An Introduction to the Enviroleel System

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Understanding Enviroteel

Enviropeel is a unique re-usable thermoplastic coating system that has been proven to reduce the costs of corrosion and wear by up to 95%.

A durable, flexible material at normal temperatures, Enviropeel is melted in a specially designed mobile application unit and sprayed as a liquid on to any size or shape of substrate, cooling to a solid in seconds. Built-in inhibitors are released on to every surface, providing active protection, penetrating deep into every crevice and flowing round every joint. The material forms a tough flexible cocoon around the target area providing an impermeable, corrosion-inhibiting barrier that will protect for the lifetime of the system. Enviropeel is quick to apply, environmentally friendly, easy to strip, re-usable and recyclable with no VOCs or harmful chemicals.

Benefits of Use

- Stops corrosion immediately
- Reduces wear & tear
- Prevents ingress
- Long-term active protection
- Reduced labour costs and maintenance-related accidents
- Extended component life
- Environmentally friendly
- Easy to remove
- Re-usable and waste free

Multiple Applications

- Bearing housings
- Flanges & Valves
- High-voltage switchgear
- Standby Equipment
- Gearboxes
- Junction boxes
- Bolt caps
- Dissimilar metal joints
- Replaces petrolatum tape
- Protection of critical spares

Enviropeel has been used by the mining and oil and gas industries offshore and onshore since 1998 - on flanges and valves in Asia, Europe and the Americas. Applications for power supply companies in the UK are preventing damage from water ingress and, in Australia, Enviropeel is specified for major mining companies, where its use on conveyor systems has increased equipment life cycles by more than 500%. Its environmentally-friendly credentials attracted the US Coastguard for bolt protection on their vessels and its ability to protect in ocean-going environments has been successfully applied to exposed pipework on LPG tankers.

Above: Spraying Enviroteel
Left: Protected flanges on an LPG carrier
Bottom: A carbon-steel gear spline after four years outside in the tropics
**Testing**

Enviropeel has undertaken a variety of tests, both in the lab and in the field, that show how well it performs. In-house and 3rd party ASTM B117 hot salt fog testing showed that areas within the Enviropeel protection zone stayed in perfect condition and other tests, including cryogenic, accelerated UV pinhole and film integrity testing, have shown outstanding corrosion protection in a variety of aggressive environments. Field trials for the US Coastguard proved Enviropeel’s performance on the high seas leading to its adoption for bolting protection on USCG vessels and on LPG Tankers. Sample testing during years of exposure to offshore North Sea conditions have shown no ill effects on Enviropeel but provided significant protection for thousands of flange applications.

Pictured left: Hot salt fog testing for Weatherford on a well-head component. The Enviropeel coating was cut away from the upper bolt before testing. The lower bolt was uncovered after the test.

**Application**

Enviropeel applications use specialized equipment and require licensed, qualified applicators, either supplied as a service for specific projects, or trained as part of an equipment sales or leasing arrangement. A wide range of equipment sizes is available, with tank sizes from 30kg/66lb to 10kg/22lb, all built to the highest standards. High capacity, twin-pump and hazardous area variants are also available.

How it works ...

This simplified cross-section shows two components joined by a bolt and protected with Enviropeel.

- **Passive Protection**: Ingress of moisture and contaminants prevented by perfectly fitting Enviropeel barrier
- **Active protection**: Inhibiting oil coats all internal surfaces under coating, preventing corrosion process

Although Enviropeel is supplied in grey as standard, it can be manufactured in a range of colors to suit any requirement.

Above: a range of flange types and sizes encapsulated with Enviropeel on a North Sea platform.

**Protective mechanisms ...**

Left: a standard 18kg/40lb Enviropeel unit complete with removable hose box

Below: the US-built 10kg/22lb application unit is a cost-effective choice

**www.ae-sys.com**
A range of Enviropeel equipment is available, from the simple Slugger to the mighty CA30. Every job is different and there is an Enviropeel unit to built to match - from the twin pump CA30, which can run two 19-metre (60 ft) hoses at the same time, to the tiny Slugger repair unit. Zone 2 CA30 & 18 units are available for offshore and hazardous area use.

**MADE TO MEASURE**

We can even tailor-make units for specific purposes. The unit below was specially manufactured with twin gas detectors and other features to meet the needs of a shipping company for its LPG carriers.
TECHNICAL BACKGROUND

Since the 1990s A&E has produced many technical papers to help others understand the power of Enviropeel - and what makes it work so well. But, before we provide a recent example of our own work produced for NACE in Houston, it’s worth a quick look at what one of the world’s largest oil companies said about us to the Offshore Technology Conference in 2010.

The extract below is from the ConocoPhillips Production Assurance Technology Division and it describes the background to the application of Enviropeel on more than 8000 flanges on one of their platforms.

The pictures on the right show, above: a mixed metal flange after 7 years of Enviropeel protection in the North Sea and below: a group of the many thousands of flanges coated on the platform.

OTC 20317
Offshore Platform Materials Integrity - Remediation Measures
ConocoPhillips, Production Assurance Technology

A platform topsides facility ... deteriorated substantially during the time between installation and the start of hookup/commissioning due mainly to the substandard coatings and workmanship. This degradation was exasperated by construction contamination and exposure to the marine environment ... Implementation of pragmatic solutions to the various issues encountered was required to ensure an on-time start-up. The required work scope entailed:

1. Bolting remediation with thermoplastic encapsulation
2. Iron and chloride contamination removal
3. Aluminum foil for heat tracing of corrosion resistant alloy (CRA) instrument tubing
4. High dry film thickness (OFT) coating qualification.

Bolting remediation with thermoplastic encapsulation

At this facility, most bolts were manufactured from low alloy carbon steel to provide a good combination of high strength and reasonable cost. Zinc/nickel electroplating followed by a passivation treatment was specified to provide corrosion protection. During deck integration, it was evident that a significant quantity of bolting materials on the platform suffered corrosion due to failure and premature consumption of the electroplated “protective” coating ... The corrosion product was superficial ... however, considering the potential for future damage to adjacent contaminated materials, remedial measures were developed.

Therefore, the application of a thermoplastic encapsulation product to prevent water ingress for bolts operating below 90°C (194°F) was recommended. Encapsulation had been used successfully on other ConocoPhillips offshore platforms and was thus a recognized, acceptable technical solution for bolt preservation in the North Sea environment. In addition, this ensured minimized disruption to ongoing construction; therefore, no further consideration was given to alternative coatings or bolt replacement using alternative materials/coating systems.

This thermoplastic encapsulation containing corrosion-inhibiting pigments (Enviropeel) is spray applied and ... was applied over bare metal or after preparation

Extract © OTC 2010
Bolt Corrosion Prevented by Corrosion-Inhibiting Spray-On Thermoplastic

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ABSTRACT

Numerous industrial facilities, especially offshore oil and gas installations, are plagued by bolt corrosion problems. With a limited record of success in prevention or cure, material loss from corrosion is often factored into maintenance planning, with bolt replacement as a solution when integrity is threatened.

An increasing focus on overall maintenance as an essential part of reducing problems in safety-critical systems makes the prevention of corrosion effects on basic components such as bolts and fasteners an increasingly important goal. This paper describes a corrosion-inhibiting sprayable thermoplastic system that has demonstrated success in the provision of extended corrosion protection on both new and rusting bolts in extreme conditions.

The system uses purpose-built equipment to spray a thermoplastic material containing inhibiting oils to encapsulate the substrate. The paper includes a review of current bolt coating systems and describes the thermoplastic system, together with field case histories showing how this product has effectively prevented or stopped on-going bolt corrosion issues found in offshore oil and gas production systems as well as the in mining industry and on LPG tankers.

Keywords: alloy, bolt, corrosion, encapsulation, fastener, flange, gas, inhibiting, offshore, oil, plating, sprayable, thermoplastic, valve, zinc
INTRODUCTION

In 2003 Karl Fischer reviewed offshore experiences with bolts and fasteners for the NACE Conference shortly after a long-term study of bolting materials and their performance in various service conditions commenced.\(^1\) The study was motivated by a need to understand how best to protect bolted systems from the effects of corrosion without a constant need for maintenance. Material selection and factory-applied coating systems were the main focus of the study but Fischer was also keen to see what remedial measures might be available in the event of failure and it was for this reason that the potential use of a corrosion-inhibiting sprayable thermoplastic system as a post-corrosion treatment was explored as part of the study.

Corrosion has always had the potential to cause catastrophic failure in infrastructure such as gas pipelines.\(^2\) In the case of bolted systems however, it is more like a death of a thousand cuts, as the progressive corrosion of fasteners affects the safety and function of the systems they are holding together.

Fischer enumerated the various bolt materials used in marine environments:

- Low alloy steel
- Copper-based alloys
- Nickel-based alloys
- Stainless-steel alloys
- Titanium-based alloys

Because of the cost and availability of corrosion-resistant alloys, low-alloy ASTM A193 B7 and A320 L7 steel bolting systems make up the majority of marine oil and gas facility fasteners.\(^3\) Because of their lower resistance, some form of corrosion protection will normally be applied. In a Bulletin, Badelek and Moore speak of their company’s experience in the North Sea, where a number of factory-applied bolt coating systems for low-alloy steels were evaluated:

- Zinc & Cadmium Electroplate
- Polytetrafluoroethylene (PTFE) Coating
- Sheradising
- Spun Galvanising

Of these, only the spun-galvanised bolts appeared to offer any corrosion resistance, with other coatings failing in as little as a few weeks.\(^4\)

Similar results were obtained in the initial findings of the Fischer study, where all but one of a similar range of coatings exposed in the splash zone failed in 18 months, despite an exhaustive search for the most suitable candidates (Figure 1). Failures in washer coatings and materials were even more pronounced than those in the fasteners.

The zinc/nickel plated L7 bolts shown in Figures 2 to 5 are from a newly constructed platform in the North Sea before it was commissioned. Typically, in a laboratory salt spray test, a zinc/nickel coating
would be expected to last at least 1,000 hours before ‘red rust’ occurs. An accelerated test such as this is designed to demonstrate the potential longevity of a coating system on the basis that the test conditions are so extreme, the lifetime of the coating should, for example, be 10 years under normal conditions if it could last 1,000 hours in a salt-spray cabinet.

Offshore however, conditions are far from normal; 1,000 hours is only 6 weeks. The bolts in these photographs have been exposed to constant salt-spray conditions for more than a year.

Figures 2 and 3: zinc-nickel plated L7 bolts on stainless steel flanges

Figures 4 and 5: zinc-nickel plated L7 bolts on a mixed stainless/carbon steel substrate

High levels of bolt corrosion on offshore structures are not uncommon and may be exacerbated by galvanic and crevice corrosion. In both the illustrated examples, the bolts are carbon steel; in one case the bolts are fastening stainless flanges, in the other, a combination of stainless and carbon steel. In such situations, low-alloy bolts are extremely vulnerable to galvanic effects.

For this platform, the client insisted on remedial action before handover - which would normally involve either blasting and painting or replacement of the one million corroding bolts. Because of the potential costs and delays involved, a review of potential solutions was undertaken which included the use of a
corrosion-inhibiting spray-on thermoplastic (CIST) recommended by the client company as it had been using it for a number of years on a platform suffering similar failures in PTFE coated bolts.

**CIST EXPLAINED**

The system involves the application of a thermoplastic barrier coating material that contains corrosion-inhibiting oils. Although the material is a solid at normal temperatures, when heated to 170°C it becomes a sprayable liquid which can then be easily applied to any substrate configuration. Substrate preparation is minimal. Removal of debris and light wire brushing is sufficient. On cooling, the material returns to a solid state without any loss of its original properties. The result is a rubbery solid, continuous plastic coating which can encapsulate any size or shape of substrate. Because of the inhibiting oils, the coating not only provides a barrier to water and oxygen but also actively prevents the progress of the corrosion process (Figure 6).

![Material function diagram](image)

*Figure 6: diagram of principles*
The advantage of such a system is that it works at every level to protect a bolted assembly. Spray application adapts to any size and produces a coating that conforms to every contour of the substrate. The resulting outer skin acts as a barrier to the ingress of oxygen and water - and every surface within the encapsulation is in direct contact with the inhibiting oil as it works into every crevice. This allows CIST to be applied to substrates where corrosion already exists (Figures 7 and 8) and can prevent galvanic, pitting and crevice corrosion. Easy to remove and repair, small areas of the CIST material can be cut away for monitoring or maintenance and reinstated without affecting the overall performance.

**CASE HISTORIES**

Since 2003, CIST has been in use on North Sea platforms for remedial protection of failing bolted systems. In the illustrated case the PTFE and electro-plating on low-alloy carbon steel bolts had not performed well (Figure 9) and a rolling program of CIST encapsulation using an Enviroleel system was implemented to prevent further deterioration.

*Figure 9: an area of corrosion affected valves*
Over the years both the operator and application engineers have removed sample applications from flanges to assess their condition. Inspection has shown that further deterioration of the bolts has been arrested by the CIST application (Figures 10 and 11).

![Figure 10 and 11: sample removal shows previously rusting substrate and inner surface of CIST encapsulation coated with oil](image)

Satisfaction with the performance of CIST on this North Sea platform directly influenced the decision to use the system for protection on a bridge-linked platform commissioned in 2008. A best practice specification for the use of CIST for bolt corrosion remediation is being developed by the company.  

Bolt protection requirements are not just the province of the offshore oil and gas industry. Gas transport systems in Malaysia and Canada have used CIST systems to protect flanges and bolted systems for onshore installations and long-term testing in the UK at a major gas terminal was successfully concluded in 2009 after 4 years of testing. Examination of the substrate following removal of the coating showed that oil was present on all internal surfaces and no corrosion had occurred (Figures 12 and 13). The terminal is directly adjacent to the North Sea and, while annual precipitation is low, the installation is subject to high salt and moisture levels.

![Figure 12 and 13: Application in 2005 and following removal in 2009](image)
On LPG carriers, flange bolts required repainting several times a year prior to the use of CIST which is used to protect flanges and valves on all deck pipework (Figure 14). The use of CIST has eliminated the need for repainting on such areas for these vessels.

Figure 14: CIST protected deck pipework on LPG carrier

OTHER APPLICATIONS

The combination of inhibition and encapsulation has shown impressive results in other areas too. In the Australian mining industry the material was used by an engineering company to eliminate corrosion in stored equipment waiting for installation. Engineers for the client of the engineering firm were intrigued by the new material and asked for investigations to be undertaken to see if the material was suitable for use on operating equipment.

These engineers had a particular interest in application to conveyor bearings, where failures in as little as nine months were commonplace in some areas. As there were many thousands of bearings on hundreds of miles of conveyor systems, frequent replacement, at $7,000 to $10,000 for each change out, was a costly and time consuming process.

Before the applications could take place, tests on bearing temperatures and lubrication were undertaken as there was concern that the encapsulation might affect these areas. No contraindications were found, but testing did discover that CIST’s lubricating qualities allowed it to be applied directly on to the bearing shafts without preventing rotation. This allowed complete encapsulation of the bearing housing, combining corrosion protection and particle ingress protection in one application.

Test applications and subsequent field applications over the past five years have shown a 100% success rate, with no failures in any CIST protected bearings. CIST protection is now mandatory on all mining conveyor bearings for the two largest mining companies in Australia.

In Figure 15, removal of CIST from trial bearings shows the bearing housing to be unaffected while the unprotected roller shows clear signs of deterioration.

An analysis conducted by the mining companies of performance data from the trial and subsequent implementation of the CIST protection showed significant direct cost savings as well as reduced maintenance requirements and lower risk exposure levels.
CIST PERFORMANCE DATA (2004 to 2009)

On stored conveyor pulleys

- Return for replacement without CIST: 44.5%
- Failure rate with full CIST: 0%

On operational pulleys

- Average bearing life in original location: 9 months
- Current bearing life in original location with CIST applied: 48+ months
- Resulting component life increase: 500+%%
- Resulting saving in pulley changeout costs: 500+ %
- Reduction in maintenance costs: 95 %
- Percentage of CIST costs to rebuild costs: 10 to 15 %
- Percentage of CIST costs to pulley change out costs: 5 to 7 %
- Resulting percentage reduction in risk exposure: 90+ %
- Anticipated increase in component lifetime: 500+ %

ASSET MAINTENANCE

The UK Health & Safety Executive (HSE), an independent regulatory authority charged with oversight of health and safety issues throughout the UK, issued a redraft of its 5-year Materials and Corrosion strategy document for the Oil & Gas Industry in September 2010. This document is aimed at securing the life-cycle integrity of offshore installations and refers to the danger from the severe corrosive effects of the North Sea environment on its ageing infrastructure.

When it comes to external corrosion, its guidance is quite clear: operators are not only responsible for ensuring the integrity of safety critical areas but must also make sure plans and procedures are in place to ensure all plant & equipment are in good repair with respect to corrosion. It lists the following as areas for concern:
Walkways and stairways
Cable trays including fittings and brackets
Bolted connections
Flanges
Pipe supports and pipes
Valves

A variety of solutions exist for remediation of corrosion in these areas and CIST would not be practical in every category but the list makes it clear that preventing failure in complex assemblies joined by bolts and fasteners is a priority to meet safety concerns.

Such concerns exist all around the world and many ageing structures are suffering. CIST can provide a reactive solution to existing problems, with long-term pro-active effects that have eliminated corrosion entirely for some users and offers the potential to do the same in a wide variety of areas. And, because it is re-useable, recyclable and toxin-free, it’s better for the environment too!

CONCLUSIONS

1. Long-term evaluations have shown CIST effectively prevents bolt corrosion in aggressive marine and mining service.
2. CIST provides bolt corrosion control for both existing and new build applications through encapsulation and inhibiting oil.

REFERENCES

2. For example, the August 2000 rupture of a pipeline in Carlsbad, New Mexico caused 12 fatalities and widespread damage as a result of corrosion. NTSB Report NTSB/PAR-03/01.
6. As estimated by operating company engineers.
7. Enviropeel is a trademark of the A&E Group.
How to Manage External Corrosion

Recent UK HSE reports have highlighted the need for dutyholders to monitor asset integrity in non-safety-critical as well as safety-critical applications, with effective maintenance management systems for walk and stairways, piping and pipe supports, cable trays and fittings, bolts, flanges and valves. The 2007 KP3 Report asserted that there had been a failure to adequately monitor asset integrity and pointed to the need for those with a duty of care to have a better understanding of the potential impact of degraded, non-safety-critical plant and utility systems on safety-critical elements.

Since 2007 many improvements have been made and moves for a shift of focus from safety critical elements to include a greater concentration on overall asset integrity management - but much remains to be done. A 2009 OSD review concluded that major ongoing efforts were required, with ageing infrastructure presenting major challenges. It is with a view to addressing these challenges that some of the issues raised in the HSE ‘Management of External Corrosion’ document are examined in the light of what can be done using Enviropeel to provide prevention and remediation in the event of corrosion in offshore structures.

AREAS OF CONCERN

The HSE ‘Offshore external corrosion guide’ lists six areas of concern: corrosion under insulation, firewater mains & deluge systems, flanges & plant bolting, valves, pipe supports & coatings and threaded plugs. A number of accelerating factors are highlighted, including the presence of water traps, mixed metals and saltwater conditions.

HOW ENVIROPEEL CAN HELP

Most offshore installations regard a certain amount of rust as a necessary evil – conditions are such that a good deal of redundancy is built into systems, allowing for degradation from corrosion as part of the natural lifecycle of marine infrastructure. In many cases the need, for example, to cut bolts off because they are too corroded to unscrew, is regarded as standard procedure. Corrosion prevention is HSE’s preferred option but, where levels of corrosion are allowed to develop, they insist on verifiable performance standards that define the limits beyond which components must be repaired or replaced.

The aim of HSE, of course, is to maintain safety standards. Naturally, the inspection and maintenance of offshore structures must be of the highest standard to ensure safety - but good maintenance is also necessary for optimum production levels over the lifetime of the structure.
listed above, a corrosion-inhibiting encapsulation of the vulnerable components will prevent any degradation of the substrate, eliminating the need for bolt changes, equipment replacement or repair.

INSPECTABLE

Although it is well established that bolted systems and components protected by Enviropeel remain corrosion-free for many years, it is essential that, when required, inspection of the substrate can be easily undertaken. Because Enviropeel is easily removed, all or any part of the protective layer can be easily peeled away to reveal the target area and, once inspected, the protection can be reinstated, either by complete reapplication or by resealing a specifically removed area. Enviropeel recommends an annual visual inspection regime with targeted removals and inspections as part of its 5 and 10-year warranty programmes.

EFFECTIVE

You can be confident that Enviropeel will provide the protection you need because of the way it works. Corrosion requires a number of elements to develop. For aqueous corrosion this would normally be the metal substrate, oxygen and water. Enviropeel isolates the substrate by providing an external barrier, preventing water ingress and coating the surface in an inhibiting oil which prevents the flow of oxygen and the electron transfer that is essential to the corrosion process. This isolation process works for galvanic, pitting and crevice corrosion as well as normal atmospheric corrosion.

The Enviropeel system uses a corrosion-inhibiting, sprayable thermoplastic to provide a close-fitting active barrier coating on steel substrates of any size or shape with minimal surface preparation.

FLEXIBLE & ADAPTABLE

Not only is the Enviropeel material flexible, allowing it to expand and flex with movements in the substrate but the system itself is very flexible in use, allowing a wide variety of solutions on a range of problem substrates. Whether it is being used to protect bolts, flanges, valves or pipe supports, it provides supremely adaptable protection, allowing encapsulation of almost any configuration.

WASTE-FREE, RECYCLABLE AND NON-TOXIC

While it is not part of a specific safety regime to reduce the environmental impact of materials, it is worthwhile noting that Enviropeel does fulfill this objective. The material itself can be reused or recycled – waste material can immediately be used in the application unit – and no special disposal measures are required as the material is non-toxic and contains no VOCs.

The HSE Offshore Division (OSD) seeks a lifecycle management approach which starts with the initial selection of appropriate materials and follows through the lifecycle with effective inspection, maintenance, repair and replacement. For more information on HSE OSD and corrosion mitigation you can visit their website: www.hse.gov.uk/offshore/corrosion.htm
Flange Joint Protection in the North Sea

Enviropeel had been successfully protecting flange bolts on a large gas platform in the North Sea, operated by two of the world’s largest oil companies, for more than five years. So, when it came to choosing a system for bolt protection on a new linked platform, the operators decided that Enviropeel was the best approach to use. Even before commissioning, the new platform was suffering from the corrosive effects of the severe North Sea environment on its bolted systems and a new contract for joint encapsulation across the platform was awarded for the use of Enviropeel.

PLANNING
The original specification called for 6087 flanges on 25 pipe systems throughout the platform. Following several weeks of planning, two survey trips were completed by Enviropeel personnel using the platform design isometrics to identify and tag all flanges that were to be protected. The initial plan was to mobilize a six-man team per rotation with three machines and an intended start date of February 2008, ending in August at the time of the departure of the accommodation platform.

MOBILISATION
Although a first mobilization did take place in February, accommodation and commissioning issues delayed the second trip and application only began in earnest in mid June – reducing the time available from 7 months to less than three.

The reduction in the time available forced a number of operational changes on the project. Manpower was increased from 6 per rotation to 8 per shift, with an extra application unit and full utilization of all machines, rather than having one or two on standby as originally intended. Maximum manning was achieved in August when up to 24 personnel and five application units were on the platform to complete as many flanges as possible before the accommodation platform departed.

As well as less time, an examination by the operators of the schedules used to allocate suitable flanges and systems determined that an increase in the workscope was required, with an additional 831 joints to be completed – a new total of 7123. Unfortunately, isometrics of the new workscope didn’t match those originally supplied for the two tagging surveys. This, plus...
missing tags lost or removed in the months between the survey and start of the project, meant a significant increase in workload surveying and maintaining accurate application data.

With pressure for increased joint numbers, at the same time as a requirement to maintain strict quality control, it took a massive effort by the teams, supervisors and client to streamline the identification, recording and application process, allowing the teams to begin increasing the numbers of joints completed. Although equipment servicing issues (arising from the unprecedented throughput of material), pressure testing and other operational issues brought delays as the platform systems went ‘live’, numbers steadily increased until up to 200 joints a day became possible. The final

*Left: two applicators work from either side of a large flange joint.*

*Below left: applications on deck.*

*Below right: before and after application to a large joint suffering from bolt corrosion.*
Above: the application builds coats in succession, working from underneath, around the sides and finally above with two coats to provide maximum protection. The underside is the most difficult area to finish aesthetically but trimming between and after each coat ensures full protection. All trimmings and drips/spills are collected and recycled.

tally, as the team packed for the departure of the accommodation platform, was 6231, leaving about 800 joints to be completed at a later date.

CONCLUSION
Overall, a very satisfactory result. Meeting the production targets in such a drastically reduced
timescale created challenges that could not be solved by simply increasing manpower and equipment levels – no easy task in itself with mobilization dates being put back week after week. This was the first Enviropeel project to operate with more than two machines, but tripling the workforce and adding extra application units did not have the same effect on the output; working practices and logistics all had to be revised as the project developed, to maximize productivity.

Early setbacks were overcome by the dedication of supervisory and other staff, working with a client that understood the extra pressures that had been created. The final result was not just a higher number of joints completed than the original workscope, but also a greater understanding of what was required to meet these new challenges.

*Right and above: A review of the finished applications shows the high standards maintained throughout the project.*
Robil Engineering of Port Hedland in Australia is a company that works extensively providing engineering services for the mining industry. They first came across Enviropeel in a UK chartered publication. Following a visit to the Enviropeel UK head office, an initial machine was purchased to provide an engineering solution to problems experienced with corrosion on machined surfaces and also stored equipment.

Initial results on a variety of components and equipment were extremely positive and, with the addition of two extra machines, Robil set about revolutionising their approach to component protection. In order to provide added value to their refurbished assemblies, Robil undertook trials with the protection of the bearing and seal systems on various sized conveyor pulleys from BHP Billiton, coating around the complete bearing housing and seal assemblies after rebuild.

The material was sprayed over the housings and seal areas, up to and completely around the shaft. This doubled the effectiveness of the barrier, providing corrosion protection and an additional barrier against contamination ingress, effectively an ‘extended labyrinth’, on to the shaft.

With proven success on stored equipment, the next logical step was to trial the same system on operational machinery.

Left: Australia can be an extremely severe environment as the condition of the illustrated equipment shows.

Below: At first the refurbished bearings were coated with Enviropeel ready for storage.
Enviropeel bearing housing protection has produced a huge increase in bearing life. Previously, bearings in this location were lasting an average of nine months before they required urgent change out but, in 2007, four years after the first applications, no pulleys with Enviroleel-coated housings had shown any sign of failure. All of the bearings that Robil have trialed and tested in service so far at both BHPB and Dampier Salt were chosen from particularly severe areas, with high spillage in dirty and salty environments.

**Conclusion**

Enviropeel has proved itself in many parts of the world and under a wide variety of conditions, but perhaps, it is in Australia where the adaptable nature of the system has shown itself most clearly. It provides users with the ability to extend component life, avoid expensive double handling, significantly reduce maintenance as well as down-time costs and dramatically reduce the exposure of people to risks associated with working with this type of equipment. Enviropeel coating of bearing housings has been adopted as standard practice by BHP Billiton and Rio Tinto in Australia for their conveyor systems.

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**Results from BHP Billiton/Rio Tinto**

**ON STORED CONVEYOR PULLEYS**

- Average return rate for replacement on inspection prior to installation on pulleys without Enviropeel: **44.5%**
- Failure rate with full Enviroleel protection (improved after early testing): **0%**

**ON OPERATIONAL PULLEYS**

- Average bearing life in original trial location: **9 months**
- Current bearing life in original location with Enviroleel applied: **48+ months**
- Resulting component life increase: **500+%**
- Resulting saving in pulley change out costs: **500+%**
- Reduction in maintenance costs: **95%**
- Percentage of Enviroleel costs to rebuild costs: **10-15%**
- Percentage of Enviroleel costs to pulley change out costs: **5-7%**
- Resulting percentage reduction in risk exposure: **Approaching 500%**
- Improvement in safety relating to pulley change out operation: **Approaching 500%**

**It is expected that the minimum component lifetime increase should be 500+%**
So, in 2011, Enviropeel started an intensive programme of application on gas insulated switchgear and other power transmission infrastructure. In most cases, the substrates do not require corrosion protection as they are constructed from a light alloy and use stainless steel bolts. However, the substrates have to be extremely lightweight and consequently can be vulnerable to damage resulting from water ingress between joint surfaces. Enviropeel proved to be very successful in trials and adoption across the UK is growing apace.

Needless to say, the Enviropeel application team had to undergo considerable training to be able to work in such hazardous locations!
Typically, Enviroeel is applied to flanges either on a horizontal pipe or a vertical pipe, the pipe would be expected to have an intact protective coating as in the example shown in Fig 1. Here we can see that the flange edges and bolts are corroded but that the main pipe coating is in good condition.

A standard Enviroeel application, as shown in Fig 2, encapsulates all the vulnerable areas and continues the coating until a reasonable area of intact coating has also been covered.

Although, on the unpainted steel test substrate in Fig 3, a small margin can be detected where moisture meets the inhibitor, on a painted substrate the effect is completely insignificant. All the vulnerable areas are locked in a moisture-free, inhibitor rich environment, away from any potential ingress. The example in Fig 4, shows a substrate which, without encapsulation, would have bolts failing within 18 months because carbon steel bolts in a stainless substrate suffer badly from galvanic corrosion. As can be seen, no corrosion has occurred within the encapsulation.

On a vertical pipe, there would seem to be more potential for problems but the right application techniques will prevent ingress even in the worst possible circumstances. In long-term salt-water deluge tests, shown overleaf, the ability of
Enviropeel to prevent corrosion in these areas is clearly demonstrated.

For the test, an uncoated carbon steel pipe and flange test piece was placed in a stream of 20% salt water. To emulate splash zone conditions, the flow was turned on and off on a 12 hour cycle.

To ensure no protection of any kind was on the substrate, a 15cm strip was abraded with an angle grinder (to remove mill scale etc) along the whole length of the pipe.

The test was run over three months, following which the Enviropeel was cut away to reveal the results.

Fig 5 above: substrate and Enviropeel encapsulation shortly after the beginning of the trial. On potentially vulnerable edges, cable ties provide extra security.

Fig 6 left: two weeks into the trial, the circular water delivery system can be seen at the top of the photo.

Fig 8 below: initially, strips of Enviropeel are removed from the substrate.
Fig 9 above: the removal of the mill scale is clearly visible.

Fig 10 above right: following removal of all the Enviropeel material from the joint, the level of protection is clearly visible.

Figure 11 below: cutting through the sealing tie reveals a sharp line between the protected and unprotected areas of the substrate.

Because Enviropeel cools and contracts on to the substrate, with a constant release of inhibiting oils, moisture is prevented from entering the interface. Where there is likely to be substantial or sustained water pressure, extra material is applied and cable ties are employed to provide extra security. Sealing upper edges securely is particularly important as these are the areas that are subject to rain and water flows.

As this test shows, despite the high salinity and constant flow of water, no corrosion or penetration of any kind can be seen within the Enviropeel encapsulation.
North American Limestone Mining

In February of 2011, Enviropeel was installed on conveyor belt pulley bearings in a central Indiana aggregate limestone quarry. Twenty-four new bearings in particularly harsh locations were chosen to be encapsulated with Enviropeel due to their exposure to constant limestone dust and the water used to wash the aggregate.

Reclaimed water full of silt is blasted at the base of these conveyors to keep limestone from building up around the tail pulley. This water is necessary for the operation but washes grease out of bearings while introducing contamination into the rotating system, resulting in premature failure. Constant pressure automatic lubrication systems were previously installed to purge contamination, with only limited success and life expectancy for many of these bearings was between 2 and 6 months. Downtime is costly for these feeder conveyors, costing the plant more than $5,000 for every hour not in operation. A solution was desperately needed and the plant manager turned to Enviropeel for help.

Over a 2 day scheduled plant shutdown, all 24 bearings were encapsulated with Enviropeel, and the coating was extended out onto the pulley shaft to add more sealing surface. Despite temperatures reaching below 10 degrees Fahrenheit, the installations were completed on time.

Top: a fresh application on a pulley bearing. Note that the Enviropeel coating continues around the rotating shaft providing excellent ingress protection.

Right and below: on site at the Indiana Martin Marietta Aggregate limestone quarry.
After one year of Enviropeel protection, all coated bearings are still in operation with no sign of failure. Due to the isolation of the bearings from contamination, lubrication frequency has been significantly decreased, resulting in lowered maintenance costs. Additional benefits include rotating shaft protection and the ability to eliminate some previously required mechanical guards. The plant manager estimates a savings of over $20,000 in bearing costs alone in this first year of protection. This does not take into account the savings from downtime, labor for replacement, or lubrication savings. Given the success of Enviropeel in this plant, implementing our product into other area plants has begun.

Before and after: the pictures show the difference between a new application and others after a year of exposure to mine conditions.
Method Statement for Encapsulating Joints at a Nuclear Electric Substation

Reference: A&E Ref: CA1423

Siemens Ref:

Produced By: Safety Officer Date: 18.07.11
Accepted By: Senior Manager Date: 18.07.11

**Work Scope**

This method statement covers the application of Enviropeel within Substation Compound to all Gas Insulated (GIS) flange and hatch covers to prevent water ingress plus procedures for joint encapsulation.

**Exact Location**

Substation Compound
All flanges

**Access & Egress**

Note: There must be no access/egress across site or any other route not agreed with the SAP / Site Safety Manager / Engineer.

All operatives will have attended the Site Induction Training

All operatives will log their attendance on site by signing the site attendance register located in the site office.

All personnel will have their certificates of competence and operator’s licenses checked and copied before access into the compound is permitted.

All vehicle movements will be along approved, designated routes and supervised by the site supervisor.

The flanges and covers will be accessed by a MEWP driven by an authorised operator. The flanges immediately leaving the building will be accessed by Scaffolding. Great Care will be taken when working on pressurised GIS equipment especially Small bore pipework.

**Objective**

To negate further degradation of substrate due to corrosion and prevent water ingress for all designated areas.
In order to ensure good practice and minimise disruption:

1. Daily site reports to be kept and copies filed for Enviroleel records
2. All incidents (Enviroleel or others) must be reported in accordance with the appropriate reporting chain. This reporting chain will be briefed to all Enviroleel personnel prior to work commencing.
3. Plan ahead for site services and notify accordingly
4. Liaise with operator and other contractors to avoid work conflicts
5. Confirm equipment checks and certification are complete before commencing work

Pre-work documentation.

Prior to preparing a site for / carrying out Enviroleel operations an Enviroleel Pre Operations Risk Assessment must be carried out by Project Manager / Project Supervisor to identify and eliminate any unforeseen hazards during survey.

The Project Manager / Project Supervisor will carry out a “tool box talk” prior to the commencement of working operations.

Preparation

Using wire brushes, remove loose material such as paint and rust particles and brush or wipe down as necessary to remove and avoid contamination of Enviroleel material. All debris to be collected in a suitable receptacle or by laying a tarpaulin or similar sheeting under the application area and disposed of in accordance with site regulations.

Application Equipment

Enviroleel Application Unit CA30. All equipment to have pre-mobilisation safety check prior to mobilisation and confirmed on site each day prior to work commencement.

Application procedure and specification:

Locate 415V power supply within vicinity and safety check any supplied extension cables.
Locate the application unit within the application radius of the supplied hoses (between 10 and 19 metres).
Set up safety signs and barriers.
Sheet off where necessary for weather protection.

1. Load the heating tank with the Enviroleel chips.
2. Switch on the unit and set the heating tank temperature control to 170°C.
3. Monitor the heating up phase until the ready light illuminates.
4. All flanges/joints, as identified in work pack, will be coated with E170 Grey to a minimum thickness of 4mm; two coats will be required to attain this thickness.
5. By means of application through the spray gun, apply the first coat to the underside of the joint then apply to the top section to complete first stage of the encapsulation.
6. Once coating of the substrate has been completed all excess material will be trimmed and recycled for later use. Any heavily contaminated material to be disposed of into hazardous waste bags and placed in the relevant skip.
7. Repeat the second coat in the same manner as the first coat.

Quality control

1. All applications must be two coats, with a minimum average DFT of 4mm. Coating thickness to be checked using Elcometer 355 or similar dry film thickness gauge with 5mm+ capacity.
2. Every application must be checked visually for any holidays (holes) in the coating using inspection mirrors where necessary for inaccessible areas. If any are identified the application must be removed, material recycled in the unit heating tank and the application repeated.
3. All relevant data (joint number, material batch number, dates and operative) to be recorded on daily work sheet report for quality control purposes.
4. Shift Supervisor is responsible for quality of all applications on his/her shift.
5. Random daily checks to be carried out by Project Supervisor on all work undertaken
6. All failed applications must be immediately removed and marked for reinstatement
7. Reasons for any application failures must be reviewed and addressed with retraining if necessary

Health & Safety

Objective:
To ensure the safe working environment at site for other contractors and Enviropeel personnel on site whilst the above stated work is carried out, also to minimise the disruption to site personnel and other contractors.

Related documents

- Risk assessment – Enviropeel
- Work scope – Siemens
- Training certificates – Enviropeel
- Material MSDS and COSHH sheets – Enviropeel
- Application Machine certification – Enviropeel
Safety equipment

Standard Personal Protection Equipment (PPE) - hard hat, safety glasses, flame retardant high visibility overalls, ear protectors (for use when required) and safety boots.

Extra PPE required for Enviroteel application – Eye and face protection – normally a full face visor but a face mask may be used where access is restricted, Kevlar gloves when using knives, heat and oil resistant gloves when operating application unit.

Safety considerations

- Ensure all work is executed in accordance with the SAP / Safety Managers instructions.
- Erect safety barriers and signs. Observe existing ones.
- Ensure all walkways are kept clear of tools and equipment. Protect hoses and cables that cross the walkways.
- Make sure isolations are in place (see below).
- Adhere to safety distances when working near to adjacent live circuits.
- Erect tarpaulins in windy conditions.
- Where it is unavoidable to have spray hose crossing walkways use walkway ramps to negate any tripping hazard.
- Maintain a clean work area. Good housekeeping is high priority.
- Liaise with other work forces working nearby and plan accordingly to ensure a smooth and safe work pattern is achieved.
- Take time after each break to assess any change in conditions i.e. review the risk assessment and log any new hazard or changes identified.

Isolation of Site equipment

To only be carried out by Siemens / NG employed Senior Authorised Persons.

Training requirements

- All Enviroteel operatives are approved for the application of Enviroteel.
- Enviropeel personnel must attend a site induction.
- All personal are required to have BESC, EUSR Persons and CCNSG Safety Passport.

E170 storage and MSDS docs

E170 is non-hazardous and will be stored in plastic buckets each containing 10 kg, which in turn will be stored in a secure and dry location. All health and safety data sheets will be available at all times.
Signing on Register

I, the undersigned, have read, discussed and fully understand the above method Statement and Risk Assessment on encapsulating joints at the Nuclear Electric Compound and will adhere to all its method of working and conditions set down.

<table>
<thead>
<tr>
<th>PRINT NAME</th>
<th>COMPANY</th>
<th>SIGNATURE</th>
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NOTE: - All personnel in the work party must read, agree and sign the above prior to commencing the work.

If during the course of the work there are any changes to the method of work, the work must stop and a new R.A.M.S. produced in line with the method / conditions of work.
ENVIROPEEL barrier coating

High-build, solvent-free strippable and re-usable thermoplastic polymer, can be used in conjunction with Enviropeel Pre-treatment Inhibitor.

For the anti-corrosion protection of steel and other metals, especially flanges, pipework etc, transit protection of machinery and components, long and short-term protection of stored machinery and components. Speedy stripping and re-application for inspection and maintenance on site.

ASTM B117 3000 hr - hot salt - fog compliant

Enviropeel hot spray application unit / Slugger 170 hand unit

Standard Grey - Clear/other colours on request

Greater than 200°C/392°F

No volatile organic compounds or other harmful by-products

4mm/160 mil minimum (two coats)

Using the special Enviropeel units a D.F.T. of approx 2000 microns/80 mil per pass is achievable.

Touch dry - 1-2 minutes - handling time 15 minutes.

High temperatures & UV may accelerate inhibitor loss from the material surface and could cause some surface effects. This will stabilise and not affect corrosion prevention, providing sufficient material is applied to take this into account. Grey or white E170 is recommended for such conditions

Substrate temp down to -15°C/5°F without ice/frost/moisture. Apply in a continuous operation. Max substrate temp 80°C/176°F.

Low ambient temp (below 6°C/43°F) may require special measures

A wide range of aqueous solutions including sea water

Single pack: Alocit HB Primer - Matt

10 Kg/22lbs plastic containers (re-usable).

36 months in original container stored at 20°C/68°F

120°C/248°F

160-175°C/320-347°F

180°C/356°F

NB - Oil separation may occur during heating - avoid by mixing regularly. Material levels in tank should be kept at or near maximum to prevent degradation etc.

MINIMUM - wire brush, remove loose flaking paint etc

STANDARD - as min. plus clean water wash, dry before applying E170.

OPTIMUM - abrasive blast clean to bare metal, one coat primer, one coat finish

Use Enviropeel Solvent Free Equipment Cleaner.
SAFETY DATA SHEET

September 2013
Version No S3/E92013

Document reference no: MSDSE170

1. Identification of the substance/preparation and of the company undertaking

Product: Enviropeel E170

REACH registration: All components of the blend are registered

Application of the preparation: Anti-corrosion coating applied by spray

Supplier address: A&E Systems, 3 Charles Wood Road, Dereham, NR191SX, UK
Tel: + 44 (0)1362 694915 Fax: +44 (0) 1362 695350
Email: enviropeel@ae-sys.com
24 hr emergency contact: +44 (0) 7825 987326

2. Hazards identification

2.1 Classification of the substance or mixture

Classification (EC1272/2008): Hazard statements: None required
Precautionary statements: None required
Classification (67/548/EEC): Signal Word: None required
Hazard symbol: None required

2.2 Label elements

Label in accordance with (EC) No. 1278/2008: Hazard pictogram: None required
Signal Word: None required
Label in accordance with Directive 67/548/EEC: Hazard symbol: None required
Risk phrase: None required
Safety phrase: None required

2.3 Other hazards

When using material in the molten state ensure adequate ventilation and take precautions to prevent burns.

3. Composition/information on ingredients

<table>
<thead>
<tr>
<th>Name</th>
<th>EC No.</th>
<th>CAS-No.</th>
<th>Content</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Oil (&lt;=3% DMSO extract by IP346)</td>
<td>265-155-0</td>
<td>64742-52-5</td>
<td>5.0-10.0%</td>
<td>Not classified</td>
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</tbody>
</table>

4. First-aid measures

General information

Burns: Must be treated by a physician.
Inhalation: Provide rest, warmth and fresh air.
Get medical attention if any discomfort continues.
5. Fire-fighting measures

5.1 Extinguishing media: Use dry powder, foam, carbon dioxide (CO2), water spray to cool surfaces exposed to fire and protect personnel. Unsuitable extinguishing media: Do not use water jets as these may spread the fire.

5.2 Special hazards arising from the substance or mixture: Dangerous combustion products include smoke and oxides of carbon. Fire creates toxic gases/vapours/fumes of carbon monoxide and carbon dioxide.

5.3 Precautions for fire-fighters: Standard - wear self contained breathing apparatus in confined spaces.

6. Accidental release measures

Environmental precautions: Do not allow to enter public sewers and watercourses. If contamination of drainage systems or water courses is unavoidable, immediately inform appropriate authorities.

Spill clean up methods: Collect and reclaim or dispose in sealed containers in licensed waste.

7. Handling and storage

Usage precautions: Ventilate well, avoid breathing vapours. Use approved respirator if air contamination is above accepted level.

Storage precautions: Store at moderate temperatures in dry, well ventilated area.

8. Exposure control and personal protection

Name: Base Oil
Specific Gravity: 0.812
(<3% DMSO extract by IP346)

<table>
<thead>
<tr>
<th>Component</th>
<th>Std</th>
<th>LT - ppm</th>
<th>LT - mg/m³</th>
<th>ST - ppm</th>
<th>ST - mg/m³</th>
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</thead>
<tbody>
<tr>
<td>Base Oil</td>
<td>OES</td>
<td>5.0</td>
<td>0.000005</td>
<td>10.0</td>
<td>0.0001</td>
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INGREDIENT COMMENTS: OES = Occupational Exposure Standard. Exposure risk from oil mist not present when incorporated into E170 base polymer as ingredient

Protective equipment: Gloves - see comments on hand protection

Process conditions: Use engineering controls to reduce air contamination to permissible exposure level.

Engineering measures: Provide sufficient ventilation during operations which cause vapour formation.

Respiratory equipment: Respiratory protection must be used if air contamination exceeds acceptable level.

Hand protection: Chemical resistant gloves required for prolonged or repeated contact. Use protective gloves made of Nitrile / Butyl rubber.

Eye protection: Wear splash-proof eye goggles to prevent any possibility of eye contact.
Hygiene measures: Wash at the end of each work shift and before eating, smoking and using the toilet.

9. Physical and chemical properties

9.1 Information on physical and chemical properties

Appearance: Oily Solid
Colour: Colour as per colour variant on label
Odour: Characteristic
Solubility: Insoluble in water
Flash point (°C): 190 Sh CC (Setaflash closed cup).

10. Stability and reactivity

Stability: Stable under normal temperature conditions.
Conditions to avoid: Avoid contact with strong alkalis / oxidising materials.
Hazardous decomposition products: Fire creates oxides of carbon.

11. Toxicological information

Inhalation: Gas or vapour from the molten product is harmful on prolonged exposure or in high concentrations. May cause irritation to nose, throat and upper respiratory tract.
Ingestion: May cause discomfort if swallowed.
Skin contact: Prolonged or repeated exposure may cause severe irritation.
Eye contact: Particles in the eyes may cause irritation and smarting.

12. Ecological information

Mobility: Absorbs to soil and is not mobile
Bioaccumulation: Low potential for bioaccumulation.
Degradability: Not readily biodegradable
Water hazard classification: WGK 2 (company)

13. Disposal conditions

Disposal should be in accordance with local, state or national legislation. Incinerate in suitable combustion chamber.

14. Transport information

General: Not classified as hazardous for transport.

15. Regulatory information

Risk phrases: None
Safety phrases: None
Hazard statements: None required
Precautionary statements: None required
16. Other information

General information: Sections revised - 1,2,5,9,15,16
Information sources: Croner’s: Dangerous Substances.
Croner’s: Substances Hazardous to Health.
Revision date: 13-9-13
Revision comments: Changes made with reference to classification EC1272/2008
Replaces: MSDS E170 10-2010
Safety data sheet status: Approved.

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text. All information is based on results gained from experience and tests and is believed to be accurate but is given without acceptance of liability for loss or damage attributable to reliance thereon as conditions of use lie outside our control. Users should always carry out sufficient tests to establish the suitability of any products for their intended applications. No statements shall be incorporated in any contract unless expressly agreed in writing nor construed as recommending the use of any product in conflict of any patent. All goods are supplied subject to A&E Systems Ltd General Conditions of sale.

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