1 Protective Coating Performance

This review provides an overview of the performance of protective coating in sewer, specifically for application in large man entry pipes and manholes. The review was undertaken from 2009-2010.

1.1 State of Coating Systems

- Two types of coating systems are used in protecting sewer pipes and related infrastructures against microbiologically induced corrosion; polymer and cement based coatings.
- The coating system includes the surface repair material and primers, which may be used by the asset owners if deemed required (see Figure 1).

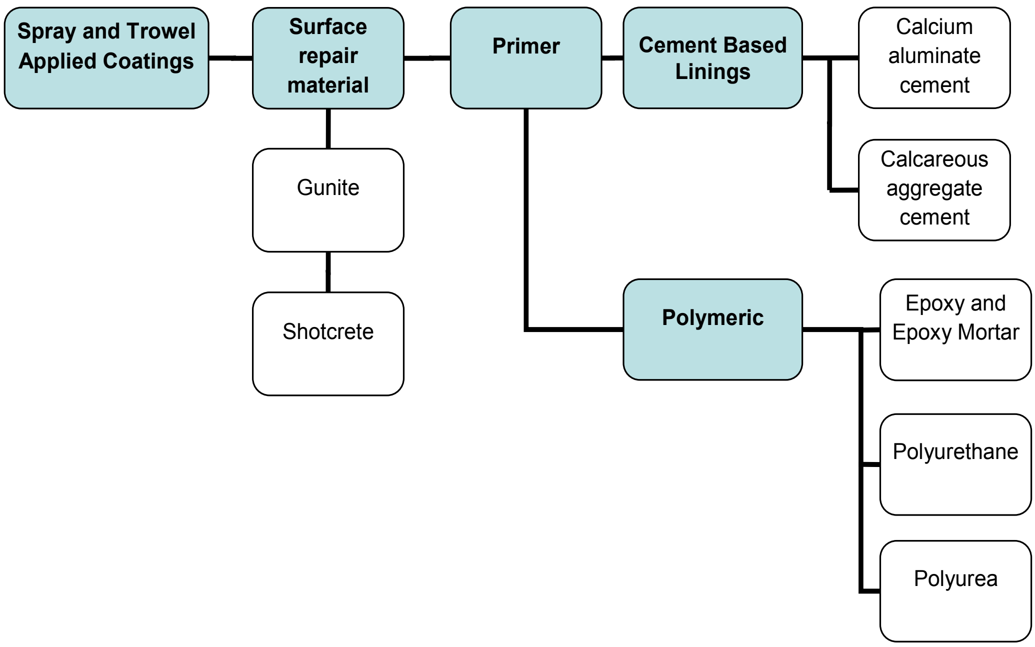

Figure 1. Spray and trowel applied coatings technologies for sewer protection

Polymeric Coatings

- Three types of polymers are used as protective coatings; epoxy/epoxy mortar, polyurethane and polyurea.
- Among the polymer based coating the use of epoxy and epoxy based mortars has dominated the market. There appears to be three principal suppliers used by the water utilities surveyed today, Sika, Parchem and Hychem, but more recently Fernco has also began to enter the Australian market.
- Although polyurethane and polyurea have been used extensively in the UK and US, particularly in protecting water mains, there is little application of these coatings in

Australia with the exception of utilities in Queensland where this is used extensively in rehabilitation of manholes.

- Previous trials have shown that polyurethane had difficulty in adhering to the moist concrete substrates, and since most rehabilitation works occur in live sewer environments, its use is limited.
- There has been no other trials in the use of polyurea, although Sydney Water (SW) sees this as an emerging coating.
- Epoxy and other polymeric based coatings are currently applied only for protection of sewer pipes and related infra-structure.

Cement based linings

- There are two types of cement based lining are currently used by the industry, calcium aluminate cement (CAC) and calcareous aggregate cement.
- Two types of CAC are currently supplied by Kerneos for sewer rehabilitation, Sewpercoat (40% Al_2O_3) and Sewperspray (16% Al_2O_3).
- The number of CAC supplier has increased to three in 2011. Previously the market was monopolised by Kerneos (previously known as Lafarge). Today two additional suppliers have entered the market BASF and Parchem, both supplying the equivalent of Sewpercoat.
- Calcareous aggregate cement is manufactured by incorporating limestone into OPC or high early cement and maybe supplied by Humes Cement.
- Cement based lining may be applied for both protection and to provide structural integrity to the corroding pipe.

Surface Repair Materials

- Two types of surface repair material are currently used in the restoration of corroded pipes after cleaning, gunite and shotcrete, which are fast curing portland cements.
- These materials are essentially similar. Shotcrete is the trade name from BASF and is widely used because it was the first product of its kind. Gunite is a more generic name. These are used in restoration because they are cheap and could be quickly and easily applied.
- Primers are used concurrently with some coating applications, but its use is not consistent with all application.
- It appears the primers used are prescribed by the manufacturer and cross-using coating and primers from different manufacturers is currently not practiced.

- Although epoxy is known to be self priming, primers is usually required or recommended if significant amount of moisture is present on the concrete substrate. Most technical data sheets refer to the requirement of 'dry' conditions on the concrete prior to epoxy application. A more quantitative measure of the moisture content do not appear in all TDS, but some refer to the requirement of less than 5%.

1.2 Performance of Epoxy Coatings

The performance of *epoxy coatings* is highly variable in the field and is characterised by various features including:

- Long-term resistance to biogenic acid attack
    - Lowering of the surface pH of the coatings with time indicates epoxy is not immune to microbiological growth and attack.
    - Some of the epoxy based coatings, however, are able to demonstrate reasonable performance and resistance to microbiological attack.
    - Sikagard 63N/Sikadur 41 in SW showed good conditions after 15 years
    - Hychem TL5 in Melbourne Water sewer after 9 years of service. The performance is demonstrated through reasonable adhesion and their resistance to acid permeation. Hychem TL5 did show some localised delamination and blistering after 9 year.

- Premature failure (failure in less than 1 year occurring as delamination)
    - Most epoxy coatings, should they fail prematurely, do so by delamination.
    - Various reasons were put forward for the possible causes of delamination including the coating being too thin (<5 mm) and is thus unable to provide sufficient resistance to the more aggressive sewer gas and the formation of pinholes during application.
    - The use of thicker coatings (20 mm) however has been shown to delaminate and despite adhering to application instructions and holiday testing to avoid and detect pinholes, coatings were still observed to delaminate. Suggesting that other factors may also be contributing to the formation of these defects.
- Defects
    - After coating application and whilst it is in service, epoxy coating manifest various types of defects including blister formation, sagging, bulging, cracking, partial delamination (*peeling of a partial layer of coating*), full

delamination (*peeling of the full layer of coating*), softening and discolouration.
  - The exact effect of all these defects, with the exception of delamination, on the coating performance and the remaining service life of the coating in unclear to the water utilities.

1.2 Performance of Cement Based Coatings

Calcium Aluminate Cement

- *Calcium aluminate* has been trialed by SW, Melbourne Water, SA Water and Barwon Waters, all with satisfactory results for various periods from 3-19 years.
- The tests carried out in Barwon Water covering 13 years of trial demonstrated that CAC lost only between 7-8 mm (or rates of 0.5-0.6 mm/yr) from the 50 mm initially installed in the highly corrosive environment (25ppm in winter and 65 ppm H_2S in summer).
- In SW, the installed Sewperspray lost only 4.5 mm in 15-16 years of service (or the rate of 0.3 mm/yr) in 3-5 ppm H_2S environment.
- Forecast based on a fitted diffusion controlled model, suggests that CAC under the same environment would lose less than 15 mm of the coating in 50 years. Thus the prescribed 50 mm thick CAC coating would suitably provide protective over this period. These results however need to consider the expansion and also the conversion of CAC with time.
- Testing in the more aggressive Virginia experimental sewer in South Africa, revealed a slow loss in material for the first 12 years 1-1.2 mm/yr, but this shifted to 1.9 mm/year between 12-14 years. This was attributed to the inevitable mineralogical conversion of CAC to its more reactive phase inducing faster corrosion in the long run. Conversion also results in increased porosity further enhancing the rates of corrosion.
- CAC is subjected to the natural softening on its surface as a result of corrosion. However other forms of defects may also become evident after application or whilst the coating is in service and may include cement shrinkage, crazing, cracking and loss of cement strength and hardness. This are attributed to various factors including water:cement ratio, poor mixing, poor curing, conversion (natural mineralogical transformation of CAC to a more reactive phase) and exceeding the shelf life of the cement.

Calcareous Aggregate Cement

SP2 (ARC Sewer Corrosion and Odour Research Project)

- No performance data on *calcareous aggregate cement* was made available to this survey from the water utilities. Published literature suggests however that calcareous aggregate cement is able to extend the life of normal OPC by 2-5 times.

1.3 Performance of Surface repair material and primer

Surface Repair Materials

- Surface repair materials are used to fill in bug holes in the concrete after the removal of corrosion products and to create an even surface on which protective lining (e.g., epoxy) will be applied.
- Although surface repair materials are considered as coatings in the US, in Australia these are not considered to offer adequate protection against corrosion.
- There are currently no data available on the performance of surface repair materials

Primers

- Primers appear to affect coating adhesion and the formation of blisters.
- In general, when used, primers appear to improve adhesion. However coatings that have been applied without primer have also been shown to have adequate adhesion. Thus its merit is difficult to judge without controlled testing.
- It should be noted that epoxy can act as self primer if the substrate is reasonably dry.
- The effect of primers on blister formation appears to be more consistent. The use of Sikadur 31 and 32 primers on Sikagard 63N/Sikadur 41 showed no blistering even after 15 years of service in SW. Whist Nitomortar ELS and Biocrete in SW and Hychem TL5 in Melbourne Water, which were applied without primers, showed blistering that increased in occurrence and size with time.
- Primer may therefore function as a sealer and/or modifier of the substrate surface, preventing undesired defects such as blistering in coatings.
- Again because there is very little known about blister formation, controlled testing is required to confirm the effect of primers on blister formation.

Further Information

ARC Linkage Final Report- SP2 Report 2 Survey Report Part 2 Coating Performance