ADDRESSING ABOVE GROUND ISSUES WITHIN AGING UTILITY SYSTEMS

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Summary
While most utilities have programs to address decay at groundline, most are only beginning to develop methods for addressing decay higher up on their structures. This paper discusses the types of decay and then outlines some potential approaches for addressing this problem in both existing and new poles.

1. Introduction
The preservative treated wood used to support the North American electrical grid has provided exceptionally reliability and long service life. Much of this performance can be attributed to well written specifications that ensured that a pole was well treated prior to installation and auditing to ensure that these specifications were met. Over time, however, preservatives can slowly migrate from the wood to the point where the protective level of the original treatment declines below a threshold that allows fungi to invade and weaken the pole. Alternatively, seasoning checks that open beyond the depth of the original treatment zone allow fungi and insects to invade the core of the pole. Both of these activities reduce pole properties and shorten service life. Regular inspection and application of supplemental internal and external treatments can arrest this attack and markedly extend the useful life of the pole.

A variety of supplemental treatments have been developed for this purpose (Morrell, 1996; Morrell and Corden, 1986). While they cannot completely reduce the risk of decay, they have reduced the rate to the point where service lives of 60 to 80 years are achieved in many parts of North America (Mankowski et al., 2002). With a few exceptions, however, inspection and application of supplemental treatments has been confined to the groundline region of the pole and the risk of above ground decay in pole tops, cross arms and other areas has been largely ignored. This approach was of little importance when issues at groundline led to much earlier pole replacements, but groundline treatments have improved service life to the extent that poles now remain in service long enough for the decay to develop above the ground. The environments at or below ground differ markedly from those found above that zone and these differences have important implications for biological attack.

The area at or below ground is characterized by the presence of moisture at levels suitable for development of decay over most times of the year (Rhatigan et al., 2002). While moisture levels can vary seasonally and with climate, there is generally sufficient moisture at some point along the pole length for decay to develop. In addition, soil adjacent to the wood contains an abundant
array of potential decay organisms as well as nutrients that can diffuse into the wood to enhance biological activity. As a result, rates of wood decay in soil contact are many times greater than those for similar wood exposed above ground in many locations (Zabel and Morrell, 1992).

The environment above the soil typically represents a lower risk of decay because soil is a potent source of both microbial propagules and nutrients. The above ground environment also tends to have less consistent moisture conditions that result in periods where the moisture content is suitable for decay development and others when the wood is too dry. The result is a slower rate of degradation than would occur in soil under the same climatic conditions. Decay above the groundline is typically more predictable and an index developed by Scheffer (1971) uses average monthly temperature and number of decays per month with measurable precipitation to predict decay risk above ground. This approach has been extended to other countries, including Canada (Morris and Wang, 2008) and has proven to be remarkably accurate. Despite the slower rates of decay, damage above ground eventually becomes an issue in many environments. Decay can be initiated at the top of the pole, particularly when the pole is cut to length after installation (Figure 1). This compromises the treatment and exposes untreated wood to possible fungal attack. Fungal decay can also develop as deep checks penetrate beyond the depth of the original treatment. These checks allow water and fungal spores to penetrate beyond the protective treatment.

Moving down the pole, the risk of decay is primarily driven by the development of seasoning checks that penetrate beyond the depth of the original treatment. It can also develop wherever holes are drilled through the treated zone. The process of decay development in checks or through field drilled holes tends to be slow and highly dependent on climate. For example, above ground decay is much more common in the Pacific Northwest than other parts of North America because heavy winter rains coupled with strong winds tends to push moisture into seasoning checks. A survey of poles in the States of Oregon and Washington showed that over 25% of some lines contained decay fungi.
Figure 1. Example of severe decay in a pole top exposed near Hilo, Hawaii (Morrell and Schneider, 1994). Interestingly, decay fungi were even present in poles located in very dry parts of the region. This suggests that decay may even eventually develop in these poles, but at a much slower rate.

Finally, the crossarm represents a critical, but under-appreciated component in the system. Most crossarms are composed of Douglas-fir, which has a moderately resistant heartwood that performs well above the ground. Arms have also been traditionally treated with pentachlorophenol in heavy oil. Douglas-fir heartwood is resistant to preservative treatment and the resulting process produces only a thin barrier. However, this barrier remains highly effective above the ground because the primary source of fungal inoculum is spores and these tend to be more sensitive to chemicals. The primary problems with crossarm performance are the development of deep checks that penetrate beyond the depth of treatment and surface weathering (Morrell and Love, 2005). Checks on the upper arm surface can collect water that creates ideal conditions for fungal growth. Weathering discolors and weakens the wood surface, but the damage is generally shallow and develops slowly (usually less than 1 mm per decade). Weathered arms are often removed from service due to their appearance. An evaluation of older arms removed from service revealed that, while most were heavily weathered and checked, very few contained active decay fungi and nearly all retained sufficient material properties.

As utilities increasingly utilize the array of inspection tools and remedial treatments to prolong pole service life, the issues associated with above ground decay have begun to take on increased importance. In addition, some utilities are considering how to revise and enhance their initial specifications to produce improved support structures. The remainder of this report will describe
the treatments available for arresting decay above ground and then outline solutions for limiting the risk in newly installed structures.

2. Arresting Above Ground Decay

While there are a diverse array of tools available for detecting and arresting decay at groundline, few of these are effective above this zone. For example, there are a number of non-destructive test methods for detecting decay at groundline, but these become cumbersome and less efficient when used above ground. Similarly, there are a number of internal treatments used to arrest fungal and insect attack. However, many of these treatments are more difficult to use above ground because of the risk of spills or the need for the applicator to be a licensed pesticide applicator. While MITC-FUME (solid methylisothiocyanate in an aluminium tube), dazomet (a crystalline solid that decomposes to MITC, or fused boron rods could all be used above ground, only boron rods have been used to any extent because of concerns about the risk of spills or leakage. These rods are available in two forms, a relatively pure boron system and another that contains boron with supplemental copper. These rods can be effective, but are highly dependent on moisture in the wood (Freitag et al., 2011; Rhatigan et al., 2002). The difficulty with using rods is that they must be placed where the wood moisture content will be above 30% for sufficient boron movement to occur. Field trials on pole stubs indicated that MITC from MITC FUME moved well above ground, while MITC movement from dazomet occurred at much lower levels due to the need for water to decompose activate dazomet decomposition. Boron movement from the rods was also limited and variable. Despite these limitations, boron represents one of the few treatment options for these locations along a pole.

3. Improving Specifications

It is generally easier to prevent decay than it is to stop it once started and the most effective approach in this regard is to improve specifications to prevent the initial treatment zone from being compromised. There are a number of approaches that can be taken.

*Capping of Poles:* The simplest approach to limiting top decay is to avoid cutting poles after installation and then to apply a water shedding cap. Field tests indicate that these caps sharply reduce the moisture content of the pole, thereby reducing the risk of fungal attack (Figures 2, 3) (Rhatigan et al., 2000). Moisture can also be excluded by application of polyurea coatings to the area around the pole top. In both cases, the goal is to exclude moisture (Figure 2).
The other approach to improving above ground performance is to improve the initial treatment. Utilities have long known that drilling numerous holes through the wood around the groundline region or through boring, markedly improves the depth of treatment, virtually eliminating decay in that zone (Morrell et al., 2011; Morrell and Schneider, 1994)(Figure 4). Through boring has slight effects on flexural properties and is widely used across North America to improve the performance of Douglas-fir poles (Mankowski et al., 2000). This process could also be used to protect other zones of the pole. Limited tests on full-length through-bored Douglas-fir poles showed that the process produced deeper, more uniform treatment with no significant negative effect on pole flexural properties (Newbill et al., 1999). One major utility in the U.S. requires through boring of
Figure 3. Moisture contents in pole sections with and without a water shedding cap.

Figure 4. Example of through boring pattern on a glued-laminated time. This process produces nearly complete preservative treatment of the drilled area.

The pole top to reduce the risk of decay development and allow them to field frame poles without fear of creating pathways for decay fungi to enter the untreated core. Through-boring represents
one approach to improving treatment above the ground to reduce the risk of internal decay development.

**Protection of Field Drilled Damage:** Nearly all treatment standards require that any untreated wood exposed through drilling or cutting be supplementally treated with a topical preservative. While it is clearly not possible to replicate the depth of treatment achieved using pressure processes, the goal is to at least provide some surface protection. Unfortunately, these requirements are rarely met. Most line personnel object to the oily nature of the supplemental treatments and it is virtually impossible to confirm that a field drilled hole has been treated.

This failure to protect field drilled holes posed less of a problem when utilities were primarily dealing with energized lines plus a limited amount of telecommunications equipment on a given structure, but the proliferation of cable, internet and other services that require accommodation on a structure have sharply increased the risk of decay development in field drilled holes. The simplest approach would be to increase the number of holes that are drilled prior to treatment, but this requires that attachers have specific sites for their systems and this does not appear to be possible.

At present, may utilities face the unpleasant prospect of knowing that virtually all of their poles contain unprotected holes. One alternative to accepting this fate is to consider using preservative coated bolts. Preliminary trials with bolts coated with copper/boron and copper/fluoride based pastes typically used for external treatments below ground showed that the copper moved to only a slight extent but the boron and fluoride both diffused short distances away from the bolts over a 5 year period. The result is a protective zone around the bolt that can limit the risk of fungal attack above ground. While these bolts are not commercially available, they would offer the potential for the structure owner to require that other utilities attaching to the pole use treated bolts with markings indicated that they met a standard for chemical protection. This would allow the pole owner to used ground-based inspection with binoculars to confirm that a treated bolt was used.

**Crossarm Protection:** As noted, many crossarms appear to be removed because of their appearance and, beyond sounding with a hammer to detect large voids, there are no easily used methods for inspecting these materials in place (Figure 5). Many utilities routinely replace crossarms when they upgrade their wires and there is some logic to this approach, given the high costs associated with bringing line personnel to the energized portion of the system. However, it also means that large numbers of perfectly functional arms are unnecessarily removed from service. Given the difficulty of accurately and economically assessing these arms in place, it might be more prudent to improve the initial specifications to limit the development of deep checks and weather, the two most important causes for removal.
Checking in arms has long been an issue in arms. Checks that open beyond the depth of the original treatment can allow fungi to begin to decay the center of the arm, leading to failure. Checks can also open to the degree that they allow the pins to drop through leading to line failure. Some utilities used metal bands or S-irons to help control checking. Recently, one manufacturer has begun to use end-plates to limit checking (Figure 6). These plates are not new, they have been successfully used for decades to limit splitting in railroad ties. Field tests of penta-treated Douglas-fir arms with and without these plates showed that the plates reduced both the number and width of checks that developed (Figure 7). The results suggest that plates can reduce the risk of splitting and deep check development on crossarms.
The other problem that leads to crossarm removal is weathering. Initial treatment with a heavy oil helps reduce the risk of weathering, but ultra-violet light is a potent surface degrader of wood and even treated arms eventually appear to be degraded. While this damage is generally shallow and does not appreciably reduce material properties, it leads to the perception of weakness and results in early replacement. One approach to limiting the damage associated with weathering is to coat the arms. While conventional paint films might be effective for short time periods, they will eventually degrade and crack. Cracking paint films can sometimes retain more moisture, creating conditions that may actually increase the risk of decay. The polyurea coatings mentioned for protecting pole tops have also been explored for this application for both
protecting against UV damage and limiting woodpecker attack. Field exposures of polyurea coated penta treated Douglas-fir arms near Hilo Hawaii have shown that the coating remains sound and flexible after almost 4 years of exposure to severe UV conditions (Figure 8). These barriers can be applied to the entire arm or to specific location such as the upper arm surface to limit deep check development or to the underside in some locations where specific woodpecker species such as acorn woodpeckers cause problems.

Figure 8. Example of section of Douglas-fir crossarms with or without a polyurea coating and exposed for 3 years near Hilo, Hawaii. The arms show evidence of weathering on the upper surfaces, but the coating remains sound and intact.

4. Conclusions

While the aging utility system will experience increasing levels of decay above ground, there are a number of methods for effectively arresting this damage to further prolong service life. In addition, there are a number of methods for improving the quality of newer poles and crossarms that enter the system to ensure that these materials provide even longer, reliable service than their predecessors.
5. Literature


