FINANCIAL BENEFIT TO A CORROSION AWARE MINE SITE CULTURE

W. Gray[1], G. Harrison[1], P. Farinha[1], M. Risbud[2]
[1.] Extrin, Western Australia
[2.] Curtin University, Western Australia

SUMMARY: In Australia, the mining industry has a lingering reputation of being 'behind the times' and the corrosion awareness of the mining industry has been compared unfavourably to that of some other industries (e.g. the Oil & Gas industry). Traditionally, mining had exhibited a replacement mentality, but this has changed over the last 10 – 15 years to a more sustainable, maintenance based approach, with an increased awareness and understanding of corrosion risk to assets and its associated consequences.

Though this increased awareness has been accompanied with a marginal change in outlook of some site personnel, what is required is an overall change in mine site culture to that of a Corrosion Aware Culture. Such cultural change is not an easy objective to achieve. However, though challenging, it is definitely achievable as one analogy proves, that is, the move over the last 20 years to a more proactive Work Health and Safety (WHS) approach, where it was found that behavioural based safety systems worked better than penalty systems; in other words, rewarding positive behaviour to bring about culture change.

On a mine site, whilst a failure to complete a maintenance job on a mechanical item, such as a pump rebuild, may be immediately obvious, corrosion related degradation of structural steel and concrete assets can take years to propagate. Thus, it has been observed that basic corrosion management implementation at the time of design and installation, with planned maintenance strategies, will provide most cost effective service life enhancement, reduce overall maintenance costs, and ultimately maintain safety.

This paper will illustrate, using semi-quantitative analysis of actual case histories of corrosion issues from mine sites in Australia and overseas, the financial benefit that may be gained by an appropriate Corrosion Aware Mine Site Culture. It will outline the steps necessary to progress this cultural change, followed by pragmatic, straight forward and easy-to-remember implementation models to mitigate corrosion related issues over the life of the asset, through corrosion management education campaigns that are presented to middle management and plant operators aimed at instilling a corrosion aware culture onsite. These campaigns are engaging and enable personnel to embrace small, easy, low-cost, effective changes in their work to protect assets for longer. The approach addresses the relatively simple, easily rectified issues such as galvanic corrosion couplings, poor wash down techniques, repairing coatings, covering bolts and proper storage parameters, and through this, engender an awareness of corrosion and promotion of a corrosion aware mine site culture.

Keywords: Mining, Civil, Infrastructure, Integrity, Reliability, Concrete, Structural Steel, Corrosion, Risk Based Management, Inspection, Corrosion Culture.

1. INTRODUCTION

Schein (1990) defines organisational culture as the system of shared beliefs and values that develops within an organisation and guides the behaviour of its members [1]. According to Wood (1995) culture consists of observable culture, shared values and common assumptions [2]. An organisation's culture can be thus be seen as *'Just the way we do things around here*'.

Mine sites in Australia are generally remote and many have a fly-in fly out workforce. The changing and often transient workforce means that the organisational mine site 'culture' is often static, and current practices, *'the way things are done'*, continue as is unless driven my management and operational change. Raising an awareness, through education, is one way of driving such organisational change.

2. BACKGROUND

In Australia, the mining industry has the reputation of being "behind the times" regarding corrosion awareness compared to other industries, such as Oil and Gas. Though this has changed over the last 10 – 15 years with an increased awareness and understanding of corrosion risk to mine assets and the associated consequences, what is required is an overall cultural change in the industry itself to that of a Corrosion Aware Mine Site Industry Culture.

Such cultural change is not an easy objective to achieve. However, though challenging, it is definitely achievable as one analogy proves, that is, the move over the last 20 years to a more proactive Work Health and Safety (WH&S) culture, where it was found that education, awareness and behavioural based safety systems worked better than penalty systems; in other words, raising awareness and rewarding positive behaviour to bring about culture change.

2.1 What is a positive culture?

All workplaces have a 'culture'; good, bad or indifferent. Using the safety culture as an example, the prime features of a positive or good culture include:

- Employees belief (awareness) - that the organisation cares about them, and that they do place safety ahead of production and costs.
- Employees take an active role - to keep each other safe.
- Employees have a desire to contribute to and improve workplace - whether it is production, safety, etc.

This cultural profile extends beyond simply compliance to include a moral obligation.

2.2 Work Health and Safety in Australia– A recent culture change example.

A good example of a positive culture change has recently taken place in Work Health and Safety (WHS). A WHS culture change is now being achieved in many workplaces, including the Mining Industry, but this has taken many years of education, raising awareness of the need for change and intervention policies.

2.3 A Corrosion Culture - How to improve it

A Corrosion Culture refers to how an organisation behaves in terms of corrosion control or mitigation. It includes aspects such as what attitude and actions management takes regarding corrosion risk, and in particular the attitudes and beliefs of individuals and groups at work concerning the perceived magnitude of risks and the necessity and practicality of preventative measures [3].

A positive corrosion culture is one that, among other things:

- Encourages and retains learning
- Promotes open & honest reporting
- Is just and prepared to identify its own shortcomings as easily as it seeks to address any violation of orders or instructions
- Rewards innovation and accepts constructive suggestions willingly for its continuous improvement [4].

Senior managers are the key to a successful corrosion culture. Due to its preventable nature it can be argued that managers and supervisors need to be held accountable for corrosion-related incidents in the same manner as production or safety.

Corrosion culture is about developing a good corrosion awareness attitude in people on the ground (maintenance personnel) but it is also good corrosion management established by organisations. Good corrosion culture means giving the appropriate high priority to address corrosion issues. A good corrosion culture, much like a good safety culture, implies a constant assessment of the significance of events and issues, in order that the appropriate level of attention can be given [5].

3. NEED FOR A CORROSION CULTURE

The benefits realised from a culture change will be both direct and indirect. Direct benefits are financial whilst indirect benefits include a reduction in unplanned failures, improvements in safety and happier work environment.

3.1 Financial benefit

According to NACE International, corrosion costs are 3.1% of GDP for an industrial economy. The figure is based on US Government funded research that analysed a number of key sectors, namely: Infrastructure, Utilities, Government, Transport and Manufacturing; however these costs only involve direct costs and does not include indirect costs experienced by customers. Indirect costs are estimated to be at least same as direct costs which add up to 6.2% of GDP. At US $2.2 trillion, the annual cost of corrosion worldwide is over 3% of the world's GDP. Yet, governments and industries pay little attention to corrosion issues except in high-risk areas like aircraft and pipelines [6].

The GDP in Australia in 2009 was $920 billion with an annual cost of corrosion estimated to be around $70.6 billion. Reports show that about 30% of the cost could be saved by applying today's knowledge in corrosion prevention and education. For Australia, the annual savings would translate into $6.6 billion per annum [7].

Studies carried out over recent past on marine coastal assets to investigate the benefits of regular wash downs with potable water on maintenance cost reduction concluded that much of the corrosion cost is influenced by the effect of adjacent marine chloride deposition over all asset surfaces (painted/unpainted steels, equipment and concrete infrastructure). It was found that a wash down regime which focused on surfaces that receive no natural wash down were likely to extend the services life of the assets over a 3 – 5 years period given the identified costs of corrosion related maintenance activities. A savings of 3.0 – 4.0% in expected corrosion related expenditure would adequately cover the cost of periodic potable water wash down.

Essentially this is about maintaining the 'Goldilocks principle': the aim is to spend "just the right" amount of money in the correct areas in order to ensure assets are fit for service (from a safety and production point of view) until the day the plant closes. Spending **too little (not enough)** would lead to revisiting the issue before life-of-mine (LoM) is reached, which will prove more costly in the longer term while spending **too much** (i.e.: overkill) would mean wastage of money through a "bells and whistles" implementation approach.

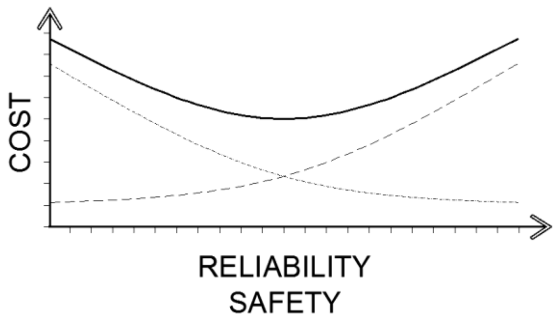


Figure 1 - Illustration of Goldilocks Principle

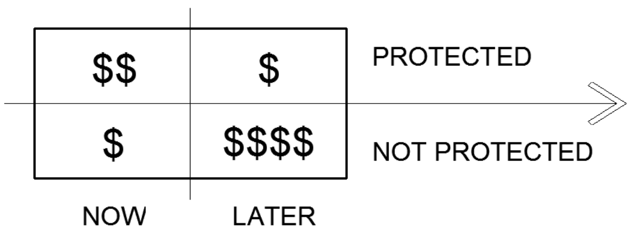


Figure 2 – Diagrammatic Corrosion costs for protected vs. non-protected assets

This model (Fig. 1 above) needs the asset owner to look at expenditure over the whole life of the operation. In mining this is frequently extended past the original intended life of the mine; in the authors experience less than 5% of mine sites close at the end of the original life-of-mine. Examples of corrosion-related maintenance cost blowouts (brief case studies examples)

1. A catastrophic failure (i.e.: conveyor collapse)
2. Lack of stripe coating (initial stripe coat costs versus insitu recoat costs)
3. Bolts unprotected (replacement time/effort versus use of a protective tape)

4. SCENARIOS ILLUSTRATING COST BENEFITS OF A CORROSION AWARE CULTURE

Over the last two decades, mine sites in Western Australia have been moving away from a replacement mentality to that of a more sustainable, planned approach. Preventative maintenance, instead of reactive maintenance, has seen improvements in recovery due to a reduction in unplanned shutdowns due to corrosion failures. As the majority of the operational assets on a mine site are made of metal and concrete, corrosion is a real threat to production and overall life of mine. Ongoing preventative maintenance of metallic assets ensures mine longevity and continued production.

Perhaps due to the fact that corrosion, for the majority, is a relatively imperceptible process, complacency can be an issue while dealing with corrosion issues promptly. Not only does the slow deterioration of a material mean that significant issues may not be identified in time but corrosion can occur in areas which are not readily able to be inspected. All too often issues that involve corrosion damage are "too little – too late" and costly repairs and downtime is a consequence. The good news is that corrosion is mainly preventable and this approach can be incredibly cost effective.

This section of the paper explores the costs of undertaking corrosion protection approach at the start of the assets' life (at construction), during the life (regular scheduled intervals of 5,10,15 years) and at the end of the life (assuming failure at 20 years).

Over the last 20+ years, the authors have undertaken over 80 processing plant maintenance inspections, of which approximately two thirds are annual inspections at the same plant, and in this paper look at illustrative cost comparisons of proactive corrosion mitigation strategies. Naturally, this sort of cost comparison is subjective and only semi-quantitative at best, and no net present value calculations have been done; however the authors experience with inspection, maintenance and repair of mine site assets, over multiple sites has allowed data to be collected and compared over a wide range of maintenance related repairs on a wide range of assets.

The three examples that will be explored for cost comparisons and illustrative financial benefits of proactive corrosion control are:

1) Leach and adsorption tank internal coatings
2) Refurbishment of concrete sump walls
3) Structural steel maintenance protective coatings.

4.1 Chronological Cost Comparison Scenario 1: Tank Internal Coatings

Over the years there has been a need to ascertain the internal condition of Leach and Adsorption tanks in gold mining at various mine sites, and to subsequently develop a scope of work for the repairs and/or refurbishment of tanks affected by coating failure and internal corrosion.

Analysis of the reports produced from these inspections has identified the root causes of coating failure and contributing corrosion mechanisms.

Figure 3 – Externals of a Carbon In Leach (CIL) tank in gold mining

Figure 4 – Internals of a Carbon In Leach (CIL) tank in gold mining

Commonly requests for such inspections are the result of perceived or identified problems, for example, a wall perforation or an observed section of failed coating blocking screens or floating on the surface of the contained slurry. The tank is then emptied for inspection, and the full extent of potentially costly repairs is revealed. For this example of a cost comparison we will consider a typical coated leach tank approximately 12 m in diameter and 12 m in height over the first 20 years of its operations.

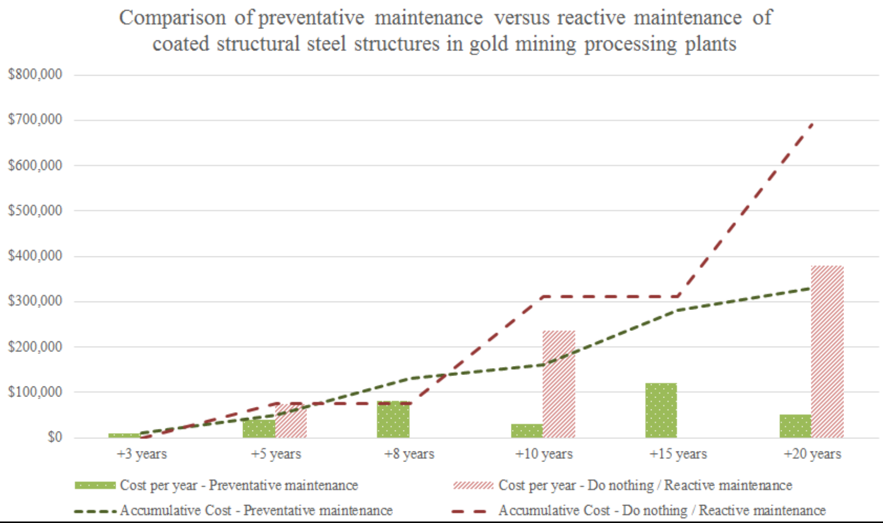
Illustrative cost comparisons for tank maintenance inspections and repairs have been produced. See Table 1.

The first assessment involves a **proactive** maintenance regime, which consists of periodic inspections and regular scheduled maintenance with necessary works i.e.: protective coating touch-ups, impact damage and mechanical damage repairs, undertaken. Based on experience, costs for this regimen for the 20 year tank life is estimated to be in the order of $ 330,000, with comparatively minor works and costs incurred at each periodic inspection, as a result of impact damage and localised coating failure and wear.

Should no regular maintenance be undertaken, and a **reactive** approach be employed, it has been observed that major maintenance issues will occur by the 10 year timeline. These can include significant wall and floor repairs due to perforations and/or general steel loss, as well as total coating refurbishment. Such refurbishment-related costs in this instance would be anticipated the order of ~$700,000.

Table 1 – Comparison of preventative maintenance versus reactive maintenance scenarios of coated structural steel structures in gold mining processing plants.

Construction	+3 years	+5 years	+8 years	+10 years	+15 years	+20 years
Periodic inspection & maintenance	Localised coating touch-ups	Coating touch-ups (wear areas), local boilermaker (BM) works	Coating refurb to high wear areas <15%, moderate boilermaker works	Coating touch-up to high wear areas, boilermaker works	Major coating refurbishment (50%), incl. significant boilermaker works	Coating touch-up to high wear areas, boilermaker works
	$10,000	$40,000	$80,000	$30,000	$120,000	$50,000 ($330,000)
Labour	$7,500	$28,000	$56,000	$21,000	$78,000	$35,000
Materials	$1,000	$6,000	$13,000	$4,000	$26,000	$7,000
Equipment	$1,500	$6,000	$11,000	$5,000	$16,000	$8,000
Do nothing – reactive maintenance		Coating refurbishment >20%, BM patch repairs – floor & baffles, welds		Installation of new floor, major coating works to floor, lower walls, baffles >60%		Installation of new floor, re-strake lower walls (steel loss) total coating refurb 100%
	$ 0	$ 75,000	$ 0	$ 235,000	$ 0	$ 380,000 ($ 690,000)
Labour	$ 0	$ 42,000	$ 0	$ 110,000	$ 0	$ 175,000
Materials	$ 0	$ 18,000	$ 0	$ 85,000	$ 0	$ 140,000
Equipment	$ 0	$ 15,000	$ 0	$ 40,000	$ 0	$ 65,000



4.2 Chronological Cost Comparison Scenario 2: Concrete wall restoration due to chloride ingress

It is commonplace in the mining/mineral processing industry to construct concrete structures/items such as mill support plinths, pedestals, bund areas, tank ring beams, sumps, etc. and to leave them exposed to high chloride laden process water, sulphates and other chemicals for the life of mine. Often these mines are initially issued an estimated finite life, of say 5 or 7 years, however the reality is that the identification of new deposits will increase the actual life of mine significantly. The result is that within 7-10 years many of these concrete items, some of them critical assets, require replacement or major costly refurbishment. To complicate the situation, these activities are often required to be undertaken "in service", as to cease production is extremely costly.

Illustrative cost comparisons have been produced for a processing plant drive-in sump (See Table 2). This containment area captures all saline water for a gold mine milling footprint, which is continually recycled. Wall dimension are approximately 22 metres in length and an average of 1.6 metres in height (Total of 70m² surface area). The option of a protective coating applied at, or soon after, construction is considered versus a “do nothing” approach which results in major concrete demolition work and re-pouring of containment walls once the concrete reinforcement steel has almost entirely corroded away (~15 years).

Figure 5 – Example of failure of unprotected wall; corroding reinforcement from chloride ingress

Figure 6 – Expensive remedial activities required to reinstate wall integrity, New wall sections poured

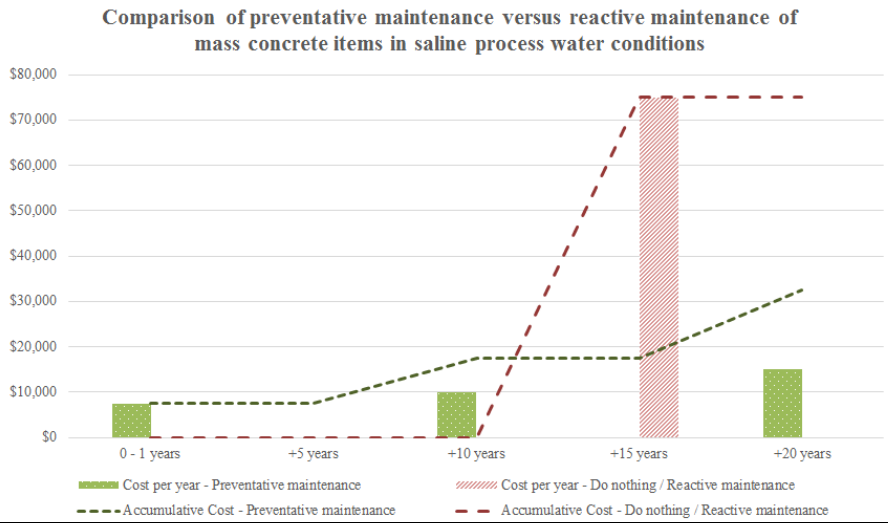
Figure 7 – Remedial activities complete, wall integrity restored

Post-construction application of a hydrophobic impregnation and coating system for protection against chloride ingress has been factored in as the proactive approach. This has been calculated at a cost of about $ 7,500. Realistically, period inspection and testing work may reveal some localised concrete repair requirements. Factored into the costs are minor breakout and repair works at the 10 year mark, and again at 20 years (an estimated 10m² in total). This has accrued a further $ 25,000 in maintenance costs, resulting in a total cost for the period of $32,500.

If left alone for the 20 years (no testing, no action), total demolition and reconstruction has been costed at $ 75,000 (actual case study). This is a factor of 2.3 times for a lack of corrosion management foresight at the construction stage.

Table 2 – Comparison of preventative maintenance versus reactive maintenance scenarios of mass concrete items in saline process water conditions

Construction	0 - 1 years	+5 years	+10 years	+15 years	+20 years
Initial protection & periodic inspection & maintenance	Impregnation &/or protective coating system application		Localised breakout and patch repair to affected areas~4m2		Localised break out and patch repair to affected areas~6m2
	$ 7,500	$ 0	$ 10,000	$ 0	$15,000 ($32,500)
Labour	$4,500	$ 0	$ 6,250	$ 0	$ 9,500
Materials	$2,500	$ 0	$ 2,300	$ 0	$ 3,500
Equipment	$ 500	$ 0	$ 1,500	$ 0	$ 2,000
Do nothing – reactive maintenance				Demolish wall and reconstruct	
	$ 0 ($ 0)	$ 0 ($ 0)	$ 0 ($ 0)	$75,000	$ 0 ($ 75,000)
Labour	$ 0	$ 0	$ 0	$38,000	$ 0
Materials	$ 0	$ 0	$ 0	$25,000	$ 0
Equipment	$ 0	$ 0	$ 0	$12,000	$ 0



4.3 Chronological Cost Comparison Scenario 3: Structural steel stripe coat application/QC inspections

The failure to stripe coat, and indeed to provide a lack of diligent painting supervision generally, during construction of a new mineral processing operation, can and has resulted in vast amounts of wasted monies through prematurely failed coating systems. Through no fault of the coating or its manufacturer, poorly adhered coatings can delaminate and peel away within the first two years of service, resulting in premature corrosion to important steel structures. Protective coating refurbishment costs can far exceed the original application costs due to access requirements/difficulties, environmental challenges (wind, rain, process-related contamination) and likelihood of additional labour for heights or confined space work locations (safety observer).

Coating application at the time of construction is prone to lapses in quality due to fabrication and assembly pressures. In fact, a number of instances are known whereby important coating works have occurred “out of spec”, including instances of painting below dew point and at times of precipitation, due to these pressures. Common causes of premature coating failure include a lack of a brush-applied stripe coating, steel surface contamination, insufficient blast profile and painting outside the specified environmental parameters.

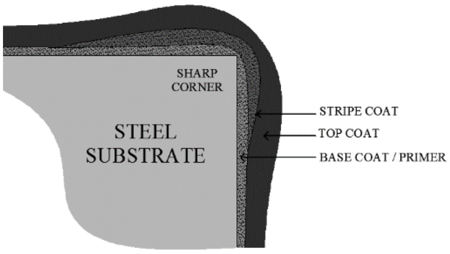


Figure 8 – Stripe Coating Schematic diagram

Figure 9 – Stripe coating in progress

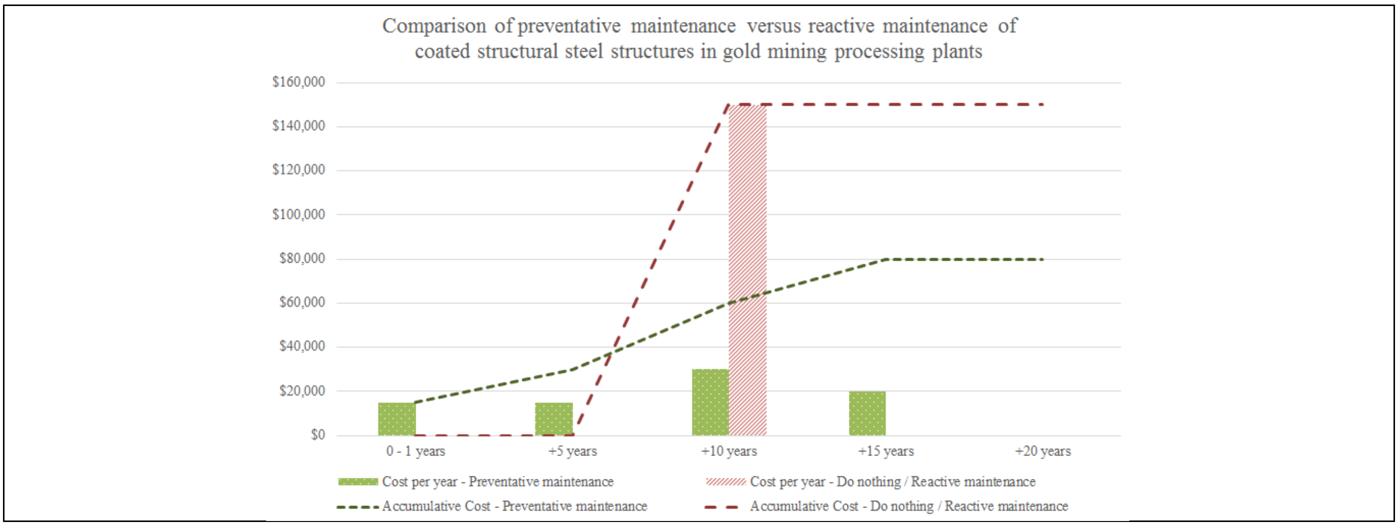
Figure 10 – The result of a lack of stripe coating and poor Quality Control

An illustrative cost comparison is provided below for a typical pipe rack structure (nominally 30 metres in length) for a mineral processing plant based on a 20 year life. (See Table 3). The first option, a **proactive one**, includes costs for a stripe coating stage in the initial coating application work and the periodic attendance of a coating inspector to ensure that quality control requirements are adhered to. It also allows for periodic coating touch-ups (every 5 years) to attend to locations of defects caused by impact damage, localised failures, etc. Total costs over a 20 year period are estimated at $80,000.

This is compared against a **reactive** scenario, where unidentified coating failure allows steel to corrode and the underlying steel experience sectional loss. This would then require a full blast and paint campaign with extensive scaffolding requirements. This one-off campaign is likely to incur typical costs in the order of $150,000; approximately double that of a proactive approach.

Table 3 – Comparison of preventative maintenance versus reactive maintenance scenarios of coated structural steel structures in gold mining

Construction	0 - 1 years	+5 years	+10 years	+15 years	+20 years
Periodic inspection & maintenance	Stripe coating application and coating inspector presence (QC)	Localised touch-ups from EWP; spot blast and brush work	Localised touch-ups from EWP; spot blast and brush work	Localised touch-ups from EWP; spot blast and brush work	
	$15,000	$15,000)	$30,000	$20,000	$ 0 ($80,000)
Labour	$7,500	$10,000	$20,000	$14,000	$ 0
Materials	$1,000	$ 1,500	$ 3,000	$ 2,000	$ 0
Equipment	$1,500	$ 3,500	$ 7,000	$ 4,000	$ 0
Do nothing – reactive maintenance			Major 4 week refurbishment incl. scaffold, full blast and spray application		
	$ 0	$ 0	$ 150,000	$ 0	$ 0 ($ 150,000)
Labour	$ 0	$ 0	$ 90,000	$ 0	$ 0
Materials	$ 0	$ 0	$ 30,000	$ 0	$ 0
Equipment	$ 0	$ 0	$ 30,000	$ 0	$ 0



5. IMPLEMENTATION OF A CULTURE CHANGE

A work Culture in any organisation plays a very important role as it can affect the workforce behaviour and performance outcomes either way. At the same time behaviour and performance outcomes can also shape work culture within an organisation. A corrosion 'wise' workforce can identify the corrosion issues at mine-sites in its infancy allowing more time effective remedial actions, in turn reducing the corrosion mitigation costs. Table 4 represents "six sources of influence" vital to bringing a culture change in an organisation [8]. These leading change and communication experts discuss exactly what is required to be an influencer/leader and create change. Through their research they have found that change will be more successful by identifying a few vital behaviours that will have the most impact in contributing to the desired change. Essentially, there is a need for at least 4 of the following to implement a culture change that works:

Table 4: Implementing culture change requires at least 4 of the items below to be successful [8]

	Motivation	Ability
Personal	**Make it Desirable** Do they want to engage in the behaviour?	**Skill Building**, help them surpass their limits Do they have the rights skills and strengths to do the right thing?
Social	**Harness Peer Pressure** Are other people encouraging or discouraging behaviours?	**Find Strength in Numbers** Do others provide the help, information and resources required?
Structural	**Design Rewards + Demand Accountability** Are systems rewarding the right behaviour and discouraging ineffective ones?	**Change the Environment** Are there systems that keep people in place and on progress?

5.1 HOW TO IMPLEMENT CULTURE CHANGE – MINE SITE SPECIFIC

As a part of site corrosion audit or assessment work, the education of relevant site personnel has proved to be welcomed and very successful (particularly in lesser developed regions). This typically involves the following actions/activities:

1. Engaging site operational personnel in discussion/ to increase corrosion awareness,
2. Encouraging personnel in taking ownership of assets and issues (behave like an owner),
3. Advising all interested site personnel about what is being done and why,
4. Complimenting personnel on the positive and proactive activities/actions observed,
5. Take relevant personnel on area walk around/s, to show them interesting, unusual or important issues,
6. Dedicate time to present a visual summary of site corrosion issues to relevant and interested site personnel,
7. Suggest and discuss implementations beneficial to site, budgets and/or safety.

Additionally, undertaking training courses for site personnel in a wide range of corrosion-related topics have proved to be very well received both in Australia and overseas.

Figure 11 – Education of site personnel, PNG.

Figure 12 – Maintenance personnel training, DRC.

Inclusion of Posters: Steps could be Educate about corrosion, locate the corrosion, and prevent/reduce corrosion. This can be incorporated along with WHS practices as educating miners about corrosion will prevent unwanted consequences (e.g. Accidents) leading to preservation of WHS record. A regular review of procedures as well as periodic training will keep the corrosion wise culture intact despite the expected changes in the workforce.

6. WORKING EXAMPLES - IMPLEMENTING CULTURE CHANGE

Sometimes innovative, creative and even novel methods of implementing a culture change can be effective and unwittingly/unconsciously embarked on a process of creating simple, direct slogans or catchphrases that maintenance personnel can easily remember and put into practice.

This section discusses three working examples of some of the most observed prevalent (and easily addressed) corrosion issues on mine sites today. The implementation steps are similar for all three examples:

- Step 1. Introduce concept at daily start up meetings and email to all personal site wide.
- Step 2. Discuss the reasons and benefits
- Step 3. Advertising campaign onsite – Acronyms to facilitate awareness
- Step 4. Training/education of site personnel in corrosion-related potential for harm and preventative measures, how to recognise potential issues, etc.
- Step 5. Reward positive behaviour

6.1 Example 1 – Covering of bolted connections

The first such phrase ***"Bolts need helmets too"*** stems from the fact that OH & S requirements mandate that mine site personnel need head protection to keep them from harm in the form of a hard hat, or helmet. To draw a parallel, unprotected bolts on a mineral processing plant have been seen to corrode quite rapidly when exposed to high saline process water and process debris. The use of a non-metallic cap or petrolatum wrap can extend the life of bolts considerably and this is an area of ongoing area of site personnel education. The phrase "Bolts need helmets too" may seem silly at first but because of this and the fact that it is true that bolts need to be protected in the same manner that a hard hat protects, lends itself to be readily remembered.

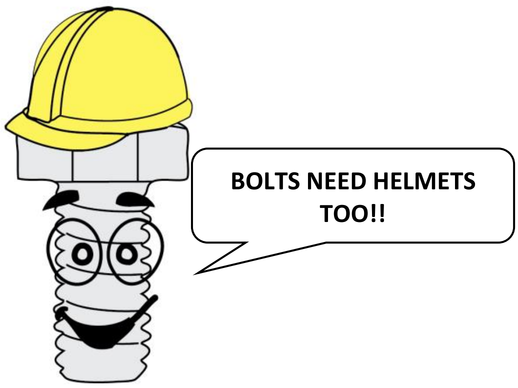


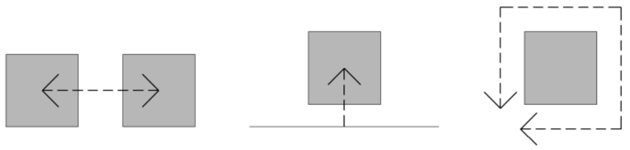
Figure 13 – "Bolts need helmets too" proposed mascot

Figure 14 – Examples of protected bolts with petrolatum tape wrapping

6.2 Example 2 – Adequate Protection of stored or warehoused items

Visits to most mines in the tropics have caused concern when the stores laydown areas were inspected. Steel items were stored with full exposure to the elements which, as well as sun, rain, acid sulphate soils and chloride (seawater) included sulphur steam. Recommendations were made to reduce atmospheric corrosion whereby the items were raised off the ground, positioned so that water did not collect, and be covered to protect against the elements.

The phrase ***"Protect steel from corrosion - It only takes a SEC"*** includes an acronym for **S**eparate, **E**levate and **C**over, was initiated to educate the personnel and develop a change of culture at this location.



"Protect steel from corrosion – it only takes a SEC"

Separate - Ensure that items are sufficiently spaced to allow drainage of water and debris, and allows for good ventilation.

Elevate - Ensure that items are lifted off the ground and supported to facilitate drainage.

Cover - Ensure that water and wind-blown debris cannot access the items surface

Figure 15 – Example of poster material to promote correct storage of materials

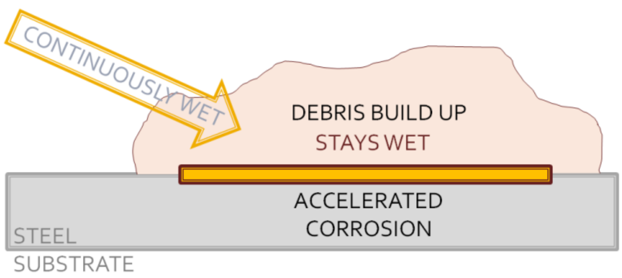
Figure 16 – Examples of items that are not stored suitably

6.3 Example 3 – Regular housekeeping of assets will reduce poultice corrosion

With many mine sites in Australia having hyper saline process and wash-down waters that have been measured can be 2 -3 times more saline than seawater, it is important to ensure that all surfaces are kept relatively free from moisture. It may seem counter intuitive to this fact to recommend wash down all surfaces but, in doing this, asset owners are ensuring that structures are not at risk of suffering from poultice corrosion or under-deposit corrosion.

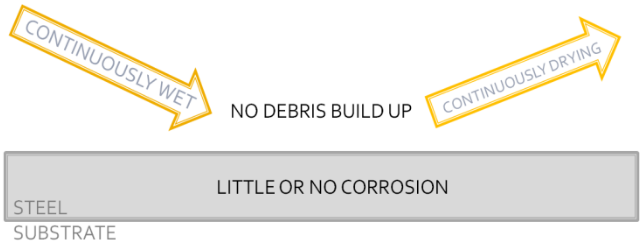
Poultice (Under-deposit) corrosion occurs under collected debris and deposited water. The collected debris usually promotes moist or wet conditions which creates the ideal conductive environment for a corrosion cell to develop. These areas remain wet almost continuously, within the deposit; moisture content is about 50%, with highly corrosive debris due to the moisture entrapment effect of the poultice. This is an insidious form of corrosion, as it usually goes unnoticed until it is too late (location perforates on the underside). The effects of under-deposit corrosion can occur both directly and indirectly. When the attack is direct, the deposit itself contains corrosive substances which when concentrated at a localised or generalised site can cause wastage. An example of such a deposit would include high levels of chlorides.

The slogan ***"Wash down and see - corrosion free"*** promotes the idea that regular wash down keeps the structures clean and thus in a safe, corrosion free.



"Wash down and see - corrosion free"

Figure 17 – 1) Accelerated corrosion occurs due debris build-up.



Deposit build up increases corrosion. Regular wash down decreases corrosion

Figure 18 – 2) Little or no corrosion is occuring due to regular removal of debris.

7. CONCLUSION

It has been shown through three (3) separate case study examples that with a Corrosion Aware Mine Site Culture, and with proactive effective protection during, or immediately post construction, as well as periodic inspection and assessment of assets, financial savings of between 2 – 3 times can be achieved between that of a culture where maintenance is a proactive rather than reactive to corrosion issues. If a little more money is spent at the commencement of a mining project, particularly in determination of likely aggressive environments and/or micro-environments and scheduling planned maintenance activities then managing the maintenance in future years will be an easier and less costly task. The costs savings may be even greater than our examples illustrate, as flow on effects such as a reduced maintenance/integrity team and the need for less contracting groups (and their associated inductions, mobilisation to site, meals/accommodation, etc.) can be factors in the bigger overall picture of maintenance-related savings.

It has been observed that the corrosion culture at mine sites has been improving gradually over the past 20 years or so. This has developed from upper management and percolated down through the ranks due to periods of "belt-tightening" through recession times in the mining industry. Further education and awareness of mine site personnel can only assist in developing a more Corrosion Aware Mine site Culture and reap the financial benefits overall.

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9. AUTHOR DETAILS

Mr. Wayne Gray

ACA Coating Inspector

Wayne Gray has been involved in the concrete diagnosis and repair and the protective coatings industries for the past 24 years. He is a certified Australasian Corrosion Association Coatings Inspector and has represented material suppliers, contractors and asset owners. Hence, Wayne has a broad perspective and knowledge of the industry.

Since joining Extrin in 2008, Wayne has been involved in many and varied Inspection, QA/QC and Project Management roles throughout Australia and overseas. Wayne has recently undertook and successfully completed the Corrosion Engineering course with the Institute of South Africa (CORRISA).

Mr. Giles Harrison

B.App.Sc. M.Arch. Grad.Dip.Corr.Eng.

Giles' expertise lies in the refurbishment of existing concrete and steel structures. This spans from the initial investigation into the modes of corrosion through to devising the best method of repair, preparing documentation and then carrying out the project management of the refurbishment.

Recently Giles has been involved with managing major civil repairs at various ore processing facilities as well as dealing with various corrosion issues at port authorities throughout Western Australia.

Dr. Peter Farinha

B.Sc. M.Sc. PhD.

As a specialist corrosion engineer, holding both a MSc and PhD in Corrosion Science & Engineering, Dr. Peter Farinha has been involved in identification and problem solving of corrosion related issues in steel corrosion and reinforced concrete including inspection, identification, failure analysis, materials selections, coatings, specification and repair methodology for over 30 years.

Dr. Mandar Risbud

B.Sc. M.Sc. Ph.D

Mandar is currently working as Research and Teaching Fellow at Curtin University, He has worked on projects involving materials and corrosion research in areas like, weld qualification methods, development of corrosion domain diagrams, self-repair coatings, cathodic protection, pitting corrosion, material testing, etc. More recently he has been involved in the development of electrochemical techniques for measuring pitting corrosion mechanisms and monitoring etc.