Development of Method to Assess the Integrity of Metal Streetlight Poles

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This project is being undertaken in order to establish a new and improved metal pole inspection methodology for West Coast Energy Pty Ltd. The current process relies upon the personal judgment of the operator conducting the inspection in regards to the severity of the corrosion that is observable. The key objective is to evaluate technologies and identify a method that could improve the overall efficiency of the inspection process, remain simple to carry out and improve objectivity and accuracy. The criteria for evaluating the technologies is that they should lead to significant financial business value to the company - in the forms of cost savings and competitiveness. By improving the ability to reliably detect corrosion, West Coast Energy clients will benefit from a reduction in hazards and an improvement in assessing the economic life of the asset.

By gaining a more complete understanding of the corrosion that is leading to the failure of metal poles, technologies of interest have been identified. By liasing with the potential suppliers the capabilities of their technology will be evaluated analytically and via site demonstrations.

1. Introduction

This investigation is focused on the method by which metal poles are inspected by West Coast Energy Pty Ltd (WCE) to assess their structural integrity. The current method in place is inefficient – in terms of the time taken for the assessment (including the recording of the data) and the accuracy. Currently, all poles are excavated around their circumference and visual inspection is performed, with simple treatments performed on site if appropriate. Corrosion is the main concern, as aside from uncontrollable incidents (e.g. being hit by a car), it is the principal unassisted failure mode for metal streetlight and power poles. At present, it is not possible to determine whether the inside surfaces of the poles are corroded as it is only the outside that is visually inspected, an improved method could address this. Another issue is the subjective personal judgement that is inherent in current inspections. A way in which the level of corrosion could be objectively quantified is desirable.

An efficient inspection method can reduce costs for WCE by reducing the time taken for inspections. Additionally, WCE will be more competitive in securing future tenders- not just in Western Australia, but in New Zealand (where parent company Northpower operates) and throughout other states of Australia. Another important consideration for the project is the frameworks used by client organisations that any improved method must be compatible with, and these frameworks vary from client to client.

There are a number of nondestructive testing methods available for detecting the corrosion of metal. The most promising for this application use either eddy currents or ultrsonics as their foundation. It would be particularly advantageous for candidate technology to eliminate the need to excavate the pole could be removed from the process..

2. Process

2.1 Current Method

The first step in the investigation was to understand the current inspection methodology. This was achieved by reviewing the work practice guidelines that WCE must abide by, and participating in site trips with inspection crews to conduct routine inspections. Table 1 below shows the classification system used for grading the serverity of corrosion.

Severity	Description	Actions Required	Total Time (average)
S1	Hole or crack greater than 10% of pole circumference, extreme corrosion present signifying loss of metal thickness	Fault crew called for immediate action	>60 minutes
S2	Small point holes or cracks less than 10% of pole circumference, severe corrosion present	Pole must be replaced within 3 months	35 minutes
S3	Pitting, flaking of metal or major surface corrosion	Pole requires inspection within 18 months, pole cleaned and galvanising spray applied	30 minutes
S4	Minor surface corrosion of metal	Pole cleaned and galvanising spray applied	30 minutes
S5	Visible loss of coating only	Pole cleaned and galvanising spray applied	30 minutes
No corrosion	No corrosion can be seen around the pole	No action required	5- 10 minutes

Table 1 Severity classifications, their actions and inspection times

The process for an inspection as it stands is summarised as follows:

- Inspection crew ensures accessability to the site and performs a voltage test on the pole to make sure it isn't live before proceeding.
- A 300 x 300 mm area around the base of the pole is excavated, or as close to this as possible if there are obstructions. This takes ~5 minutes where the area is soft dirt. If gravel or hard ground surrounds the pole, then a pickaxe is used and this takes ~15 minutes.
- If the pole is in good condition (i.e. no corrosion) present then the hole is filled in.
- If there is corrosion evident, then the pole is cleaned with a wire brush and scraper to better observe the condition.
- Pictures are taken and the severity level is decided by the inspector as per Table 1 above.
- Where galvanising spray is required, the inspection team perform this on site after the pole surface has been cleaned. The spray is allowed to dry for ~30 minutes before the hole is filled in. Nearby poles can be inspected whilst the spray is drying to minimise downtime.
- S1 and S2 poles require no on the spot galvanising since they will be replaced immediately and in 3 months respectively. Time taken to notify fault crew and for

them to respond is beyond WCE control and varies depending on location, time of day, business of crew etc.
- Some poles are encased in concrete and this presents an additional cost since the concrete must be cracked and removed for the inspection to take place, then reinstated (by professionals) afterwards. The cost for these poles to be inspected is ~5 times that of other poles and takes ~90 minutes for one pole regardless of severity of corrosion.

For all inspections, manual data entry is required, and this takes more time than the inspection itself in most cases. Data such as location, pole type, type of lighting, etc. is required for all poles as well as the results of the inspection. Based on an initial, small sample size of 100 poles, it appears that the majority of poles show no corrosion (~80%). There are very few S2, S3 or S4 condition poles, combined accounting for ~2%. S5 poles make account for ~15 % and S1 the remaining 3 %. Due to the small number of poles in this sample, future work is needed to provide a more reliable indication of the population's breakdown.

It was also sought to develop an understanding of the root cause of unassisted pole failures. Corrosion is the mechanism, but building an understanding of the progression of the corrosion is important. In-ground corrosion of galvanised steel is something that is hard to predict accurately due to the number of variables in play. However, it has been shown that it is accelerated by highly acidic soils, the presence of soluble salts, high bacteria concentrations or low resistivity soils (Robinson, 2005). Reviewing a large volume of past pole failures through either pictures from the inspections or by retained evidence of removed poles, is being used to develop a map of the stages that the corrosion goes through. The age data of the poles is not always readily accessible, which does limit the range of data than can be considered.

2.2 Nondestructive Testing Techniques

A review of literature regarding nondestructive testing (NDT) techniques identified eddy current testing and ultrasonic testing as having potential. Other methods that were reviewed included magnetic particle testing, magnetic flux leakage, radiography and dye penetrant testing – however all had the weakness that excavation would still be required. Since this was a key part of the criteria for an improved inspection method, they were not pursued further.

In eddy current testing, by holding a coil carrying an alternating current close to a test object, the magnetic field will induce eddy currents in the test object. These eddy currents create their own magnetic field (the secondary field), which will oppose the primary field. The magnitude of this secondary field will change if the coil passes over regions that contain defects, as the defect will alter the resistivity of the test object at that point. Eddy current testing requires test specimens that conduct electricity (Bøving, 2015).

Benefits of the eddy current method are that it is quick since, surface preparation is not required (though smoother surface conditions are optimal). Direct contact between the coil and test object is not necessary to perform an inspection and this could remove the need to excavate.

Ultrasonic testing involves a high frequency oscillatory pulse being transmitted into the test object. As the pulse propagates through the object it will be partially reflected upon passing a defect or bouncing off the opposite side of the object. The time between reflections can be measured in order to determine the location of defects, or the thickness of the object (Bøving, 2015).

Advantages to ultrasonic testing include its high sensitivity and penetration, it is non-hazardous, portable and accurate (relative to other NDT methods). Some limitations are that it requires significant operator training (including to interpret results) and becomes increasingly complex when the thicknesses vary greatly for a test specimen. Ultrasonic testing has been applied to inspecting buried objects such as long underground pipes without excavation.

2.3 Identifying Potential Technology

Once an understanding of the concepts behind possible inspection methods was gained, focus turned to identifying available technology. A number of hurdles arise due to geography – international suppliers showed promise, but the high costs required just to test the technology were not feasible. Another hurdle was to find suppliers of technology rather than companies who offered the service instead. Three strong candidates were identified within Australia and contact with the relevant companies was established. These will be discussed further in the results and discussion section.

3. Results and Discussion

3.1 Corrosion Progression

A database of past and current inspection photos has been established in order to observe the process of corrosion. The early stages and final are well defined, but the intermediate stages are less well characterised. It is important to note that most poles examined to date have been predominantly from one location. The corrosion begins right below ground level, with the critical zone being approximately the first 200 mm that has been buried. The early stages of corrosion tend to appear uniformly around the pole circumference. An example of a pole in the minimal S5 condition is shown in Figure 1. The dark grey patches are the early signs of corrosion, and although it is hard to see in the picture the layer is thin and is not yet causing any noticeable loss of thickness. At this time the age of each pole is not immediately available as the data is retained on the client's system not the inspection system used by WCE.

Figure 1 Example of S5 pole condition after excavation and cleaning

It was common to see evidence of corrosion even after past treatments, indicating that the treatments may not be having the desired effect. The most likely reason for this is that the surface was not sufficiently cleaned for the past treatment or the spray was not allowed enough time to dry. Further investigation into the exact causes could be benficial for WCE and client's if this treatment plan is to remain.

All severe S1 condition poles showed highly localised corrosion that at certain points was so far progressed that there was a hole or cracks equivalent to 10% or greater of the pole circumference. Figure 2 below shows an example of this level of severity with the holes circled (they are hard to see since the inside of the pole has filled with dirt).

This pole was noticeably worse on arrival to the site – it was possible to see the corrosion "bulging" around the pole's circumference due to the build up over time. Figure 2 was taken after this excess had been removed, as initially the hole was not visible. Most S1 cases had the same feature of a bulging ring of corrosion that was visible before any digging took place.

Figure 2 Example of S1 pole condition after excavation

3.2 Candidate Technologies

To date three promising candidate technologies have been identified that are available in Australia and will be referred to as Technology 1, 2 and 3. Technology 1 uses guided wave ultrasonics that traditionally are used in inspection of long, buried pipes. By using a higher frequency source, a smaller distance is able to be inspected with a higher sensitivity. Meeting with a supplier of this technology, a demonstration was performed that showed that the technology would work for the buried portion of street light poles. However, the time taken for one pole was estimated to be in the order of one hour, which is not feasible for the inspection alone since at present the inspection (excluding data recording and action required) time is 5-10 minutes. Unless improvements regarding the speed of inspection can be made this technology will not be further pursued.

Technology 2 utilised the eddy current principle. The technology was packaged into a hand held sensor unit connected to a small terminal that displayed real time results regarding the condition of the pole, with the ability for deeper analysis on poles showing corrosion. However, at present this technology is not able to remove the need for excavation around the pole. There was belief by the supplier that they could adapt it to achieve this, but the costs required on WCE's behalf was significant and beyond the budget for this project at present. It may be the case that the supplier decides to pursue the funding of the improvements itself in which case there is potential that their equipment can be reconsidered.

Technology 3 also uses eddy currents for inspection. Unlike Technology 2, it has already been implemented overseas for the purpose of inspecting metal street lights without digging around the base. A demonstration of this technology is to be performed in the near future to verify the use and to see what requirements would be necessary in order to adopt it as WCE standard practice. The technology has different sized sensors depending on pole dimensions, that take a reference measurement of thickness at a point on the pole that is deemed structurally sound and free of corrosion. For example, about 1 m above ground is usually fine. Then the sensor is placed on the ground against the pole and it can measure up to 200 mm below ground level. This entire process is repeated for each quadrant of the pole and then the reference measurements compared to the ground level readings allow a loss of thickness percentage to be calculated. Depending on the loss of thickness identified, the severity of the corrosion can be estimated. This process takes ~3 minutes per pole regardless of surrounds (including concrete encasement). This technology still requires a site demonstration to verify the claims.

4. Conclusions and Future Work

At present the project is waiting on a demonstrations of Technology 3. Over the course of the project to date, the requirements of WCE have changed slightly in that it may be better for their future business to have not only a method for inspecting metal poles, but a complete package of technology that can be used on metal, wooden, concrete poles etc. This is beyond the scope of this project, but may still impact the decisions made by WCE moving forward or leave room for further work after the current project. The implementation process will require consideration of client needs when approaching them with a new inspection method.

Additionally it would be beneficial if the age data of inspected poles can be corroborated with the inspection reports. This will allow a model of pole life predictions in certain areas to be possible and if this was combined with quantified condition of each pole, then clients would be presented with a thorough understanding of their asset network.

5. Acknowledgements

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6. References

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