KNOW YOUR SEWER- CORROSION PROTECTION OF SEWER ASSETS

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ABSTRACT

Concrete sewer assets are corroded in situ by acid produced in the sewer. Stricter pollution norms and changes in our dietary habits has increased rate of corrosion substantially over the last 2 decades.

Tens of billions of dollars worth of sewer assets in Australia are today under threat due to corrosion. Rehabilitation of these sewer assets will not only cost hundreds of millions of dollars but will also result in immense operational challenges.

One of the solutions to stop corrosion is by spraying Magnesium Hydroxide Liquid (MHL) on the surface of concrete sewers. Compared to exsiting corrosion protection technologies like plastic lining, MHL spray coating is 7 times cheaper over the life cycle of the asset and does not require flow diversion or man entry for application. This technology has been tested and used as a mainstream corrosion protection mechanism over the last 12 yrs in the USA and Australia.

1.0 INTRODUCTION

Concrete sewer assets and asbestos lined assets are highly prone to corrosion due to acid attack. The corrossion phenomena in concrete sewer assets is a 2 stage process. The sulphur reducing bacteria present in the slime layer of the asset reduce the sulphate (SO_3) in the waste water to sulphide ions, as S^- or HS^- (Hydrogen Sulphide). At low pH, the HS^- is volatized to the gas phase to form H_2S, hydrogen sulphide gas. This gas generated in the sewers is the cause of the rotten egg smell. Thiobasillicus Bacteria, also known as Sulphur Oxidising Bacteria (SOB) reside on the crown of sewer lines, and above the water level in sewer assets. The SOBs, with the help of moisture, convert this gas to Sulphuric acid (H_2SO_4), as shown in Fig.1.

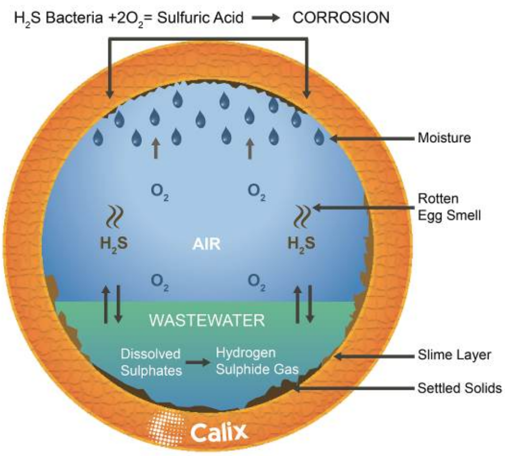


Figure 1: ***Mechanism of H_2SO_4 Production in Sewers***

Sulphuric acid attacks the alkaline concrete. The acid reacts with the calcium hydroxide, the binder in the concrete, to form calcium sulphate, a soft product with no binding properties. The acid continuously eats into the concrete, and then the steel reinforcing, until the structural integrety is compromised which can lead to failure of the asset.

Stricter pollution laws have stopped dumping of industrial waste and poisons in the sewer system. In the past these wastes would counter the sulphur in the sewage keeping the H_2S and thus acid levels low. In addition our eating habits have changed over the last 2-3 decades with the food containing more sulphur. Also the detergents contain more sulphur. The combined impact of these changes in the material entering the sewer system, has been a ten-fold increase in the corrsosion rate of sewer assets. Sewer assets originally designed to last 100+ years now corrode away in less than 50 yrs. Figure 2 below depict a corroded sewer line.

Figure 2: ***Sewer Line Corroded by Acid Attack***
Source: Corrosion & Odour in sewerage systems – Engineers Australia Nov2009

It is presumed that Australia's $40 billion of concrete sewage infrastructure, if left untreated, could corrode away in 8 years from sulphide attack. In the US, $40 trillion in sewage infrastructure has about US$16 billion spent each year in repairs, which the American Institute of Engineers says, is less than 1/3 of the spending needed to maintain the infrastructure.   There are three approaches to counter this. Continuous sewerage treatment to reduce the H_2S to a level that not only suppresses odour, but also reduces corrosion; protecting the concrete from futher corrosion; and using sewage pipes that are corrosion resistant. This paper is focussed on remediation of corroding pipes.   Corrosion resistent pipes are not currently commercially available at a competitive price and performance.

The remediation problem is enormous and is not limited to sewer pipes but also wet wells, manholes, manhole covers, inlet works to STPs etc . There are limited options available today for corrosion protection. Currently the technology that is most frequently used is plastic relining. For larger diameter sewers, wet wells and manholes, the spray technology is 7 times cheaper over the life time of the asset compared to plastic relining, even if the coating has to be carried out every 3-4 yrs. Fig 3 below shows the cost comparison between MHL spray technology and Plastic lining. Above 1000mm diameter, MHL spraying becomes more cost effective.

Inspite of its ease of use, considerably lower cost over the asset life and low upfront cost, this technology has only been utilised by only one water authority in Australia.

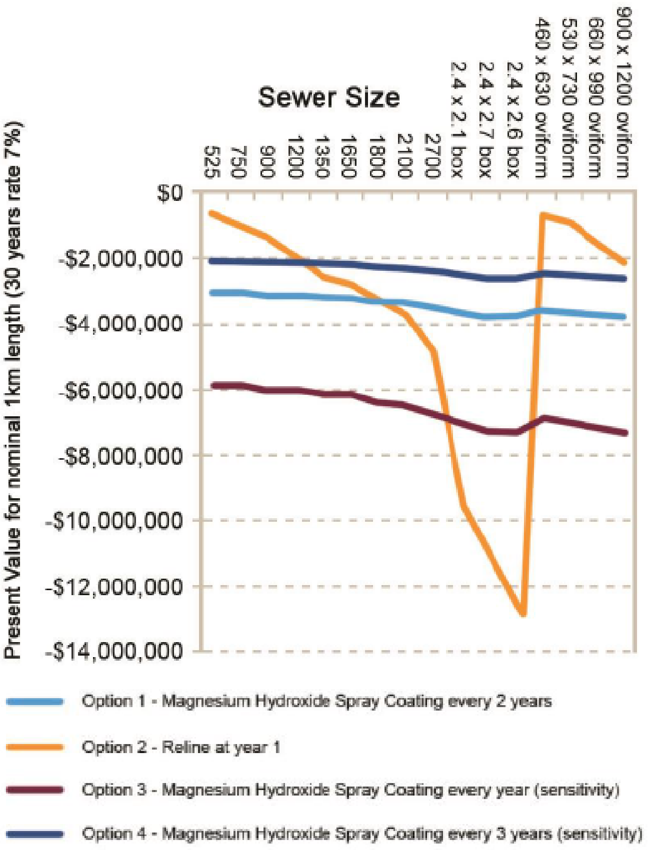
2.0 DISCUSSION

2.1 Background

Water Authorities in California were actively looking for a solution for stopping the acid attack on their sewer lines.

The concept of spray coating of alkaline chemicals was proposed and in 1989 field trails were carried out (*Sydney et al.* 1996) in California. It was a generally agreed theory that raising the pH of the affected sewer walls will destroy the bacteria and thus stop corrosion. During the trials, in addition to pH measurements, the quantity of Sulpur Oxidising Bacteria (SOB) was also measured on the coated samples. The SOBs being the mechanism for forming the acid, measuring their number was the most objective test. It was seen that on application of most of the alkaline compounds, the SOB quantity reduced from 10^7 to 10^2 cells/gm of corrosion product (10^2 being the smallest measurable quantity) and pH increased from 2 to 9. The time for the SOB colony to increase to background levels was then measured for each coated sample. It was seen that samples coated with MHL had the highest pH and restricted the return of the SOBs the longest. An interesting conclusion was also that when certain chemicals with biocidal properties were sprayed, they did not increase pH, but were effective in reducing the SOB quantity. The final conclusion from the 1989 tests was that SOBs are eliminated by coatings that increase wall pH and also impart biocidal properties and MHL was by far the most effective coating medium.

In the USA, Los Angeles County Sanitation District has been using this technology since 1990s.



<u>Figure 3:</u> ***Cost comparison MHL costing v/s plastic lining***

Source: Corrosion Protection of Sydney Water's Sewer Assets Using Sulfalock HiIGEL™ – Barclay S, Sydney Water Corporation

2.2 MHL Spray Technology in Australia

Sydney Water embarked on testing this technology more than a decade ago. An article published by Sydney Water and a MHL supplier (Barclay et al. c 2007) details the testing carried out on the sewer line the Sans Souci Carrier.

#	Test Point Description	Treated/ Untreated	22/08/03 Initial pH	24/09/03 pH after 1 month	02/12/03 pH after 3 months	05/03/04 pH after 6 months	23/06/04 pH after 9 months	22/09/04 pH after 12 months	08/12/04 pH after 15 months	01/03/05 pH after 18 months	10/06/05 pH after 21 months	06/09/05 pH after 24 months	15/09/06 pH after 36 months
1a	MH C – In MH	Untreated	3.9	3.6	5.8	4.7	3.0	2.7	3.3	3.2	2.7	3.0	3.7
1b	MH C – In MH	Treated	n.d	9.6	10.1	7.5	9.1	9.0	9.2	9.2	9.3	9.5	8.3
2	MH B - sewer crown (D/S)	Treated	3.6	9.3	9.6	9.1	8.9	7.4	8.3	6.1	7.6	8.5	4.2
3	MH B – In MH	Treated	3.7	9.8	10	8.6	9.4	9.2	9.2	9.2	9.3	9.4	8.7
4	MH B - sewer crown (U/S)	Treated	3.4	9.5	9.3	9.4	9.1	8.4	8.2	8.0	8.2	8.4	6.4
5	MH A - sewer crown (D/S)	Treated	3.6	9.5	9.7	8.9	9.5	9.3	8.5	9.1	8.3	8.6	6.8
6	MH A – In MH	Treated	3.6	9.9	9.8	9.4	9.5	9.5	9.4	9.3	9.3	9.4	8.9
7	MH A - sewer crown (U/S)	Treated	3.9	4.1	2.9	4.9	4.0	3.4	3.5	3.4	3.2	4.2	3.8
8	Control point	Untreated	3.5	3.2	2.9	3.9	3.2	3.0	2.8	3.0	2.9	3.4	3.8
9	Special Sample (Roof D/S of B)	Treated	-	-	-	-	9.5	-	-	-		-	-

n.d. = No data D/S = Downstream U/S = Upstream

Figure 4: ***Wall pH over 36 months***

Source: Extending Sewer Asset Life and Deferring Major Capital Expenditure with the use of Sulfalock HiGel™ –Barclay S et al

This asset when inspected in May 2000 (Barclay et al. c 2007) showed to have aggressive acid attack on the concrete. MHL coating trials were carried out on this asset. The positive effects of the MHL coating can be seen clearly in Fig 4 above, which compares the wall pH of treated and untreated sewer walls over a 36 month period. Even after 3 yrs, the asset walls were well above neutral pH which means that the SOB colonies have not grown to background levels. High pH relates to no acid formation thus the asset is well protected against acid corrosion.

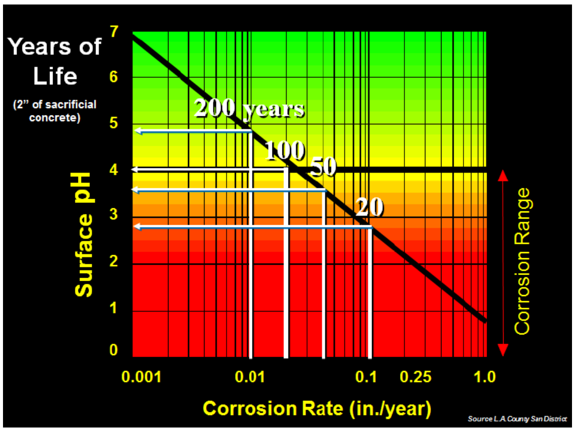
Sydney Water since has been using MHL spray as a mainstream technology for corrosion control on their large sewer assets. During 2011 to 2013 more than 17 kms of sewer lines were protected using this technology.

Other water bodies across Australia are also keenly considering the use of this technology.

2.3 Australian Sewer Assets

Australian sewer assets that have been installed 30 yrs or more ago face corrosion issues. Currently the methodology for countering asset corrosion is to undertake CCTV inspection of the assets, and those found to be highly corroded are rehabilitated. As preventative maintenance is not possible, it is typical to wait for asset to be termed highly corroded or structurally compromised, the "Smoking Gun", before rehabilitation is carried out. With the MHL spray coating technology, preventative maintanance is absolutely possible. A simple testing of the asset wall pH can be an indication of the state of the asset .

Fig 5 below shows the direct co-relation between the wall pH and the ensuing asset wall corrosion in inches/year. It also predics the service life of an asset based on wall pH. Measuring the pH of the asset wall, a very simple process, thus can be an indicator of the state of the asset. Typically assets that are getting corroded, in other words have a large and effective SOB colony, will have a wall pH around 2 to 3. In this case it can be said beyond reasonable doubt that the asset is loosing its concrete layer due to acid attack at a rate of around 2.5-3.5 mm/year (0.1 to 0.2 inches/year). A low wall pH is the "Smoking Gun" indicating that immediate action is needed on the asset. Instead of waiting for the asset to further deteriorate, it is prudent to coat it with MHL and extend it's life.



<u>Figure 5:</u> ***Relation of Wall pH with Corrosion Rate and Life of Asset***
Source: Thioguard® TST and LA County San District USA

2.4 Developmen by Calix

Calix has developed the MHL for spray application ground up in Australia. Calix manufactures highly porous thus highly reactive MgO. The high porosity also imparts the MHL enhanced biocidal properties.These properties allow Calix hydration plants (converting MgO to MHL) to have a small footrpint. MHL contains almost 60% water by weight. Transporting MHL over long distances thus means increased costs. Calix business model is to build such hydartion plants close to the customer and recently build a plant on the Gold Coast for the QLD market.

Calix has made the technology easily accessible also to the local regional councils and local water bodies. For those who had not considered this technology or were not introduced to it, it is now easily acessible, cost effective simple to implement. Councils should implement this technology and take advantage of it.

2.5 Recent Projects

Sewer Coating
Calix has been coating MHL from Sydney Water. In March 15, within 3 days of coating an asset, Sydney was hit with a one in 50 yrs storm event. The asset was flowing full with a turbulant flow for 3-4 days. CCTV carriedout in the asset after the storm event showed that the coating was intact and without any dissolution. Photo Fig6, shows a coated sewer pipe.

<u>Figure 6:</u> ***MHL Coated Sewer Pipe***

Manhole corrosion protection
Calix has developed and deployed a new approach to manhole corrosion protection. This technology is suitable for any verticle coating application.

Calix a developed a vehicle mounted rig that can safely, and cost effectively coat manholes with a quick turnaround time. Some of the key advantages are flow stoppage is not required, any overspray helps odour control, the base of manholes and manhole covers are also protected (fig 7 below). Also the coating is very forgiving, any damage to the coating during any riutine maintenance can be easily touched up.

Figure 7: ***Calix Coating Rig*** ***Corroded Manhole*** ***Ccoated Manhole***

3.0 CONCLUSION

This technology can be easily implemented for assets like large sewer pipes, manholes, wet wells and parts of STPs. The asset is cleaned with a high pressure water jet and then MHL is sprayed using a gear or a air less pump. Coating thickness of 1.2mm can be achieved easily. The MHL itself is very safe to use and any overspray into the sewer itself actually helps reduce odour and the formation of H_2S. This is the best preventative maintenance technology available today and very cost effective.Fig 11 belows shows the of concrete sewer assets that can experience corrosion due to acid attack.

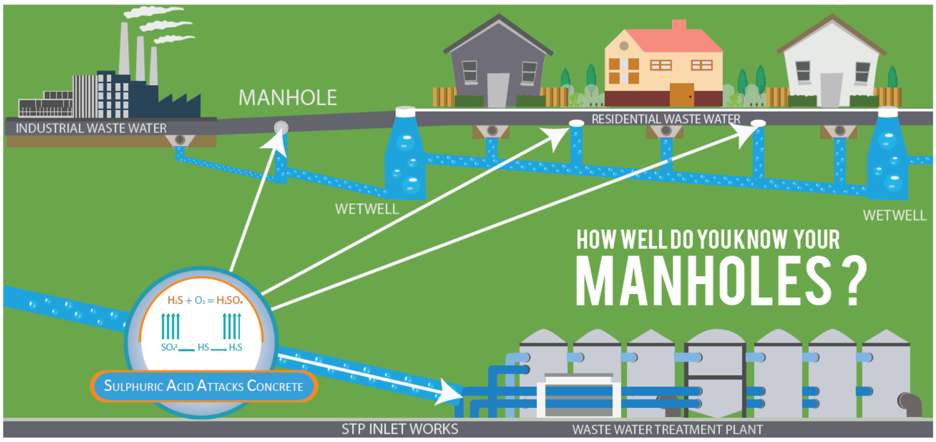


Figure 8: ***Sewer Assets where Corrosion can Occur***

4.0 REFERENCES

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