A Critique of Western Power's Wood Pole Serviceability Dilemma

Erica Ho

Dr. Brett Smith
Business School
The University of Western Australia

Prof. Adrian Keating
School of Mechanical and Chemical Engineering
The University of Western Australia

Raphael Oszvath
CEED Client: Western Power

Abstract

Western Power currently holds approximately 660,000 wooden poles that are inspected at four to six year intervals for signs of damage, decay, fungal and insect attacks. To determine the serviceability index of a pole, a trained inspector locates damaged areas from just below ground line to ~2m with the use of a sounding hammer, then proceeds to drill a hole for a probe to determine the amount of good wood available. There is, the possibility of inspectors missing decayed areas or recommending repairs when they are not required. Hence, to minimise these issues and optimise inspection costs, Western Power reviewed potential non-destructive technologies and determined the PortaScan device provided the best option for replacing the Good Wood tool. To further determine the value of using PortaScan, a cost-benefit analysis was conducted. However, it became apparent that the data used to measure the accuracy of inspections did not reflect Western Power's latest inspection practice for determining the serviceability index (SI). The latest practice eroded the financial benefit of moving to the use of the PortaScan device. A detailed analysis investigating Western Powers' methodology for determine the serviceability index of a wood poles, and its impact on the non-destructive tool search,, is summarised briefly in this paper.

1. Introduction

Western Power receives a number of inaccurate inspections of internal decay which is the largest contributing factor, leading to Unassisted Pole Failures (UPF) in the existing wood pole network. The inability to accurately detect internal decay is primarily due to impreciseness in the use of the Good Wood tool, which is used to quantify the severity of internal decay. The Good Wood tool is used widely in the utility industry and remains the key tool used to try and quantify internal decay. Western Power aims to improve the ability to identify and quantify internal decay, and thus reduce UPFs, by finding a tool that can better characterise the decay severity in wood poles. This would therefore reduce early pole replacement, optimise the economic impact of pole replacement expenditure.

Through an extensive market research of non-destructive tools, Western Power determined the PortaScan device provided the best option for replacing the Good Wood tool. Earlier studies (Western Power 2016) comparing the accuracy and precision of the existing Good Wood tool and the alternative PortaScan device, provided positive results for the PortaScan device. This was tested by undertaking a full cost-benefit analysis for adopting the PortaScan as the principal wood pole inspection instrument.

2. Inspection Methodologies

2.1 Good Wood

The wood pole network is largely made up of Jarrah wood, which accounts for 90% of Western Powers UPFs. Wood pole inspections often fail to assess internal decay accurately, as the Good Wood method measures the "good" wood available (as marked in a dotted line in figure 1and assumes uniform decay throughout the pole as marked in a white circle (i.e. r_1 in figure 1).

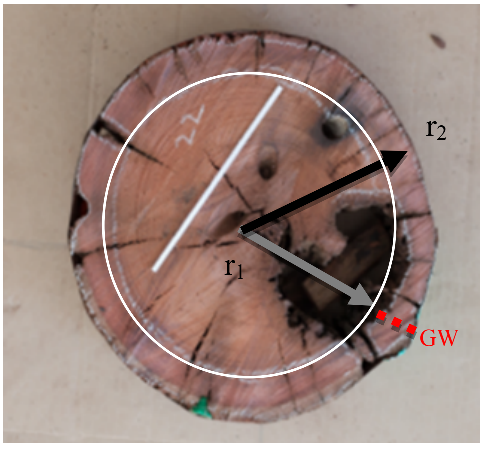

Figure 1 Wood Pole Intersection (Courtesy of Western Power)

To locate the decayed area, a carpenter's hammer is used to strike the pole. A healthy area will resonate a loud and deep 'whack' noise, whereas a decayed area resonates a light and empty noise. When the suspected area is located, a 16 mm diameter hole at 5° to 15° from the horizontal axis is drilled into the wood using a suitable power drill.

A Good Wood probe, figure 2, is then inserted into the drilled hole. The probe must be inserted slowly, while gently scraping the back and forth searching for soft spots or decay pockets. The probe measures in 10 mm increments, and the maximum measurement for pole with no decay is the radius of the wood pole.

Figure 2 Good Wood Probe

2.2 PortaScan

The PortaScan, as shown figure 3, is the latest hand held portable device that utilises Gamma-rays to measure variations in timber density, determining a pole's Section Modulus by scanning around a section of the pole.

The PortaScan device initially measures any background radiation as a base measure, before measuring the density of a wood pole. After unlocking the device with a key, the device is held against the outside of the pole. When it is in direct contact with a pole a proximity detector activates the radiation emission. These safety mechanisms ensure no tampering of the device will occur and no harm would come to the operator, the public or the environment. There is not enough radiation in the PortaScan to cause any significant harm It complies with the relevant regulations for radiation safety, and any operator would receive less than 3% of the annual safe working limit dose (Source: PortaCAT Industries 2013).

Unlike the Good Wood tool, the PortaScan is able to provide a visualisation of the inside of a pole. The low energy Gamma-ray penetrates about 100 mm into hardwoods (penetration is dependent on the density of the timber pole), and measures the energy reflected back. This is presented in the form of bar graphs and translated to a circle image to better visualise the damage report; the PortaScan assumes all deterioration is on the outer edge, represented in white, where the strength of the pole is most critical.

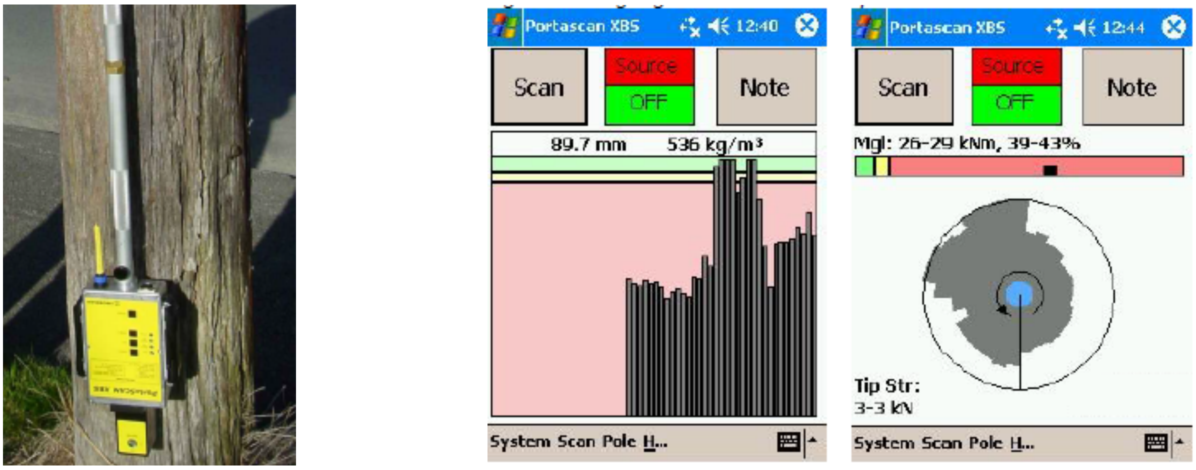

Figure 3/4 Portascan Device (left), Portascan Result (Right)

3. Cost Analysis

With the implementation of this radioactive device, comes multiple requirements for Western Power and inspectors, due to operational and Radiological Council requirements. The requirements for using and then implementing radioactive devices are as follows:

- Radiation Safety Training
- Operator Training
- Radiation Safety Officers (at least 3 or more, depending on the spread of area for inspections)
- Personal monitoring service provider (radiation tags)
- Relevant regulatory authority (registrant fees for operating radioactive devices)

- ICT changes to Western Powers data collection (from Good Wood to PortaScan)
- Changing the serviceability index assessment methodology
- Proper transport and storage facilities
- Key locked in shielded position

The main expenses and their costs as displayed in Table 1 below. These expenses are based on 100 operators, to be trained in groups of 10 for the Radiation Safety Training. Some information, such as the number of devices Western Power requires, and the individual rental price negotiated with the supplier are not available for publication. In total, the PortaScan device will cost an estimated $1.36 million per annum in addition to start-up costs, more than to the Good Wood tool.

Table 1 Portascan Costs

Expense	Description	No. of Units	Cost per Unit	Total Cost
A. Radiation Protection Test	Radiation Tags	100	$ 15.40	$ 1,540.00
Registration Fee	Western Power	1	$ 2,090.00	$ 2,090.00
PortaScan Device	PS Unit	#	#	$ 1,144,800.00
Operator Training	Radiation Safety	10	$ 2,000.00	$ 20,000.00
	Operation	100	$ 600.00	$ 60,000.00
ICT	ICT	1	$ 132,000.00	$ 132,000.00
			Total	$ 1,360,430.00

4. Benefit Analysis

In 2015, a Measurement System Analysis (MSA) was conducted by Western Power, to directly compare the PortaScan and Good Wood tools precision and accuracy. Three inspection teams carried out measurements using the PortaScan and Good Wood tool on a representative selection of 15 Jarrah wood poles, ranging from new to severely decayed. To assess the accuracy of both tools, the Section Modulus measured using the PortaScan and Good Wood tool were compared to the actual Section Modulus result. The actual Section Modulus was measured by cutting pole discs of the scanning/drilling sections and mapping all decay pockets by Western Powers Asset Performance Team.

It was later discovered for the project that the calculations in the MSA did not reflect Western Power's latest model to calculating the Section Modulus. As of March 2016, the Serviceability Assessment Model (SAM) for calculating Section Modulus in wood poles was updated, and the remaining diameter of a pole when assessing decay, after taking into consideration the presence of CCA (chemical treatment), was updated. Before the update, at the time of the MSA on PortaScan and Good Wood in 2015, the measurements were:

$$Hardwood: D_{CCAModified} = \begin{cases} D_b - 5\ Treated \\ D_b - 30\ Untreated \end{cases} \quad (1)$$

These factors are intended to compensate for the ability to accurately assess the remaining good wood when using the Good Wood tool. 30 mm are removed for untreated hardwood poles and 5 mm are removed for treated hardwood poles.

In 2015, a review of the relationship between chemical treatment and residual fibre strength of wood poles was conducted by TimberED Services. The project used destructive test data of wood poles from various wood pole companies, including Western Power. This report concluded that CCA treatment does not improve long-term ground-line nominal strength. Therefore, Western Power made the decision to change the diameter modification equations to Equation 2 shown below.

$$Hardwood: D_{CCAModified} = D_b - 10 \quad Treated \tag{2}$$

It is understood, after speaking to the Asset Engineer, that the value 10 mm was chosen by the team as a compromise of both treated and untreated poles from the previous equations used by Western Power, after several break point tests were conducted.

The latest model for calculating the Section Modulus was applied to the MSA data, which is reflected in figure 5 as "Good Wood New", the Good Wood value has shifted towards the normalised line and is nearly identical to PortaScan, excluding pole 6 and 10 that were not chemically treated. The convergence in accuracy between the PortaScan and Good Wood tool indicates limited benefit of one methodology over the other, the level of improvement does not outweigh the operational cost of implementing the PortaScan as part of the full inspection process.

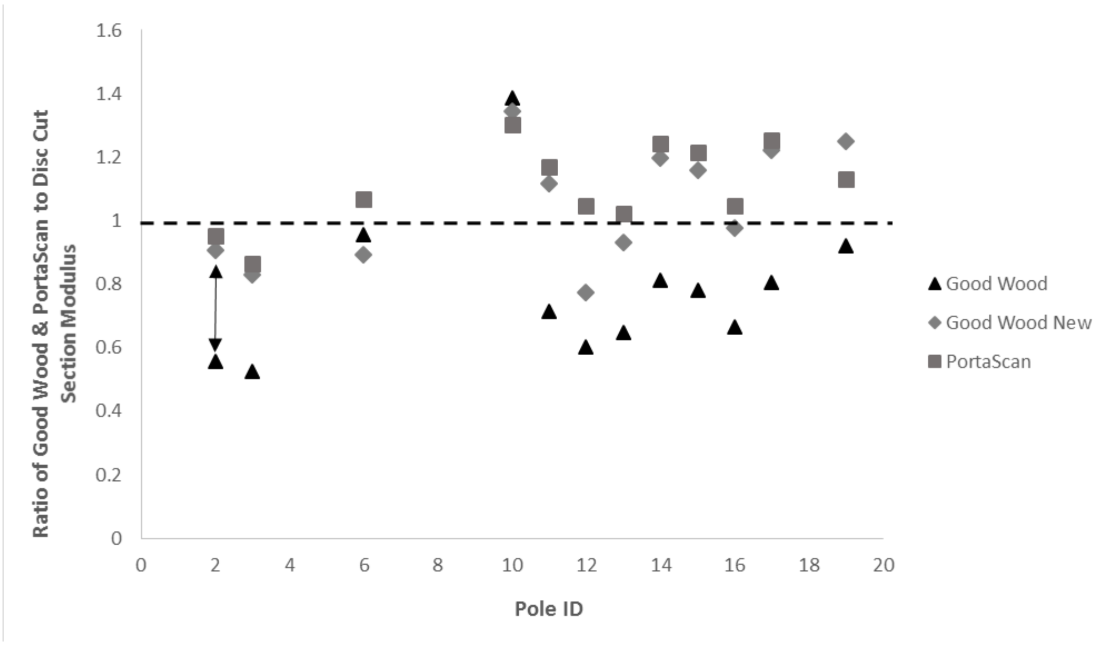

Figure 5 Normalised Results of PortsScan and Good Wood before & after update

5. Conclusion & Future Works

The aim of this project was to determine the suitability and cost effectiveness in transitioning to PortaScan in the inspection process at Western Power. Presented with all data, the PortaScan device was assessed as not providing a sufficient cost effective benefit in a large scale roll out project as initially proposed. The driving factor being the operational cost of renting devices, at about $1.30 million per annum, and analysis indicating limited improvement offered by PortaScan over Good Wood.
Although initial analysis, based on the results of the MSA study, showed the PortaScan as the favoured option, an update to Western Power's serviceability model altered the Good Wood

readings to having comparible accuracy readings of Section Modulus to the PortaScan. The update included a modification to the diameter corrections for calculating the Section Modulus of a wood pole, to account for chemical treatments. The modification was made after other studies confirmed that chemical treatments did not affect a pole's strength. It is recommended that a deeper analysis into the optimal diameter modification factor be conducted, given its' large impact on the calculation of a pole's serviceability. Despite studies concluding that there is no connection of chemical treatment to pole strength, Western Power's model still has the modified correction factor for chemical treatments.

Future works aim to continue working with the supplier of PortaScan to test improvements of the device and continue to explore other tools in the market to improve the accuracy of identifying decay in wood poles. The supplier of the PortaScan device have informed Western Power of a change to X-rays instead of Gamma rays. This switch has the potential to reduce the cost of rental, and may be the solution to the cost-benefit analysis. Furthermore, an investigation to the accuracy or calibration of the PortaScan device. A recommended approach would involve the intentional drilling in healthy poles to create controlled decay pockets eliminating density variations in a pole when scanning for the Section Modulus. This however, cannot be done by Western Power but by the supplier of the PortaScan.

Beyond PortaScan, the widespread use, acceptance and refinement of the Good Wood model that showed statistically similar results to the PortaScan, suggest that some effort to continue to modify the existing Good Wood procedure (or model) may continue to yield improvements to the detection of problematic poles by Western Power.

6. References

PortaCAT Industries 2013, *PortaSCAN XBS User Manual Isotech*. Avaliable from: PortaCAT Industries. [3rd July 2016].

Western Power 2016, PortaScan Study, March 2016. Available From: Enterprise Data Management. [23rd July 2016].