BACK TO THE FUTURE
– mitigating the challenges of vandalism

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ABSTRACT

Perhaps one of the greatest concerns facing pipeline operators and cathodic protection engineers is the integrity of the cathodic protection (CP) system. As long as the CP system is working, there is confidence that the asset is protected.

In years past, impressed current cathodic protection (ICCP) system integrity was primarily tied to anode life, rectifier maintenance and the age of the system. Increasingly, theft and vandalism has become a significant threat to CP systems.

Various devices and strategies have been devised throughout the world, to protect CP components[1]. These include attempts at camouflage. Others have tried to dissuade vandals by changing hardware designs, such as using plastic test posts. There have been many attempts to alert authorities by means of alarms and micro labelling of copper cables. Rectifier enclosures have been strengthened using reinforced concrete. And there have even been attempts to use crane-lifted lids to try and prevent ingress by vandals. Each mitigation attempt has had varying degrees of success, which is often short-lived.

Improvements in pipeline coatings[2] and pipe laying techniques have opened another door to vandalism mitigation. Since the current demand has reduced dramatically, returning to the use of sacrificial anodes rather than ICCP systems has become a practical reality. Zinc rather than magnesium anodes have provided a possible answer to many of the vandalism challenges, without compromising on system life or efficacy.

Concealed installations can be readily located (and re-located) by means of sub-metre accuracy GPS instruments.

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INTRODUCTION

Recent economic studies have validated an accepted premise, that pipelines (and their integrity) are key to the economic development of societies[3]. Keeping the pipelines operational is obviously fundamental.

Buried steel pipelines were first used in the late 1800s. It quickly became evident that corrosion was a challenge that needed to be mitigated, as uncontrolled corrosion of a pipe wall led to leaks. These leaks in turn resulted in interruptions in delivery and dramatic pipeline ruptures caused extensive damage and even deaths.
It became evident that the reliability of the pipelines depended on the effectiveness of corrosion control measures [4]. This, in turn, led to the development of coatings and cathodic protection. In addition, in some countries, government agencies mandated corrosion protection through the application of protective coatings and the installation of supplementary cathodic protection [5].

Today, pipeline operators and cathodic protection engineers are well aware that disruptions in the integrity of the cathodic protection system can jeopardise the integrity of the pipeline. Maintaining the integrity of a cathodic protection system is key to ensuring adequate functioning of the pipeline.

CATHODIC PROTECTION SYSTEM VANDALISM

Cathodic protection (CP) systems located in industrial plant locations and on tank farms are generally enclosed within the secure boundaries of the facility. These are therefore not subjected to significant vandalism and theft.
By contrast, infrastructure located on long cross-country pipelines as well as those on pipelines traversing urban areas are more difficult to monitor and keep secure.

To some extent, remote monitoring facilities have assisted with security. Many of these systems have incorporated “unauthorised access” alarms. These alarms can alert control room personnel when unauthorised entry (and possible theft) is occurring. One possible drawback is that the control room may be located a substantial distance from the infiltrated or affected facility and response times can be slow.

One of the significant causes of disruptions to pipeline protection arises due to the vandalism and theft of CP infrastructure. The increase in this vandalism in recent years may, in part, be attributable to increasing urbanisation in many parts of the world [6].

Of interest is that in first world countries, vandalism of CP infrastructure is often related to superficial damage of equipment, possibly by bored or delinquent perpetrators. In less-developed countries, vandalism of CP infrastructure is largely

associated with concurrent theft. Increasing challenges to CP infrastructure in countries such as Mexico, Nigeria and South Africa are well documented [1,7,8].
This vandalism & theft combination appears to be correlated to the socio-economic conditions of the communities surrounding the infrastructure and where sale of scrap metal (often copper) is perceived as a useful source of income.

Solving the real problems associated with vandalism is often outside the expertise of the asset owner and may require major societal and environmental reforms. However, in order to keep cathodic protection systems operational, various devices and strategies have been devised throughout the world, to protect CP components.

Some of these include:

1. CABLES

1.1. Several types of cable have been developed to deter theft. An example of this is Kwena™ cable. This consists of copper and steel woven / braided strands. This is difficult to cut mechanically and as the copper and steel cannot easily be separated, Kwena™ cables have extremely low or nil scrap value. It should be noted that whilst this may not prevent the first theft, the lack of scrap value does prevent repeat vandalism/ theft occurrences.

1.2. Micro-labelling of cable has been used by several asset owners in an attempt to identify the source of copper cable held by scrap metal merchants. This information can be used during prosecution.

2. TEST POSTS.

A number of ingenious test post modifications and designs have been developed in an effort to combat vandalism and theft. These include:

2.1. Changing the test post locking mechanism such that it requires a specialised key or tool to open. These have had varying degrees of success.

2.2. Replacing galvanised test posts with plastic tests posts [2]. Whilst this reduces the risk of the theft of a galvanised test post for the scrap metal value of the test post itself, it does not mitigate the risk of easy access to the cables within the test posts which still remain vulnerable.

2.3. Replacing pole mounted or galvanised test posts with concrete bunkers. A number of concrete bunkers are available of differing concrete strengths, steel door thicknesses, etc. Many of these have had some success, although their footprint on the land is larger and in many instances it is merely a matter of time before the additional security measures are breached.

2.4. Sealed water proof, buried test stations are being developed. With improvements in GPS accuracy, it is not impractical to bury a monitoring point or monitoring chamber and have access based on GPS location. Further, these can be fitted with remote monitoring facilities to ensure that remote access is possible.

3. TRANSFORMER RECTIFIER UNITS (TRU)

TRUs have special appeal to vandals and thieves as these units provide a source of copper and high value components.

Gone are the days when a TRU could be housed in a weather proof steel cabinet with a surround fence.

Many installations now use concrete bunkers to increase the protection for the transformer rectifier unit. As vandals find ways to enter them, so the bunkers are upgraded. Rectifier enclosures have been strengthened using thicker steel rebar, thicker concrete, secure “safe”-type doors, hinges which are welded to the reinforcing cage so that the door can not be broken out of the concrete, etc. Partially buried bunkers which require crane removal of the lids have been used on some projects.

A patent for a vandal resistant unit has been registered in USA, where the rectifier is housed in a subterranean enclosure which is hermetically sealed but makes provision for heat removal [9].

New bunkers with cabling intrinsically installed during the casting of the concrete have been proposed, in an effort to reduce the theft of the CP cables.

Switch mode power supplies may be a feasible alternative to conventional TRUs. These have virtually no resale / scrap value which reduces their repeated vandalism / theft.

In rectifier units which are solar powered, the possibility of obtaining “free” solar panels and batteries make these an extremely high risk target. In efforts to minimise the risk, solar panels are being embedded in the roofs of rectifier bunkers.

Unfortunately, the cost of vandal-resistant enclosures is often on a par with or even exceeds that of the TRU itself. This can make the overall cost of the impressed current cathodic protection system less affordable.

In all instances, the value of the materials stolen is far less than the costs associated with procuring and reinstalling the CP hardware.

Case History #1

On one particular pipeline project there was significant AC interference as well as severe stray current interference from an adjacent DC rail.

- Cathodic protection, AC mitigation (ACM) and stray current mitigation were all indicated.

- Sadly, during construction, vandalism and theft of the infrastructure was so rampant that the test posts were vandalised within weeks of being installed.
- Decisions were made to move the CP and ACM hardware into the valve chambers and the pipeline design engineers upgraded the security on the valve chamber lids.
- These however were soon breached and after several iterations, chamber lids weighing in excess of 2000kg and requiring specialised crane removal were installed.
- To a large extent these extreme measures reduced the vandalism.
- However, they also reduced the possibility of effective CP and ACM system monitoring as the chambers are no longer accessible for routine monitoring.

A DIFFERENT APPROACH – SACP

Another approach to the vandalism problem is related to the choice of cathodic protection system itself.

Historically, impressed current cathodic protection systems have been used extensively for buried pipeline protection. However, as discussed, the transformer rectifier itself as well as other pipeline hardware have attracted opportunistic crime and in Mexico a survey revealed that approximately 15% of transformer rectifiers on a large pipeline network had been vandalised and were not operational at one time. This is cause for grave concern as this implies that 15% of the pipeline network is no longer experiencing cathodic protection[1].

Early pipeline coatings were based on coal-tar and bitumen products. Whilst these coating afforded a degree of protection to the steel, they were generally water permeable and required significant cathodic protection current densities. Design current densities of 0.5 - 2mA/m^2 were not uncommon and the relatively high current demand was met with the use of large impressed current cathodic protection systems with high current outputs.

With increasing use of modern high-insulation value coatings, the current demand has dropped dramatically. Liquid coatings (rigid polyurethanes and epoxies) and multi-layer polyolefin coatings generally have current demands in the µA/m^2 range. With lower current requirements, sacrificial anode cathodic protection has become a practical option.

Using zinc rather than magnesium as the sacrificial anode has obvious benefits in terms of reduced self-corrosion and better self-regulating characteristics in terms of its ability to continue to provide sufficient current for adequate protection without excessive current wastage [10].

CASE HISTORY #2

On a recent pipeline installation in South Africa, cathodic protection was indicated. Experience on other pipelines in the vicinity had demonstrated that rampant vandalism and theft of CP hardware had rendered the systems ineffective and left the pipelines unprotected. On this new pipeline, a sacrificial anode system was designed, using zinc ribbon anode groundbeds. Initially the design had called for buried anode connections to the pipeline. However, the decision was made to connect the anodes to the pipeline via link panels housed in small monitoring bunkers. Despite social unrest and vandalism of other structures, the small bunkers remain untouched and the system is operational, ensuring on-going protection of the pipeline.

Another positive outcome of the use of the zinc anode CP system was the lack of decoupling required between the AC mitigation system and the CP system itself. This reduced the visible infrastructure on the pipeline servitude and thereby has resulted in reduced theft and vandalism. A further benefit has been that the overall cost to the owner was significantly reduced due to the lack of AC mitigation electronics.

WHERE TO FROM HERE?

Sadly, until the socio-economic disparities between communities are challenged and rectified, theft and vandalism of cathodic protection infrastructure is unlikely to diminish.

Malcolm X is credited with the following quote: “There is no better than adversity. Every defeat, every heartbreak, every loss, contains its own seed, its own lesson on how to improve your performance the next time.”

And so it is with vandalism and theft. Every breakthrough by the vandals, every loss of CP hardware contains lessons on how to improve and minimise the risk to the pipelines as a result of vandalism in the future.

Vandalism of CP infrastructure can only be combatted with collaborative efforts between designers, manufacturers, operators and end users, the development of creative and innovative designs for cathodic protection and its hardware and the willingness of asset owners to try out some of the newer innovations.

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