Sydney Desalination Pipeline Cathodic Protection System Performance Review after 3 Years

Introduction

As part of a NSW State Government initiative to provide Sydney with a long term drought proof water supply solution, a desalination plant was built in Kurnell. The delivery point for the desalinated water was Erskineville, a Sydney suburb approximately 4 km from Sydney CBD. This required the construction of a 16.8km pipeline (see Figure 1).

This study assesses the performance of the cathodic protection system and other corrosion mitigation and monitoring systems over the 3 year period following commissioning.

Design Brief

The pipeline was designed and constructed by the Water Delivery Alliance, which was made up of a number of consulting and construction companies and Sydney Water.

The main design requirements for the Alliance included the delivery of up to 550 million litres of water per day and an operating life of 100 years. This required the construction of a large diameter pipeline. The Alliance prepared the basis of design and a project brief (Table 1).

The pipeline design and construction was an engineering challenge and had to take into consideration; a high water table, sub-sea crossing, pipeline tunnelling in high density residential areas and traversing contaminated soils, all requiring different construction techniques.

Table 1: The design brief [2] given to the corrosion consultants included:

1.	The minimum operating life of the pipeline is to be 100 years.
2.	The pipeline is to be protected from corrosion failure over this period using a combination of coatings and cathodic protection systems.
3.	The pipeline corrosion levels were to be monitored over the life of the pipeline.
4.	Any DC stray current effects are to be mitigated.
5.	The pipeline route to be checked and mitigated from High Voltage AC induced/fault currents.

Pipeline Construction

The water delivery pipeline has the following characteristics

The trenched, mounded, above ground and the concrete encased micro tunnelled pipe sections are all carbon steel DN1800 mm, 12 mm (minimum) wall thickness and internally cement lined. The trenched pipe sections are bell and spigot joint with a full circumferential weld internally and externally while the tunnelled sections utilise full butt welds.

The pipeline external coating is ultra high build 2-pack epoxy or HDPE. All field joints were either mastic lined heat shrink sleeve or petrolatum tape.

The sub-sea section consists of twin carbon steel DN1400mm pipelines 17.5mm wall thickness, internally cement lined. A tri-laminate external coating was applied along with a cementitious weight coat. All field joints were coated using a mastic based product.

The tunnelled pipeline sections are all DN1800mm with internal cement lining as previously stated. Externally, the tunnelled pipeline sections are uncoated except for a few select areas, but have been concrete encased.

The pipeline has been electrically isolated at numerous locations. These locations include the extremities (to provide electrical isolation from foreign structures at the pump station and tie-in point) and at each transition from cathodically protected to non-cathodically protected pipe sections.

Cathodic Protection System Overview

The pipeline has been divided into sections, due to the mixture of construction techniques. Each section was looked at separately with the most suitable cathodic protection system selected. Both impressed current and sacrificial anode CP systems were installed to protect the pipeline against external corrosion. The CP systems were designed to complement the external pipeline coating system.

Gypsum bentonite packaged magnesium sacrificial anodes were installed at all mounded and trenched pipeline sections which are relatively short in length and an impressed current CP system was installed to protect the 7.1km twin pipe sub-sea crossing.

Monitoring of the CP system is via test points, located both above and below ground. At a number of locations within the tunnelled sections, LPR corrosion monitoring probes have been installed to monitor corrosion rates.

CP And AC Mitigation System Operation & Performance

Commissioning of the CP systems was undertaken following installation of each pipe section between 2008 and 2010. Final commissioning was undertaken in 2010. This confirmed all cathodically protected pipe sections shifted to fully protected potentials, in accordance with Australian Standard AS 2832.1 and the design report, which stipulated a minimum potential of -0.85 Volts vs Cu/CuS04 free of significant voltage gradient error.

Since commissioning, the pipeline potentials have remained stable at all test points. As expected, the impressed current CP system output has decreased as the pipeline polarised.

The test results over the past 3 years show the trenched and mounded pipeline sections, which are protected using sacrificial anodes and have an

Figure 1: WDA Pipeline Route Kurnell to Erskineville.

approximate 3.2 km length, require an average of approximately 950 mA to achieve full protection. This equates to a current density of 0.05 mA per m² of pipe. This is acceptable given the relatively short (6 m) pipe lengths which have field wrapped weld joints and significant soil resistivity variations along the route. Note there has been little variation in the current demand (less than 10%) and potential variations during this time. The variations noted appear to be related to ground moisture.

The sub-sea pipelines require an average of 400 mA for full protection

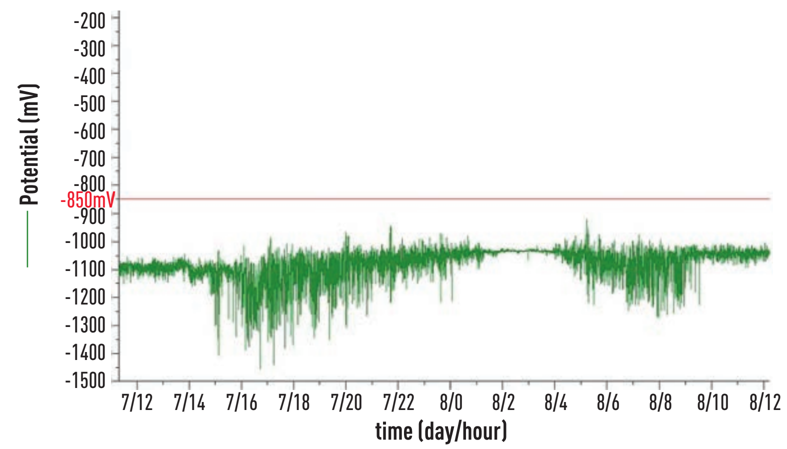

Figure 2: DC Stray Currents Recorded Over a 24 Hour Period.

of the approximate 13.6 km pipeline length. This equates to a current density of 0.01 mA per m² of pipe. This result is expected as the sub-sea pipelines have a thick factory applied cementitious weight coat which protected the tri-laminate during construction. The current required to protect the sub-sea pipelines has decreased by approximately 30% since commissioning, which is to be expected as the pipelines have polarised with time.

At the tunnelled pipeline sections where no cathodic protection has been installed, potential testing to permanent references shows stable potentials exist, with little variation. In addition, the permanent LPR corrosion probes have stabilised and readings indicate minimal corrosion is occurring in these sections.

This stable environment and low corrosion rate is to be expected as the concrete encased pipeline in the tunnelled sections is buried at depth where an oxygen depleted environment exists.

Some sections of the pipeline are subject to stray current effects, mostly relating to NSW Railway activity which is DC powered. As can be seen from Figure 2, most activity occurs during the morning and afternoon peak activity with minimal stray current activity during the night when minimal rail activity occurs.

Conclusion

During the 3 year period since commissioning, the cathodic protection systems (sacrificial and impressed current) are operating satisfactorily. The CP system design parameters made during design stage are being met. These parameters include pipeline external coating loss and current density. The decrease in current density, especially in the sub-sea sections, is to be expected as the pipelines have polarised.

The test results also show no corrosion is occurring at the tunnelled pipeline sections where no cathodic protection has been installed. The stable potentials and low corrosion rates again confirm the design parameter assumptions are being met.

For additional information, refer to 18th International Congress Paper No. 359, by J. Galanos and J. Kalis (2011).

Author: Jim Galanos
Engineering Manager,
Corrosion Control Engineering