

A New Approach for the Management of Cathodic Protection Systems

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Abstract

Impressed current cathodic protection (ICCP) for reinforced concrete structures is a proven technology which has provided long term corrosion prevention for a number of marine structures owned by the NSW Department of Industry (DoI) Lands.

The main challenge associated with ICCP systems is related to ongoing maintenance, which can often extend for a system design life of 30 years or more, and the ability for successive maintenance managers and their consultants to access all of the relevant data to operate their systems over that period. This data includes the original specifications, original drawings, maintenance records and performance records. In addition to this, having a simple, modern, reliable and cost effective system for maintenance and monitoring of multiple assets is one of the challenges for asset managers for the long term preservation of their structures.

Six of the wharves and jetties owned by DoI Lands along the NSW coast, from Eden to Coffs Harbour, are protected by ICCP systems. Since 2013, these systems have been managed using a web based Cathodic Protection Management System (CPMS). This system allows online access to all system documentation in digital format; incorporates an alarm function which immediately identifies any interruption to ICCP system current delivery to the structure(s); provides a platform for DoI Lands to check and verify the status and monitoring data for their structures; and, provides a simple and consolidated status report for the purpose of maintenance planning.

This paper will provide a case study of how a Cathodic Protection Management System has assisted DoI Lands in the implementation of a long term maintenance program for their assets.

Keywords: Corrosion, cathodic protection, infrastructure, maintenance, concrete

1. Introduction

Over the past 25 years, impressed current cathodic protection (ICCP) systems have been used extensively in Australia for the corrosion protection of concrete and steel structures which are susceptible to chloride induced corrosion in marine environments. Cathodic protection in concrete structures promotes the development of steel passivity as a result of the production of hydroxyl ions at the steel-concrete interface which creates a protective passive film. In addition, the direct effect of CP includes shifting the steel potential to more negative values, which inhibits the corrosion of iron, and moves the chloride ions away from the steel towards the anode.

1.1 Maintenance of CP Systems

One of the main requirements of CP systems is the delivery of uninterrupted CP current to the structure and adequate monitoring and maintenance over the design life of the system. The lack of systematic maintenance of CP systems may impact on the long term corrosion protection of the structures and may result in additional repair costs due to ongoing corrosion resulting from the lack of proper system operation during the service life of the structure. For some

assets owners, in order to eliminate the future maintenance costs which are associated with impressed current CP systems, they have instead opted for less efficient, less reliable and more expensive corrosion protection systems which have been selected and implemented for the corrosion protection of their assets. The primary reason for owners not selecting impressed current cathodic protection technology has often been the perceived complexity of these systems, and the confusion and inefficiency regarding ongoing maintenance.

1.2 Cathodic Protection Management System

This paper will provide a case study about the Department of Industry – Lands (DoI Lands) which has six wharves and jetties along the NSW coast that are protected by ICCP systems. The case study will reveal how these systems are being managed using a Cathodic Protection Management System (CPMS) which was developed for this asset owner in 2013. CPMS is an online platform for CP system maintenance and for monitoring the continuous delivery of CP current to marine structures. The system incorporates an alarm function which immediately notifies of any interruption to CP current delivery to

the structures and provides a live platform for Dol Lands to check and verify the status and monitoring data of their structures.

Additionally, CPMS provides online access to all system documentation in digital format and provides a simple and consolidated status report for each structure. This information is saved on the CPMS server and the objective is to enable easy and simplistic maintenance reporting and planning.

This paper will elaborate on how the Cathodic Protection Management System has simplified the process for Dol Lands in the implementation of a long term maintenance program for its assets.

2. Background Information

Before embarking on the initial development of the CPMS, a detailed assessment of the problems facing Dol Lands was undertaken through open discussion with the system designers.

Some of the main concerns associated with the efficient long term maintenance and monitoring of CP systems were as follows:

- All system documentation was in the form of multiple reports submitted by different consultants over the years to different employees at Dol Lands and stored in paper format on shelves in the department's offices. The majority of communications related to these systems were in the form of email correspondence between different consultants and various Dol Lands employees who were responsible for maintenance and operation of the CP systems. In short, no common consolidated documentation procedure was available for these systems.
- The installed control systems were from different manufacturers and operated on different software. The department's access to these systems required the installation of various types of modems in the Dol Lands offices for access to the systems. For simple verification of system functionality, some level of specific communication, software and hardware knowledge was required to dial into these systems. In addition, different types of modems were installed on various PC's in the department's offices and modem and PC upgrades were necessary from time to time to maintain connectivity to these systems.
- Some of the systems were manually operated with no remote connectivity (for the purpose of monitoring). Ensuring that a CP system is operational could only be achieved during the yearly visit by a consultant/CP Engineer. In practice, the system could be faulty or

switched off for extended periods of time due to simple power supply failures and there would be no practical means for the asset owner to confirm system operation prior to receiving the consultant's/CP Engineer's report.

2.1 Dol Lands Requirements

The components for an acceptable system for Dol Lands included the following four key requirements:

1. A platform to consolidate all relevant information and data related to the CP systems including the original construction drawings, commissioning reports, maintenance records, specifications, consultant's reports...etc. This information needed to be in digital format, be securely stored, and be quickly accessible for the department's staff and nominated consultants.
2. Simple and up to date operational status report for each CP system.
3. The ability for real time verification of CP current delivery to the structures. The verification capability should be available to staff to perform at any time without the need to use any special modems or manufacturer software required to be installed on the department's computers.
4. A tool to assist in developing simple, clear and methodical long-term maintenance and monitoring programs for the CP systems and to assist with budget planning.

2.2 Development of CPMS

Based on Dol Lands requirements, a cathodic protection management system (CPMS) was developed by Remedial Technology to address the department's specific requirements. In part because of site visits to the structures and upgrades of communications, the system was developed progressively from mid-2013 until late 2015. The final operating version of CPMS has now been operational for over one year and meets the requirements set out by the department.

3. System Description

The Cathodic Protection Management System (CPMS) has the following user attributes:

- Secure access for approved users through a password protected web site.
- A simple one page interface containing all portals, identification information and photographs of each CP-protected structure

and its operational status, system and monitoring data.

- A portal via the Pervasive Telemetry website for 24/7 monitoring of the ICCP systems. This monitoring allows real time verification of CP current delivery to the structures.
- Advanced alarm functions for issues/problems related to CP current delivery to the structures.
- Digital, functional and performance reports which are available online as soon as onsite testing has been completed. This function eliminates the need for traditional hardcopy reports.

3.1 System Interface

The main page of the CPMS website displays the CP-protected structures side by side. An example of the main page is shown below.

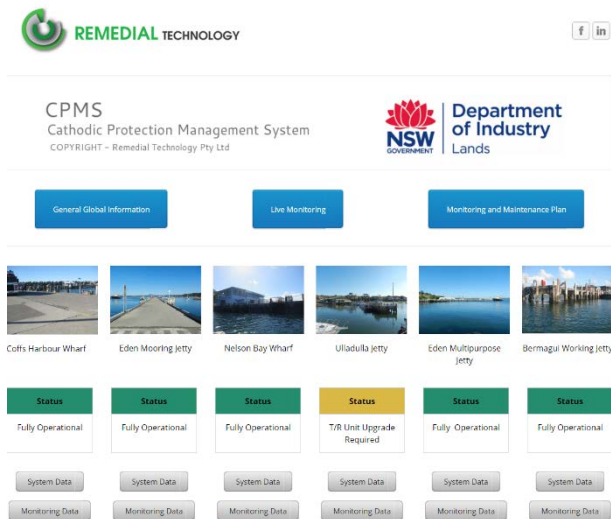


Figure 1 Main page of CPMS. This page is setup for six CP-protected structures located in NSW and managed by Dol Lands.

3.2 System Portals

On the main page are three portals which are used to extract information for global management of the systems. The portals are 'General Global Information', 'Live Monitoring', and 'Monitoring and Maintenance Plan'. Each portal contains essential information and their value to the user is summarised as follows:

3.2.1 General Global Information

This portal contains general information about cathodic protection which is applicable to the structures. Information includes 'System Monitoring & Inspection Guidelines' and the Australian Standards which are relevant to the maintenance of in-concrete CP systems. The files in this portal serve as background information

about industry guidelines and are updated when necessary.

3.2.2 Live Monitoring

This portal allows the user to check in real time whether CP current is being provided to their structures. This function is highly useful for asset owners because they can confirm whether their CP system(s) are operational and have the assurance of an alarm notification (via email or SMS) if electrical power to their structure is disturbed or if there is a fault with the CP system.

Crown Lands NSW

Site Name	Zone1 Current	Zone1 Voltage	Reference H11Z1A1	Zone2 Current	Zone2 Voltage	Reference H522A1	Cabinet Temp	Last Data			
Bermagui Working Jetty	0.18 A	1.39 V	-0.37 V	0.22 A	1.42 V	-0.55 V	26.5 °C	20/09/15			
Site Name	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6	Zone7	Zone8	Zone9	Cabinet Temp	Last Data
Coffs Unloading Wharf	1.13 A	0.28 A	0.52 A	0.45 A	0.57 A	0.66 A	0.77 A	1.29 A	0.42 A	39.31 °C	20/09/15
Site Name	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6	Zone7	Zone8	Zone9	Cabinet Temp	Last Data
Eden Multi Purpose Jetty	3.96 A	2.3 A	1.31 A	0.14 A	0.39 A	0.2 A				23.18 °C	20/09/15
Site Name	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6	Zone7	Zone8	Zone9	Cabinet Temp	Last Data
Eden Mooring Jetty	0.93 A	0.16 A	0.19 A	0.74 A	0.93 A	0.44 A	0.15 A	0.28 A	0.1 A	27.31 °C	20/09/15
Site Name	Zone3	Zone4	Zone5	Zone7	Zone9	Zone10	Cabinet Temp	Last Data			
Nelson Bay Wharf	0.23 A	0.0021 A	0.38 A	0.09 A	1.98 A	0.75 A	31.62 °C	20/09/15			
Site Name	Steel Piles Z1	Headstock Soffit Z2	Headstock Sides Z3	Edge Beams Z4	Cabinet Temp	Last Data					
Ulladulla Jetty CPMS	0.0 A	2.05 A	4.65 A	0.0 A	25.31 °C	20/09/15					

Figure 2 Live monitoring provides a consolidated web page displaying vital operating data such current (A), voltage (V), cabinet temperature... etc. for each CP-protected structure. The data which is accessible via live monitoring can be selected to suit the technical attributes of each CP system.

For Dol Lands, verification that CP current is being delivered to six structures is vital information and the built-in alarm function ensures that there will be no significant time lapse in carrying out rectification work in case of electrical disruption or malfunctioning hardware in the CP systems.

3.2.3 Monitoring and Maintenance Plan

This portal contains the yearly Monitoring and Maintenance Plan for all Dol Lands CP systems. This is a highly useful maintenance and monitoring tool for asset managers, as it sets out all planned and executed repair work, adjustments and remote checks for each system.

Monitoring & Maintenance Plan 2017																
Remote Testing and Remote Check												Performance Check and Site Inspection				
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Q1	Q2	Q3	Q4	
RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC				
RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC				
RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC				
RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC				
RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC				
RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC				

Figure 3 The above sample monitoring plan indicates that a remote check of system functionality has been carried out in January 2017 and February 2017 on all six Dol Lands CP systems. Regarding onsite testing, the program indicates that four site inspections have been completed in the first quarter, and three site inspections are planned for the third quarter.

The information in this plan is updated as soon as the work is completed and asset managers can use this portal to view an updated summary of all maintenance and monitoring work for the year.

3.3 Structure Specific Information

For each individual structure there is a CP system operation status bar and two portals which contain the 'System Data' and the 'Monitoring Data' of the system.

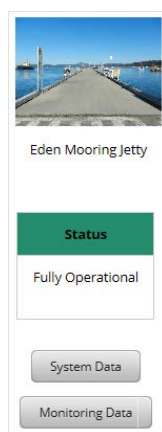


Figure 4 Identification, operational status, consolidated background information and performance data for an individual CP system.

The 'System Data' portal leads to all background information for an individual CP system, including the original specification, drawings, the operation manual, the system commissioning report, all past monitoring reports for the system, key information data for the system including a general description of the system, photographs, warranty information, address and contact details of manufacturer of control system...etc.

The 'Monitoring Data' portal leads to all yearly data associated with functional checks, CP performance reports and the yearly inspection reports for the system.

In brief, CPMS provides a consolidated documentation platform for each operating CP system. All documentation is in digital format, is securely stored and periodically backed up on the Remedial Technology servers. This allows for easy and reliable retrieval of system information by Dol Lands staff, and importantly, simple handover of all operating information to successive asset managers.

4. Planning for Longevity of an Asset

In order to achieve optimal long term performance of an asset, maintenance planning must be simple, clear and planned over the asset's entire life span. To achieve this, Dol Lands has organised and consolidated all system information needed for maintenance planning, and also to adequately pass

on operational information to successive managers who will continue with these responsibilities.

The application of cathodic protection systems to structures has a significant initial cost, and some ongoing costs associated with monitoring and maintenance work. When system information is properly maintained, maintenance issues and problems are easily identifiable and rectification work (when required) can be carried out in a timely manner. This will keep the overall CP system maintenance costs to a minimum over the life of the structures owned and managed by Dol Lands.

4.1 Audits

An initial major site audit of a CP system and the structure by an experienced CP Engineer is a key component of CPMS. Based on the author's experience in auditing CP systems, it is often revealed that there are numerous non-performance issues related to cathodic protection systems operating in marine environments. While some issues are minor, others are serious and related to the protection systems, with some problems sometimes consistently overlooked for years. Routine audits, as part of CPMS, carried out by experienced CP Engineers will minimise the incidence of non-performance issues.

4.2 Decision Making

One of the key barriers to the efficient running of an individual or multiple CP systems is the large volume of reports, operation manuals, drawings and other documentation which is normally kept on file. It is often the case that this documentation is unorganised, and contains a lot of duplicate and irrelevant information. This state can potentially clutter and slow down the decision making process for owners. In the worse cases, it may lead to necessary maintenance actions being delayed or completely overlooked. In the case study of Dol Lands, CPMS has been operation since 2013, and has already streamlined and simplified maintenance planning procedures.

5. Conclusions

The implementation of CPMS for Dol Lands has been effective in consolidating online all CP system data which is essential for system monitoring and maintenance. Further, standard reporting has been eliminated, and now all inspection reports, functional checks and monitoring reports are directly uploaded to CPMS after completion and are made immediately available to Dol Lands' staff. CPMS has allowed the owner to verify the operational status of their six systems at any given time, and to ensure that there is no significant time lapse during which the structures are not receiving cathodic protection current. Overall, CPMS has achieved its objective of organising and consolidating CP system

operating data, and over the years to come, will facilitate clear, efficient and achievable long term maintenance planning for Dol Lands' structures fitted with ICCP systems.

6. References

[1] AS 2832.5-2008 – Cathodic protection of metals Part 5: Steel in concrete structures.

[2] A. Cheaitani, Management of Cathodic Protection Systems In Marine Environments, Corrosion & Prevention 2014 Paper.