Factors Affecting Sound Wood Wall Thickness of Timber Poles and Implications for Service Life Prediction

Prepared for Johnny Shan:

By Michael Powell (timberadvice@gmail.com)

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Executive Summary

This report delivers a comprehensive assessment of the key factors affecting sound wood wall thickness (SWWT) in timber utility poles and their direct impact on service life prediction. Central to the analysis is a robust evaluation of decay rates calculated from United Energy (UE) inspection data. These rates are not only statistically sound but also strongly corroborated by independent research findings and established predictive models, reinforcing their credibility and practical relevance for asset management strategies.

The calculated annual SWWT loss rates for UE poles, averaging 1.81 mm/year for Durability Class 1, 1.95 mm/year for Class 2, and 2.28 mm/year for Class 3, are supported by long-term field data and align with decay progression trends observed in CSIRO's Timber Service Life Prediction Model. These rates reflect realistic degradation patterns influenced by timber species, preservative treatment, environmental exposure, and biological activity.

Comparative studies, including trials at Wedding Bells State Forest and network data from NSW, confirm that preservative type and retention levels significantly affect decay rates. For example, creosote-treated poles consistently outperform CCA-treated counterparts, and poles with higher preservative retention exhibit slower degradation. The CSIRO model's k-wood values and climate hazard zones further validate the observed decay rates, reinforcing their applicability across varied conditions.

Overall, the decay rates used in service life predictions are well-founded, statistically robust, and corroborated by independent research, making them a reliable basis for asset management and replacement planning.

1. Introduction

This report independently assesses the reasonableness of United Energy's wood pole decay rates used to predict wood pole service life based on sound wood wall thickness measurements. This is achieved through a comparison with other relevant sources of decay rate and exploring issues relating to variability in measurement and timber properties, degradation agents and environmental factors that govern the physical reduction of sound wood wall thickness over time and therefore impact service life predictions based on sound wood wall thickness measurements.

The sound wood wall thickness of a timber utility pole represents the residual annulus of intact, structurally competent wood surrounding any internal voids or decay. It is a critical determinant of section modulus, bending strength and remaining service life. There are several factors that can affect the measurement of remaining sound wall thickness as they are that lead to its reduction.

Measurement parameters, inherent pole properties, and degradation factors affecting service life predictions and those that are most heavily relied on by the In-Ground Model are summarised and discussed. In the final section of this report the pole degradation rate data under consideration sourced from UE pole measurement records are compared to those generated by the CSIRO Design for Durability Timber Service Life Model together with relevant real-life data from other research.

2. Measurement Parameters and Data Issues Affecting Wall Thickness and Service Life Prediction Calculations

Accurate measurement of sound wood wall thickness (SWWT) is central to estimating residual strength and remaining service life of in-service timber utility poles. Wall thickness, defined as the radial distance from the pole's external surface to the boundary of internal decay or voids, has commonly been inferred using auger drilling methods and, increasingly, using non-destructive test (NDT) methods such as resistance micro-drilling, stress-wave timing/tomography, and/or ultrasonics. Accurate determination of SWWT is a product of fully removing external degradation (soft rot/surface softening) and identifying where, internally, the good wood stops and incipient/early decay or voids start. Incorrect estimates of wall thickness can occur through operator/process error or as a consequence of the naturally heterogeneous nature of degradation.

2.1 Database Records

The data used to derive average wall thickness reduction for various age classes of poles of different durability classifications requires accuracy in several areas. Whilst the significant quantity of data points allows averaging and statistical processing that can negate some of the variability and inaccuracy, there are some key characteristics that have more of an influence than others.

- **Durability Class**

A more detailed description of the effects of Durability Class on pole performance are provided below. From a database point of view there are two main issues; inaccurate and missing data. Previous studies in Victoria, NSW and Queensland have demonstrated that up to 20% of pole species disc details are inaccurate. Where the wrong species is shown these are often of an equivalent strength group and durability class to the correct species but may also be stronger and more durable or less strong and less durable by one or two classifications.

In poles where no record exists or the details have become confusing or are forgotten a default classification is often used (ZZ-species unknown). A ZZ pole is typically considered to be a Durability Class 3 (DC3) and Strength Group 3 (S3) species even though significant proportions of this sub-population have been shown to be of a higher classification (in one study in Victoria ~59% of ZZ poles were found to be DC1 and ~24% were found to be DC3[1]). The incorrect assignment of highly durable poles to a lower durability class for service life predictions will have a significant effect on the accuracy of the calculations.

There are no available studies to help define the prevalence of species misidentification within UE. It is likely to be of a similar order to that of other utilities. It was calculated (see Section 8.1) that approximately 0.7% of the UE data were assigned to a “species unknown” category

- **Date Values**

The supplied records, indeed, records from many/most utilities, suffer from inaccurate installation dates. Where disc details are not available default values such as 1900 may have been used, skewing the age groupings.

In addition, there appear to be several poles that have installation dates later than the most recent inspection, this is either in error or potentially the pole has been replaced but not yet inspected and the old records remain. Carry-over of old data to new poles confounds attempts to analyze service life.

Approximately 0.8% of the supplied UE data records appeared to contain incorrect dates.

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[1] Powell (2018) CitiPower/Powercor:,ZZ WOOD UNKNOWN Timber Pole Species Identification Trial Report.

2.2 Business rules

The following section highlights issues that can affect the accuracy of measurement, they are based on Australian practices with a focus on (and examples from) Victoria.

Many network distribution businesses operate their inspection processes using similar but different sets of rules. These can influence SWWT measurements and hence service life prediction in a number of ways and may change over time. The listed issues provide a snapshot of some of the steps required in cleaning/weeding/refining data before analysis of measurements can be started.

- **Drilling Depth**

When drilling a pole an inspector may be required to drill to a set depth, e.g. 100mm or 150mm. For a solid pole this value is then used as an input to the database as the SWWT regardless of the actual wall thickness which may be less than 150mm (for a pole with diameter <300mm) or greater than 100mm (up to 150mm for a 300mm diameter pole).

Similarly, for some time periods as a result of system changes or directives, inspectors have used a “nonsensical” default value for SWWT e.g. 999. These data can be ignored or converted to a standardized value (say 100mm or 150mm) but even then, they will add a bias to the data.

The supplied analysis of the UE data had ignored values for wall thickness of 999, converting them to 150 would add another ~7100 records to the analysis. Other ‘nonsensical’ wall thickness values also exist within the data.

- **Measurement Accuracy/Resolution**

SWWT is determined from a hole drilled into the pole. In some instances, this is done at a pre-determined (e.g 30^{O} degree) angle and the measurement is adjusted to calculate a horizontal equivalent. Inspection hole angles are not always drilled at the exact angle and these differences add variability to the analysis.

The probe used to measure the SWWT is calibrated to 5mm increments (previously 10mm) and the practice is to round down as a conservative measure. Measurements are therefore subject to the resolution of the measuring tool and the bias of rounding down. This will only occur once the SWWT falls below the default values (if any).

- **Resi Drill Specific Factors**

Whilst most of the SWWT records/measurements used for the service life prediction calculations would have been derived from auger drilling, more recent data may be from resistance drilling (ResiDrill). This device uses a slightly different method and rules for determining sound wood and is influenced by other factors.

- Device settings (e.g. gap tolerance and signal amplitude threshold) significantly impact SWWT measurement.
- Calibration drift and bit wear: Resistance drilling systems can exhibit calibration drift due to bit wear, battery state, and frictional heating; this may over- or under-report resistance, shifting the inferred decay boundary.
- Bit deflection/wander: In dense timbers, or at knots, or across grain deviations, in checks and cracks, slender drill bits can curve/deviate, producing asymmetric profiles and biased/inaccurate wall estimates.
- Penetration speed and feed pressure: Excessive feed compresses soft or decayed tissue and can obscure boundaries between sound and decayed wood; modern instruments log both resistance and feed to improve interpretation, but appropriate speed settings and detection thresholds are critical.

- **Reinforced/reinstated poles**

When a pole is nailed/staked/reinforced/reinstated the inspection process changes. After installation of the reinforcement the effective ground-line for inspection becomes the top of the stake whereas the data from previous inspections at/around the ground-line may persist within the data leading to apparent step change differences in wall thickness between closely spaced inspections, sometimes an increase. Whilst this is reported to not be the case in UE it does affect some utility data. Any data that may have been affected by this must be verified or weeded out.

3. Intrinsic Factors Affecting Wall Thickness

3.1 Natural Durability Class

Timber species differ widely in their natural resistance to biological attack. AS 5604 defines Durability Classes (DC) for various exposure conditions including for heartwood performance in ground contact. These range from DC1 (highly durable) to DC4 (non-durable) based on long-term trial data from sawn specimens of outer heartwood. Outer heartwood tends to have the highest concentrations of durability enhancing extractive chemicals and therefore decays at rates lower than the inner heartwood and the untreated sapwood of poles.

The classifications are generalizations and variations within species and between location/environment differences exist, such that a sample of one species might perform as a Class 2 species in some environments but as a Class 3 in others. Similarly, not all Class 1 species perform equally; there is a range of performances within each of the classifications[2].

[2] Cookson (2003). The In-Ground natural Durability of Australian Timbers

The sapwood of all durability class timbers, being permeable to air and water and low in bioactive extractives, is highly susceptible to decay and termite attack and considered to be below that of a Class 4 species for in-ground durability.

These variations in decay susceptibility (Durability Class and radial differences) are further compounded by the differences in termite resistance that are also listed in AS5604. Species are shown as either not resistant (NR) to termite or resistant (R) however this does not mean that they are immune to attack.

3.2 Heartwood and Sapwood Distribution

For preservative treated poles, the annular thickness of the outer sapwood band determines the volume available for treatment. Different species (and even poles of the same species) have different thicknesses of sapwood. Typically, these range from 10-20mm in most Australian hardwoods, although thicker sapwood is possible in some species such as blackbutt and spotted gum (up to 40 or 50mm). Once preservative effectiveness declines, the remaining sound wall is then reliant on the durability of the outer heartwood. In low durability species this can be quickly reduced through fungal and/or termite activity.

3.3 Preservative Treatment Effectiveness

Preservative type, formulation, and penetration depth directly influence long-term wall preservation. Copper-chrome-arsenate (CCA) salt formulations achieve durable fixation and resistance to leaching when correctly treated to H5 levels. Creosote appears to remain mobile within the pole during its service life and through the actions of gravity can accumulate around the ground-line of the pole. At the same time some soil organisms (fungi and bacteria) are breaking down some components of the creosote, potentially reducing its efficacy. These processes occur simultaneously but at different rates depending on biotic and environmental factors.

As a result of variations in preservative treatments at the time of the poles' manufacture as well as depletion over time, the poles within a network will exhibit a range of preservative retentions (both creosote or CCA) with many (mostly older poles) not having sufficient preservative retention to pass today's standards (AS1604).

Retention of preservative is key to the performance of sapwood for all Durability Classes of treated poles. Unfortunately, it can also be highly variable as can be seen in the following tables which have been extracted from an ENA research report that investigated the progression of soft rot in preservative treated poles from two test sites and two network areas in New South Wales.

Wedding Bells State Forest is a State Forest area close to Coffs Harbour that has been used since the 1960's to test the interactions between pole types and treatments (initial and remedial). These pole stubs were prepared especially for the trials and were therefore treated to a relatively high retention (The current relevant Australian Standard [AS1604] requires 1.2% mass/mass retention for Hazard Class 5 CCA treated hardwoods, and 1% for softwoods).

Table 2. Mean CCA retentions in Wedding Bells SF CCA-treated specimens (from Gardner et al., 1998)

Installed	Species	Treatment	CCA retention, %m/m
1976	Spotted gum	CCA – Tanalith C	1.2
1976	Radiata pine	CCA – Tanalith C	1.02
1979	Spotted gum	CCA – Tanalith C	1.34

In practice these standard retentions are not always achieved, (and at times have changed) and the following tables demonstrate that for both network poles from Country (now Essential Energy) and Integral Energy (now Endeavour Energy) spotted gum treated in the 1970's (0.73% and 0.84% respectively) exhibit retentions significantly lower than those treated in the 1980's (1.30% and 1.12% respectively).

Table 6 Mean CCA retention in poles inspected in the Country Energy area (from Gardner et al., 1998(2))

Species	Treatment	Year treated	CCA retention, %m/m
Blackbutt	CCA	1971-1975	1.46
Blackbutt	CCA	1981-1985	1.51
Spotted gum	CCA	1974-1975	0.73
Spotted gum	CCA	1982-1986	1.30

Table 8 Mean CCA retention in poles inspected in the Integral Energy area (from Gardner et al., 1998(2))

Species	Treatment	Year treated	CCA retention, %m/m
Blackbutt	CCA	1968-77	1.50
Blackbutt	CCA	1981-84	1.77
Spotted gum	CCA	1970-73	0.84
Spotted gum	CCA	1981-84	1.12

These differences are equivalent to those between an H4 (0.7% m/m) and an H5 treatment requirement (1.2%). Using the design for durability model TimberLife software for poles in-ground contact the difference in decay rate for the two treatment levels where all other variables are kept the same is around a twofold faster decay rate for the lower H4 retention compared to the higher H5. It is highly likely that all Australian timber pole networks will contain poles that exhibit a similarly variable range of CCA retentions.

The situation with creosote poles is likely to be similar although no data are available. There have been significant changes in creosote formulations during the lifespan of many of these network poles with at least three (now four) major varieties;

LTC, Low Temperature Creosote (up to late 1960's)

HTC, High Temperature Creosote (late 1960's to 1970's/80's)

PEC, Pigment Emulsified Creosote (1970's/80's to 2000's and still in use)

More importantly perhaps are the observed difference in performance between (1) creosote treated and CCA treated eucalypts and, (2) differing performance of poles of the same DC. These differences are discussed in more detail in a later section concerned with the CSIRO Timber Service Life Prediction Model.

The Wedding Bells SF/Belanglo SF/Country Energy/Integral Energy Trial showed, amongst other findings, that for surface softening (external loss of wood);

Spotted gum treated with creosote performed significantly better than those treated with CCA in both network areas and at Wedding Bells SF, and blackbutt poles treated with creosote performed significantly better than those treated with CCA in both network areas (there were none installed at Wedding Bells).

The report concluded that;

- *When treated with CCA or creosote, blackbutt poles perform better than spotted gum poles treated with the same preservative.*
- *Creosote performs better than CCA.*

Blackbutt and spotted gum are both DC 2 species and this finding somewhat contradicts the earlier CSIRO service model that treats all Durability Class 2 species as equivalent. More concerning is that the Model appears to consider that a creosote treatment to an H% standard is inferior to an H5 CCA treatment whereas they should be equivalent or as with these results Creosote may better CCA.

3.4 Past Remedial Treatment Practices.

One of the early remedial treatment practices for naturally durable species was the *in-situ* charring/sterilization of the outside of poles around the ground line and drench with creosote. This had the effect of creating a variable thickness of preserved wood on the outside of the pole that has a resistance to decay far greater than the wood itself. This protective layer depletes over time. This practice was undertaken more commonly in some maintenance planning areas than others, similarly some areas were used as trials for other (boron based) externally applied remedial treatments that would also have affected decay rates for some periods on some poles.

The use of Polesaver rods as an internal remedial treatment may also have slowed rates of internal decay and termite attack compared to degradation rates calculated from other sources that have not used or do not adequately account for remedial treatment practices.

One Victorian maintenance planning area is known to have historically treated large numbers of poles with persistent termiticides leading to a significant reduction in the prevalence of attack within their area but also potentially biassing the SWWT degradation data as a future performance indicator now that the effective repellant chemicals are no longer available and current treatments rely on growth inhibitors that can kill whole nests.

4. Biological Factors Affecting Sound Wall Thickness

4.1 Fungal Decay

Decay fungi (white-rot, brown-rot, and soft-rot) progressively consume cell wall components once moisture exceeds the fibre saturation point (~25-30%) and oxygen is available. Groundline conditions provide near-ideal decay environments: alternating wet-dry cycles, moderate oxygen, and sustained moisture. Decay initiation typically begins at checks or untreated zones and can progress inward and outward at rates of 0.5–4 mm per year, depending on species, temperature, and preservative retention.

Soft rots tend to be found in wet environments attacking high durability heartwood or preservative treated sapwood. Basidiomycete decay fungi (brown and white rots) can degrade faster than soft rots but typically attack inner heartwood or aged outer heartwood in which the naturally occurring durability enhancing chemicals have been depleted.

Another significant factor in accurately assessing the SWWT from one or even two auger drillings is the heterogeneous nature of decay and termite attack. In early to moderate stages of internal degrade the central column of decay/void is rarely, if ever central and circular. Decay columns/termite pipes are usually irregular in shape and off-centre. In these circumstances relying on one or two drilling results or the mean or minimum thereof can give a false impression of the remaining wall thickness. The choice as to whether mean or minimum SWWT (and historically this may have changed) is used will strongly influence the calculation of degradation rates. The more intensive the testing, the more likely it is to produce a representative result.

The heterogeneous nature of decay also affects rates of external loss to soft rot. It is common during pole inspection to observe significant variability in peripheral softening around the circumference of a pole below ground line. This variability may be due to uneven preservative treatment or local soil differences and can be exacerbated by parts of the pole being in close proximity to other materials such as breast logs or concrete curbs that can trap moisture or offer nutrients that accelerate the decay process in localized areas.

In terms of a typical decay process for a de-sapped untreated Durability Class 1 pole the outer heartwood will initially degrade slowly, and the core wood (inner heart) will decay more rapidly, after around 40-50 years the outer heart will start to decay more rapidly, and the inner core will already have partially degraded and may be attacked by termites. A preservative treated Class 3 pole will exhibit a similar decay pattern with the exception that initial external decay is of the treated sapwood and once this is depleted then the decay progresses more rapidly into the moderately durable outer heartwood whilst the inner wood will have completely decayed/been consumed by termites by 40-50 years leaving a thin shell of sound wood. Decay of Class 3 outer heartwood is estimated to progress at around 3.5 times the rate compared to Class 1 outer heartwood[3].

Core wood (inner heartwood) is estimated to decay at rates 2-times those of outer heartwood for all DC's.

4.2 Termite Attack

Subterranean termites, particularly *Coptotermes* spp, *Heterotermes* spp, and *Nasutitermes* spp, pose a significant hazard across most of Australia including large parts of Victoria. In poles, termite galleries frequently follow the path of least resistance between annual rings, often concealed behind a thin outer shell. In Class 3 poles, once the preservative barrier is breached, internal wall loss can occur at rates exceeding 5 mm per month under active attack. Effective preservative treatment, soil barrier or internal treatment maintenance, and regular inspection are essential to prevent accelerated wall reduction. Termite treatments are not always successful and rapid attack can occur between inspections. Data that show significantly large drops in SWWT between closely spaced inspections may be due to termite attack and consideration should be given to treating these as separate sub-populations as the large SWWT reductions that they exhibit may skew the data for some groupings. Early detection and effective treatment can prevent significant termite attack.

4.3 Interaction Between Decay and Termites

Decay and termites are synergistic: fungal decay softens lignocellulosic tissues, making it easier for termites to tunnel; termite galleries, in turn, increase aeration and moisture infiltration, accelerating decay. This feedback loop can rapidly thin the sound shell once the preservative annulus is compromised.

4.4 Internal Collapse and Radial Checking

Some species (e.g. messmate stringybark and blackbutt) are prone to internal growth stresses that lead to the creating of star checks and voids within poles. These can give the impression of a reduced wall thickness when there is none but also they can allow the ingress of termites and decay accelerating the degradation of these poles at faster rates than those within the same durability class that are not prone to collapse/checking.

5. Environmental and Site Factors

The microenvironment around the pole base is a dominant influence on biological activity. Key variables include soil type, pH, drainage, aeration, and local climate. Poorly drained clay soils or shaded sites maintain high moisture and low oxygen, favouring soft-rot and white-rot activity, while sandy or well-aerated soils slow decay but may permit more brown rot and termite ingress. Temperature and rainfall/ground water strongly correlate with decay rate and the risk of termite attack. Vegetation cover and organic debris accumulation around the pole base retain moisture and can provide additional nutrients (such as nitrogen) that increase local decay potential. Whilst

[3] MacKenzie *et al*. (2007). Timber service life design guide. Forest and Wood Products Australia. 109 pp

Network wide averages are informative, regional variations are to be expected and may help to prioritise resource allocation.

6. Global Comparison of Wood Utility Pole Service Life Prediction Methods

6.1. Australia

Australia applies climate-driven hazard modelling through the Timber Service Life Design (TSLD) system. Decay rate and termite hazard models are climate-calibrated, with utilities using field inspections and NDE updates to estimate remaining life and risk-based replacement intervals.

6.2. United States

The U.S. relies on AWPA fungal decay hazard zones, supplemented by extensive field inspection and remedial treatment programs. Utilities use hazard mapping to set retention levels and inspection intervals. Remedial treatments can extend pole service life by up to 30%.

6.3. United Kingdom

UK Distribution Network Operators (DNOs) follow the Common Network Asset Indices Methodology (CNAIM), combining age, condition, and risk-based scoring. Emerging innovations include in-field residual-strength testing and improved pole inspection data models.

6.4. New Zealand

New Zealand's Transpower and EEA guidelines emphasise structured visual/sounding inspections, condition coding, and competency standards. National training standards ensure consistent recording and assessment of wood pole condition.

6.5. Comparative Analysis

• Australia's TSLD explicitly integrates engineering reliability, while the U.S. focuses on empirical decay hazard zones.
• UK DNOs are advancing toward quantified risk-based models (CNAIM).
• New Zealand prioritises practical, system-wide consistency and training.
• Global convergence trends show all regions moving toward condition-based, data-driven asset management.

7. CSIRO Timber Service Life Design Prediction Model[4].

7.1 Overview

The CSIRO Timber Service Life Prediction Model (developed under the 'Design for Durability' project) provides a quantitative method to predict decay progression and service life of timber in-ground—including utility poles, posts, and structural members. It forms the scientific basis for the TimberLife software and Australian durability design guides. The following sections provide a brief summary and critique of the Model and explain how it has been used to create predicted values for comparison with those United Energy calculated from inspection data.

7.2 Model Basis and Data

The model was developed from three long-term CSIRO field tests:
• A 35-year test of 77 untreated heartwood species at five sites.
• A 2.5-year test of radiata pine sapwood at 38 sites.
• A 30-year test of treated wood stakes (CCA and creosote).
It was validated using pole data from Wedding Bells (NSW), Brisbane, and Melbourne test sites.

7.3 Core Decay Model

Decay depth (d_t) over time (t) follows a bilinear relationship:
• A time lag (tlag) before decay begins.
• A steady decay rate (r) once decay starts.

The model considers the decay process for poles in two parts, external and internal.

1.8 Attack Patterns for Round Poles

Decay in a timber pole can initiate both from the perimeter progressing inwards and from the pith zone progressing outwards, as illustrated in Figure 4.5.1. It is observed also that both the lag time and decay rate of treated perimeter sapwood as well as corewood of a timber pole are different from that observed from small stake tests.

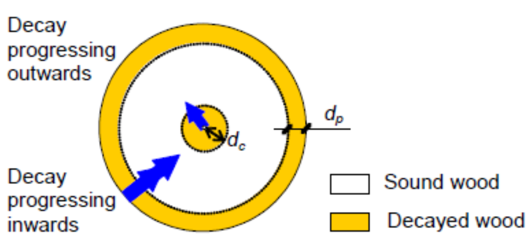


Figure 1.5 Decay patterns of round poles.

[4] Wang, C-H., Leicester, R.H., & Nguyen, M.N. (2008). Manual No. 3: Decay in Ground Contact. CSIRO Sustainable Ecosystems, FWPA Project PN07.1052.

And provides different options for external and internal decay progression based on pole type;

Model parameters for decay progressing inwards

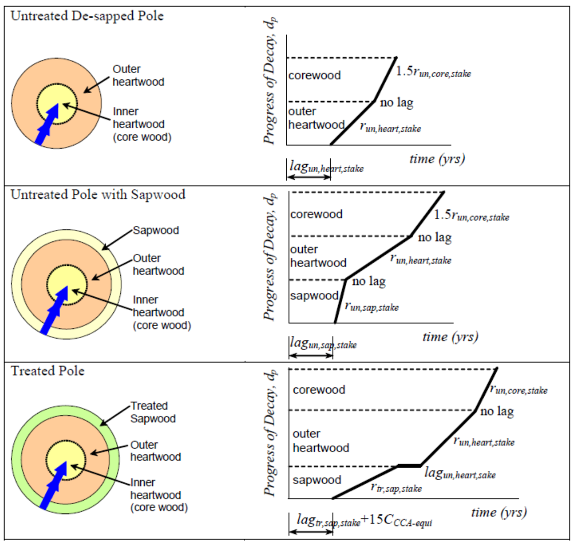


Figure 1.6 Decay of poles progressing inwards

Model parameters for Decay Progressing Outwards

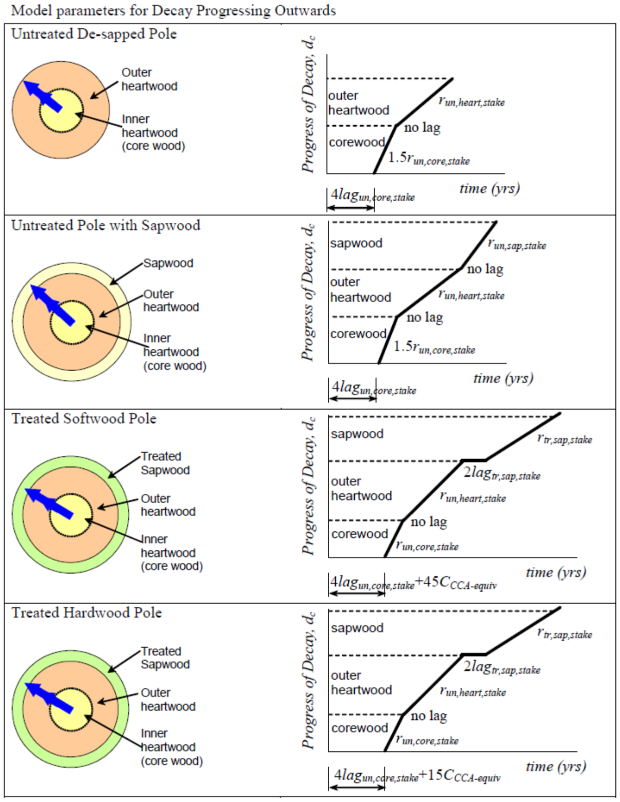


Figure 1.7 Decay of poles progressing outwards

The model offers various *k*-factors/multipliers to allow for Durability Class/wood type, climate, treatment etc and contains some questionable assumptions currently under review (e.g. see Sections 7.6 and 7.7). The service life estimates it provides are merely to be used as a guide and have been created using only a selection of the available options.

7.4 Wood Parameter (*k*-wood)

Wood Type	Durability Class	*k*-wood Value
Heartwood	1	0.23
Heartwood	2	0.48
Heartwood	3	0.76
Heartwood	4	1.36
Sapwood (Hardwood)	-	2.72
Sapwood (Softwood)	-	5.44
Corewood	-	2 × *k*-heart

7.5 Climate Parameter (*k*-climate)

k-climate is derived from rainfall (R), temperature (T), and number of dry months per year and broadly converted to a regional hazard map (more appropriate to above ground decay than in-ground due to moisture retention properties of soils and the presence in many locations of ground water.)

Australian decay hazard zones:

- Zone A – Low hazard (*k*-climate 0.5–1.0)
- **Zone B – Moderate (1.5–2.0)**
- Zone C – High (2.5)
- Zone D – Very High (3.0)

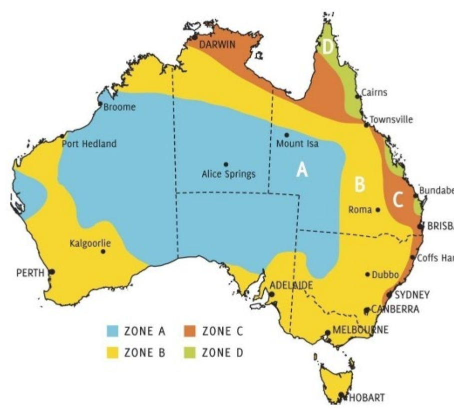


Figure 1.3 A hazard map of Australia for timber in-ground under attack of decay fungi (Zone D is the most hazardous).

7.6 Treated Timber (CCA / Creosote)

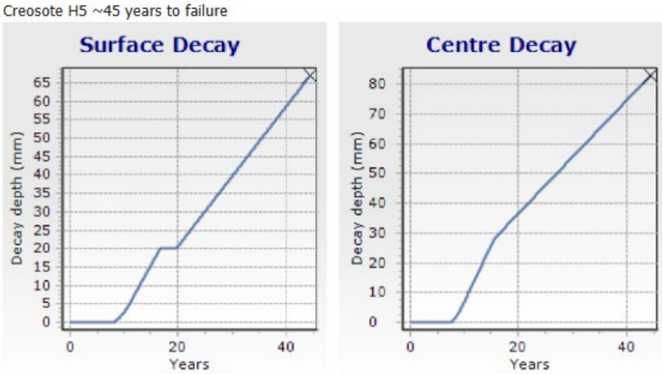
Decay rates for creosote treated sapwood are considered by conversion to CCA equivalents and adjusted for softwoods or hardwoods.

Current hardwood H5 CCA requirement is 1.2% total active elements by mass/mass (TAE m/m) of wood. Current H5 hardwood creosote requirement is 13%TAE m/m and these are deemed (by AS1604) to have equivalent performance. This creates a factor of 0.1 whereas the factor shown in the model appears to be an order out (0.01). Until this discrepancy is resolved (this work is underway with the Australian Timber Pole Research Co-Op) only the CCA data is used and considered to provide (based on the Wedding

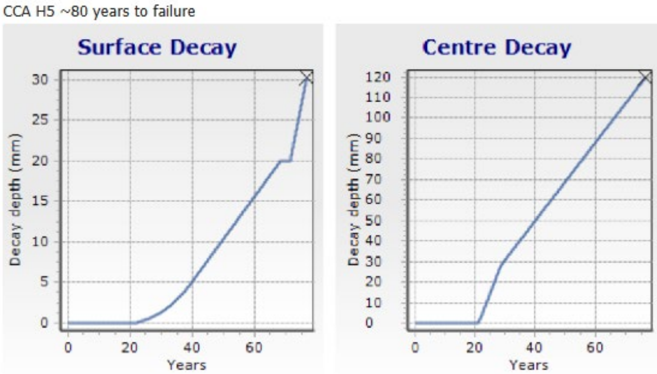
Bells SF etc data) performance slightly under that of creosote treated poles of the same species.

To illustrate how these factors may be affecting the predictions, I have prepared two examples for a Class 3 pole in Zone C treated with either creosote or CCA to H5 the performance should be similar but expected/predicted service lives are quite different;

Creosote H5 ~45 years to failure



CCA H5 ~80 years to failure



This is likely to be incorrect and result from an error in the way the model calculates CCA equivalence for creosote treatment.

7.7 Maintenance and Retreatment Effects

According to the Model maintenance treatments are proposed to add a time lag before new decay starts although these are based on somewhat inappropriate and irrelevant data (e.g. Wedding Bells SF trial where external remedial treatments were installed at the time of original installation rather than after decay had initiated):

- Osmoplastic or Wolman bandage: +5 yrs (perimeter)
- Creosote or Copper naphthenate: +2 yrs (perimeter)
- Internal boron or diffusion chemicals: +5 yrs (centre)

Whilst the concept is probably sound, the blanket advantages that have been applied are too general and do not apply to the most commonly used external treatments. The potential influence of remedial treatments has been excluded from the Model calculations in this instance due to insufficient data supporting these service life extensions.

8. Comparisons of service life performance data from several sources

The sound wood wall thickness measurement is a combination of external and internal degradation resulting from decay and/or termite attack. Rates vary due to differences in durability, exposure situation and preservative treatment.

8.1 UE data

The calculated decay rates for the network poles were supplied by durability class and decades of service. The calculated annual rates for loss of SWWT expressed as mm/year for each Durability Class (DC1-DC3) were;

Decay rate (mm per year)	0-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	90+	**Average**
Class 1	1.06	1.96	2.52	1.75	1.65	2.03	2.15	2.81	2.09	**1.81**
Class 2	1.22	1.89	2.33	3.28	2.57	2.23	3.53	3.75	2.79	**1.95**
Class 3	1.37	1.84	**3.22**	**3.78**	2.73	2.02	2.16	2.88	2.59	**2.28**

These averages include loss to termites and also appear to have included ZZ unknown poles as DC3 as per Network practice (this will have affected the calculated values) and may include other attributes that could be used to refine the data further (such as regional and treatment differences).

There were some questions over the elevated rates observed for Class 3 poles in the 31-40 and 41-50 age groups (highlighted) compared to older poles within the same Class.

This may be due to several factors including changes over time to treatment specifications, variations in pole source/quality or result from the analysis due to small numbers of poles in these groups or through (by default) only considering the better-quality poles that have survived to 60+ years compared to a younger set that contains a more representative range of pole durability. A fuller life-cycle analysis can account for these earlier losses of lower quality poles in the data and provide a more accurate picture of likely decay rates at all age groupings.

Data categories in the supplied spreadsheet that contain questionable or uncategorized data include.

Pole Class: around 1.7% of records
Disc Year (installation date): around 0.5% of records
Year of Measurement: around 0.3% of records
SWWT Measurements: around 1.9% of records
Pole Species: around 0.7% of records
Pole Type: around 0.3% of records

There is overlap/interaction between these categories such that when combined a total of ~4.8% of records are potentially invalid. The current UE analysis appears to have completed some if not all of this data cleansing.

8.2 Anonymous utility (Class 1 poles only)

Data obtained in-confidence from a different utility was used to calculate decay rates for a similar set of network poles however only the Class 1 data were available. These showed a broad similarity with the Powercor/CitiPower/UE data;

Decay rate (mm per year)	0-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	90+	**Average**
Class 1	0.98	2.11	2.29	2.44	2.48	2.48	2.6	2.67	2.32	**2.26**

There were notably higher rates in the 41-50 and 51 to 60 age groups and a higher overall average compared to the UE data. This could be due to a range of factors including a greater reliance on untreated poles and slightly different exposure hazard conditions.

8.3 TimberLife Durability Model

For the purposes of the TimberLife Model, several archetypal poles with nominal dimensions were investigated to calculate approximations of average sound wood wall loss (mm/year) over 50 years. These data are based on the TimberLife model with some minor adjustments to account for likely range of poles in and exposure conditions experienced by Victorian networks. With more work (currently progressing) to identify and refine some of the more questionable assumptions, the model offers a good starting point for predictions. The SWWT decay rates have been approximated from combined external and internal models.

Durability Class	Treatment	Diameter	Sapwood thickness	TimberLife SWWT Decay Rates Zones A to C (mm/year)
1	untreated	300	None	0.1 to 1.1
2	CCA	300	20mm	0.1 to 1.5
3	Creosote[5]	300	20mm	0.1 to 1.9

These predicted rates appear lower than the averages calculated from the UE data but are not calibrated for the effects of termite attack which would significantly increase rates. There are other issues with the decay model (previously discussed) however these values considering they exclude termites do support the rates calculated from the UE data.

8.4 Wedding Bells SF/Country Energy/Integral Energy Assessments

Average external decay data from this ENA project were calculated for spotted gum and blackbutt poles (presented separately and combined as treated Class 2) with either

[5] See previous discussion, in this case the inbuilt calculation for CCA equivalence is ignored.

creosote or CCA treatment to H5/H4 retentions. These average external decay rates are calculated for a 13-year period some 20 to 35 years after installation. They represent only external loss of sound wood (soft rot or surface softening).

Species	Treatment	Annual **external** decay rate (mm)	Approximate Timber Service Life Model Predictions (**External** degradation only)
Blackbutt	CCA	0.19	
Spotted gum	CCA	0.30	
Class 2	**CCA**	**0.24**	**~0.25 mm/year**
Blackbutt	CREO	0.16	
Spotted gum	CREO	0.21	
Class 2	**CREO**	**0.19**	**~1.0[6] mm/year**

These values demonstrate the significant impact that internal degradation/loss can have on overall SWWT decay rates as well as the differences between species and treatments. The protective effect of preservative treatment is particularly strong in the first 20 to 40 years and diminishes with time. They also demonstrate differences between species (of the same durability class), the differences between treatments (that are supposed to be equivalent) and show that the CSIRO Model has some use but also requires improvement particularly with creosote treatments that are so well represented in the UE data.

[6] See previous discussion on CCA equivalence.

9. Conclusion.

The UE data for annual SWWT degradation rates appear compatible with several previous studies (by e.g. ENA or other network operators) and National in-ground durability models. A more in-depth analysis may be possible and additional data cleaning may be required but would offer further opportunities to differentiate between preservative treatments as well as between treated and untreated Class 1 poles, as well as different maintenance planning areas; factors that are known to affect performance. Calculating the relative contributions of external decay versus internal degradation including termite attack is more complex but may also be possible (potentially from termite records and comparison of SWWT with diameter changes.

Alternative, more advanced analysis can allow for poles that have already been removed from the network that may have degraded quicker than those that remain.

10. Report Sign-Off

Prepared by

Name:	Michael Powell
Position/Title:	Timber Consultant
Organisation:	Biotica EC
Signature:	
Contact:	timberadvice@gmail.com
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