50 Years of Coatings Testing at SA Water

Paul Vince, Principal Materials Engineer, SA Water

Background

SA Water owns and has managed South Australia's water infrastructure for over 150 years and provides water and wastewater services to 1.6 million people. With 43 water treatment plants, 24 wastewater treatment plants, 26,000 km of water mains and 8,500 km of sewers with asset value at $13 billion in total, it is important to consider the measures of minimising deterioration of these assets and to maximise their service life; as well as to provide knowledge for future designs of water infrastructure in the South Australian environment.

Under some of the most aggressive operating environments, the demanding role of containing and transporting pressurised water and corrosive wastewater challenges many construction materials that must be able to resist reaction with their environment.

In this article 'environment' is defined as the surroundings which candidate materials are exposed to in their real life applications. The test sites simulate these surroundings, and typically account for; local climates, the soil in which the pipe was laid, the substances being contained, or a combination of the above.

History

In the early 1960's, the necessity to choose economic and corrosion resistant coatings and products with proven performance was recognised. In order to obtain independent performance measurements, three test sites were established on the River Murray for testing coatings in 1965. These test sites utilised atmospheric condition, half immersion and full immersion into river water to represent the application environment of candidate coatings. More than 300 samples were tested in the first five years. Products showing satisfactory performance were reinstated into similar testing environments established at Morgan in 1971. Various materials and protective coatings have been exposed at these test sites since then.

On the wastewater side, a sewage/sewage gas test chamber was installed at Bolivar Waste Water Treatment Plant (WWTP), and two test sites were established in Glenelg WWTP. One made use of the treated sludge while the other was exposed to the local mild marine atmosphere, and all of these sites commenced testing of coating products in 1965. The Bolivar test continues to this day and is believed to be the longest running sewage exposure test facility in the world.

During the late 1960's, a soil burial site was constructed at Bolivar WWTP to determine the effect of severely corrosive soil on materials and external pipeline coatings.

In 1974, testing began at the eighth test site, located at Christies Beach WWTP under severe marine atmosphere conditions.

Aim of SA Water Testing Program

- To review the performance of products specified by manufacturers by subjecting their products to test conditions resembling their service environments
- To produce estimates on serviceable operating life of new infrastructure and assets
- To provide alternative means for possible life extension of existing infrastructure and assets
- To ensure coatings and materials for use in SA Water infrastructure are suitable for their intended application.

Over the past 50 years, more than 600 products and 2300 test samples have participated in the test program. Many tests have been running for more than 20 years at SA Water's sites. There are

Inside the sewage environment test chamber at Bolivia.

currently well over 100 samples under test. When all is said and done the commitment of SA Water to quality assurance and continuity of service to our customers is paramount.

From test results generated across the eight environmental test sites, laboratory testings and special projects, some observations and conclusions on product performance were drawn as follows.

Key findings of coating performance

i) Products from the same generic group (e.g. epoxy) can vary widely in their performance. In some cases, the operating life of one brand is twice as much as another.

ii) Product cost is not a useful guide for product performance.

iii) Coatings applied on new structures and assets perform better than recoating on refurbished surfaces. This is usually due to poor accessibility, surface contamination from daily operation and the low priority given to maintenance jobs.

iv) Epoxy coatings, coal tar epoxy and micaceous iron oxide epoxy in particular, are best for sewage application and river immersion. They are economical, easily applied and can be repaired at faulty spots. Epoxies also perform well in corrosive atmosphere, though they might chalk badly when exposed to UV but this has little effect on durability.

v) Inorganic zinc silicates have been proven to be excellent under atmospheric conditions after they were first applied to the Morgan-Whyalla Pipeline in the 1940's. It can be used as an original complete coating or as an overcoat for life extension. They should not be used for immersion service as zinc depletes rapidly. Blistering occurs when inorganic zinc silicates are over coated by most other products.

vi) 'Sintakote' used on new steel mains has outperformed coal tar enamel in corrosion resistance, deformation, splitting and sagging. Sintakote also has a low current demand for cathodic protection. (Sintakote is a proprietary fusion bonded medium density polyethylene coating)

vii) Petrolatum tapes work well, even on poorly prepared surfaces.

viii) Some vinyl coatings have performed well in all environments and are easily repaired and maintained onsite. However, their very low volume solids (% volume of dried to wet coating film) means four to six coats are required to obtain the desired thickness and this incurs uneconomically high costs for application. For this reason they are now rarely used.

ix) Numerous rust treatments, conversion coatings (turn metal surface into part of the coating) and maintenance coatings for rusted steel have been examined. Many of these products have provided satisfactory performance in atmospheric exposure but none offer long term protection in immersion environments.

x) Aluminium pigmented epoxy mastic maintenance coating applied to hand cleaned salt laden rusty steel surface has outperformed traditional metal primer or topcoat maintenance systems. The minimum dry film build must be at least 200µm for effectiveness as low dry film builds (<150µm) have resulted in very early failures.

xi) There is no substitute for good surface preparation for long life coatings on steel. Abrasive blast cleaning according to AS 1627.4 Class Sa 3 is recommended for immersion exposure.

xii) Advancement in exterior acrylics have improved their performance over alkyd enamel, though the latter is still specified for mechanical plant and pipe work in buildings for its oil and petrol resistance.

xiii) To ensure consistent product quality APAS (Australian Paint Approval Schemes) approved products are specified when suitable.

Key findings of material performance

i) Type 316 austenitic steel is the minimum requirement for immersion service in sewage and potable water. Type 303, 304, 431 and 3CR12 have all suffered severe corrosion and SAF 2304 also performed poorly in sewage systems and should therefore not be specified.

Rack of samples for River Murray exposure.

Racks for Rural Atmospheric Exposure at Morgan.

River Murray Pontoon used for river exposure samples.

ii) All grades of aluminium have given excellent results in the River Murray and performed very well in a coastal atmosphere although some surface pitting and oxidation occurs. In sewage environment, aluminium suffered from severe corrosion. Since aluminium is anodic to most other metals, direct contact should be avoided to minimise galvanic corrosion. Alkaline environment must also be avoided including contact with damp concrete.

iii) Fibre glass reinforced with isophthalic polyester pultrusion has given excellent results in all test environments with only some surface loss of resin under UV exposure.

iv) Ductile iron pipe sleeved with LLDPE (linear- low-density polyethylene) and laid in high resistivity, free flowing backfill sand has performed well during a five-year test in an aggressive soil environment, when compared to the same material laid on a mixture of the same backfill sand and natural soil. The importance of a defect free sleeve was also evident from the test; as rapid corrosion occurred at a purposely made sleeve defect.

v) Non-metallic materials for pipeline such as uPVC (un-plasticised polyvinyl chloride), glass reinforced polyester and polyethylene provide excellent corrosion resistance to water and sewage environment. Care needs to be taken during transportation, handling and installation as damage can shorten their working life. The mechanical properties, both short and long term, need to be considered and well understood by designers and those who specify them.

The Future

The results achieved by the test program are used to inform SA Water standards and to provide guidance in the formation of tender documents associated with the supply and fitting of major water infrastructures. Information gained from testing done by paint manufacturers and other test agencies such as APAS are used to supplement data from the SA Water program. Testing in the actual environment where products are deployed still provides excellent knowledge of product performance. This in-service reliability is particularly important for sewage applications. Unfortunately the sewage test chamber has been off line for significant parts of the last two years but will be back on line soon for future testing. The sewage environment remains the most demanding due to a complex combination of hydrogen sulphide gas, humidity, acids, bacteria and contaminants. Coatings, liners, cementitious products, chemicals and antibacterial products have been trialled and all have shown some success. SA Water is constantly learning and adjusting and implementing the lessons learned through the testing program. Ultimately the aim is to maximise the life of SA Water's assets and the testing program is making a positive contribution. As the Federal Government and other state governments take up the challenge of producing more sustainable infrastructure the performance data from the SA Water exposure testing sites is likely to become a national performance standard. In an ideal world it would be good to see a substantial return on investment in these long term monitoring and assessment programs come back to South Australia after so many years of commitment and service in corrosion mitigation.

References

DJ Ellis, GC Moore (1992) Materials and Coating Selection for Water Supply and Sewerage – An Essential Component of Asset Management, Corrosion Australasia, Vol 18 No 4.

P Vince (2009) Accelerated Testing of Coatings for Wastewater Applications, Corrosion & Prevention 2009, Australasian Corrosion Association, Coffs Harbor, Paper 13.