC input to the TR contained a significant amount of noise. This disrupted the thyristors’ firing pulses and was responsible for the unstable output.

The oscillogram shown above presents the voltage waveforms from phase to earth on site (green and yellow) contrasted with a stable supply (purple and pink). The voltage scale is 25Vac per box and noise in excess of 35Vac can be seen. Depending upon where this noise falls in the sine wave it prevents the control electronics from firing the thyristor at the correct position and the output will not stabilise. As a solution Cathodic Protection
Co Limited’s design team developed a filter network and an increase in the hysteris value of the zero voltage comparator circuit. This has enabled all of our units to cope with noisy AC power supplies which may be found in remote or highly industrial sites. The table (Figure 4) demonstrates the stability improvements provided by the circuitry changes.

In conclusion modern pipeline coatings and improved application techniques are reducing the initial current needed to protect pipelines and also the in service requirements. Conventional Thyristor driven transformer rectifiers typically struggle to provide stable control at very low outputs which may compromise protection levels. Microprocessor control and ‘multi-modal’ TRs such as our TRUst design provide a solution to these problems whilst still providing capacity for pipeline protection in the future as current requirements increase.

Cathodic Protection Co Limited has been providing successful Cathodic Protection and Marine Anti-Fouling solutions for over 50 years. We are able to offer a full turn-key solution from survey to design, to procurement, to manufacture, to installation, and on-going maintenance of both our own and other installations. For any further information on our services and abilities please contact us on cpc@cathodic.co.uk or 01476 590666 or visit our website at www.cathodic.co.uk.
A MULTIFUNCTIONAL COATING FOR AUTONOMOUS CORROSION CONTROL

Luz M. Calle, NASA, Kennedy Space Center, FL 32899; Wenyan Li, Jerry W. Buhrow and Scott T. Jolley, ESC-Team QNA, Kennedy Space Center, FL 32899

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ABSTRACT

Corrosion is a destructive process that often causes failure in metallic components and structures. Protective coatings are the most commonly used method of corrosion control. However, progressively stricter environmental regulations have resulted in the ban of many commercially available corrosion protective coatings due to the harmful effects of their solvents or corrosion inhibitors. This work concerns the development of a multifunctional smart coating for the autonomous control of corrosion. This coating is being developed to have the inherent ability to detect the chemical changes associated with the onset of corrosion and respond autonomously to indicate its presence and to deliver corrosion inhibition. The multi-functionality of the coating is based on microcapsules specifically designed for corrosion control applications. This design has, in addition to all the advantages of other existing microcapsules designs, the corrosion controlled release function that allows the delivery of corrosion indicators and inhibitors on demand only when and where needed. Corrosion indicators as well as corrosion inhibitors have been incorporated into microcapsules, blended into several paint systems, and tested for corrosion detection and protection efficacy. A self-healing function to repair mechanical damage, such as a scratch, is also being developed. Microencapsulation allows the incorporation of autonomous corrosion indication, corrosion inhibition, and self-healing functionality into a coating, singly or in the desired combination, to meet its corrosion protection performance requirements.

1. INTRODUCTION

Nearly all metal and their alloys are subject to corrosion that causes them to lose their structural integrity or other functionality. It is essential to detect corrosion when it occurs, and preferably at its early stage, so that action can be taken to avoid structural damage or loss of function of metals and their alloys. Because corrosion is mostly an electrochemical process, pH and other electrochemical changes are often associated with it, so it is expected that materials that are pH or otherwise electrochemically responsive can be used to detect and control corrosion. The authors have developed pH-triggered release microcapsules for early corrosion detection and protection.1 Microcapsules to deliver self-healing agents when a coating is mechanically damaged are also under development. The following sections will briefly describe the relationship between pH and corrosion, the design of pH-sensitive microcapsules and their synthesis. Selected test results from experimental coatings with pH-sensitive microcapsules for corrosion indication and inhibition and with self-healing microcapsules will also be included.

1.1 Corrosion and pH

Corrosion is largely an electrochemical phenomenon, because, in most cases, it involves the transfer of electrons between a metal surface and an aqueous electrolyte solution. For instance, when iron corrodes in near neutral environments, the typical electrochemical reactions are:

Anodic reaction: \( \text{Fe} \rightarrow \text{Fe}^{2+} + 2e^- \)
Cathodic reaction: \( \text{O}_2 + 2\text{H}_2\text{O} + 4e^- \rightarrow 4\text{OH}^- \)

In the case of localized corrosion, such as pitting corrosion, as shown in Figure 1, the electrochemical cell set up between anodic and cathodic sites on an iron surface undergoing pitting corrosion. The anodic reaction happens in a confined area, the metal ions produced are precipitated as solid corrosion products, such as iron(II) oxide, Fe(OH)\(_2\), (often further oxidized to iron(III) oxide, Fe(OH)\(_3\)), which covers the mouth of the pit. This covering traps the solution in the pit and allows the buildup of hydrogen ions, H\(^+\). The overall effect is that, while localized corrosion happens, the anode area often has an acidic pH and the cathode has an alkaline pH.\(^2\)

Besides pitting, crevice corrosion and dissimilar metal corrosion result in pH changes as illustrated by the simple demonstration shown in Figure 2, where a universal pH indicator was dissolved in agar gel to show the pH changes that occur during corrosion of a metal such as steel. In this demonstration, most of the steel was exposed while a strip in the middle was wrapped in copper tape. The color change of the pH indicator shows that the exposed steel tends to be acidic (yellow color) while the strip wrapped in the copper tape tends to be basic (purple color) due to the oxygen reduction reaction and the release of the hydroxide ion, OH\(^-\). Therefore, materials

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1. Figure 1. The electrochemical cell set up between anodic and cathodic sites on an iron surface undergoing pitting corrosion.

2. Figure 2. A simple demonstration showing pH changes during corrosion.
that are pH or otherwise electrochemically responsive can be used to detect and control corrosion. Various pH and electrochemically responsive materials, as well as their potential applications in smart coatings for corrosion control, can be found in our previous review.3 Self healing is another new development in material design that is important to corrosion control. 4,5,6 The authors are also engaged in encapsulating self-healing agents for inclusion of the self-healing function into the multifunctional coating for autonomous corrosion control.

1.2 pH-sensitive Microcapsules

The authors developed a controlled-release system that combines the advantages of corrosion sensing and corrosion protection by using pH-triggered release microcapsules for early corrosion detection and inhibition.3,7,8,9,10 The key component of this technology is a pH-sensitive microcapsule with a wall designed to break down and release the encapsulated contents in response to the pH increase at the cathodic site of localized corrosion (as illustrated in Figure 2 above).

1.3 Smart Coating Based on pH-Sensitive Microcapsules

Microencapsulation is a versatile approach to incorporate multiple functionalities into a corrosion protective coating because it allows the encapsulation of an unlimited number of materials, in solid and liquid phase, and even in the gas phase when the gas is entrapped in aerogel. Corrosion indicators, corrosion inhibitors, self-healing agents, and dyes can be encapsulated and incorporated into coatings for corrosion indication and control applications as illustrated in Figure 4. The versatility of the design is of special interest in corrosion inhibition applications. Almost all corrosion inhibitors are chemically active reagents. Very often, the reactivity that makes them effective corrosion inhibitors also causes them to be environmentally unfriendly, such as in the case of chromates. Because of this, research for new and environmentally friendly corrosion inhibitors is an on-going effort in the corrosion protection industry. Usually, the incorporation of a newly identified corrosion inhibitor into a paint formulation takes a long time. Microencapsulation of the inhibitors, to be released on demand when corrosion starts, can facilitate the paint formulation process for new inhibitors by simply changing the core content of the microcapsules.

The pH-controlled release microcapsule design has, in addition to all the advantages of the microcapsule design, the true controlled-release function for corrosion applications. Most microcapsules release their contents when they are mechanically broken. However, pH-sensitive microcapsules release their contents only when corrosion occurs. Mechanical damage in a coating is one of the important causes for corrosion of the base metal. However, many forms of defects in coatings, such as air bubbles, uneven thickness, permeation, porosity or edge effects, will also result in poor corrosion protection of the coating and allow corrosion to occur. pH-sensitive microcapsules will release their content for corrosion detection or protection regardless of the corrosion cause.
2. CHEMISTRY OF PH-SENSITIVE MICROCAPSULES

The pH sensitivity of the microcapsules specifically developed for corrosion control applications relies on a base-catalyzed ester hydrolysis reaction that causes the microcapsule wall to breakdown autonomously when corrosion starts. The polymeric walls of the microcapsules include a cross-linking agent that has one or more ester and mercapto groups. Since this cross-linker is not a good film former, other pre-polymers or monomers are needed to provide the structural integrity of the microcapsule wall. Examples of film-forming monomers and pre-polymers include urea formaldehyde and melamine formaldehyde monomers and pre-polymers.

Capsule wall breakdown under basic conditions has been observed visually. Figure 5 shows breakdown of a microcapsule with a pH indicator in its core upon exposure to a sodium hydroxide, NaOH, solution of pH 12. Soon after the NaOH solution was added, the solution started to penetrate the microcapsule wall, as indicated by the color change inside the microcapsules (Frames b-d). In frame e, the microcapsule begins to slowly release its contents (as evidenced by the small droplet that begins to form on the bottom left quadrant of the frame). The content continues to be released until (as seen on frame i) it dissipates into the solution. The microcapsule wall eventually collapses as shown in frames j through n.

3. ENCAPSULATION PROCESS

3.1 Encapsulation Methods

pH-sensitive microcapsules are the key component in the development of a smart coating for corrosion control. Several methods such as spray drying, emulsion polymerization, interfacial polymerization, as well as in-situ polymerization have been used to synthesize pH-sensitive microcapsules. Interfacial polymerization is illustrated in Figure 6 as an example. There are two main steps involved in the interfacial polymerization process: micro emulsion formation and microcapsule wall formation. This technique can be used to form both oil (or hydrophobic) core and water (or hydrophilic) core microcapsules. Figure 6 shows a schematic representation of the steps involved in forming oil-core microcapsules: the micro emulsion is formed by adding the oil phase (with pre-polymer, shown in yellow) to the water phase (with surfactant, shown in blue) and mixing; the last step is the formation of the microcapsule wall (shown in green) by interfacial polymerization. The illustration shows the use of oil, or hydrophobic solvent soluble wall forming pre-polymer. A similar process can be developed to use water soluble wall forming materials by dissolving the wall forming pre-polymer in the aqueous phase and the catalyst in the oil phase. The reaction at the interface will form the microcapsule wall.

In situ polymerization is also used to form pH-sensitive microcapsules. The in situ polymerization process is similar to that of interfacial polymerization. The difference is in the location where the polymerization reaction occurs. In interfacial polymerization the reaction occurs at the interface while in the in situ polymerization process the polymerization reaction occurs in the continuous phase and the polymer formed in the reaction deposits at the interface to form the capsule wall.

Spray drying involves dispersing the wall forming pre-polymer and component to be encapsulated (the core material) into a continuous phase (water for instance). The mixture is sprayed into a mist in a hot gas flow where the liquid droplets are dried into solid particles. In the process, the core material is encapsulated inside the wall.

Interfacial polymerization and in situ polymerization are the main approaches used by the authors for microcapsule synthesis. Spray drying has been used to synthesize solid core microcapsules and as a useful method for drying microcapsules into a free flowing powder form without forming clusters.

3.2 Microcapsule Synthesis

Different active core contents, including corrosion indicators, corrosion inhibitors, dye, and self healing agents, have been encapsulated. An active compound that can be dissolved or dispersed in a hydrophobic solvent, such as oil, can be encapsulated into oil-core microcapsules. However, water soluble materials, such as salts or polar molecules can also be encapsulated into oil-core microcapsules with the aid of a polar co-solvent and adding the resultant solution to the oil phase. Alternatively, a surfactant can be added to the oil phase. This will dissolve or disperse the polar or water soluble reagents.
into the oil phase. The oil-in-water emulsion can then be formed and the interfacial reaction can be used to encapsulate these reagents into the oil-core of the microcapsules.

Similarly, if a compound can be dissolved or dispersed in water, with or without the aid of a co-solvent, or a surfactant, it is possible to encapsulate it into water-core microcapsules. For example, phenolphthalein does not dissolve in water, but ethanol can be used as a co-solvent to dissolve moderate amounts of the indicator in water making it possible to encapsulate it into water-core microcapsules (Figure 7).

Various compounds of interest for corrosion control applications have been encapsulated into oil-core microcapsules. These compounds include: corrosion indicators such as phenolphthalein, phenol red, and fluorescein; dyes such as Rhodamine B; healing agents such as epoxy and polysiloxane; and various solvents, such as chlorobenzene, which can be used as a healing agent. Figure 8 shows SEM images of microcapsules with siloxane healing agents. In addition, various corrosion inhibitors and indicators have been encapsulated into water-core microcapsules, such as the corrosion indicator phenolphthalein, and corrosion inhibitors sodium molybdate (Na₂MoO₄), cerium nitrate (Ce(NO₃)₃), sodium phosphate (NaH₂PO₄), calcium metaborate, and phenylphosphonic acid.

An optimization process is usually needed after a microcapsule formula is developed to obtain microcapsules of suitable size and desired properties for its intended application. The capsule size can be controlled by adjusting the emulsion formula or by varying the mixing speed of the mixer during the emulsion formation. These methods can be used to obtain microcapsules of a desired size within a narrow range of size distribution. Sizes from 200 nm to 200 µm (micron) can be obtained, with a typical size from about 1 to 5 µm.

The SEM images in Figure 9 show capsules of spherical shape with less than 1 µm in diameter size. The capsule wall thickness is about 50-100 nm as shown in the SEM images of the microcapsules obtained using a transmission electron detector (Figure 10).

4. RESULTS FROM EXPERIMENTAL SMART COATINGS

Encapsulated corrosion indicators, corrosion inhibitors, as well as self-healing agents have been incorporated into different commercially available coatings in order to test their functionality. Preliminary results of these tests are presented page 18.

4.1 Corrosion Indication Tests

Corrosion indication is one of the functions of the smart coating for corrosion detection,
control, and self healing. This function can be incorporated into the coating by encapsulating a corrosion indicator into pH-sensitive microcapsules. Figure 11 shows the results from salt immersion test of steel panels coated with a clear urethane coating containing 10% of microcapsules with corrosion indicator. The panels were scribed and observed for visual changes over time. It was observed that the indicator signaled the onset of corrosion in the scribe about 1 minute after immersion which is considerably earlier than the 2 hours it took for the appearance of the typical color of rust.

In addition to early corrosion detection, another potential application of the smart coating is to detect hidden corrosion. A conceptual illustration of how these coatings can be used to detect hidden corrosion on structural bolts is shown in Figure 12. Bolts tend to corrode on the hidden shaft area before visible corrosion is seen on the bolt head or nut. Often, the head and nut are in pristine condition, even when significant corrosion has occurred on the shaft. There is no method to identify the degree of corrosion without removing the bolt from service. A coating that changed color on the bolt head or nut when corrosion started would greatly speed up the inspection process.

An experiment was designed to test the ability of the encapsulated indicator to detect hidden corrosion when incorporated into a coating system. Several coating systems were prepared in order to find a coating system that would indicate crevice corrosion as can be expected to occur in a nut and bolt set up. As can be seen in Figure 13, the epoxy/urethane coating system demonstrated the ability of the coating to indicate hidden corrosion as evidenced by the appearance of the purple color.

### 4.2 Corrosion Inhibition Tests

Test panels were coated with Carboline Carbomastic 15 FC epoxy mastic coating containing water-core microcapsules with an inhibitor and tested using a salt fog test. The results are shown in Table 1.

<table>
<thead>
<tr>
<th>Carbomastic 15 FC Coating Systems</th>
<th>Sample #</th>
<th>Rust Grade</th>
<th>Scribe Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10</td>
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<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>10% (w/v) phenylphosphonic acid microcapsule</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>5</td>
<td></td>
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<tr>
<td>2</td>
<td>10</td>
<td>5</td>
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</tr>
<tr>
<td>3</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Rust Grade and Scribe Rating of Carbomastic 15 FC experimental coatings.
chamber, for approximately 6 months, following the ASTM B117 standard method. Panels were evaluated for both rust grades (ASTM D610) and scribe ratings (ASTM D1654). Several coating systems were tested; the coating containing 10% phenylphosphonic acid microcapsule performed the best. The corrosion ratings of these panels are shown in Table 1, in comparison with the controls.

4.3 Self-healing Tests Results
Test coatings were prepared by incorporating the self-healing system of interest into a 2-part epoxy coating and applying it to steel panels. The thickness of the applied coatings was approximately 250 to 400 μm. The steel panels were tested using the ASTM B117 salt fog test procedure. In order to evaluate the healing performance of each self-healing system, three parallel scribes of different the healing performance of each self healing system, three parallel scribes of different

siloxane systems exhibited excellent corrosion protection when compared to control (as shown in Figure 16).

5. SUMMARY
A multifunctional smart coating for the autonomous control of corrosion is being developed using pH-sensitive microcapsules. The microcapsules are designed specifically to detect the pH changes that are associated with the onset of corrosion and respond autonomously to indicate its presence early, to control it by delivering corrosion inhibitors, and to deliver self healing or film forming agents capable of repairing mechanical damage to the coating.

Various pH-sensitive microcapsules with hydrophobic or hydrophilic cores were synthesized through interfacial polymerization reactions in an emulsion. The microencapsulation process was optimized to obtain monodispersed microcapsules in a size range suitable for incorporation into commercially available coatings. The microcapsules can be obtained in suspension or in free-flowing powder form.

Preliminary results from salt fog testing of panels coated with commercially available coatings in which the microcapsules and particles were incorporated indicate that microcapsules and particles can be used to detect corrosion before visible rust appears and to deliver corrosion inhibitors.

Current work is being focused on optimizing the concentration of indicator in the microcapsules or particles as well as on optimizing the release properties of the microcapsules and particles when incorporated into coatings of interest. Encapsulation methods for self healing agents and film forming compounds are being developed to incorporate the self healing function into the multifunctional coating.

6. ACKNOWLEDGEMENTS
The authors gratefully acknowledge the financial support from the following funding sources: NASA’s Exploration Technology Development Program, NASA’s Innovative Partnership Program, and the U.S. Department of Defense.

7. REFERENCES
BELZONA REPAIRS LEAKING CAUSTIC TANK

In September 2011, Belzona refurbished a leaking caustic tank for a global soft drink manufacturer at their bottling plant in London.

The engineers at the plant were looking for a long term repair solution for a caustic tank suffering leaks on the welded seams where the caustic acid was leaking from the painted mild steel tank. The tank was situated within a stainless steel secondary containment area and was made up of four half round sections which were welded together. The tank contained around 8000 liters of 28% caustic soda.

The tank was fully drained prior to the application and the front of the secondary containment area was removed to aid access. A scaffold was erected to gain access to the higher parts of the tank.

Application service provider Belzona Technosol won the contract to refurbish the tank. The entire area was pressure washed to ensure full adhesion of the Belzona products. An 80mm wide repair area was then masked off along the length of the welded seam and prepared using a Monti® MBX Bristle Blaster, a hand-held surface preparation tool suitable for use on a variety of substrates including metals, rubbers and plastics.

The product selected for the repair of the leaking areas was Belzona 1111 (Supermetal) a multi-purpose, machinable, repair and rebuild system. The two-component paste grade product is based on a ceramic steel reinforced polymer system which when cured is durable and chemical resistant. The product is ideally suited to applications on tanks, pipes, casings, keyways, bearing housings, shafts, hydraulic rams, engine blocks and flange faces.

The first layer of Belzona 1111 (Supermetal) was applied incorporating Belzona 9341 (Reinforcing Tape) to the repair area. Once cured, a second coat of the reinforced product was applied. After removing the masking tape the product was left to cure.

This application will provide a long term, corrosion protection solution for this caustic tank.

DENSO SEASHIELD GIVES LONG-TERM PROTECTION FOR TRINITY HOUSE PIER

A major refurbishment project has recently been completed on the Trinity House pier at Harwich in order to facilitate loading of newer and larger vessels now using the harbour. The work, which included the addition of new independent fender piles alongside the original pier, was carried out by contractors Bam Nuttall.

A Winn & Coales Denso SeaShield system was again chosen to protect the new independent fender piles as well as the existing piles from the corrosive marine environment. This can be a major problem in splash zones, inter-tidal and subsea environments and the difficult area where the pier pile meets the pier platform.

A Winn & Coales Denso SeaShield system was again chosen to protect the new independent fender piles as well as the existing piles from the corrosive marine environment. This can be a major problem in splash zones, inter-tidal and subsea environments and the difficult area where the pier pile meets the pier platform.

Winn & Coales specified SeaShield 2000FD as being the most effective product in the range for this particular project. It commenced with application of Denso Paste S105, Denso Marine Piling Tape and then the HDPE jackets which were put into position with stainless steel fixings. Denso Marine Piling Tape, a cold-applied petrolatum-based tape for application under water, is the primary anti-corrosion protection in the SeaShield system with a proven 35-year record. The jackets will also give abrasion protection for the Tape system.
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Tel: 02380 742222  Fax: 02380 742200
Email: enquiries@dyerandbutler.co.uk  Website: www.dyerandbutler.co.uk

HERRINGTON INDUSTRIAL SERVICES LTD
GRITBLASTING, METAL SPRAYING & APPLICATIONS OF SPECIALISED COATINGS
Crown Works, Crown Road, Low Southwick, Sunderland, Tyne & Wear, SR5 285
Tel: 0191 516 0634  Fax: 0191 584 1553
Email: herringtonltd@gmail.com  Website: www.herringtonltd.co.uk

27
<table>
<thead>
<tr>
<th>Company Name</th>
<th>Address</th>
<th>Phone</th>
<th>Fax</th>
<th>Email</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHUTDOWN MAINTENANCE SERVICES LIMITED</td>
<td>Beaumont House, 8 Bernard Road, Romford, RM7 0HX</td>
<td>01708 749202</td>
<td>020 85909885</td>
<td><a href="mailto:tom.costello@wgbeaumont.co.uk">tom.costello@wgbeaumont.co.uk</a></td>
<td></td>
</tr>
<tr>
<td>W G BEAUMONT &amp; SON LTD</td>
<td>Brandlesholme House, Brandlesholme Road, Bury BL8 1JJ</td>
<td>0161 609 0000</td>
<td>0161 609 0468</td>
<td><a href="mailto:jeff.grundy@hare.co.uk">jeff.grundy@hare.co.uk</a></td>
<td><a href="http://www.williamhare.co.uk">www.williamhare.co.uk</a></td>
</tr>
<tr>
<td>STANDISH METAL TREATMENT LTD</td>
<td>Potter Place, West Pimbo, Skelmersdale, Lancs, WN8 9PW</td>
<td>01695 455977</td>
<td>01695 728835</td>
<td><a href="mailto:stuart.croft@standishmetal.co.uk">stuart.croft@standishmetal.co.uk</a></td>
<td></td>
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<tr>
<td>WALKER CONSTRUCTION (UK) LIMITED</td>
<td>Beaumont House, 8 Bernard Road, Romford, RM7 0HX</td>
<td>01708 749202</td>
<td>020 85099885</td>
<td><a href="mailto:tom.costello@wgbeaumont.co.uk">tom.costello@wgbeaumont.co.uk</a></td>
<td></td>
</tr>
<tr>
<td>WILLIAM HARE LTD</td>
<td>Woodcote Grove, Ashley Road, Epsom, Surrey KT18 5BW</td>
<td>01372 740055</td>
<td>01372 740055</td>
<td><a href="mailto:iain.wesley@atkinsglobal.com">iain.wesley@atkinsglobal.com</a></td>
<td></td>
</tr>
<tr>
<td>WEDGE GROUP GALVANIZING LTD</td>
<td>Marine Road, Maryport, Cumbria, CA15 8AY</td>
<td>01900 810299</td>
<td>01900 810299</td>
<td><a href="mailto:mike@mpmarine.co.uk">mike@mpmarine.co.uk</a></td>
<td><a href="http://www.mpmarine.co.uk">www.mpmarine.co.uk</a></td>
</tr>
<tr>
<td>WG BEAUMONT &amp; SON LTD</td>
<td>Marine Road, Maryport, Cumbria, CA15 8AY</td>
<td>01900 810299</td>
<td>01900 810299</td>
<td><a href="mailto:mike@mpmarine.co.uk">mike@mpmarine.co.uk</a></td>
<td></td>
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<tr>
<td>WALKER CONSTRUCTION (UK) LIMITED</td>
<td>Marine Road, Maryport, Cumbria, CA15 8AY</td>
<td>01900 810299</td>
<td>01900 810299</td>
<td><a href="mailto:mike@mpmarine.co.uk">mike@mpmarine.co.uk</a></td>
<td></td>
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<td>01900 810299</td>
<td>01900 810299</td>
<td><a href="mailto:mike@mpmarine.co.uk">mike@mpmarine.co.uk</a></td>
<td></td>
</tr>
</tbody>
</table>
CONSULTANTS TESTING AND INSPECTION

HALCROW GROUP LTD
Asset Management and Engineering
Lyndon House, 62 Hagley Road, Edgbaston, Birmingham B16 8PE
Tel: 0121 456 0644 Fax: 0121 456 1569
Email: segersp@halcrow.com www.halcrow.co.uk

INDEPENDENT PROTECTIVE COATINGS SERVICES LTD
IPCS House, 32 Daryngton Avenue, Birchington, Kent, CT7 9PS
Tel: 01843 845472 Fax: 01843 847722

MOTT MACDONALD
Materials & Corrosion Engineering
Spring Bank House, 33 Stamford Street
Altrincham, Cheshire WA14 1ES
Tel: 0161 926 4000 Fax: 0161 926 4103
Email: paul.lambert@mottmac.com www.mottmac.com

Paint Inspection Limited
Trafalgar House, 223 Southampton Road, Portchester, Hampshire, PO6 4PY
Tel: 02393 233147 Email: ian@paint-inspection.co.uk
www.paint-inspection.co.uk

SSE Ltd
Grampian House, 200 Dunkeld Road, Perth PH1 3GH
Tel: 01738 456000 Fax: 01738 456647

INDEPENDENT LABORATORY SERVICES
Tel: 01506 439994
Email: enquiries@scaledsolutions.co.uk
www.scaledsolutions.co.uk

SSWELL SOLUTIONS LTD

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Unit 1 Energy Development Centre, Claymore Drive,
Bridge of Don, Aberdeen, AB23 8GD
Tel: 01224 823 960 Fax: 01224 823 871
Email: info@sonomatic.com
Website: www.sonomatic.com

NATIONAL OILWELL VARCO PTE LTD
161 Pioneer Road, Singapore, 639604
Tel: (65) 62643400 Fax: (65) 6262 1853

STEEL PROTECTION CONSULTANCY LTD
PO Box 6386, Leighton Buzzard, Beds. LU7 6BX
Tel: 01525 852500 Fax: 01525 852502
Email: david.deacon@steel-protection.co.uk
Website: www.steel-protection.co.uk

TOPLINE LIMITED
40 Birali Street, GRA Phase 1, Port Harcourt, Rivers State, Nigeria
Tel: 084 46238
Email: info@toplinelimited.net Website: www.toplinelimited.net

WOOD GROUP INTEGRITY MANAGEMENT
Compass Point, 79-87 Kingston Road, Staines, Middlesex, TW18 1TD
Tel: 01708 417225 Fax: 01784 417283

ENVIRONMENT AGENCY
Thames Barrier Operational Area, Eastmoor Street,
Charlton, London SE7 8LX
Tel: 0208 3054146 Fax: 0208 8547546

FORTH ESTUARY TRANSPORT AUTHORITY
Forth Estuary Transport Authority
Forth Road Bridge Administration Office,
South Queensferry, EH30 9SF
Tel: 0131 319 1699 Fax: 0131 319 1903
Email: customer.care@forthroadbridge.org

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www.carboline-europe.com

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SOLVENT-FREE COATINGS
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Email: sales@chemcoint.com www.chemcoint.com
COUNTER CORROSION LTD
Formulators and Applicators of Customised Protective Coating and Lining Systems for Steel and Concrete
Tel: 01924 468559/380002 Fax: 01924 458019

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Llantarnam Industrial Park
CWMBRAN
Gwent NP44 3XF
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INTERNATIONAL PAINT LIMITED
Stoneygate Lane, Felling, Gateshead, Tyne & Wear NE10 0JY
Tel: 0191 469 6111 Fax: 0191 496 0676
Email: simon.daly@internationalpaint.com
Website: www.international-pc.com

PPG PROTECTIVE & MARINE COATINGS
NOW A PART OF THE SHERWIN-WILLIAMS COMPANY
Unit 3 Maises Way, The Village, Carter Lane, South Normanton, Derbyshire DE55 2DS
Tel: +44 (0) 1773 814520 Fax: +44 (0) 1773 814521
Web: www.ppgpmc.com

RBG LTD
Norfolk House, Pitmedden Road, Dyce, Aberdeen AB21 0EW
Tel: 01224 722888 Fax: 01224 723406
Email: Fraser.coull@rgb.com Website: www.rgbltd.com

SPENCER COATINGS LTD
Froghall Terrace, Aberdeen, AB24 3JN
Tel: 01224 788400 Fax: 01224 648116
Website: www.spencercoatings.co.uk

TINSLEY SPECIAL COATINGS
Enterprise House, Durham Lane, Eaglescliffe TS16 0PS
Tel: 01642 784279 Fax: 01642 782891
Email: enquiries@tinsleyspecialproducts.com

TORISHIMA SERVICE SOLUTIONS
Sunnyside Works, Gartsherrie Road, Coatbridge ML5 2DJ
Tel: 01236 442391 Fax: 01236 702875
Website: www.torishima.eu

JOTUN PAINTS (EUROPE) LTD.
Stather Road, Flixborough, Scunthorpe, North Lincolnshire DN15 8RR
Tel: 01724 400 125 Fax: 01724 400 100
Email: decpaints@jotun.co.uk www.jotun.co.uk

LEIGHS PAINTS
NOW A PART OF THE SHERWIN-WILLIAMS COMPANY
Tower Works, Kestor Street, Bolton BL2 2AL
Tel: 01204 521771 Fax: 01204 382115
www.leighspaints.com

INTERACTIVE PAINTS LTD
Llantarnam Industrial Park
CWMBRAN
Gwent NP44 3XF
Tel: 01633 874024 Fax: 01633 489012
Email: sales@hempe.com www.hempe.com
# ICATS REGISTERED COMPANIES

## ICATS REGISTERED COMPANIES WITH QUALIFIED APPLICATORS

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Address</th>
<th>Phone Number</th>
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<tbody>
<tr>
<td>Abrasion Ltd</td>
<td>1 Montague House, 74 Bryantwood Road, London, N7 7BB</td>
<td>T: 07949 130168</td>
</tr>
<tr>
<td>Access Integrated Services Ltd</td>
<td>Unit 3, Waterton Buildings, Moor Road, Waterton Industrial Estate, Bridgend, CF31 3TR</td>
<td>T: 01646 654054</td>
</tr>
<tr>
<td>Alltask Limited</td>
<td>Alltask House, Commissioners Road, Strood, Kent, ME2 4EJ</td>
<td>T: 01634 289000</td>
</tr>
<tr>
<td>Alfred Bagnall &amp; Sons</td>
<td>6 Manor Lane, Shipley, West Yorkshire, BD18 3RD</td>
<td>T: 01302 853259</td>
</tr>
<tr>
<td>APB Construction (UK)</td>
<td>Unit 3, Bramley Way, Hellaby Industrial Estate, Hellaby, Rotherham, S. Yorkshire, S66 8QB</td>
<td>T: 01709 541000</td>
</tr>
<tr>
<td>APB Group Limited</td>
<td>Ryandra House, Ryandra Business Park, Brookhouse Way, Cheadle, Staffs, ST10 1SR</td>
<td>T: 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>T: 01355 248223</td>
</tr>
<tr>
<td>Austin Hayes Ltd</td>
<td>Carlton Works, Cemetery Road, Yeadon, Leeds, LS19 7BD, UK</td>
<td>T: 0113 250 2255</td>
</tr>
<tr>
<td>Beever Limited</td>
<td>Little Coldharbour farm, Tong Lane, Lamberhurst, Kent, TN3 8AD, UK</td>
<td>T: 01892 890045</td>
</tr>
<tr>
<td>Briton Fabricators Ltd</td>
<td>Watnall Road, Hucknall, Notts, NG15 6EP</td>
<td>T: 0115 963 2901</td>
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<table>
<thead>
<tr>
<th>Company Name</th>
<th>Address</th>
<th>Phone Number</th>
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<tbody>
<tr>
<td>Cape Industrial Services</td>
<td>Cape House, 3 Red Hall Avenue, Paragon Business Village, Wakefield, WF1 2UL</td>
<td>T: 01224 215800</td>
</tr>
<tr>
<td>Cleveland Bridge UK Ltd</td>
<td>Cleveland House, Farm Road, Darlington, DL1 4DE</td>
<td>T: 01325 502345</td>
</tr>
<tr>
<td>Coating Services Ltd</td>
<td>Partington Street, Mumps Bridge, Oldham, OL1 3RU, UK</td>
<td>T: 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>T: 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>T: 0845 6850133</td>
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<tr>
<td>Corrocoat</td>
<td>Forster Street, Leeds, LS10 1PW</td>
<td>T: 01132760760</td>
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<tr>
<td>Denholm Industrial</td>
<td>21 Boden Street, Glasgow, G40 3PU</td>
<td>T: 0141 445 3939</td>
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<tr>
<td>Dyer &amp; Butler Ltd (Rail)</td>
<td>Mead House, Station Road, Nursling, Southampton, SO16 0AH, UK</td>
<td>T: 02380 667549</td>
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<tr>
<td>E &amp; P Painting Contractors</td>
<td>Rosfield Road, Rossmore Trading Estate, Ellesmere Port, Cheshire, CH65 3AW</td>
<td>T: 0151 9558141</td>
</tr>
<tr>
<td>E &amp; P Painting Contractors</td>
<td>Rosfield Road, Rossmore Trading Estate, Ellesmere Port, Cheshire, CH65 3AW</td>
<td>T: 0151 9558141</td>
</tr>
<tr>
<td>F A Clover &amp; Son Ltd</td>
<td>Bardolph Road, Richmond, Surrey, TW9 2LH</td>
<td>T: 0208 948 6321</td>
</tr>
<tr>
<td>FinClean SKJ Ltd</td>
<td>Waterloo Industrial Estate, Pembroke Dock, Pembroke, SA72 4RR</td>
<td>T: 01646 622407</td>
</tr>
<tr>
<td>Forth Estuary Transport Authority</td>
<td>Forth Road Bridge, Administration Office South Queensferry, EH30 9SF</td>
<td>T: 0131 319 1699</td>
</tr>
<tr>
<td>GABRE (UK) Ltd</td>
<td>9 Holme Road, Dromore, Omagh, Co Tyrone, BT78 3BX</td>
<td>T: 02882 897950</td>
</tr>
<tr>
<td>Harrisons Engineering Lancashire Ltd</td>
<td>Crown Works, Crown Road, Low Southwick, Sunderland SR5 2BS</td>
<td>T: 0191 5160634</td>
</tr>
<tr>
<td>Herrington Industrial Services Ltd</td>
<td>Crown Works, Crown Road, Low Southwick, Sunderland SR5 2BS</td>
<td>T: 0191 5160634</td>
</tr>
<tr>
<td>H&amp;H Painting Contractors Ltd</td>
<td>4 Hamilton Gardens, Mutley, Plymouth, PL4 6PQ</td>
<td>T: 07837 382619</td>
</tr>
<tr>
<td>Hi-Tech Surface Treatment Ltd</td>
<td>Unit B, Deacon Trading Estate, Chickenhall Lane, Eastleigh, Hants SO50 6RP</td>
<td>T: 023 80611789</td>
</tr>
<tr>
<td>Hunter Steel Coatings Ltd</td>
<td>4Pinfold Lane, Alltami, Mold, Flintshire CH7 6NZ</td>
<td>T: 01244 541177</td>
</tr>
<tr>
<td>Hyspec Services Ltd</td>
<td>Unit 3 Meadowfield Industrial Estate, Cowdenbeath Road, Burntisland, Fife, KY3 0LH</td>
<td>T: 01592 874661</td>
</tr>
<tr>
<td>Industrial Coating Services</td>
<td>5 Danesbury Crescent, Kingstanding, Birmingham, B44 0QP</td>
<td>T: 0121 384 2266</td>
</tr>
<tr>
<td>Industrial Painting</td>
<td>48-49 RCM Business Centres, Sandbeds Trading Estate, Dewsbury Road, Ossett, WF5 9ND</td>
<td>T: 01924 272606</td>
</tr>
<tr>
<td>Company Name</td>
<td>Address</td>
<td>Telephone</td>
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<tr>
<td>Interserve Industrial</td>
<td>Unit 2, Olympic Park, Poole Hall Road, Ellesmere Port, Cheshire, CH66 1ST</td>
<td>T: 0151 3737660</td>
</tr>
<tr>
<td>Jack Tighe Coatings</td>
<td>Sandall Lane, Kirk Sandall, Doncaster, DN3 1QR</td>
<td>T: 01302 880360</td>
</tr>
<tr>
<td>Jack Tighe Ltd</td>
<td>Redbourne Mere, Kirton Lindsey, Gainsborough, Lincs, DN21 4NW, UK</td>
<td>T: 01652 640003</td>
</tr>
<tr>
<td>JPV (Painters) Ltd</td>
<td>Unit 8 Prospect Way, Hutton Industrial Estate, Brentwood, Essex, CM13 1XA, UK</td>
<td>T: 01277 201515</td>
</tr>
<tr>
<td>Lanarkshire Welding Co.</td>
<td>82 John Street, Wishaw, Lanarkshire, ML2 7TQ</td>
<td>T: 01698 264271</td>
</tr>
<tr>
<td>Mabey Bridge Ltd</td>
<td>Station Road, Chepstow, Monmouthshire NP16 5YL</td>
<td>T: 01291 623801</td>
</tr>
<tr>
<td>MCL Coatings Ltd</td>
<td>Pickering Road, Halebank Industrial Estate, Widnes, Cheshire, WA8 8XW</td>
<td>T: 0151 423 6166</td>
</tr>
<tr>
<td>Northern Protective</td>
<td>16 High Reach, Fairfield Industrial Estate, Bill Quay, Gateshead, Tyne &amp; Wear, NE10 0UR</td>
<td>T: 0191 438 5555</td>
</tr>
<tr>
<td>Nusteel Structures</td>
<td>Lympne Industrial Estate, Lympne, Hythe, Kent, CT21 4LR</td>
<td>T: 01303 268112</td>
</tr>
<tr>
<td>Offshore Marine Services Ltd</td>
<td>Brumby House, Jalan Bahasa, PO Box 80148, 87011 Lubuan F.T. Malaysia</td>
<td>T: +60124244410</td>
</tr>
<tr>
<td>Opus Industrial Services</td>
<td>Ethan House, Royce Avenue, Cowpen Industrial Estate, Billingham, TS23 4BX, UK</td>
<td>T: 01642 371850</td>
</tr>
<tr>
<td>Ormac Coatings Ltd</td>
<td>Newton Chambers Road, Thorncliffe Park Estate, Chapeltown, Sheffield, S35 2PH</td>
<td>T: 0114 246 1237</td>
</tr>
<tr>
<td>P&amp;R Engineering Ltd</td>
<td>Unit 50/51 Cable Street, Wolverhampton, WV2 2HX</td>
<td>T: 01902 870637</td>
</tr>
<tr>
<td>Paintel Ltd</td>
<td>26 St George’s Road, Saltash, Cornwall, PL12 6EH</td>
<td>T: 07730 691127</td>
</tr>
<tr>
<td>P H Shotblasting &amp; Spraying Services</td>
<td>43a Drumrainey Road, Castlecaulfield, Dungannon, Co Tyrone, BT70 3NY</td>
<td>T: 028 8776 7722</td>
</tr>
<tr>
<td>Port Painters Limited</td>
<td>Unit 3, Ringside Business, Hoel-Y-Rhosog, Cardiff, CF3 2EWx</td>
<td>T: 02920 77070</td>
</tr>
<tr>
<td>Pyeroy Limited</td>
<td>Kirkstone House, St Omers Road, Western Riverside Route, Gateshead, Wear, NE11 9EZ</td>
<td>T: 0191 4932600</td>
</tr>
<tr>
<td>Roy Hankinson Limited</td>
<td>Alexander House, Monks Ferry, Birkenhead Wirral, CH41 5LH</td>
<td>T: 0870 7892020</td>
</tr>
<tr>
<td>Rowecord Engineering</td>
<td>Neptune Works, Usk Way, Newport, South Wales, NP20 2SS</td>
<td>T: 01633 250511</td>
</tr>
<tr>
<td>Shutdown Maintenance Services Ltd</td>
<td>Kingsnorth Industrial, Hoo, Rochester, Kent, ME3 9ND</td>
<td>T: 01634 256969</td>
</tr>
<tr>
<td>Solent Protective Coatings Ltd</td>
<td>Tredgar Wharf, Marine Parade Southampton, Hants, SO14 5JF</td>
<td>T: 02380 221480</td>
</tr>
<tr>
<td>South Staffs Protective Coatings Ltd</td>
<td>Bloomfield Road, Tipton, West Midlands, DY4 9EE</td>
<td>T: 0121 522 2373</td>
</tr>
<tr>
<td>Standish Metal</td>
<td>Potter Place, West Pimbo, Skelmersdale, Lancs, WN8 9PW, UK</td>
<td>T: 01695 455977</td>
</tr>
<tr>
<td>Supablast (1984) Ltd</td>
<td>Jubilee Estate, Gorseyn Lane, Coleshill, Birmingham, B46 1JU</td>
<td>T: 01675 464446</td>
</tr>
<tr>
<td>T I Protective Coatings</td>
<td>Unit 6, Lodge Bank, Crown Lane, Horwich, Bolton, Lancs, BL6 5HU</td>
<td>T: 01204 468080</td>
</tr>
<tr>
<td>TEMA Engineering Ltd</td>
<td>5-6 Curran Road, Cardiff, CF10 5DF, UK</td>
<td>T: 020920 344556</td>
</tr>
<tr>
<td>ThyssenKrupp Palmers Ltd</td>
<td>1120 Elliot Court, Herald Avenue, Coventry Business Park, Coventry, CV5 6UB</td>
<td>T: 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>T: 01949 869784</td>
</tr>
<tr>
<td>Walker Construction (UK) Ltd</td>
<td>Park Farm Road, Fulkstone, Kent, CT19 5DY</td>
<td>T: 01303 851111</td>
</tr>
<tr>
<td>Wardle Painters Ltd</td>
<td>Unit S, Wimborne Building, Atlantic Way, Barry Docks, Glamorgan, CF63 3RA, UK</td>
<td>T: 01446 748620</td>
</tr>
<tr>
<td>W G Beaumont &amp; Son</td>
<td>Beaumont House, 8 Bernard Road, Romford RM7 0HX</td>
<td>T: 01708 749202</td>
</tr>
<tr>
<td>William Hare Ltd</td>
<td>Brandleholme House, Brandleholme Road, Burs, Lancs, BL1 1J, UK</td>
<td>T: 0161 609 0000</td>
</tr>
</tbody>
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**ICATS REGISTERED COMPANIES WITH APPLICATORS IN TRAINING**

<table>
<thead>
<tr>
<th>Company Name</th>
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<th>Telephone</th>
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<tbody>
<tr>
<td>Fairhurst Ward Abbotts</td>
<td>225 London Road, Greenhithe, Kent, DA9 9RR</td>
<td>T: 01322 387000</td>
</tr>
<tr>
<td>Gemini Corrosion Services</td>
<td>Brent Avenue, Forties Road, Montrose, Angus, DD10 9PB</td>
<td>T: 01674 672 678</td>
</tr>
<tr>
<td>Company Name</td>
<td>Address</td>
<td>Telephone</td>
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<td>--------------------------------------------------</td>
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</tr>
<tr>
<td>Harsco Infrastructure Services Ltd</td>
<td>Unit 3 Manby Road, South Killingholme, Immingham, North Lincolnshire, DN4 3DX</td>
<td>01469553800</td>
</tr>
<tr>
<td>BSM Consulting</td>
<td>11 Kingsmead, Nailsea BS48 2XH</td>
<td>01275854708</td>
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<tr>
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<td>IDL Fabrications Limited</td>
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<tr>
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<td>Radleigh Metal Coatings Ltd</td>
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**ICATS REGISTERED COMPANIES**

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<tr>
<th>Company Name</th>
<th>Address</th>
<th>Telephone</th>
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<tr>
<td>A1 Powder Coatings Ltd</td>
<td>Unit 4/5 Beta Buildings, Hazel Road, Woolston, Southampton SO19 7HS</td>
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<tr>
<td>Abbey Gritblasting Services</td>
<td>Unit 13, Clopton Commercial Park, Clifton, Woodbridge, Suffolk, PO12 3TP</td>
<td>01912620510</td>
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<tr>
<td>BAE Systems Surface Ships Support Ltd</td>
<td>Room 213, Naval Base Headquarters, Building 1/100, PO127, Portsmouth, PO1 3LS</td>
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<tr>
<td>Barrier Ltd</td>
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<td>BSM Consulting</td>
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9th February 2012  
**London Branch Meeting, Speaker:** George Winning on 'Integrity and corrosion management'.  
Meet at Naval Club, 38 Hill Street, London W1 at 17.30 for 18.15 start.

20th February 2012  
**Waterproofing.**  
Speaker: Brian Dargan Of Volker Laser Ltd  
Sponsored buffet.  
Contact: Brenda Peters  
Email: brenda.peters@analysis-scientific.co.uk or 01706 871700 if you wish to attend.

28th February 2012  
**UK CUI Industrial Forum - 10 years progress.**  
John Thirkettle (Thor Corrosion).  
Contact: Aberdeen Branch for further details.

8th March 2012  
**London Branch AGM and Meeting, Speaker:** Andy Taylor, **London Branch Chairman.**  
Meet at Naval Club, 38 Hill Street, London W1 at 17:30 for AGM at 18:00; meeting at 18.15

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 at 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.

18th April 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 Akit r.akid@shu.ac.uk or Prof. Paul Lambert paul.lambert@mottmac.com

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.

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

3rd May 2012  
**London Branch Sustaining Members’ Evening.**  
Details to be announced.

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.

12 March 2012  
**Wellington Swimming Pool.**  
Contact: Brenda Peters  
Email: brenda.peters@analysis-scientific.co.uk or 01706 871700 if you wish to attend.

15th May 2012  
**London Branch publish a monthly Newsletter**  
Details of all Branch activities, dates and venues can be found at www.icorr.org