

# Value creation through innovation

Each year corrosion costs billions of dollars. It has been estimated that at least one third of these costs can be prevented or delayed by adopting appropriate corrosion mitigation measures. A major contributor to corrosion costs faced by most oil and gas operators results from coating failure.

In this respect many operators practice planned 'Major maintenance painting'. Maintenance painting is often carried out to achieve the following:

- Corrosion mitigation
- Aesthetics and appearance
- Safety and housekeeping
- Environmental concerns

The primary concern for maintenance painting for a service station will be for aesthetics and appearance but on an exploration and production platform the emphasis shifts towards corrosion mitigation. Nevertheless, aesthetics is significant, as it is disheartening for an operator to see ugly brown corrosive effects on newly painted nuts, bolts, flanges and structures.

These costs are significant and detailed analysis will confirm that the greatest costs are associated with the smaller piping systems. It has been estimated that the painting cost per square foot can be as much as three times that for structural areas. Their size, shape, restricted location and poor accessibility once installed make them one of the most difficult items to maintain as it is virtually impossible to carry out effective surface prepara-

tion, resulting in maintenance being carried out at shorter intervals.

### Background

Annual inspection reports typically identify the following as areas requiring inspection and maintenance:

- Corroded nuts and bolts
- Leaking flanges
- Corrosion under pipe supports
- Corrosion under insulation
- Riser clamps
- Splash zone

In an attempt to overcome some of the above problems, a leading owner operator in this region has adopted a policy of protecting the entire flange (including nuts and bolts) and riser clamps for their new development fields and existing platforms. They have utilised the following corrosion control products some of which have been jointly developed by Petronas Research & Scientific Services and CorroShield (M) Sdn Bhd.

### Corrosion control products

#### Nuts & Bolts Protection - CorroCaps™

The need for controlling corrosion on nuts and bolts is well recognised, as they are prone to crevices and general corrosion and at times even to



Fully protected riser clamp



Pipeline protected with Fibaroll



Silicone CorroCaps for high temperature application

galvanic and stress corrosion cracking. Several attempts have been made to minimise these problems. These include, *inter alia*, the following:

- (a) *Painting* - The best performing of all anti-corrosive conventional paints, red lead primer, is no longer acceptable for health and safety reasons, as removal and disposal

requires specialist advice, equipment and procedures and can prove to be expensive. Furthermore, given the sharp edges and poor accessibility it is extremely difficult to get a uniform coating thickness and can result in holidays (pinholes).

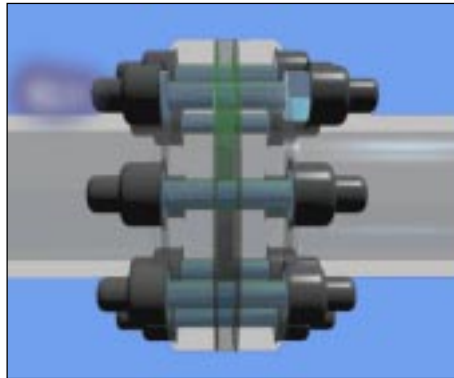
(b) *Fluorocarbon coatings*- This system which makes use of layers of protective films, including fluoro-polymer coatings, are susceptible to mechanical damage or rough handling, which are difficult to avoid in the offshore and plant working environment. The threads are particularly vulnerable, as the nuts have to be put on after the coating is in place.

(c) *Plastic caps* - These products were introduced in the mid 80s in Malaysia and were limited in their applications, as some of them required minimum exposed stud lengths whilst others were easily removed by high pressure water jetting.

In response to the need for a cost effective, environmental friendly solution, Petronas Research & Scientific Services (PRSS), in collaboration with Corro-Shield, have designed a protective cap to withstand the tough technical challenges of offshore environments. The products were tested and evaluated in compliance with ASTM B117 and ASTM B610-85 in laboratory trials and independently verified by Lloyd's Register.

The PRSS Protective Cap design is based on a unique one way valve system which essentially insulates the exposed products from the harmful effects of the corrosive atmosphere by enclosing it within a near vacuum environment.

The products are ideal against all types of corrosion and in particular against crevice and galvanic or bimetallic corrosion. Bimetallic cor-



Fully protected flange



Unprotected Flange



Leaking flange affecting surrounding areas



Installation of FlangeShield

rosion requires the following to take place:

- Difference in potential between two metals
- Presence of an electrolyte
- Electrical connection between the two metals
- Ample supply of dissolved oxygen

By creating a near vacuum environment, the PRSS Caps coupled with the flange shield system can effectively reduce or eliminate the harmful effects of crevice and galvanic corrosion on nuts, bolts and flanges.

### **Flange Protection - FlangeShield™ System and Corro-Cillin™**

The need for controlling corrosion on flanges is also well recognised in the offshore Industry as many crevices and annular spaces exist in the body of the flange and at the sealing faces (Britton 1997). These, like nuts and bolts, also suffer from mechanical damage during assembly and are difficult to coat, as adequate surface preparation is virtually impossible.

Several attempts have been made to alleviate this problem and this includes the following:

### **Flange protectors**

This system involves filling the flange void with inhibitors and protecting it with a band. The system is susceptible to crevice corrosion, as the crevice, which is formed when the band is attached to the flange, accelerates coating failure, which will lead to deformation or possible breakage of the band. The system is expensive, requires routine maintenance and does not allow inspection.

### *Caulking*

The compounds used do not bond to the steel surface and upon violation of the original seal can retain water through capillary action. The system provides no inspection ability.

### *Tapes*

The use of tapes alone does not

## Corrosion control

prevent galvanic corrosion from taking place and very often these tapes have a limited life and require routine maintenance.

### *Flooding and cocooning*

The system of flooding the flange void with waxes or inhibitors is a reasonable approach but suffers from inspection ability and is aesthetically unpleasant. It can prove expensive when flanges have to be opened and, in theory, can hide aggravated corrosion in the event of leakage.

The FlangeShield system employs a non-toxic, non-flammable, non-VOC, environmentally safe material, which is a rust converting compound, specifically designed for use in the marine environment. It involves injecting the heated up material to temporarily fill the void. The material is heated to lower its viscosity allowing it to penetrate all the crevices. The excess material is then sucked out leaving a coating of around 60 to 80 mil. The flange is available for inspection and when used with Corro-Shield Caps offers total protection for nuts, bolts and flanges.

In the event that flanges need to be opened the self-healing corrosion control compounds offers protection without the need for re-installation, providing they are not severely contaminated.

### **Application**

For all flanges, with temperatures not exceeding 105°C, the material will provide long term protection and, on areas in or around the splash zone or air/water interfaces, where short to medium term protection is required.

As an alternative to FlangeShield, which requires heating, PRSS and Corro-Shield have introduced a new product for the protection of flanges. Corro-Cillin™ is a specially blended formulation of modified waxes, containing organic corrosion inhibitors and thixotropic enhancing agents, for long term cavity protection. It is a



**Cocooning system prevents inspection**



**Thousands of flanges have been protected worldwide**



**Residual grit acts like a sponge to retain water**



**Effects of tapping**

light brown, slightly viscous, opaque solution which dries to an almost transparent film. It also contains UV tracers which, under an ultraviolet light, causes light blue fluorescence for checking treatment. This product overcomes the limitation of FlangeShield, as it requires no heating or disposal as it dries to an almost transparent film.

### **Pipe support systems**

Crevice corrosion at pipe supports is one of the major causes of external failures and premature paint failure on piping systems. Neoprene pads are commonly used. This results in a tight crevice being formed, trapping water. The original paint specifications normally are not intended to perform under water, resulting in premature coating failure and aggravated corrosion. Standard pipe rack supports are difficult to access and suffers from similar defects.

Nu-Bolts™ and Nu-Rods™ are a proven solution to the problem. The crevice is eliminated, the water kept off the pipe, the support is open to inspection and the paint system preserved.

### **Riser Protection Systems**

Riser clamps require periodical inspection and maintenance such as maintenance painting, replacement of nuts & bolts, clamps and neoprene pads. In extreme cases, parts of the riser pipe have to be cut and replaced. The neoprene pads, placed between the clamps to prevent metal to metal contact, trap moisture and force the paint, designed for splash zone conditions, to work in submerged conditions, resulting in pre-mature coating failure. The Riser Clamp Shield™ system offers cost effective long term protection, nuts and bolts are protected using PRSS protective caps and voids and crevices are filled using the FlangeShield™ system.

Surrounding areas are protected by spray application with Corro-Cillin and Corro-Shield 105 MP, which are environmentally safe, non-toxic, self-healing rust converting compounds or alternatively encapsulated with Enviro-Shield Plus a thermoplastic system. Enviro-Shield Plus is an environmentally friendly, reusable and strippable plastic coating for use in cryogenic and high ambient temperature areas. It provides a tough, flexible, abrasion resistant clear coating.

### Fibaroll

Fibaroll is a range of technically advanced composite manufactured

with glass fibre and reinforced with plastic laminates. It is produced in rolls as a tacky solid which is easily cut and moulded to fit any shape. It cures by UV and has excellent adhesion in excess of 7N/sq.mm. It forms a seamless waterproof lining for insulation on piping, can withstand foot traffic and will not dent and damage as with stainless steel cladding. It repairs pitting on piping and risers, withstands pressures up to 200 bar and forms an excellent corrosion barrier and with minor refurbishment offers corrosion protection for over fifteen years.

The below does not take into ac-

count the following additional savings:

- i) Reduced shut down periods
- ii) Faster turnaround on barge hire especially on well head nuts and bolts
- iii) Possible reduction on insurance premiums
- iv) Reduced risk through corrosion mitigation
- v) Deferred maintenance

### Conclusion

The products and services described above offer simple solutions to costly corrosion problems. They do not require expensive equipment, do not

<b>Riser case study</b>					
<b>15 year life cycle costs ( using 10" diameter as example)</b>					
<b>Existing system - Riser inspected annually and maintained every 3 years</b>					
	<b>Years</b>				
	<b>0</b>	<b>3</b>	<b>6</b>	<b>9</b>	<b>12</b>
	<b>RM</b>	<b>RM</b>	<b>RM</b>	<b>RM</b>	<b>RM</b>
Cost of annual inspection	3000	9,000	9,000	9,000	9,000
Cost of cleaning and maintenance	75,000	75,000	75,000	75,000	75,000
<b>Total Cost</b>	<b>78,000</b>	<b>84,000</b>	<b>84,000</b>	<b>84,000</b>	<b>84,000</b>
Price Escalation Factor @ 3% per annum	1	1.093	1.194	1.305	1.425
Future Cost	78,000	91,812	100,296	109,620	119,700
Discount Factor	1	0.658	0.432	0.284	0.187
Present Values	78,000	60,412.3	43,327.9	31,132.1	22,383.9
<b>Net present value</b>	<b>235,256</b>				
<b>Proposed system - Riser inspected 3 yearly and maintained every 6 years</b>					
	<b>Years</b>				
	<b>0</b>	<b>3</b>	<b>6</b>	<b>9</b>	<b>12</b>
	<b>RM</b>	<b>RM</b>	<b>RM</b>	<b>RM</b>	<b>RM</b>
Cost of inspection	3,000	3,000	3,000	3,000	3,000
Cost of cleaning and maintenance	75000	-	-	-	-
Cost of Riser Clamp Shield System	12,000	-	12,000	-	12,000
<b>Total cost</b>	<b>90,000</b>	<b>3,000</b>	<b>15,000</b>	<b>3,000</b>	<b>15,000</b>
Price Escalation Factor @ 3% per annum	1	1.093	1.194	1.305	1.425
Future Cost	90,000	3,279	17,910	3,915	21,375
Discount Factor	1	0.658	0.432	0.284	0.187
Present Values	90,000	2,158	7,737	1,112	3,997
<b>Net present value</b>	<b>105,004</b>				
Value creation in excess of one hundred thousand ringgit			130,252		
Number of risers			500		
<b>Savings for Owner Operator as a whole</b>			<b>65,126,231</b>		

(Value creation in excess of sixty five million ringgit over and above 15% required return)

## Corrosion control

New Development Field Case Study – Nuts, Bolts and Flange Protection					
25 year life cycle costs					
Incremental cashflows	Years				
	0	5	10	15	20
Present, 3% price escalation per annum	0	8,631,135	10,008,840	11,602,510	13,449,379
Proposed, 3% price escalation per annum	3,717,300	1,068,345	4,996,051	1,436,136	6,713,444
Net Cash Flow	(3,717,300)	7,562,790	5,012,789	10,166,373	6,735,935
Discount Factor @ 15%	1.000	0.497	0.247	0.123	0.061
	(3,717,300)	3,758,707	1,238,159	1,250,464	410,892

<b>Net present value</b>	<b>2,940,921</b>
<b>(Value creation of nearly three million ringgit over and above 15% required return)</b>	
Internal rate of return	24%
<b>(Every ringgit investment returns 24% per annum for 25 years)</b>	
Payback	2.5 years
Discounted payback	4.5 years
<b>Assumptions</b>	
Price escalation per annum	3%
Life span of platform – years	25
Cost of capital / Discount factor	15%
%age nuts & bolts changed every five years	50%

require shutdown and are easy to install and apply. They are neat, have the ability to inspect, are aesthetically pleasing and most importantly can offer significant savings by deferring Major maintenance programmes. Corro-Shield offers warranties of up to ten years provided regular inspection and minor refurbishments are carried out.

**PET**

ENQUIRY NUMBER: \_\_\_\_\_ **10-08**

## CSIRO PETROLEUM

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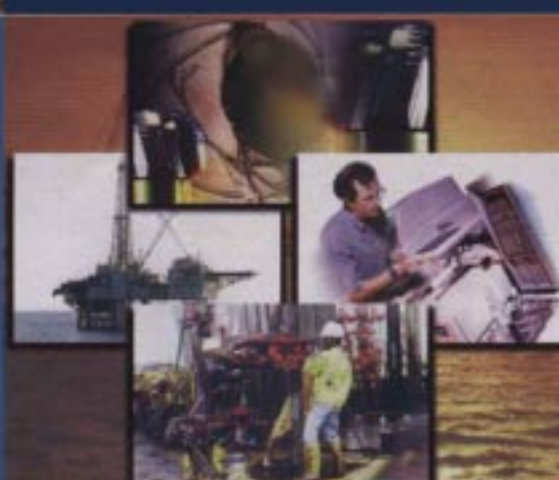
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<http://www.petroleum.csiro.au>      CSIRO Petroleum will be located at booth 3G12 at the 2001 ASCOPE Conference