Government of Western Australia
Department of Commerce
EnergySafety

2008 DISTRIBUTION WOOD POLE AUDIT REVIEW

A Review of Western Power's Response to the 2006 Regulatory Compliance Assessment of Western Power's Distribution Wood Pole Management Systems

May 2009

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GLOSSARY OF TERMS

stay means a wire cable or set of wire cables attached to another pole or to buried bed logs, concrete stay cones or screw anchors to prevent poles leaning or tipping over from the forces on the pole, pole hardware and the conductors.

reinforcing stakes mean steel (or other structural material) sections with sharpened points, driven into the ground and attached to poles, thereby strengthening the pole at the ground line. These devices are called “nails” by Western Power’s contractor UAM.

SWIS means Western Power’s Southwest Interconnected System of electricity transmission and distribution networks

safety factor mean the reciprocal of load factors (referred to in the Codes and Guidelines). A load factor of 25% is the same as a factor of safety of four (X4). Safety factors are used through this Audit Review for simplicity and clarity.

SEC and SECWA mean respectively the State Electricity Commission and its 1975 successor the State Energy Commission. Western Power now owns and operates the electricity transmission and distribution networks previously part of the SEC and SECWA.

AA2 Submission means the Western Power submission to the Economic Regulation Authority for funding approval for the period 2009 to 2012.

DFIS and DFMS mean respectively Western Power’s computer based Distribution Facilities Information System and Distribution Facilities Management System.

“low voltage” or “LV” means voltages greater than 50V and less than 1000V.

“high voltage” or “HV” means voltages exceeding 1000V but less than 60,000V.

C(b)1 means "the document 'Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines' produced by the Energy Networks Association of Australia"

PREFACE

Energy*Safety* (a division of the Department of Commerce) is the statutory regulator with the authority and responsibility to administer the technical and safety regulatory framework for the electrical industry in Western Australia. This framework covers the activities of the electricity network operators within the State as well as other matters.

Concerns about the number of wood poles physically failing in Western Power's networks prompted Energy*Safety* in 2005/06 to undertake an assessment of the degree to which Western Power's wood pole management systems comply with the *Electricity (Supply Standards and Systems Safety) Regulations 2001* and Australian electricity industry standards and practices relating to wood pole asset management. This assessment concluded with the 2006 Audit Report issued to Western Power in November 2006.

Energy*Safety* monitored Western Power's responses to the issues identified, resolved to conduct a 2008 Audit Review and decided to make public its outcome report, which is this document. The 2008 Audit Review focussed on Western Power's electricity distribution network wood pole management.

The Review pays specific attention to compliance of Western Power's current distribution wood pole management practices, with due regard to the changes and improvements Western Power has made to its systems since the 2006 Audit. The Review also identifies matters in Section 2 than cannot be remedied in a timely way by current management practices.

"Compliance" in this 2008 Audit Review does not mean that the wood pole management systems and the wood pole structures and power lines comply in every respect, but only to the extent of structural safety of the poles and stays. Some of the issues identified are relevant to other Western Power network asset management activities.

This Audit Review report reflects due consideration of comments supplied by Western Power in response to a draft copy of the report supplied in December 2008.

Ken Bowron
DIRECTOR OF ENERGY SAFETY

May 2009

EXECUTIVE SUMMARY

In 2005, Energy*Safety* initiated a compliance assessment (audit) to determine the degree to which Western Power's wood pole management systems complied with the *Electricity (Supply Standards and System Safety) Regulations 2001*. The audit was undertaken because of concerns about the number of Western Power's poles failing in service. Power line pole structural failure is a serious safety issue. This compliance audit concluded in 2006 with the Regulatory Compliance Assessment Report of Western Power's Wood Pole Management Systems dated 20 October 2006 (2006 Audit).

Energy*Safety* monitored Western Power's responses to the issues identified in the 2006 Audit throughout 2007 and early 2008, when it resolved to conduct a review of the progress made. Energy*Safety* decided to make this 2008 Audit Review public. The Review focuses on the electricity distribution network wood pole management systems as agreed with Western Power in May 2008 and does not cover these systems for the transmission wood poles.

Part 1 – Compliance of Current Practices

Part 1 addresses compliance and safety performance issues that follow from Western Power's current wood pole management systems and practices.

General

Western Power has made a number of encouraging changes and innovations over the last two years.

Unassisted pole failures have decreased from over 350 in 1999-2000 to 134 in 2007-08. While this improvement in part reflects correcting data errors during the last 12 months, some will also be the consequence of increased attention to wood pole management. While the reduction in unassisted pole failures is encouraging, the results are still poor compared with leading Australian practice.

Design of Overhead Power Lines

Adoption of the Poles'n'Wires design software potentially will ensure complying and safe wood pole line and pole designs. With further attention to several issues, Western Power will have a robust distribution design activity underpinning the safety performance of its wood pole distribution networks.

Pole Procurement

Western Power's decision to use treated radiata and marine pine poles from Western Poles Company and Koppers Wood Products Pty Ltd and a current complying wood pole procurement specification should ensure the supply of new poles with the necessary strength to deliver acceptable wood pole safety. Western Power's procurement processes need some QA attention to ensure the procurement contract delivers poles that meet the technical standards specified.

Pole Reinforcement (life extension)

The engagement of Utilities Asset Management (UAM) to design and install pole base reinforcement of poles in service has substantially addressed Energy*Safety's* concerns in the 2006 Audit. Poor coordination between those responsible for contract development, contract management, and technical (safety) performance, but for UAM's demonstrated ability, would have raised concerns about actual outcomes.

Pole Inspection (in service poles)

The other significant change is outsourcing the pole ground line inspection field activity to Transfield and Logsys, which has lifted the pole inspection rates to appropriate levels. This change is eliminating the backlog of poles not inspected to the 4-year cycle. Again, the comments about the lack of coordination of various aspects of the work chain in respect of the pole base reinforcement contract apply but, in this case, have directly affected outcomes from the inspection contracts.

Western Power has resolved to replace its sound-dig-and-drill pole inspection practice with one or more of the non-invasive systems being evaluated. Not one Australian network operator has adopted any of the new pole base-strength assessment practices on offer. Leading Australian network operators are achieving excellent wood pole safety performance with a sound-dig-and-drill inspection practice using rigorous factor of safety serviceability criteria and diligent below-ground inspection practices. This sets the benchmark for good industry practice. Energy*Safety* believes that, at this stage, the greatest improvement in this element of Western Power's wood pole management will be achieved by applying these good industry practice methods and serviceability criteria.

Contract Management

Western Power uses contractors for a range of safety-critical wood pole management services including pole inspection, base reinforcement and replacement. Western Power also purchases its poles and stay materials from external providers.

A perception gained from Western Power documents and discussions with staff suggests some Western Power personnel hold the incorrect belief that outsourcing these activities and material supply transfers risks to the contractor or supplier.

Limits on warranties and risks were not defined in the relevant contract documents or apparently understood by Western Power personnel involved.

Quality Assurance Issues

In some cases, the review found no contract or technical specification relating to the products supplied. In other cases, the quality assurance checks performed by the contractor, or independently by Western Power, did not ensure the proper performance of the service to a standard that would deliver an acceptable safety performance. Often the general commercial conditions of contract lack relevance to the product or service provided. Key people responsible for the related asset and contract management were not involved in the contract development, tender evaluation, or the negotiations leading

to execution of the contracts. There was also a worrying absence of inspection of the products supplied to ensure they comply with the technical specifications.

Issues Requiring Specific Attention

There are a number of safety-critical issues that have not progressed since the 2006 Audit and need specific attention to achieve acceptable wood pole safety performance:

1. Wood pole inspection practices including their application in the field.
2. The "good wood" serviceability criteria should be replaced.
3. Procurement processes quote technical and performance requirements, but lack adequate audits of the supply chain and inspection of the components supplied.
4. Pole replacement plans at levels that are sufficient to deliver acceptable wood pole safety across the entire population of some 630,000 wood poles.
5. Overview and continuous improvement of the wood pole management from design through to network performance.

Part 2

This Part identifies four issues that cannot be remedied by addressing the matters relating to current management systems and practices. These are:

1. The accuracy and relevance of current data are not sufficient to provide the information needed to manage the wood pole and other network assets.
2. The historical changes in permitted design strengths, coupled with continued use of poles well beyond their useful service life. This leads to the risk of under-strength poles remaining in service, particularly in rural networks.
3. The risks of reinforced pole failures with reinforcements predating the UAM systems now used. The risks with these existing reinforcement systems have not been properly assessed and their safety effectiveness is not understood.
4. Re-using old, untreated jarrah poles for upgrading and reinforcement projects adds to risks. These poles are generally well beyond their useful service life.

Other Issues

Throughout, the audit revealed a lack of diligence and rigour in the investigation and analysis of matters related to wood pole safety. In part this is no doubt due to the poor accuracy and doubtful relevance of distribution system data and information available. The information is almost always difficult to extract and of doubtful worth when assembled.

A second issue identified throughout the audit is a lack of a shared understanding of what the internal "asset owner" and "asset manager" (key elements of Western Power's business model) really want from the assets and asset management systems. Clear asset management policies and meaningful internal service agreements would benefit the management of distribution wood pole safety. These policies and agreements may also benefit general asset management practice.

Critical Issues

Three critical issues have not been effectively addressed over the last 24 months. All three were identified in the 2006 Audit. They are:

1. The effective management of the sound-dig-and-drill pole inspection activities in the field and the adoption of clear serviceability criteria to ensure unserviceable poles are identified.

2. The development and implementation of a network-wide pole replacement program to achieve at least 15,000 pole replacements per annum within three years.

3. The identification and replacement of high risk, unsupported poles in the rural distribution network. Such poles may have complied with the engineering codes when they were installed, but do not have the strength and safety factors to comply with the more prudent bending strength specified in the 1991 *Guideline for the Design and Maintenance of Overhead Distribution and Transmission Lines.*

These three matters are critical to the safety of the electricity distribution wood pole network. They must be addressed urgently. Energy*Safety* will pursue these priority items directly with Western Power from the beginning of 2009 and will issue orders shortly requiring Western Power to correct the deficiencies.

Monitoring

Energy*Safety* will monitor and report progressively on Western Power's responses and remedies to address the issues identified in this 2008 Audit Review and the original 2006 Audit.

Acknowledgement

Energy*Safety* acknowledges the professional and competent service rendered by the many Western Power employees who provided information for this 2008 Audit Review of Western Power's distribution wood pole management systems.

INTRODUCTION

In 2005, Energy*Safety* initiated a compliance assessment (audit) to determine the degree to which Western Power's wood pole management systems complied with the *Electricity (Supply Standards and System Safety Regulations 2001*. The audit was undertaken because of concerns about the number of Western Power's poles failing in service. This audit concluded in 2006 with the "Regulatory Compliance Assessment Report of Western Power's Wood Pole Management Systems" dated 20 October 2006 (2006 Audit).

Energy*Safety* monitored Western Power's responses to the issues identified in the 2006 Audit throughout 2007 and early 2008, when it resolved to conduct a review of the progress made and release this 2008 Audit Review publicly. The 2006 Audit included both distribution and transmission wood pole management. The 2008 Review has focussed on the distribution wood pole management because this involves a much greater number of wood poles than the transmission network. There are also established practices in transmission wood pole management that should deliver better safety outcomes.

The 2008 Audit Review is based on Energy*Safety's* understanding of Western Power's wood pole management systems applicable at August 2008. This review is based on:

1. The 2006 Audit findings;
2. Western Power's formal responses to these findings;
3. Discussions with Western Power's managers and key persons involved;
4. Western Power's wood pole seminars from the 23 March to the 11 June 2008;
5. Documents provided by Western Power; and
6. Field inspections of the wood pole supply chain and other field activities.

The 2008 Audit Review uses the same management model as was used in the 2006 Audit.

The purpose of the 2006 Audit and this 2008 Audit Review is to assess Western Power's wood pole management systems for compliance with the requirements of the *Electricity (Supply Standards and Systems Safety) Regulations 2001* and the engineering standards, codes and guidelines that derive from these Regulations.

The 2006 Audit concluded with the issue of the 2006 Audit Report in October 2006.

Energy*Safety's* 2008 Audit Review assesses Western Power's response to the issues identified in the 2006 Audit and relevant documents, information and discussions until the end of November 2008 (although focussing on the practices at August 2008).

The 2008 Audit Review focuses on:

Part 1:

- The compliance of Western Power's current[1] wood pole management systems; and

Part 2:

- The legacy of past wood pole management practices identified in the 2006 Audit with significant safety consequences.

The current management systems in the audit plan have been grouped into:

1. Design
2. Procurement
3. Construction (including wood pole replacement)
4. Pole and stay inspection
5. Pole Base reinforcement
6. Pole and stay replacement
7. Wood pole safety performance and process management

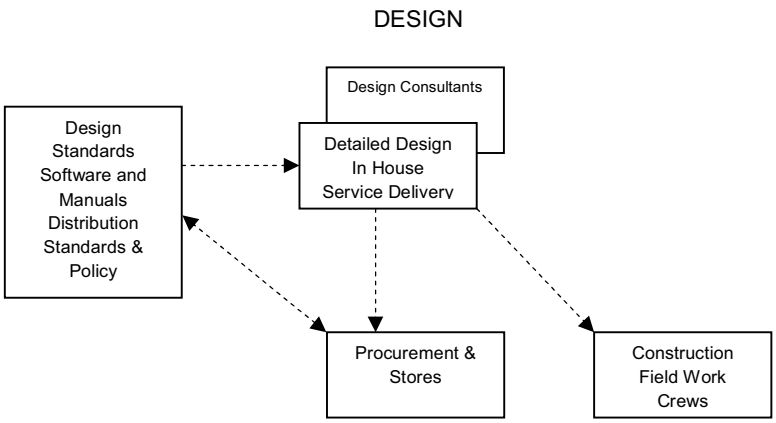
This grouping of the management systems closely follows that used in the 2006 Audit.

[1] August 2008

PART 1 - CURRENT COMPLIANCE

Design

Western Power's 2008 distribution wood pole line and pole design process has two parts:



The Distribution Standards & Policy section within the Customer Services Division is responsible for the design standards, manuals and software used in all distribution design, including the wood pole line and pole designs. This section also prepares the technical detail in the specifications for procuring poles and other materials required.

The Distribution Design section within Field Services Division prepares the detailed project designs for most of the distribution construction and asset replacement projects. This section also prepares the material lists for the designed projects that specify the materials and poles to be picked and dispatched to the construction crews.

Wood pole replacement and line repair work is managed elsewhere within the Service Delivery Division and is managed independently of the distribution design process mapped above.

As in 2006, the 2008 Audit Review did not find design records demonstrating that the distribution wood pole power lines and structures in Western Power's networks complied with relevant technical standards, codes and guidelines when they were erected. Western Power acknowledges that these design records do not exist. The absence of these records, with other issues identified in Part 2 of this report, raise concerns about the structural adequacy and safety of many poles and lines in Western Power's electricity distribution networks.

The 2006 Audit also did not find records of the designs for the distribution wood pole lines and structures erected in Western Power's networks at that time (2006). The lack of design records demonstrating compliance of recent lines and structures is a greater concern.

This 2008 Audit Review discovered information and reviewed details not available in 2006.

Design Standards and Policy

The principal Western Power standards and policy documents relevant to the wood pole line and structure designs are:

- The Distribution Design Manuals
    a. Low Voltage Aerial Bundled Cable – Vol 2 – April 1996
    b. Bare Overhead Conductor – Vol 5 Jan 2001
- The Distribution Design Catalogue of Overhead Structures
- The Distribution Construction Standards Handbook
    a. Part 4 HV Overhead
    b. Part 6 LV Overhead
    c. Part 7 LV Aerial Bundled Conductor.

Design Manuals

The Distribution Design Manuals are reference documents for professionals and technical support staff performing distribution design work. The various volumes were written at different times. They contain details from different standards, codes of practice and other sources, which were not all current at the same time and are not referenced to the source documents by name and date.

Volume 2 was issued in April 1996 and presumably contains information about line and structure design for the Low Voltage Aerial Bundled Cable that would have been taken from the *Guideline for the Design and Maintenance of Overhead Distribution and Transmission Lines – C(b)1 – 1991* (C(b)1). Volume 2 gives dimensional detail of the poles Western Power purchases, which is also changing.

Volume 5 was issued in January 2001 and therefore can be assumed to include information about line and structure designs for the bare overhead conductor lines taken from the 1999 version of C(b)1. However, Western Power has confirmed that the January 2001 version of Volume 5 is not based on the 1999 version of C(b)1, but the earlier 1991 version. Western Power does not appear to update its design manuals and documents to comply with the current (last issued) version of the relevant technical standards and codes.

With the adoption of (Poles'n'Wires) software in 2006, much of the tabular detail in Volume 5 about conductor tensions, sags and spans is now unnecessary. Potential confusion would be avoided if this detail were deleted.

Keeping the detail in these volumes current and consistent with each of the other volumes and the source documents is a formidable task, which Western Power is not managing.

Recommendation 1: Western Power should:

a. Edit and reference its design manuals, documents and computer programs for consistency and to eliminate redundancy.
b. Incorporate the latest standards and codes each time the design manuals are updated.
c. Identify in the design manuals the standards and codes with which they comply, including the exceptions to and options allowed within the standards and codes.

Design Catalogue of Overhead Structures

The Distribution Design Catalogue contains thumbnail sketches and material lists with stock numbers for each "compatible unit" used in the distribution networks. The relevant sections of this Catalogue for the Audit are:

1. High Voltage Bare
2. Low Voltage Bare and
3. LV Aerial Bundled Cable

The "compatible units" are assemblies comprising poles, cross-arms, insulators, stay wires and conductors which make up Western Power's overhead power line structures.

The audit has not discovered the records of the structural designs for each of these compatible units and the elements within them that demonstrate that these elements and compatible units comply with the relevant standards, guidelines and codes of practice. From discussions with appropriate officers these design records apparently do not exist. The manager of the Distribution Standards and Policy Section has confirmed that Western Power has commissioned a review of the compatible units for stays, which will check these elements for compliance with the current standards, codes and guidelines, provide records of the design calculations and specifications for the procurement of the appropriate materials and components required.

Recommendation 2: Western Power should check all the compatible units and the elements that make them up for structural strength and compliance with the relevant standards, codes and guidelines.

Construction Handbooks

Western Power's Distribution Construction Handbooks[2]:

> "*set out the minimum standard of construction required for the distribution network asset. This standard shall form the auditing guidelines for acceptance and hand-over of assets on the distribution network within the South West Interconnected System.*
> *The person/s engaged to undertake the construction of network assets for hand-over to Western Power Corporation shall be responsible for ensuring that these Technical Requirements are met."*

These Handbooks also nominate C(b)1-2006 as the reference for clearances, but Poles'n'Wires with which the overhead line projects are being designed complies with C(b)1-1991.

The detail in these handbooks conflicts with the approved distribution line and structure designs prepared by the Distribution Design Section using Poles'n'Wires.

These Handbooks are a necessary part of the process to ensure complying construction based on the approved designs.

Recommendation 3: Western Power should resolve whether the Construction Handbooks or the detailed line and structure designs prepared with Poles'n'Wires will be the basis for acceptance and handover of the new assets on the SWIS distribution systems.

[2] Part 1 – General Distribution Construction Standards Handbook Hb01-2007

Poles'n'Wires

The principal computer application used for the line and structure design is Poles'n'Wires, which Western Power purchased in 2006. Poles'n'Wires replaces significant parts of the Distribution Design Manuals, which require consequent review and editing.

Implementing and supporting this software is also the responsibility of the Distribution Standards and Policy Section.

The software was adopted after relying on reports from other users and representations of the supplier at the time of purchase, without any technical assessment. Western Power's post-purchase technical assessment of the software, concluded in April 2008, found the following significant issues:

1. The program is based on ESAA C(b)1 – 1991[3].
2. The program does not take into account the stresses from combined bending and axial (vertical compression) loads.
3. Two errors, which the supplier (PowerMation) has undertaken to remedy.
4. The program gives accurate results for the purposes of line and pole designs, subject to limitations identified in the Western Power's review of the software. These have been referred to and are being resolved with the software provider.

Western Power's Poles'n'Wires Verification Report states that it is Western Power's "current philosophy for overhead line design to be based on using the working stress methods as per the 1991 version of C(b)1 rather than the limit stress methods specified on C(b)1 – 1999 and 2006." Western Power's current designs using Poles'n'Wires therefore do not comply with the *Electricity (Supply Standards and Systems Safety) Regulations 2001.* Notwithstanding this, Energy*Safety* accepts Western Power's view that the design outcomes from the Poles'n'Wires program comply substantially with the 1999 and 2006 versions of C(b)1.

Thorough assessment of any new system, process or software should be part of every change made within an engineering discipline. Energy*Safety* acknowledges Western Power's rigorous technical assessment of the program and, as an informed customer, resolving the issues identified with the supplier.

Recommendation 4: Western Power should:

1. Move to and adopt design methods complying with the 1999 and 2006 versions of C(b)1 and,
2. Continue the independent assessment and verification of subsequent versions of Poles'n'Wires before adopting them.

Technical Specification - Poles and Other Materials

The Distribution Standards and Policy Manager is also responsible for specifying the technical requirements for Purchase of all the equipment and materials used in Western Power's distribution network, including the wood poles and stays within the scope of this Audit.

[3] The *Electricity (Supply Standards and Systems Safety) Regulations 2001* requires compliance with the 1999 version of C(b)1

The 2006 Audit did not assess these technical specifications because the information was not available at that time.

This 2008 Audit Review has benefited from more information about the procurement process from the Distribution Standards and Policy Section and the Group Commercial

This additional information has shown:

1. The specification used to procure wood poles was issued in 1996 and has been used, without review or editing, continuously from that time as the basis of the draw-off orders against a preferred vendor agreement for the supply of poles. The specification does not recognise organisational and other changes and no longer guarantees the delivery of poles that are fit for purpose. The specification requires core samples from the CCA treated poles to be delivered to "SECWA's East Perth Laboratories", which were closed in 2000/01. SECWA has not existed since 1995.

2. There are no technical specifications for the stay materials and components purchased for use in Western Power's distribution wood pole networks. Further, there is no technical oversight of the stay components and materials purchased to ensure they are fit for purpose within the network.

Western Power has provided a near final draft of a transmission and distribution pole specification which refers to relevant standards and is appropriate for calling tenders, or pursuing other commercial arrangements to procure poles.

Distribution Standards and Policy Section has engaged consultants to review its distribution stay practices, which will lead to appropriate technical specifications to support the procurement of materials and components that are fit for purpose. The audit found no detail as to the scope of the review, or a target date for its completion. It is unclear whether the preparation of appropriate specifications for stay materials and components used in the distribution networks is included in the consultant's brief.

Recommendation 5: Western Power should expedite the completion of the technical specifications for its wood poles and stays. This activity should be extended to include all components and equipment used in its networks.

Distribution Design

The 2006 Audit did not assess the wood pole line and structure designs because the detail needed was not available at that time.

This 2008 Audit Review is based on information from the Distribution Design presentation on the 7 May 2008 and discussions with the Distribution Design Manager and staff from that section in November 2008.

The distribution design activity includes the electrical and structural design of the network, substations and power-lines, including their support structures.

The wood pole lines and structure designs take account of a range of safety issues, including ground clearances, conductor separations, clearances from structures and vegetation, the

strength (and factors of safety) of conductors, insulators, cross arms and the poles and stays that are the focus of this audit.

The distribution design teams use the electrical design programs (LV Design and Flicker) and the power lines design program (Poles'n'Wires), which are endorsed and supported by the Distribution Standards and Policy Section. The distribution design teams also follow the standards and use the compatible units and structures appearing in the manuals prepared and endorsed by that Section.

Almost all of the distribution design work is done by the centralised Service Delivery Distribution Design team based at Jandakot. The wood pole line design work derives from projects requiring:

1. Underground-supplied green field developments to be connected to existing overhead distribution networks.
2. Customer-funded metropolitan and country underground projects to be connected to existing overhead distribution networks. Metropolitan customer-funded projects are 90% underground, with the balance supplied with overhead distribution. Most of the country customer-funded projects are supplied with overhead distribution.
3. Reinforcement of the overhead networks for capacity, supply quality and supply reliability improvement, including the remedy of safety issues.

Although not quantified, Ener*gySafety* understands that most of the overhead design work is performed by the Service Delivery Distribution Design teams, or by consultants they engage, and that:

- These contracted designers use the same standards and tools as Western Power's Distribution Design teams and
- All designs are checked by team leaders within Western Power's Distribution Design team.

Samples of the overhead line designs from the Distribution Design section were comprehensive and impressive in their clarity and detail. The computer tools and systems used provide a high level of confidence in the consistency of the design and compliance with the relevant standards, limited only by the design standards issues identified above.

The only overhead line design work that does not go through this rigorous design process is the pole replacement work arising from the pole inspection activity, and the repair work. This work is managed by other sections in Western Power's Service Delivery Division. Some of the larger pole replacement and repair projects may be referred to the Distribution Design teams, but most are directed and managed by experienced distribution supervisors. The structures used are generally the current structures used within Western Power. The existing structures may not have been designed to the standards and guidelines current when they were erected, and the new structures may not have the strength to comply with Western Power's latest standards, which assume the lines and structures are subjected to the wind and other loads specified in the current editions of C(b)1.

Recommendation 6: Western Power should include all the overhead line repair and wood pole replacement projects in the distribution design processes to ensure consistency, compliance and safety.

Procurement

The procurement process of Western Power's wood pole management systems was not assessed in the 2006 Audit because the information required was not available.

This section examines the materials procurement processes only. Procurement of the contracted pole-base reinforcement and pole (and stay) inspection services will be examined in later sections.

This section of the audit also considers the inspection and acceptance of poles and the other materials, their storage, picking and dispatch to field projects.

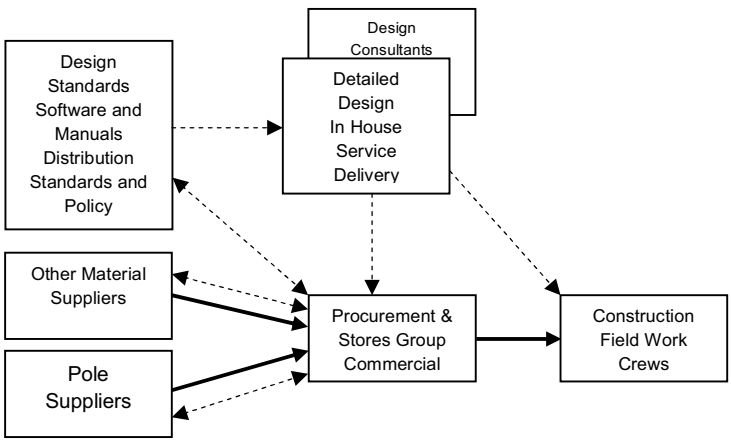
Western Power's 2008 materials procurement and management activities involve two separate and interlinked activities.

The first involves sourcing and purchasing poles and stay materials through competitive tenders or some other process, which includes assessing the compliance of the poles and materials offered to Western Power's technical requirements. This activity relies on the technical requirements from the Distribution Standards and Policy and their involvement in the assessment of materials offered and QA of materials supplied.

The second involves the picking and dispatch of poles and materials to the construction crews doing the new construction or replacement projects. This activity relies on the materials schedules from the Distribution Design Section. The final check is made by the construction crews that the materials supplied match the materials detailed in these schedules.

These procurement and stores activities are mapped in the diagram below.

MATERIALS PROCUREMENT & STORES MANAGEMENT



Poles

This 2008 Audit Review is based on information provided during 2007/08 including:

- The Group Commercial seminar on the 28 March 2008,
- Western Power's "Specification for the Selection of Preferred Vendor for the Supply of Treated Wooden Poles Tender Number: 2074.96 Specification Numbers: ES 6/86, ES 37/86, ES 8/89, & ES 9/89,Issued 19 September 1996",
- A review of the contract file for the standing offer to supply and deliver treated wooden poles,
- A review of the draft replacement pole procurement specification supplied in November 2008, and
- An inspection of the supply chain, including the Koppers treatment works and delivery dumps[4]

It was evident from the seminar that Western Power makes no assessment of the poles supplied for technical compliance with the specification, either at the point of purchase or at any point in the supply process. This does not arise because the parties in the pole supply are unwilling to provide the access and information needed. Batch records of the pole treatment process are retained by Koppers[5] and are available to Western Power. But Western Power has no system in place for audits of the treatment process, or examination of the batch records, to establish that the poles delivered comply with the specification and current pole treatment standards.

The current pole procurement specification also does not reflect the current supply arrangements and changes in Western Power's organisation. For example it requires core samples from treated poles to be sent to the SECWA laboratory in East Perth for assessment. This laboratory closed in 2000/01 and SECWA has not existed for 13 years.

Western Power has acknowledged the deficiencies in this specification and supplied a near final draft of the replacement[6]. This replacement draft refers to the relevant standards, is comprehensive and much more succinct than the current specification. Parties in the supply chain have been involved in the development of the new specification, which involved testing a sample of the treated pine poles to be supplied under it. While the draft specification and the development process followed are encouraging, details of the quality assurance processes intended to manage the contract are still to be defined.

Recommendation 7: Western Power should finalise and implement the new pole procurement arrangements based on the revised specification, and establish effective quality assurance processes to give confidence in the strength and quality of the poles procured.

Western Power and its predecessors have purchased poles from V Ridolfo, now Western Poles, for many years. Western Poles is Western Power's preferred vendor for treated wooden poles. All Western Power's poles are, and will continue to be treated with a CCA oxide preservative.

[4] 2 December 2008
[5] Western Poles pole treatment contractor.
[6] November 2008

Western Poles procures hardwood and softwood poles from the Forests Products Commission, cut from Western Australian forests and plantations. These are delivered to Koppers Wood Products yard at Picton, where they are debarked, inspected and graded for compliance with Western Power's pole specification, marked, seasoned and prepared for treatment. The seasoning process can take 3 to 4 months.

The prepared and seasoned poles are batch treated in oxide-preservative pressure vessels by Koppers Wood Products, after which they are fitted with pole caps and identification discs and stacked for dispatch. The treatment process has been refined over 25 years and is well managed by experienced operators. Core sample are taken from three poles in every batch and tested for chemical impregnation to ensure the poles in that batch meet Western Power specification. All poles are tested for chemical impregnation if there is any concern about the batch treatment from the treatment process.

Some of the treated poles are then transported to Western Poles Keysbrook yard where they are treated with fire retardant paint above and below the ground line and stacked for dispatch.

Western Power takes ownership of the treated poles in the Kopper's yard at Picton Junction and Western Pole's yard at Keysbrook on payment of the invoices presented. Other than checks of the pole numbers supplied, no verification of quality or compliance with the Technical Specification are made at the point of purchase, or at any other stage of the supply chain.

The Audit found the Western Poles-Kopper's controls through the inspection, grading, seasoning, treatment and storage justify confidence that the poles supplied will comply with Western Power's requirements.

However, two issues should be addressed by Western Power:

The lack of any audits of Kopper's and Western Poles' processes and inspections gives no verifiable assurance the poles supplied comply with the technical requirements specified.

Western Poles can and does supply poles for Western Power from sources in the Eastern States and overseas. These poles have not been through the Western Poles-Koppers processes and do not provide the same high confidence levels about technical compliance.

Recommendation 8: Western Power should establish prudent quality assurance processes at the point of purchase to ensure the poles purchased comply with their technical requirements and also to achieve the same level of confidence for all poles purchased from other suppliers or supply chains.

Both Western Poles and Koppers expressed confidence that they could accelerate the supply of treated pine poles[7] to levels in the order of 20,000 poles per year with the existing plant and Western Australian supply arrangements.

[7] Western Power has approved the use treated pine (radiata and pinastus) poles for all of its distribution lines.

Stay Materials

Western Power's procurement personnel involved in purchasing the stay wire and the other stay materials used in Western Power's distribution network have no Western Power approved specifications for these materials. In the absence of these specifications they cannot and do not make any inspections to ensure that the materials supplied meet Western Power's strength and other performance requirements.

The Distribution Standards and Policies Manager confirmed that these specifications do not exist. Western Power has engaged an engineering consultant to review staying practices and develop the required specifications.

Recommendation 9: Western Power should develop and document complying wood pole line stay designs and prepare appropriate technical specifications for stay materials.

Recommendation 10: Western Power should also establish the necessary quality assurance processes to ensure the poles and stay materials purchased meet the technical requirements and performance specified. This should include audits and inspections of the pole supply chain and treatment and critical stay materials.

Construction

The construction element of Western Power's wood pole management systems was not assessed in the 2006 Audit because the information required was not available.

Wood pole line construction involves the same activities and skills as the pole replacement activity, included in this section.

This Review of the construction activity is based on the information provided in 2008 from:

- The Service Delivery Seminar on the 5 May 2008 and
- Discussions with Service Delivery Managers and other staff.

A significant change to the field operation since 2006 was the introduction of maintenance zones, with a 4-yearly cycle of inspection of all assets included with the 4-yearly ground line inspection of the wood poles in these zones. This approach will reduce significantly the mobilisation cost for the inspection and service activities and the pole replacement and other asset maintenance required.

Service Delivery's field operations also provide some contract supervision of the pole inspection and reinforcement activities. The extent and effect of this shared responsibility for these safety-critical activities was not explored in this audit.

The inputs to the overhead line construction activities are:

- The wood pole line construction and replacement projects details in design drawings and material lists produced by the Distribution Design teams within Service Delivery ,
- The Distribution Design Catalogue of Overhead Structures and the Distribution Construction Standards Handbook produced by Distribution Standards and Policy, and using

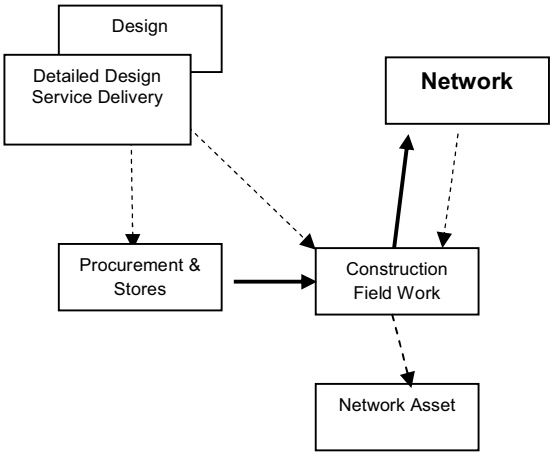
- The poles and other materials procured and delivered by Group Commercial working with the Distribution Standards and Policy section.

The outputs from the construction activity are:

- The new or replaced power lines and structures, and
- The as-constructed records of the new work for asset records.

The construction process is mapped in the diagram below.

CONSTRUCTION



The overhead line construction work is performed by Western Power line workers and contractors employed by Service Delivery. The work is controlled by managers and supervisors with many years experience. The Western Power line workers are in many cases SECWA (now Power Training Services) trained, and line workers recruited are assessed as competent by Western Power's managers and supervisors.

The competence of the contractor-employed line workers is less certain as is the quality control and assurance of the projects performed by the contract labour. Given the issues identified in the other systems, the overhead line construction activity arguably presents the least risks in the wood pole management system chain.

The 2008 Review did not assess:

- The compliance of the as-constructed work with the project design details and the Overhead Construction Handbook.
- The as-constructed asset records against the new assets in the network.

Recommendation 11: Western Power should assess and, if necessary, strengthen the compliance of the field construction activities, the management of compliance with contract construction crews and the shared involvement in contract management of the pole inspection and pole base reinforcement activities.

Inspection

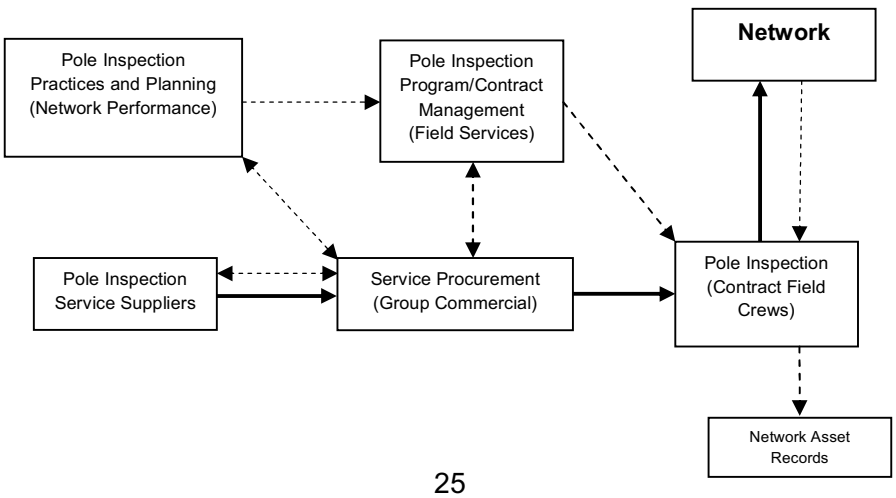
The issues identified from the 2006 Audit of the inspection element of Western Power's wood pole management systems were:

1. The underlying principles in the sound-dig-and-drill pole inspection practice employed by Western Power.
2. The 'good wood' serviceability criteria employed.
3. The less than adequate management of:
    a. The inspection program. A substantial backlog of poles has not been inspected.
    b. The inspection quality. Contractors have been allowed to use unauthorised inspectors and to avoid the requirement to dig down to inspect poles below the ground line.
    c. Pole inspector competence. No continuing assessment, appropriate follow-up action or retraining has occurred.
4. The absence of any stay inspection.
5. Less than the required pole embedment of between 0.3 and 0.5 meters.
6. The absence of any management system to ensure unserviceable poles and stays were replaced, repaired, or reinforced in a timely way.

The inspection of stays and stay poles supporting the distribution wood pole lines is included in Western Power's 2008 pole inspection activities management involves two linked processes.

The first establishes the pole inspection service contracts and the contract management for these contracts. This pole inspection contract management process is mapped in the diagram below.

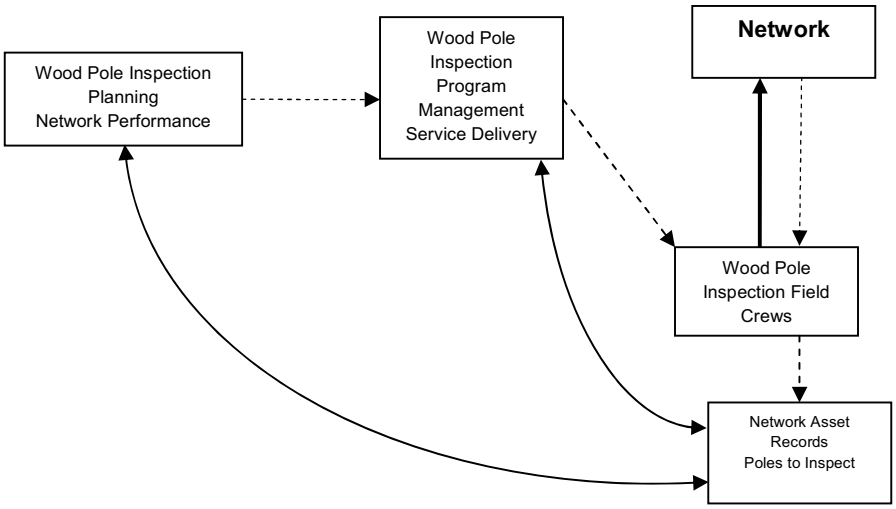
WOOD POLE INSPECTION CONTRACT MANAGEMENT



Western Power's pole inspection practice is set out in the Network Pole Inspection Manual produced by Western Power's Network Performance Branch. This and the commercial terms and general conditions of contract prepared by Group Commercial are the basis for the pole inspection contracts. The pole inspection field activity and these contracts are managed by Western Power's Field Services Division.

The second pole inspection management process involves preparing the pole inspection activity plan and managing the pole inspection program established by this plan. This process is mapped in the diagram below.

WOOD POLE INSPECTION PROGRAM MANAGEMENT



Western Power's Network Performance Branch prepares and gains approval for the pole inspection activity plan. The Field Services Division then packages and issues the pole inspection field work to the contractors. The principal outputs from this activity are the lists of:

- Unserviceable poles that can be reinforced
- Unserviceable poles that cannot be reinforced and must be replaced.

Outputs not provided by the current inspection practices are:

- Reinforced poles that are not serviceable and must be replaced.
- Unserviceable stays that must be repaired or replaced

This information then feeds to the pole base reinforcement, pole replacement, and stay repair and replacement processes that follow.

The 2008 inspection review is based on the information provided in 2007/08 from:

- The Network Pole Inspection Manual April 2003,
- The revised Network Pole Inspection Manual June 2008,

- The pole inspection contracts with Transfields and Logsys – RFT T0169 and Specification WD-T0008-07,
- The network Performance Seminar on 11 June 2008,
- The Dennis Clarke review commissioned by Western Power of its pole inspection practices and activity,
- Western Power's summary of Australian electricity network operator pole inspection practices,
- Discussion with people from both Service Delivery and Network Performance, and
- Discussions with the proponents of alternative pole inspection practices being assessed by Western Power.

Network Pole Inspection Manuals

The June 2008 edition of the Network Pole Inspection Manual does not differ in any significant detail from the April 2003 edition mentioned in the Logsys and Transfield inspection contract documents. The changes in this manual are unlikely to improve the wood pole and stay inspections performed by Western Power's contractors. The concerns identified in the 2006 Audit concerning Western Power's wood pole inspection practice have not been addressed.

Pole and Stay Inspection Contracts

Western Power contracts asset inspection and service work, within the competence of the trained linespersons (Certificate III) operators, to contractors providing this bundled service.

The contracts are for one-year, with the option to extend for a second year. They require each contractor to inspect up to 90,000 poles per annum. The combined capacity of the two contracts exceeds the annual pole inspections required (155,000 p.a.) to maintain the 4-year inspection cycle. These rates are being delivered. While there is still a pole inspection backlog, Western Power is inspecting its poles at a satisfactory rate. This is a marked improvement on the substantial pole inspection backlogs identified in the 2006 Audit.

Discussions with personnel involved in the pole inspection activity in Service Delivery and Network Performance revealed the pole inspection program is monitored weekly and reported monthly, which is reasonable for this activity. This management element would benefit from an agreement between Service Delivery (the service provider) and Network Performance (the asset manager of the network performance).

The contractors are paid for the numbers of poles inspected and returning the inspection data in the specified form. Each contractor is required to perform a random 10% QA assessment of its work and Western Power independently performs another QA assessment on a random 10% of the poles inspected.

The direct contract costs are in the order of $9,000,000 p.a. The costs of the pole inspection activity exceed $10,000,000 p.a.

The contracts refer to Western Power documents including:

1. The Network Pole Inspection Manual,
2. The Networks Employees Handbook,
3. The Distribution Catalogue of Equipment Types.

The contract terms also define Program Failures, Critical Defaults, Critical Quality Failures leading to six matters that could trigger a Contractor Default. Service Delivery persons involved in contract management indicated that only one matter (the number of poles inspected) was monitored.

Energy*Safety* repeated the field assessment of the pole inspection activity in the 2006 Audit, checking 37 random poles from those inspected in September 2008. The results found that the ground around none of these 37 poles had obviously been dug down and concluded that none of the poles had been inspected below ground. Western Power's response to this finding through January to March 2009 was to have a contract QA Officer demonstrate how the below ground inspection holes were located with minimal digging, the good-wood readings were checked and the chemical treatment was also checked to give confidence in the QA findings. This practice was demonstrated convincingly and is a significant improvement on the QA performance identified in the 2006 Audit.

However, the QA process demonstrated has been developed in the last 12 months and is not yet documented. There have also been two amendments to the QA check sheet with increasing focus on checking the below ground pole inspection.

The conclusion was that:

- The poles inspected in September 2008 from which the audit sample was drawn were most likely inspected below ground and the inspection results recorded are a credible representation of the pole condition.
- The inspection results from poles in ground that can be dug out since March 2008 have progressively improved to represent the condition of these poles below ground.

A further sample of poles surrounded by brick and concrete paving was also checked. As in the 2006 Audit, there again is no evidence that the below test results from these poles can or does represent the condition of these poles below ground.

Recommendation 12: Western Power should document and formalise the inspection QA practice demonstrated. This practice should be extended for use by the contractors as a minimum requirement for their QA checks of their work.

Recommendation 13: Western Power should develop and implement a practice for inspecting and assessing the below ground condition and strength of wood poles installed in brick, concrete and other paving that precludes access to the pole below ground using a spade.

Discussions with persons in Service Delivery and Network Performance involved in these pole inspection and service contracts (and with the pole base reinforcement contract) indicated that they were not involved in the contract development and of tender evaluation leading to the execution of the final contract. This deprived the process of the benefit of their experience and technical knowledge, and them of a sound understanding of the contract structure, the commercial and technical risks and how these were best managed within the terms of the contracts.

The inspection and service contract does not require the contractors to warrant their performance with respect to either the quantity or the quality of their inspection activities, or their accountability for any unassisted pole failure in the next 4-year pole

The contract does not detail the contractors' quality assurance requirements, or those used by Western Power when assessing the contractors work. The contract also does not include Western Power's 2009 improved QA processes. The contracts also do not include any specific inspection of the aerial and ground stays supporting the wood pole power lines.

It is unlikely that this inspection and service contract as it is presently structured will deliver an acceptable wood pole condition assessment, even with an effective pole inspection practice.

The contracts have one year to run.

Recommendation 14: Western Power must immediately inform the existing contractors of the above deficiencies, ramp up the quality and number of the Service Delivery audits and exercise the maximum influence possible under the existing contracts to achieve an acceptable below ground pole condition assessment.

Recommendation 15: Western Power also should develop an effective contract that:

a. Defines the inspection service outcomes.

b. Achieves appropriate and efficient risk sharing between the parties.

c. Defines rewards and penalties linked to performance, and

d. Involves key staff from the relevant asset management and service delivery sections in contract development and execution.

The new contract should be implemented immediately when the current contract ends.

Western Power's Review of its Wood Pole Inspection Activity

Western Power commissioned a review of its wood pole ground line inspection activity by Dennis Clarke, an experienced utilities engineer with substantial knowledge of the sound-dig-and-drill pole inspection practice. His report of June 2008 made a number of recommendations and observations, including:

- The quality of the Network Pole Inspection Manual,
- Indifferent adherence to the inspection process,
- The practice neglects the importance of the loss of good wood from the outside of the pole below ground,
- The lack of post mortem investigations of failed poles, and
- The absence of a technical expert in wood pole inspection.

Energy*Safety* agrees with many of Mr Clarke's observations, some of which were identified in the 2006 Audit.

These include the key differences between the Western Power's current practice, and those used by Ergon Energy, which also uses sound-dig-and-drill, but achieves wood pole failure rates 20 times less than Western Power's.

Western Power has initiated post mortem investigations of all wood pole failures, including reinforced pole failures, but is yet to establish a process to deliver significantly improved outcomes.

Recommendation 16: Western Power should:

1. Establish effective post mortem investigations of all pole failures, including reinforced pole failures,
2. Address the issues identified in the Energy*Safety* 2006 Audit and the Dennis Clarke 2008 Inspection Review report
3. Establish effective stay condition monitoring, repair and replacement systems.

Western Power's Trial of Alternative Pole Inspection Methods

Western Power accepts there are shortcomings with its sound-dig-and-drill, pole inspection practice and has been trying alternatives that could deliver more reliable assessment of the condition and remaining strength of its wood poles. These include:

1. The Deuar mechanical MPT40 process that measures the modulus of elasticity of the poles tested, and
2. The AVS sonic process that measures the loss of sound signal through the pole on a plane through the pole.

Both these inspection systems test the poles near to the ground line.

Both systems have been adopted by network operators in New Zealand (AVS) and the USA (Deuar MPT40).

Both systems have been reviewed and tried over long periods by Australian network operators, but none has resolved to replace the sound-dig-and-drill, inspection practice with any alternative pole strength assessment practice.

Neither Deuar nor AVS has established, by testing, the connection between the parameters they measure and pole strength at the time of testing.

Western Power intends to decide upon the pole inspection practice it will adopt by the end of June 2009.

Energy*Safety* is encouraged by the endeavours Western Power is making to identify the best pole inspection practice for its operations, but is not convinced that the trials and assessments undertaken will deliver an acceptable outcome. In Energy*Safety's* view, Western Power's June 2009 target date does not recognise the work and rigour needed to identify and implement an alternative pole inspection practice that will achieve the safety outcomes required.

Recommendation 17: Western Power should improve its sound-dig-and-drill, practice to include:

1. Serviceability criteria based on the factor of safety that recognises the realistic best estimates of the remaining pole strength and code-specified design wind and other loads.

2. Digging down to depths that identify the real condition of the pole in the critical zone below ground and using the good wood diameter of the pole in the critical zone in the estimate of the remaining pole strength.

Recommendation 18: Western Power should compare its pole inspection and wood pole management practices with the recognised industry leaders and make the changes necessary to equal their performance leadership in wood pole network safety.

Western Power's AA2 Submission

The following excerpt is taken from Western Power's most recent submission to the Economic Regulation Authority for funding under the Access Agreement 2:

Power pole bundled inspections

Western Power has bundled the ground line inspection and treatment of poles with above ground pole inspection and line inspections. This has resulted in efficiency savings but has necessitated the use of trained linespersons to carry out the inspections. The forecast for power pole bundled inspections do not include any change in the volume of inspections as they will continue to be based on the total pole population being inspected over a 4 year cycle. In addition it is proposed that Western Power carries out inspection of the customers services during the power pole bundled inspections.

However, it is proposed to enhance the pole ground line inspection process to include either full excavation of the soil around the base of the pole to a depth of approximately 500mm in line with current Australian practice or to introduce an alternative pole strength testing technique currently under trial. Either option will increase the current costs of pole ground line inspection but Western Power considers the changes necessary to improve the current rate of pole failures from 3.4/10,000 to around the industry average of 0.35/10,000.

Western Power has tested ultrasonic ground line inspection of its poles and initial results indicate a 4% failure rate which is more in-line with current unassisted pole failure rates. The forecast expenditure for this essential preventative maintenance operation has been increased from $7.6M in 2006/07 to $17.9M in 2009/10.

Energy*Safety* notes Western Power's intention to:

1. Improve its pole ground line inspection process and
2. Reduce its unassisted pole failure rates by a factor of ten (10), which would achieve acceptable wood pole safety performance by Australian standards.

The proposed change to the ground line inspection is not sufficient in itself to achieve the improvement in performance suggested. Other changes to the serviceability criteria identified elsewhere in this Audit will be needed to achieve the target improvement in the wood pole safety performance.

An increase in the unit cost of the pole inspections will be unavoidable if pole inspectors are to do this work with the diligence needed to identify unserviceable poles. However, the market's willingness to carry out the pole inspections with satisfactory diligence and deliver other efficiencies has not been assessed.

Pole and Stay Inspection Monitored and Managed

Pole inspections have increased very substantially in 2008/09[8], trending toward 250,000 a year[9].

Inspection activity is monitored and reported monthly. Western Power's Board receives more detailed reports of wood pole management activities.

The audit found a wide variation in the pole condemnation rates[10] year on year, but no analysis and explanation for these variations, nor remedies to address the underlying causes.

[8] Data for July to October 2008 – Chow Lam
[9] Advice from the Manager Network Performance November 2008
[10] Board Quarterly Asset Performance Report September 2008 - 0.5 % to 5.9%

While inspections are monitored and reported more than they were in 2006, the level is not sufficient to ensure the process is effectively managed to achieve acceptable safety outcomes.

The inspection activity is not well managed. It does not reliably identify poles that are in poor condition and unsafe to remain in service for another four years until next inspected.

Pole Embedment

Correct pole embedment is a safety issue because:

a. Under-embedment can result in poles falling over due to footing failures.

b. Over-embedment can cause unsafe conductor ground clearances.

While both are safety issues for Energy*Safety,* only under-embedment was considered in the 2008 Audit.

Under-embedments identified in the 2006 Audit are significant compared with the pole depths required for the poles used in the distribution network. The 300-500 mm under-embedment identified in the 2006 Audit equates to 20%-25% of the embedment required.

Very few, if any, poles fall over because of footing failure. The most common failure mode is the loss of wood strength in the critical zone between 300 mm above and below the ground line.

The pole disc installed by the supplier should be 1.5 m above the ground line. This provides a ready marker for checking under and over-embedment.

Some poles presently being installed are fitted with pole disc that are not 1.5 meters above the ground when the poles are correctly installed. The pole discs on these poles do not provide a check that the pole embedment is correct.

The Audit did not find any reference in the manuals and work practices to checking embedment.

Recommendation 19: Western Power should include embedment in its wood pole inspection practices and implement appropriate remedies to address the risks in incorrect embedment.

Conclusions

Inspections are the most critical element in Western Power's wood pole management systems.

The 2008 Audit Review has found:

1. Western Power has not addressed the issues identified in the 2006 Audit associated with its sound-dig-and-drill, pole inspection practices.

2. Western Power has not addressed the concerns with its good wood serviceability criteria identified in the 2006 Audit. These concerns have been reinforced by the findings of a Western Power-commissioned review of its wood pole inspection practices.

3. Western Power's new contracts have substantially increased the pole inspection rate to levels that will maintain the four-year pole inspection cycle. The magnitude of the backlog is understood to be approximately 120,000 poles, a substantial reduction on the levels identified in the 2006 Audit.

4. Western Power is now monitoring the pole inspection program weekly and reporting monthly to Network Performance.

5. Western Power still has not established an effective stay inspection and repair/replace program.

6. Western Power does not include embedment checks in its pole inspections.

7. Western Power's QA of contractor-inspected poles can now properly assess the below ground inspection and testing performed by the contractors. This improved QA process has been progressively developed over the last 12 months. Concerns remain about the below ground inspection and good wood records of the poles inspected before this period

8. Western Power is not yet inspecting the below ground condition of poles installed in brick, concrete and other hard-stand paving.

9. No comprehensive review and management of pole inspection quantity or quality take place, although some limited monitoring of quantity occurs.

10. The bundled pole inspection and service contracts do not identify outcomes required or hold the contractors accountable for achieving them. The deliverables required for payment and the absence of performance penalties and bonuses actively discourages the diligence and performance required for these contracts to be effective.

These gaps in Western Power's pole inspection activity are critical to the safety performance of the wood poles and stays. Most of these issues were identified in the 2006 Audit and Energy*Safety* is concerned about the poor progress revealed by the 2008 audit.

Recommendation 20: In addition to the actions identified above in this chapter, Western Power should:

1. Extend its monitoring and management to include the quality and effectiveness of the pole inspection outcomes; and
2. Restructure its wood pole inspection and service contracts to:
   e. Define outcomes.
   f. Achieve appropriate and efficient risk sharing between the parties.
   g. Define rewards and penalties linked to performance.
   h. Involve key staff from the relevant asset management and service delivery sections in contract development and execution.

Pole Base Reinforcement

The 2006 Audit found:

- No evidence that the pole base reinforcing Western Power had and was installing achieved the strength factors required by the *Guidelines for design and maintenance of overhead distribution and transmission lines HB C(b)1 – 1999* when the lines and poles were subjected to the wind and other loads specified.
- Western Power was intending to outsource the pole base reinforcement design, procurement and installation activity.
- No serviceability criteria to determine when reinforced poles should be replaced.
- The following differences between Western Power's Distribution Facilities Management System (DFMS) asset records and the status of pole base reinforcements installed
  - 2% of the reinforced poles were not shown as reinforced in the asset records
  - 2 % of the reinforced poles had different reinforcement arrangements recorded in the asset records.
  - 0.4% of the poles shown as reinforced in the asset records were not reinforced.

The 2006 Audit did not address the following issues:

- Field Operator Competence
- Review and compliance management of the pole base reinforcement activity because the information required was not available.

Western Power's 2008 pole base reinforcement activity management is based around a contract with a single service provider Utilities Asset Management (UAM), for the design, materials supply, recruitment and training of day labour and installation of the pole base reinforcement required.

As with pole inspection, the management is based on two interlinked processes; contract management and program management. This is mapped on the following diagram.

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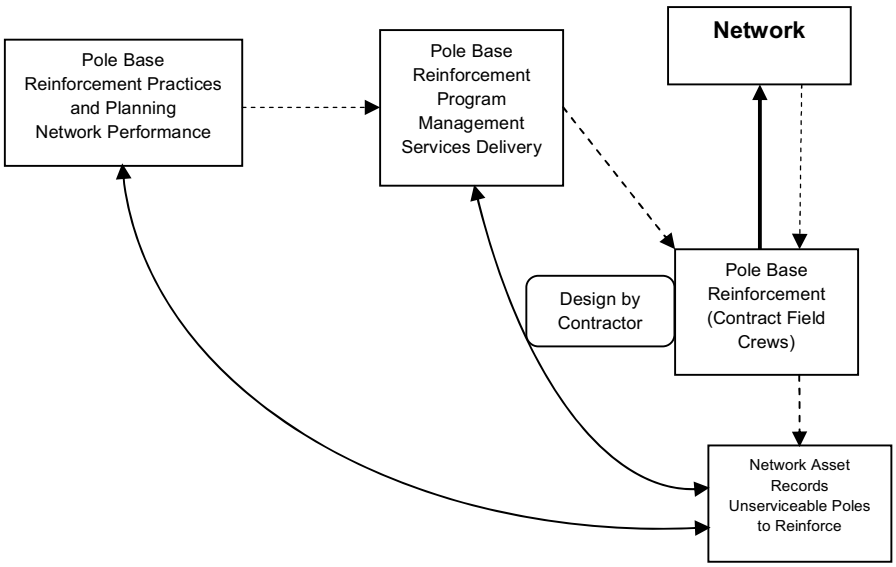
POLE BASE REINFORCEMENT PROGRAM MANAGEMENT



Western Power's Network Performance Branch prepares the technical details for the pole base reinforcement specification and with Group Commercial calls tenders and negotiates the service contract. Field Services manages the service contract with the contractor.

Network Performance develops and gains approval for the annual pole base reinforcement plan. Service Delivery manages the approved program. The contractor does the design, materials supply, day labour recruitment, training and installation.

The 2008 Audit Review is based on:

- Western Power's contract documents with UAM
- The Network Performance Seminar 11 June 2008
- UAM's "RFD Pole Reinstatement Systems Testing Process"
- Discussions with persons involved in the pole base reinforcement contract management from Western Power's Network Performance Branch and Service Delivery Division.
- Discussions with UAM's General Manager and State Manager.
- Technical Assessment Report for Pole Reinforcement Tenders November 2007.

UAM Pole Base Reinforcement Contract No T0047

UAM's contract, executed on 17 April 2007, has an 18-month term with the option to extend a further 18 months. Under it, UAM must:

- Assess poles identified by Western Power for base reinforcement to confirm they meet UAM's criteria for reinforcing (60 mm of good wood at the top of the reinforcing steel stakes).
- Assess the forces applied to the poles and conductors using UAM's proprietary software to select the reinstatement systems with the strength to provide a factor of safety of two (2)[11] under wind and other forces specified in HB C(b)1-1999.
- Procure and supply the reinforcing stakes and fixings.
- Engage, train and supervise installation field operators.
- Be able to install up to 700 reinstatements a month.

The above summary of the contract is not stated in these terms anywhere in the contract. It has been derived from the contract documents, discussions with UAM's State and General Managers and with Western Power personnel. The UAM systems use seven (7) different steel stakes individually and in pairs to achieve 13 different reinstatement configurations, each with a specified maximum tip load rating. These tip loadings have been established by UAM's internal product design and testing program.

The General Conditions of Contract (references in brackets) provide for:

- (C15) – tests by Western Power, which include examination and measurement
- (C18) – rejection of services
- (F5) – Key Performance Indicators for an assessment of the contractor's performance in the first 18 months leading to the contract extension

Discussions with personnel from Network Performance (the sponsor for this activity) and Service Delivery (the program and contract manager) indicated that the contract was running well, but they could not explain how C15 and C18 would be used to manage the contract.

Capacity to meet program targets (key performance indicator F5) was considered important, but the other three measures were not relevant. Service Delivery would set other criteria to evaluate the contractor's performance and justify extending the contract.

Section F1 in the contact requires the contractor to "Warrant the work under contract shall comply in all respects with the terms and conditions of the contract and shall be free from defects and omissions for a period of 12 months from the acceptance of the final reinforcing installation service ----".

[11] The UAM system requires no sound wood at the ground line to achieve the x2 factor of safety.

"Acceptance of the final reinforcing service" occurs upon Western Power's payment for that pole reinstatement. The Western Power personnel with whom this matter was discussed could not explain how this provision, or any other in the contract, would allow Western Power to hold UAM responsible for the failure of a pole reinstatement beyond one year.

Payment is based on the contractor submitting an invoice and providing:

- The updated and completed Direct Record Entry (DRE) file and
- The corrected map and asset information.

The contract Technical Requirements do not specify the factor of safety the pole base reinforcement must achieve, under what conditions or for how long. A service life of 20 years is mentioned but this is not related directly to reinforcements installed. A service life of 20 years in some of Western Australia's acid soils is open to doubt.

Contract development and management

The contract is under the sponsorship of the Network Performance Branch, with a nominated person responsible for it. A nominated person within the Service Delivery Division is responsible for its management and contractor supervision. None of the personnel responsible was directly involved in developing the Request for Tender, evaluating the tenders, clarifying the bids or negotiating with the successful bidder. Their knowledge and experience were not brought to bear on the contract-making process. They had no opportunity to understand the commercial risks involved and how these should be managed.

The GHD Pty Ltd Technical Assessment Report is dated November 2007, some seven months after the contract was executed. The report makes the following statements about UAM's RFD Reinstatement System:

> *"A number of technical clarifications were requested by GHD of the initial proposals received from UAM and Pole Foundations. The Western Power assessment group submitted GHD's and a number of other contract queries to UAM. Refer Appendix B for the responses received;*
>
> *In summary UAM clarified its product designs and its position as the designers and manufacturers of the RFD Pole Reinstatement System. UAM confirmed that it is able to assess each pole load in the field in accordance with HB C(b)1-1999 with all bending moments calculated at ground level and a factor of safety of 2.0 used. (UAM noted that it normally would use a Factor of Safety =1.8 but would use 2.0 as requested by Western Power).*
>
> *UAM confirmed that it had installed over 150,000 steel reinforcing stakes without known structural failure. UAM also advised that where a small number of failures had been recorded due to shock loads had been able to remain serviceable preventing conductors from contact with the ground.*
>
> *UAM did not present all data from all of its previous field tests but confirmed tests performed for many separate companies since 1980. Importantly it has employed the services of Avery Consulting Engineers and Structural Engineer Fred Avery to supervise field tests and coordinate lab tests.*

Further UAM had utilised the services in 1998 of Dr Barry Li at Monash University to coordinate results from different tests and provide summation of results from field tests, lab tests and theoretical calculations. A statistical analysis was used to provided ultimate loads and loads with safety factors applied for each steel reinforcing type. This allows for the field installer to quickly compare loads determined for each pole to be compared to the required capacity of each UAM steel stake.

UAM confirmed that any pole being assessed for reinforcement must have a good wood annulus of at least 60mm, the RFD steel stakes can be placed at any orientation and neither welding nor grinding were required to installation."

This reassuring assessment of the structural adequacy and safety of the system was supported by the 2008 Audit Review of the UAM supplied RFD Pole Reinstatement System Testing Process and discussions with UAM's General Manager. The document is comprehensive and detailed in its description of the tests performed and the results obtained. UAM is also very committed to maintaining its 'no reinstatement failure' performance with over 200,000 pole reinstatements in service around the world. The system also has a long and sound development history commencing with the SECV almost 30 years ago.

Western Power Audit of UAM Systems and Process

Neither Western Power, nor GHD assessed the UAM software and systems used to calculate pole forces and select the correct system reinstatement arrangement to deliver a factor of safety of x2 or more. Western Power is undertaking a 30 pole sample audit of the UAM pole reinstatements installed in the first 18-months of the contract, which will culminate in an independent structural assessment of these systems, deriving the factors of safety achieved with the wind and other loads specified in HB C(b)1-1999. This independent assessment should, subject to the findings from the Western Power audit, justify confidence in the UAM process and systems being installed.

Western Power intends to repeat this audit with the scope and frequency of future audits dependent on the results from this and subsequent audits.

Continuing Inspection Required

The following excerpt from the RFD Pole Reinstatement System Reinstatement Process identified the need for continuing pole inspections following reinforcement:

"In practice, however, there are very few instances where there is complete deterioration of the entire pole butt throughout the service life of the RFD Pole Reinstatement System. It should be recognised that whilst the RFD Pole Reinstatement System provides a cost effective alternative to Pole Replacement, good on-going inspection practices are considered an essential element in the overall design. This inspection process should note the presence of termite activity or any factors that may contribute to un-serviceability of the staking system."

UAM Reinstated Pole Replacement Criteria

The UAM inspection recommendation above mentions termite activity, but does not identify the other "factors", or deterioration sufficient to compromise the pole reinstatement. These factors would be the criteria for identifying UAM reinstated poles no longer serviceable and requiring replacement.

Recommendation 21: Western Power should develop and implement prudent reinforced pole replacement criteria, which should become part of the pole inspection manual and practice. This should include the reinforced poles in the network (before UAM) that are known to be unsafe and should be replaced.

Conclusions

The 2008 Audit Review has found reassuring evidence that the UAM pole reinstatement system Western Power now employs is well engineered. Western Power's pole base reinforcement will, subject to the findings of its audit of the UAM systems installed to date, deliver pole base reinforcement with factors of safety of two (x2) or more with the lines and poles subjected to the wind and other loads specified in HB C(b)1-1999.

Western Power is still to address the issue of reinforced pole serviceability criteria, which should determine the conditions, which if not met, will require the UAM reinstated poles to be replaced.

The 2008 Audit Review did not reassess the differences between the asset records and the reinforcement systems installed in the network. This issue will be included in matters to be resolved in Part 2 of this report.

Field operator competence will be addressed in Western Power's audit of the UAM systems installed to date, to the degree that the reinstatements deliver the required factors of safety, which is the primary issue for this Energy*Safety* audit.

The 2008 Audit Review also found that responsible persons from Western Power's Asset Management and Service Delivery branches were not included in the contract development, request for tender, tender assessment or negotiations with the successful bidder. This deprived the contract process of their experience and skills, and them of critical knowledge of the contract they are to manage.

Recommendation 22: Western Power should:

- Conclude its audit of the UAM pole reinstatement installed to date;
- Include appropriate asset management and service delivery staff when developing or reviewing contracts in future.

Pole (and Stay) Replacement

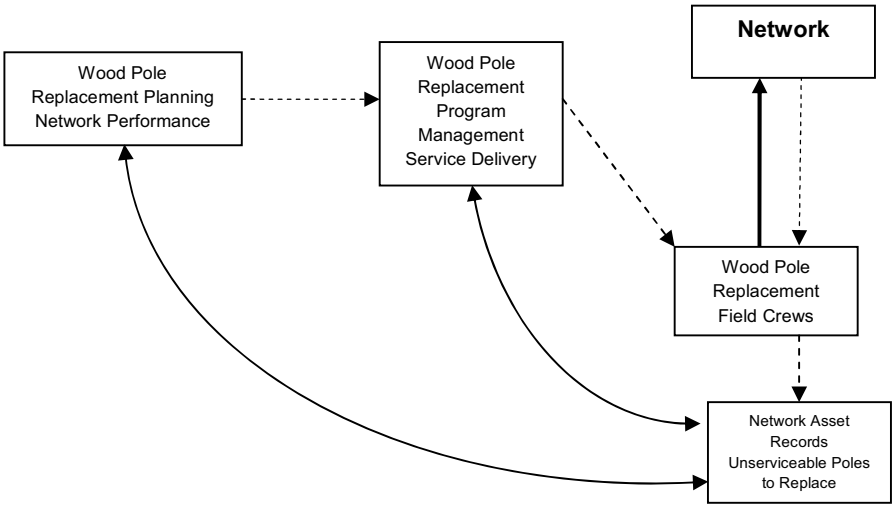
The 2006 Audit found:

- Very low pole replacement rates of 1672 or 0.25% of the wood pole population in the 12 months to 30 April 2006. This rate, if sustained, would replace the distribution network pole population in 400 years, which implied an ever-increasing risk of still more un-assisted pole failures.
- Condemned poles were replaced at rates less than the pole condemnation rates. The conclusion was that poles identified to be unserviceable were remaining in service in the network, which is also a recipe for continuing pole failures at an unacceptable rate.

The 2006 Audit did not assess the pole replacement field activity because the information needed was not available at that time. This field activity uses the same inputs, skill sets and delivers similar outputs to the wood pole line construction activity and has been included in that section of this Audit review.

Western Power's 2008 wood pole replacement activity uses Service Delivery to manage the pole replacement program prepared by Network Performance. This is mapped in the diagram below.

WOOD POLE REPLACEMENT PROGRAM MANAGEMENT



Network Performance prepares and gains approval of the pole replacement plan for the coming 12 months. Service Delivery schedules the pole replacement with other work in work packages for the field crews.

The 2008 Audit Review is based on:

- Distribution Poles and related Data August 2000 – A Fernihough
- SWIS Distribution Network Asset Management Plan 2007/2008 October 2006 – R Ong
- Asset Mission Distribution Poles 3 May 2008 – D Perkins
- Asset Mission Distribution Poles and Related Data 6 May 2008 – S Abbot
- SWIS Distribution Network Asst Management Plan 2008/09 – 2017/18 June 2008
- Network Performance Seminar 11 June 2008
- Discussions with persons from Network Performance and Service Delivery

The 2008 Audit Review endeavoured to answer two questions:

1. How does Western Power ensure that unserviceable poles identified from the inspection activity are reinforced or replaced in a timely manner with due regard for the safety risks of these poles remaining in service?
2. How does Western Power ensure that its wood poles do not remain in service beyond a safe and realistic service life?

Pole Inspection will not identify all unserviceable poles

Western Power has relied for almost two decades on its sound-dig-and-drill, inspection activity to identify all the unserviceable poles that should be reinforced or replaced. Some within Western Power have doubts about the efficacy of this pole inspection practice and the reliance placed on it.

The 2006 Audit raised concerns with the principles on which the sound-dig-and-drill, inspection practice is based, the way Western Power was applying the practice and the serviceability criteria Western Power was using. These issues were identified in the 2006 Audit and are again in this 2008 Audit Review.

The 2006 Audit also identified substantial backlogs in the pole inspection program. While the pole inspection practice does not identify every unserviceable pole, inspecting fewer poles will mean even fewer unserviceable poles are identified. This in turn entrenches the flawed belief that there are only small numbers of unserviceable poles and they are not a significant safety risk in the distribution network.

Western Power is giving a high priority to finding the best pole inspection practice that will reliably identify all unserviceable poles. The Australian electricity supply industry has been searching for this practice for 30 years. Some inspection practices are better than others and some are better applied than others. Network operators in the USA and New Zealand have adopted some of the non-invasive systems considered by Australian network operators. None of these pole inspection practices has demonstrated the ability to identify every unserviceable pole and only the unserviceable poles. Pole inspection is a necessary part of any prudent network operation, but is not sufficient on its own to ensure the safety of the wood pole networks. An effective and well founded pole replacement plan is necessary to achieve the safety required.

No System to Ensure Unserviceable Poles are Reinforced or Replaced

Persons within Service Delivery confirmed priority-one unserviceable poles are not ‘packaged’ with other works, but dispatched to work crews directly for replacement. Priority two and three unserviceable poles are ‘packaged’ with other works to achieve greater efficiencies through lower mobilisation costs. A list of the unserviceable poles is not regularly reviewed to identify the poles that have not been remedied. The concept of timely replacement based on the risk (probability and consequence) of the pole failure was not part of the pole replacement management.

The replacement of unserviceable poles packaged with other work can get lost and the safety risk of these poles remaining in the network overlooked while managing the work packaging process. While the merits of work packaging are obvious, some additional process is needed to ensure the safety risks associated with unserviceable poles are not overlooked.

Poles requiring reinforcement are not packaged with other work because all reinforcement work is done by dedicated special contract crews. As a consequence, these poles are less likely to be overlooked than the replacement poles packaged with other work.

Network Performance personnel said they review the outstanding unserviceable poles at the end of each year and include them in work plans for the following year. This does not give

replacement of unserviceable poles the priority it deserves and the Audit found no evidence that this priority work is actually carried out.

Recommendation 23: Western Power should establish systems that track unserviceable poles identified for reinforcement or replacement and produce monthly reports of the poles remedied and those not. The list should identify the priority assigned to each pole, the date it should have been remedied, the project in which the pole replacement has been packaged and the responsible officer for that project.

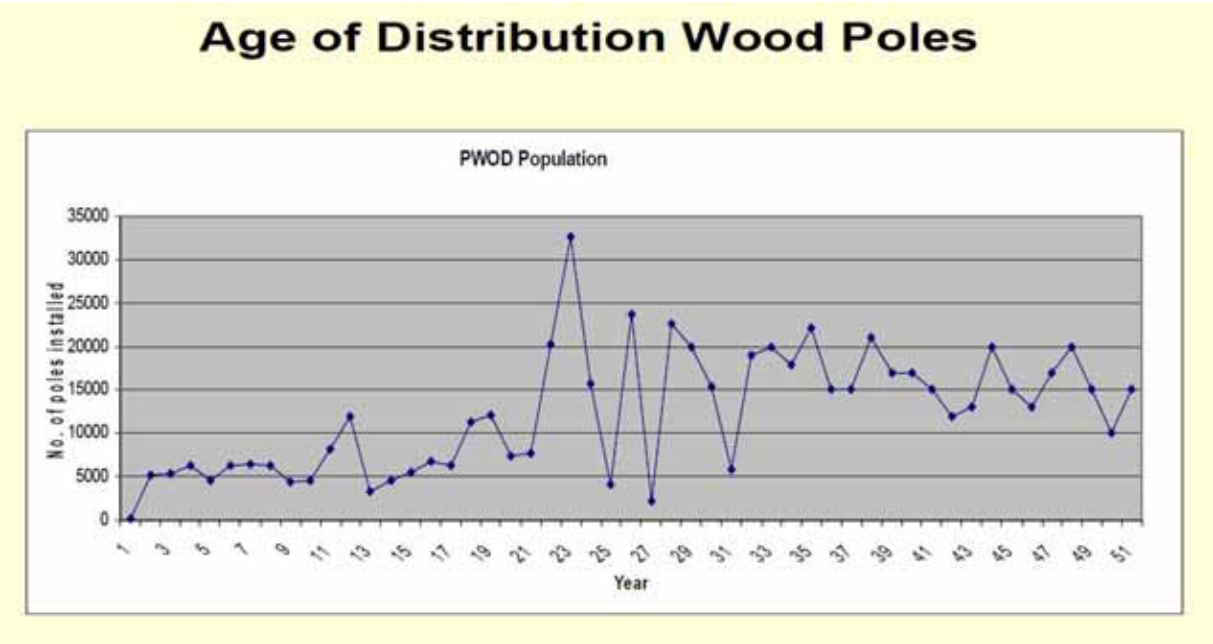
Pole Population Average Age & Age Distribution

Pole inspection and effective management of identified unserviceable poles are necessary but not sufficient. They must be supported with pole replacements based on realistic safe service life. The average age of poles in a network is at best a snapshot of pole condition, but does not give the true picture in sufficient detail to be useful. The average age of wood poles in a network could be reducing because the oldest poles are systematically replaced first, which reduces the risk of unassisted pole failures as a consequence. Alternatively, the average pole life could be reducing because the network is expanding and the new poles lower the average age.

Both cases indicate improving health and safety of the wood poles in the network. In the first case, this would be true. In the second case it is not, as the old poles remain in service, are getting older and the safety risks of these aging poles are not recognised and addressed.

The 'Age of the Distribution Wood Poles' chart presented in the Network Performance Seminar 11 June 2008 is a good example of the data needed to manage wood pole replacement.

Distribution Wood Pole Age Profile - Network Performance Seminar 11 June 2008



Clearly, the oldest poles at the right hand of the chart should be replaced first. There may be some debate about the significance of the highs and lows in the chart, but the inescapable conclusion is that such older poles should be replaced immediately, with the work continuing for at least 25 years at 15,000 poles per annum. All the poles older than about 28 years are

untreated jarrah with service lives of 15-25 years un-reinforced and 40 years reinforced[12]. Untreated jarrah poles older that 25 years should either be replaced, or if suitable, reinforced. All untreated jarrah poles older than 40 years should be replaced immediately.

The chart supplied cuts off at 51 years, but the push to extend pole life in what is now the South West Interconnected System (SWIS) commenced almost 10 years earlier. The oldest untreated jarrah poles in the SWIS network are more than 60 years old. This does not include the pre-WWII poles in the network that were taken over from the local councils.

Pole Service Life

Western Power has no data or other evidence supporting the pole life figures quoted in its various documents. The 2000 Distribution Poles and Related Data document, quotes pole life as 35 years and up to 100 years with reinforcing and good antifungal treatment. The 2007/8 SWIS Distribution Management Plan includes a nominal pole life of 35 years, with expected life of 40 years and an extended life of 60 years.

One year later the updated SWIS Distribution Management Plan 2008/09-2017/18 gives the same nominal and expected pole lives, but reduces the extended pole life to 50 years. In the same document, pole life extension (pole base reinforcement) will achieve 20 years and elsewhere 20-25 years, again with no reasoned argument supporting the figures.

Network Performance personnel with whom this matter was discussed had no evidence supporting any of the figures quoted, nor for the changes in the figures between documents. Western Power's AA2 proposal reverts to the 35/40/60 year figures used in the 2007/08 document.

The ten year difference in pole life is very significant in planning pole replacement for safety outcomes, particularly when many of the poles[13] are a lot older than prudent industry standards allow. Australian Standard AS 2209 gives a service life for untreated jarrah poles in ground as 15 to 25 years and above ground 40 years. Almost half the poles[14] in Western Power's distribution network are untreated jarrah installed from the early 1950's to the late 1970s. The oldest of these are almost 60 years old and the youngest almost 30 years old. Prudent practice would have reinforced all these poles at the ground line at 25 years and systematically replaced them at 40 years, starting with the oldest poles first. None of this is evident in Western Power's SWIS Distribution Asset Management Plan 2008/09-2017/18.

This approach to managing the untreated jarrah poles based on prudent Australian practice could be varied responsibly given reliable operational data and experience. Western Power does not have data to support an alternative approach to that proposed in the standards and is not acquiring such data. Until it has a reasoned alternative for managing the aging untreated jarrah poles, the prudent approach would be to follow that recommended in the standards, which is based on the best available industry experience. Australian Standard AS 4676 gives different pole lives for treated poles and a different approach for their management. These reasonably differ from untreated jarrah poles, given they are treated to slow deterioration in

[12] AS 2209 – see discussion below under Pole Replacement
[13] Untreated jarrah poles.
[14] There are in the order of 300,000 untreated jarrah pole's in Western Power's distribution network

service. As all these poles are less than 30 years old, Western Power should initially focus on the older and shorter-lived untreated jarrah poles.

This focus is not evident in Western Power's SWIS Distribution Asset Management Plan 2008/09-2017/18.

Treatment and Species are Important

Clearly, species and treatment are important to pole life and network safety. The quality treated pine poles being supplied, with good preservatives and fitted pole caps, may last 100 years but this can be determined only by operational experience, diligent data collection and analysis. Western Power is not differentiating in its planning and asset management between older, untreated jarrah and younger, treated hardwood, pine and other species. It is also not gathering the data and doing the analysis to manage the single most costly asset in its network. Species other than jarrah and pine will complicate the asset manager's task in the years to come. Fortunately, they are relatively few in number and a small part of the distribution wood pole network.

Acceptable pole replacement rate

Balancing economic life against reliability and safety risks requires data Western Power does not have but should collect.

In the short run, while the necessary data are gathered and analysed, the prudent path is to use the best information available and err on the side of caution.

The 15,000 poles per annum projected replacement rate in Western Power's most recent Distribution Asset Management Plan is consistent with the age profile presented by Network Performance on the 11 June 2008. This is a prudent pole replacement rate until reliable information supports a reasoned alternative pole replacement plan..

Western Power's pole suppliers believe they can supply more than this number of poles year on year, but this leaves unanswered questions about adequate skilled labour and finance. Also unanswered is how Western Power will select the additional poles to be replaced over and above the condemned poles identified by its (improved) pole inspection practice.

New Poles in Western Power's Rural Distribution Networks

Drive-by observations of the Western Power's rural networks show substantial quantities of new three-phase power lines and poles in the north, east and south of the State. This is comforting, but begs the question as to whether these are new additions to the network, or replace older power lines. If they are new, and the old poles and lines still exist, the failure risk in absolute terms has not reduced. If they replace older, recovered lines, the risk has been reduced.

This drive-by observation suggests the quantity of new poles in rural areas substantially exceeds numbers replaced, identified in the 2006 Audit and in 2008.

This question about the real number of pole replacements was posed to both Service Delivery and Network Performance. The Service Delivery response was that the asset record system only identifies a new pole as a replacement when it is installed in the same location as the pole it replaced. If, as an example, ten new poles were installed in a line in different locations to the

existing poles, and ten old poles were then recovered, these ten new poles would not be counted as replacements. This could be an explanation for the difference between the drive-by observations mentioned above and replacements reported by Western Power.

Group Commercial provided details of distribution pole numbers issued from store year-on-year from 1991. While there is confidence in recent[15] data, earlier figures are open to doubt. Recent pole issues vary between 6,300 and 12,300 per year, substantially more than the 1,600 to 3,000 replacements identified by Western Power.

Network Performance said substantial quantities of new high voltage power line poles had been installed to upgrade the system capacity, but no breakdown of new (additional) poles and new (replacement) poles was provided. They acknowledged the pole replacement data recording deficiency.

The 2008 Audit Review has not resolved the uncertainty about pole numbers replaced, new poles added and the consequences of this for the trends in age profile and safety.

Western Power's October 2008 AA2 proposal includes estimates of the distribution wood pole replacements for the next three years (Table 7-7).

Table 7-7 – Distribution pole replacement Capex forecast ($M)

Item	09/10	10/11	11/12	Total
Pole replacement ($M)	39.57	45.09	61.92	146.58
Forecast volume (poles)	6,200	7,000	9,350	22,550

These rates are a significant increase on recent years, but still much lower than a prudent and effective pole replacement plan should deliver

Conclusions

Western Power has increased its pole replacement activity, but not to a prudent level. The pole replacement rates proposed equal the rate at which poles are condemned.

Western Power's pole inspection activity has not been applied diligently and is almost certainly not identifying all the unserviceable poles inspected.

Western Power does not have systems ensuring the unserviceable poles are replaced (or reinforced) in a timely way, with due regard to the condition of these poles and safety risks if they remain in service.

Western Power focuses on pole average age and the extended pole life. This has lead to a false conclusion that no significant work and expenditure are needed for another 15 to 20 years.

Western Power has not implemented effective stay inspection with appropriate repair, or replacement of defective or ineffective stays. Stay inspection and repair or replacement are the second most critical element in Western Power's wood pole management systems.

[15] The last 7 years

Recommendation 24: Western Power should:

1. Establish management systems that ensure unserviceable poles are replaced (or reinforced) in a timely way.
2. Differentiate between its untreated jarrah and treated jarrah and pine poles in its asset management planning.
3. Gather and analyse operational data necessary to validate service lives of its wood pole population by species and treatment as the basis for replacement planning.
4. Develop and implement pole asset management plans based on credible pole life by species and treatment.
5. Establish effective stay inspection and maintenance.

Safety Performance & Process Management

Although not specifically reported, the 2006 Audit found no evidence of any comprehensive monitoring and review of wood pole safety performance, or the effectiveness of the management systems influencing that performance. The absence of information at that time precluded assessment of any systems that may have existed and their effectiveness.

The 2008 Audit Review is based on:

- All the documents and discussions identified in the preceding sections of this report.
- Specific questions seeking to identify the policies and standards governing and defining the required outcomes, performance accountability and reporting necessary for the separate wood pole management elements and asset performance.
- Specific discussions with the Managers Standards, Policy and Data Quality and Network Performance.

Many asset management systems, including Western Power's wood pole distribution management, include the elements of design, materials procurement, construction, inspection, life extension and finally replacement. The 2008 Audit review also found Western Power's wood pole management activities include contracted services for design, construction, pole inspection and pole base reinforcement, which add another level of complexity to the asset management.

In every case the asset management elements are developed and delivered by different groups in different parts of the organisation. The lead asset management role is divided between the Standards, Policy and Data Quality and Network Performance Branches within the Customer Services Division. The design, construction, inspection, pole base reinforcement and replacement service was delivered by one or more branches within the Service Delivery Division, or contractors managed by Service Delivery.

The 2008 Audit Review did not find a person or group responsible for monitoring and managing the overall performance of each of these management elements. Further, the 2008 Audit

Review did not find any process to review and manage the overall performance of the wood pole asset management systems including the safety performance of these networks.

Policy Documents and Service Agreements

The excerpt below from the Economic Regulatory Authority (ERA) Assessment Report of Western Power Asset Management System 26 May to 6 June 2008 states that an asset management policy exists. The 2008 Audit Review did not find any policy documents encompassing any of the wood pole management systems within the scope of this audit.

> *"Generally it is felt that the Western Power asset management system, which is applicable to both the transmission (ETL2) and distribution (ETL1) systems, is effective and, in some areas, aligned with good industry practice. The Network Performance Branch of the Customer Services Division (the Asset Managers) has modelled the asset system on the requirements of PAS55-1 Specification for the optimised management of physical infrastructure assets. This is in line with global best practice as PAS55-1 is being adopted by asset intensive business around the world especially in the utilities sector. An Asset Management Policy is available detailing the high level requirements from the asset management system and that this policy was aligned with other organisational policies."*

The policy documents sought would define the asset owner's requirements of the asset managers. These asset management policies would be comprehensive, but clearly include the wood pole networks, lines and structures. They would define the network performance required, the asset manager's authority and responsibilities and the reporting required from the asset manager to the asset owner.

The 2008 Audit Review also found no documents defining the asset manager's requirements of those servicing the networks, including the wood pole lines, structure and stays. These service delivery agreements between the asset manager and the service provider would define the service activities and performance required the authority and responsibilities of the parties to the agreements and the reporting necessary from the service providers to the asset manager.

The 2008 Audit Review also did not discover any documentation identifying the asset owner, the asset managers, or the service providers. From the activities observed it appears that that the Manager Standards, Policy and Data Quality, and the Manager Network Performance within Western Power's Customer Service Division are the asset managers. The service providers were generally the branches and sections within Western Power's Service Delivery Division and the contractors engaged to support them. Neither the managers within the Customer Service Division, the service providers within the Service Delivery Division or the contractors working for them believed or expected the asset manager to have any oversight or exercise any review of the service delivery performance.

There was evidence of some formal reporting of the wood pole safety performance and management activities to the Board from the Manager Network Performance. This begs the question as to who is the asset owner. Is the asset owner the Western Power Board, the Chief Executive Officer or the General Manager Customer Services? Again, other than the Quarterly Board Report there was no evidence of the oversight and review that would be expected from the asset owner of the asset manager's activities and performance.

Conclusion

In the absence of asset management policies and service agreements defining the activities, performance, authorities and responsibilities of the asset manager and reporting to the asset owner and, similarly, service agreements defining the functional relationship between the service providers to the asset managers, the processes and relationships necessary for the function of an effective asset management systems do not exist.

Recommendation 25: Western Power should establish asset management policies and service agreements to establish and maintain effective asset management processes, including those needed for managing the wood pole power lines, structure and stays. These asset management policies and service agreements should clearly define the roles reporting accountabilities and feedback processes.

Recommendation 26: Western Power should review periodically its asset management systems, with specific references to safety and compliance with the relevant Regulations and technical standards.

Current Compliance Audit Outcomes Summary & Score Sheet

Design

The wood pole design standards and policies are set out well in design manuals and construction handbooks. The detailed overhead electrical and line design built around the electrical design software and the wood pole line design software, Poles'n'Wires introduced in late 2006, is both comprehensive and robust. The mix of internal and contract design staff is well managed and the process linked through the Distribution Quotation Management system gives a high level of design confidence.

The gaps identified by the 2008 audit are the absence of:

- Structural design records verifying compatible units (CUs) have the necessary strength to comply with the relevant engineering standards and codes.
- Technical specifications for the procurement of the poles and components that make up the compatible units.
- Comprehensive review of the design activity for compliance with relevant engineering standards and business objectives.

Western Power is reviewing the structural adequacy of the components that make up the compatible units for stays and producing the necessary technical specifications for the procurement of both poles and stays.

One less obvious issue concerns the pole replacement and repair work managed within Service Delivery. It follows a different process and may not benefit from the rigour of this distribution design process.

The missing design records for the compatible units is understood to extend for all compatible units used in the overhead power lines and, while beyond the scope of this audit, is an issue Western Power should address.

Procurement

The disappointing finding for the procurement activity is not in any way a reflection on the people from Group Commercial, who were most professional, competent and supportive through the audit. The issues are the absence of:

- Standards and policies governing the procurement processes and related activities.
- Technical specifications for the materials procured.
- Inspection, testing or audits of the supply chain to ensure the quality and compliance of the materials supplied.
- Systematic review of the procurement activities for compliance with the defined standards and policies and business objectives.

Construction

This element in the value chain is managed by competent and experienced managers and supervisors and is arguably the strongest element in the wood pole management system.

Pole and Stay Inspection

This is the weakest element in the wood pole and stay management process. In common with most of the other elements, there were no standards or policies defining the outcomes and accountabilities for the performance of the activities within the inspection processes, nor was there any periodic review and assessment of the process.

The issues with the inspection practice identified in the 2006 Audit, reinforced by Western Power's own audit, were not addressed. Western Power's QA of the contractor pole inspections has improved in the last 12 months and if sustained will improve the field application of the pole inspection practice. This improved inspection QA should be formalised and extended to the contractors' QA activities. The below ground pole inspection should be extended to all poles, including those in brick, concrete and other hard-stand paving.

There was also no stay inspection process in effect at the time of this 2008 Audit Review.

The 2008 Audit Review identified a marked increase in pole inspections and better management of the inspection program.

Serviceability criteria

This element also scored poorly because the inadequacies with the good wood serviceability criteria which do not compare the pole strengths with the pole stress at design wind pressure. There are also no serviceability criteria identifying reinforced poles that are no longer serviceable and should be replaced.

The inspection practice and serviceability criteria inadequacies arguably contribute the most to the low pole condemnation rates, low pole replacement and high unassisted failure rates.

Pole base reinforcement

This element showed a marked improvement over the 2006 Audit due in the main to implementing the UAM RFD pole reinstatement systems. The audit identified opportunities for improvement in the procurement of these specialist services and related contract management. Western Power intends to conduct an independent assessment of 30 pole reinstatements installed by UAM, which will provide further confidence in this element of the wood pole management.

One gap is the absence of any systems to ensure the poles identified to be reinforced are reinforced in a timely manner, with due regard to safety.

Pole Replacement

As with most other elements, no service agreements were identified between the asset managers and the service providers for this activity, nor was there any periodic review or audit

of the activity to test for compliance with the required standards and business objectives. No management system was discovered that would ensure unserviceable poles were replaced in a timely manner. Although the pole replacement rates are now higher than those reported in the 2006 Audit, they are not sufficient to replace the highest risk poles at an acceptable rate and deliver acceptable wood pole safety.

This element also contributes significantly to the high unassisted pole failure rates.

Wood Pole Safety Performance

This management process is presently not in Western Power's current wood pole management. The principal gaps are:

- The standards and policies defining the wood pole (and stay) safety performance.
- Those accountable for achieving that performance.
- The periodic audit and review of the integrated wood pole management systems for compliance with relevant technical standards, safety performance and business objectives.

Implementing this process would integrate the performance of each separate element in the wood pole management system.

The scores in the table below reflect the audit findings. The scores are derived on a scale of 1-5 based on those used in the Economic Regulation Authority audits.

	Description	Rating
Fully Complying	Comply- no action required	5
Complying	Comply apart from minor issues and recommendations	4
Partially Complying	Meets minimum requirements in most areas but improvements are required to maintain compliance	3
Non-Complying	Does not meet minimum requirements	2
Significantly non-Complying	Significant weaknesses and/or serious action required	1

Audit Score Sheet – Current Practices

Design	Score
Distribution Standards and Policy	3
Distribution Design Engineering	4
Distribution Design review and compliance management	2

Procurement	Score
Standards and policies	2
Procurement specifications	1
Acceptance inspection and QA	1
Contract development and management	2
Service Contracts – Pole inspection and pole base reinforcement	2
Procurement review and compliance management	2

Construction and pole replacement	Score
Construction Standards	4
As constructed reporting and recording	4
Competence and training of construction persons	4
Construction review and compliance management	2

Inspection	Score
Standards and Policies	2
Pole and stay inspection practices	2
Competence and training of inspectors	2
Inspection field activity QA	2
Inspection review and compliance management	2

Pole serviceability criteria – Reinforce or Replace?	Score
Reinforce/replace decision criteria	2
Reinforced pole replacement criteria	2
Records of the reinforce/replace data and decisions	3
Reinforce/replace review and compliance management	2

Pole Reinforcement field work	Score
Pole base reinforcement system design UAM	4
Pole base reinforcement system design UAM	4
"As reinforced" reporting and recording	Not assessed
Competence and training of UAM subcontract operators	Not assessed
Reinforcement review and compliance management	2

Pole Replacement	Score
Pole replacement management systems and service agreements	2
Pole replacement field activity	3
As replaced reporting and recording	Not assessed
Competence and training of pole replacement workers	4
Pole replacement review and compliance management	2

Wood Pole Safety Performance	Score
Standards and policies	2
Wood pole asset performance monitoring	3
Wood pole safety performance review and compliance management	2

PART 2 – SAFETY ISSUES IN THE EXISTING DISTRIBUTION NETWORK

Network Data and Management Information

The 2006 Audit identified differences between as-constructed assets and the records in the Distribution Facilities Management System (DFMS) for conductors and pole base reinforcement. It was difficult to get answers to questions about pole numbers in the distribution network, the average age and age distribution of these poles and the breakdown of these data by pole species and treatment.

The numbers of wood poles reported in Western Power's documents discovered in the period 2006 to 2008 range from 619,000 to over 800,000. Western Power's Distribution Facilities Information System (DFIS) in 2006 gave the distribution pole numbers as 659,249. The most recent Distribution Asset Management Plan reports 618,777 and 725,514 poles respectively in different places in the same document. Pole numbers implied from unassisted pole failures and distribution pole integrity indices in the September 2008 Board Report range from 670,000 to 715,000.

It is difficult to rely on data fundamental to managing the wood pole assets that vary as much as these pole population figures. Data in Western Power's DFIS and DFMS systems are not considered reliable.

The unassisted pole failure data have been 'cleansed' during 2007 to eliminate pole failures from other causes. These were inflating the reported figures. This data cleansing has not been extended to include all the data reported in Board Reports, thus diminishing confidence in the trends reported.

The reported pole condemnation rates also range from 0.5% - 5.9% in the September 2008 Board Report. Western Power's AA2 submission to the Economic Regulation Authority reports pole condemnation rates varying between 2% and 4%, and expected to rise to 5%. Reported pole replacement rates also vary and Western Power's staff identified difficulties with the fieldwork activity classifications which mask the real pole replacement rates. For example, a new pole installed in a different hole to that occupied by the pole being replaced is not reported as a pole replacement.

The Manager Standards, Policy and Data Quality indicated that the asset data integrity index was 80%, which they plan to improve. This index measures the time for the asset data to be conveyed from the field to the office and entered into the computer records, and the accuracy of the data entry process This index does not check the accuracy of the computer records against the field assets and has not addressed the data accuracy issues identified above. Improving this index will not provide the information needed for Western Power to manage effectively its wood pole assets. The focus of data and information management must be the intended use of the information in terms of accuracy and timeliness, specifically in terms of what needs to be managed and what information is needed to manage the outcomes required.

Recommendation 27: Western Power should identify the information and data needed to manage its wood pole assets and build the data gathering and processes to provide the management information.

The lack of policies and service agreements defining the performance required and how it will be measured has allowed the wood pole management information systems and data to degenerate to levels where the systems effectively do not exist, or the data and information are inaccurate and unreliable. The 2008 Audit Review observed the continuing difficulties experienced acquiring the information needed to manage Western Power's wood pole assets.

Recommendation 28: Western Power should formalise the policy statements and service agreements defining the objectives, outcomes, accountabilities and reporting required by the asset owner of the asset managers, and the asset managers of the service providers.

The 2008 Audit noted the enhanced reporting to the Board but little of this information is known to or used by the subordinates managing the day-to-day activities.

Pole Strengths

The 2006 Audit found evidence of poles that failed because they did not have the required strength and factors of safety required when subjected to the wind loads specified in HB C(b)1 at the time they were installed. Examples were:

- 6 poles that failed in the Esperance region from 2 to 15 December 2004 (now in Horizon Power's system)
- 1 pole that failed on Kardinya Farm New Norcia 26 December 2004

Since the 2006 Audit, some 30 poles failed between Denmark and Albany in a storm in July 2008. While flying debris could have been a factor in some of these pole failures, similar issues to those identified in the 2006 Audit could be relevant in some of these pole failures as well. Pole failures are not reportable events[16] and Energy*Safety* is not aware of all the pole failures in Western Power's networks.

Western Power has not investigated and reported on the causes of these Albany-Denmark pole failures. This is common for pole failures in storms, but is not considered a prudent practice.

There was no flying debris or loads other than the wind on the poles and lines in the Esperance and New Norcia pole failures.

Western Power's investigations of the Esperance and New Norcia pole failures found:

- All seven were untreated jarrah poles
- All were installed more than 28 years ago
- None had been reinforced
- None had any lateral support from service conductors to customer premises or other wires transverse to the power line

[16] Reportable events are those defined in the Electricity (Supply Standards and System Safety) Regulations 2001 that must be reported to the Regulator – Energy*Safety.*

- All had recorded below and above-ground good wood measurements at the last pole inspections suggesting very little, if any, internal rot and that these poles were as strong as when erected

- All failed as a consequence of strong winds.

Energy*Safety:*

- Observed from actual recorded data that all the poles failed in wind speeds substantially lower than the design wind speeds.

- Observed from the Western Power reports that all poles when installed had factors of safety substantially below the four times required for untreated wood poles by the 1962 and 1974 versions of the *Code of Practice for Overhead Line Construction* and the 1991 version of the *Guidelines for the design and maintenance of overhead distribution and transmission lines* that followed these earlier Codes.

- Identified in the 2006 Audit research into the loss of wood pole strength with age, which casts doubt on the good wood readings used to conclude that these poles were as strong as when erected.

The credibility of below-ground good wood readings is considered in Part 1 (Inspection section).

Changes in the Overhead Lines Codes and Guidelines

Three significant changes in the *Codes of Practice for Overhead Line Construction* and *Guidelines for design and maintenance of overhead distribution and transmission lines* are most relevant to the strength of wood poles and this Audit Review. These changes occurred in the period from 1962 to 1999. They are:

1. The maximum allowable bending stress in the poles caused by wind and other forces on the poles and lines. This is known as the Modulus of Rupture (MoR) in bending.

2. The factors of safety that must be achieved or exceeded. The factors of safety are the ratio between the allowable bending stress or Modulus of Rupture and the bending stress resulting from the application of the wind and other short term forces specified in the Codes and Guidelines.

3. The code-specified wind-caused forces that must be used in calculating the design stresses in the poles.

Western Power does not have design calculation records for any of the current wood poles in its distribution network, or the Modulus of Rupture, factors of safety and design stress limits used.

Recommendation 29: Western Power should retain all design data and calculations for its power lines and poles for the life of these assets.

Modulus of Rupture in Bending Halved - 1991 Guideline

The allowable bending stress in power poles decreased significantly over the last 50 years. The 1962 and 1974 *Codes of Practice for Overhead Line Construction* referred to the CSIRO Timber Design Handbook, which specified the MoR for jarrah poles to be 10,000 psi for green poles and 16,000 psi for seasoned poles. The industry generally used figures in the order of 100 MPa in decimal engineering units, which is at the high end of the seasoned pole strength.

The later 1991 and 1999 *Guidelines for the design and maintenance of overhead distribution and transmission lines* reduced this allowable bending stress to 50 MPa[17]. This required larger diameter and stronger poles to comply with the new (lower) allowable bending stress limit.

Safety Factors and Wind Pressure Changes Offset Each Other – 1999 Guideline

The times four safety factor for untreated poles specified in the 1962 and 1974 Codes and in the 1991 Guideline required the design bending stress in the poles to not exceed 25% of the allowable bending stress with the lines and poles subjected to the specified wind loads.

This safety factor was reduced to two in the 1999 and subsequent *Guidelines for design and maintenance of overhead distribution and transmission lines,* which doubled the allowable design bending stress from 12.5 MPa to 25 MPa.

This halving of the safety factor was accompanied by a near doubling of the design wind pressures. These two changes effectively offset each other, with minimal effect on the size and strength (diameter) of the poles required to comply with the 1999 Guidelines.

The net effect of these changes is that:

1. the allowable bending stress in the 1991 Guideline approximately halved the figure allowed in the earlier *Codes,* increasing the size (diameter) and strength of the poles needed to comply with the change in the 1991 Guideline.
2. The subsequent changes in the 1999 Guideline, with a halving of the safety factor and almost doubling design wind pressure made little change to the size and strength of the poles required to comply with the specified requirements in the 1999 and later Guidelines.

Forty year's experience with untreated hardwood poles prompted the reduction in the Modulus of Rupture by the Electricity Supply Association of Australia in 1991. This change is supported by the Curtin University pole sample testing commissioned by Energy*Safety* in 2008 (see below) and research into the loss of wood pole strength with age identified in Energy*Safety's* 2006 Audit.

Curtin University Clear Sample Tests from Shelley Transformer Pole Failure February 2008 – 2008 Audit Review.

Energy*Safety* commissioned clear sample bending tests of above and below-ground samples taken from the pole and pole butt of the transformer pole that failed in Riverton Drive Shelley on

[17] Reference AS1720.1

26 February 2008. The tests were commissioned to discover the bending strength of the wood in this pole, which had been inspected and found serviceable just 24 months before failure. This is well within Western Power's programmed 4-year planned inspection cycle. The pole appeared sound in all other respects and there was no reason to suspect the serviceability of this untreated jarrah pole in service for 34 years. The wood fibre strength in this old pole was thought to be a possible explanation for the failure.

The results showed the bending failure stress to be on average 90 MPa above ground and 57 MPa below ground, although there was a wide variation in the test results in some specimens. Two of the above-ground test specimens failed at bending stresses below 40 MPa.

The test results supported:

1. Previous research findings into the loss of wood fibre strength with age. Up to 50% of the initial wood fibre strength can be lost over the service life of wood poles in ground (15 to 25 years) and

2. Use of 50 MPa as the allowable bending stress in poles below ground, which is the current allowable bending stress for jarrah[18]

3. Caution in allocating allowable bending stresses in old poles noting the variations in the test results. This is consistent with notes in recent Guidelines, which state that "Tests of poles and cross arms that have been in service a long time show a wide variation in the ratio of calculated to actual strengths. Due to this uncertainty it is recommended that strength factors at the lower end of the range be used in the absence of specific data suggesting higher confidence."

It was not possible to test the bending strength of the wood in the plane of the pole failure, which would be less than that found in the clear sample tests.

Investigation Reports Pole Strengths – Factors of Safety and Ground Line Stress Calculations

The 2008 Audit Review reviewed the design strengths of the seven Esperance and New Norcia pole failures reported in the 2006 Audit based on the 1974 and 1991 design standards.

Calculation of the pole design strengths using the C(b)1-1974 specified 100 MPa allowable bending stress and wind pressures in that Code show that all but one of these poles had the required strength and safety factors to comply with the design requirement when these poles were installed. This contradicts the observations made from Western Power's investigations of these pole failures reported in the 2006 Audit that none had the required 4x factor of safety to comply with the design standards.

The conclusion is that one (or 14%) of the seven poles investigated did not have the strength required to comply with the design standards at the time these poles were erected and that inadequate design was a factor in the pole failure. The sample is small, but the conclusion is concerning.

[18] AS 1720.1 - 1997

Repeating these calculations of the allowable design strengths using the lower C(b)1 – 1991 specified 50 MPa allowable bending stress and the wind pressures specified in this Code shows that only one of the seven poles would have had the required strength to comply with the design requirements had the poles been installed in 1991 or later.

The conclusion is that 86% of the poles that failed would not have had the required strength to meet the design standards had they been installed in 1991 or later, and that inadequate design would have been a factor in 86% of the pole failures. The adoption of more prudent design standards questions the strength and safety of significant numbers of the poles installed in Western Power's distribution network prior to 1991 and particularly the untreated jarrah poles in the rural networks.

Untreated Pole Age

Untreated jarrah poles were installed in the SEC's and SECWA's (now Western Power's) distribution network from the late 1940s until the late 1970s. The youngest of these untreated jarrah poles are 29 years old and the oldest are approximately 60 years old. The Australian Standard for wood poles (AS 2209) quotes the service life of untreated wood poles in ground to be 15 to 25 years, and above ground 40 years.

Many of these untreated and unreinforced jarrah poles are well beyond their prudent service life of 25 years. Any reinforced, but untreated, jarrah poles older than 40 years are also beyond their prudent service life.

Even these older reinforced poles may not have the necessary strength and safety factors to comply with the 1991 and later versions of C(b)1 using the more prudent 50 MPa Modulus of Rupture. Age is currently the best estimate of remaining strength above reinforcing steel stakes and the effective safety factor to determine remaining strength and safety.

Conclusions

1. The conclusion in the 2006 Audit deduced from Western Power's pole failure investigation reports that all of the seven pole failures investigated did not have the required strength and safety factors to comply with the requirements of C(b)1-1974 was not correct. The 2008 Audit Review has found that all but one of the seven poles investigated had the required strength and safety factors to comply with the requirements of C(b)1-1974.

   The 2008 Audit Review has not enquired into the algorithm used in Western Power's Distribution Facilities Management System, which may be flawed.

2. The 2008 Audit Review also found that only one of the poles in the seven unassisted pole failures investigated had the pole strength and safety factors required to comply with the reduced maximum allowable bending stress of 50 MPa specified in the 1991 version of C(b)1 (which includes AS 1720 requirements).

3. The rural pole failures identified in the 2006 Audit are continuing.

4. Many of these failed poles were untreated jarrah that:

   a. Had been in service for 29 to 60 years, well beyond their prudent service life

b. In many cases were not reinforced at the ground line

c. Were in-line poles with no lateral support from overhead wires supplying adjacent customers or other wires transverse to the power line

d. Were most likely designed to the Modulus of Rupture, safety factors and allowable bending stresses (in the order of 110 MPa and 28 MPa respectively) specified in the Codes and associated standards applicable before 1991

e. Would not have had the strength and safety factors to comply with the allowable bending stresses and safety factors required in the 1991 and subsequent versions of C(b)1

5. Considerable variation occurs between the calculated and actual strength of wood poles (and cross arms) in service for a long time.

6. Western Power does not have records of its pole procurement specifications and line designs from the 1950s that show the design stress and factors of safety for the poles installed.

7. Western Power does not have the technical design details of the poles procured the 1950s to the 1990s

8. Western Power has not addressed the rural pole risk issue, identified in the 2006 Audit

9. Prompt and prudent action is required to identify the extent of the risk and to replace poles consistent with the risks identified

The following recommendations are not the retrospective application of more recent standards to existing assets. They address a stark safety issue by adopting pole strength information not available when the poles and power lines were designed and erected.

Recommendation 30: Western Power should carry out a desk-top study using available data to identify untreated jarrah poles in its rural networks that do not have the strength and factors of safety (four) with the specified wind loads and the bending strength of 50 Mpa to comply with C(b)1-1991. Alternatively, the desk top study could be based on the lower factors of safety and the higher wind loads specified in the 1999 and later versions of C(b)1.

Recommendation 31: Western Power should then develop a program to replace these untreated jarrah poles progressively, starting with poles having the lowest factor of safety. This program should recognise that the actual wood pole strength in old poles can be significantly less than the maximum allowable bending stress specified in C(b)1 and that compliance with the 1991, 1999 or subsequent versions of C(b)1 does not mean the poles have sufficient strength and are safe. The factors of safety are to be used to apply priorities for the pole replacement program.

Recommendation 32: The desktop study and pole replacement program should also address the pole-base reinforced rural untreated jarrah poles, with the focus on the pole strength and bending at the top of the reinforcing steel stakes.

Pole Base Reinforcement

The 2006 Audit found:

- Approximately 60 different types of pole base reinforcement systems installed in the distribution network.
- No calculations or trials to demonstrate any of these systems have the strength to ensure these reinforced poles are safe.
- No serviceability criteria to identify which reinforced poles that are no longer serviceable and should be replaced, and
- Reinforced pole failures:
    - Above the reinforcing stakes
    - Of the pole between the reinforcing stakes
    - Of the reinforcing stakes and the pole

The 2008 Audit Review found:

- Approximately half of Western Power's 620,000 distribution wood poles have been reinforced.
- Continuing reinforced pole failures.
- UAM is installing all new pole base reinforcement, which addresses the concerns with Western Power's pole base reinforcing in 2006.

Conclusions

The 2008 Audit Review found that some 310,000 wood poles in Western Power's distribution system have been reinforced with variety of pole base reinforcement systems. None of these have been shown by calculation or trial to have the strength necessary for them to be safe. While not in large numbers, these continuing failures of reinforced poles present a real safety risk in the distribution network that should be assessed and managed.

Recommendation 33: Western Power should:

1. Assess the failure risk of the (approximately) 60 different pole base reinforcement systems installed in its distribution network based on trials, calculations and failure experience.
2. Develop and implement serviceability criteria based on the risks identified in the first recommendation in its pole inspection practice, and
3. Implement a reinforced pole replacement plan to minimise the risk from these pole failures in the future.