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Factors affecting the service life of poles in BC

Leon A. Joseph

British Columbia Hydro
Engineering Quality Management
Burnaby, B.C.

Abstract

For more than a century, BC Hydro has relied extensively on wood poles to support overhead Transmission and Distribution power lines. The following report presents a historical overview of "lessons learned" over the years regarding wood species selection and the use of treated wood. It will explain progressive steps that BC Hydro has taken to address performance, safety and environmental issues as they emerged. Several pole-related concerns and observations will also be discussed that may be of interest to other utilities and the wood pole manufacturing sector.

Introduction

In1883. BC Hydro's predecessor, the Victoria Electric Illuminating Company energized the first commercial electric lighting system in Canada. This spurred a province-wide demand for electrical service in the many fast-growing BC communities. Subsequently, the construction of power lines became a very common sight in all parts of the province. Obtaining poles and timbers for projects posed no challenge. The forests of British Columbia contained an abundance of high-grade cedar pole material.

Constructing power lines in British Columbia was a daunting task. The Province's rugged terrain and harsh weather conditions made the work very challenging for line crews. Rockslides and avalanches frequently disrupted construction projects or damaged energized power lines. There was also BC's biological diversity which comprises a remarkable variety of ecosystems spread over 95 million hectares. Prior to the 1960s, the wood destroying mechanisms that were common to each area did not appear to generate much concern. It appears that the principal focus of line designers and construction managers was the electrification of the province.

This mindset continued for several decades despite the numerous premature failures that occurred due to decay and insect attack. It is likely that BC Hydro's predecessors anticipated and accepted the frequent disruptions to electrical service. Pole failures were a risk of doing business in a very hazardous environment. At the same time, rebuilding power lines consumed valuable resources that could have been used to expand the Province's electrical system. As years passed, it became very apparent that improving the service life of wood poles represented a tremendous savings for BC Hydro.

The consensus of line managers was that wood specie selection and the use of wood preservatives were two crucial factors that needed to be addressed in BC Hydro's long-term business plan. Unfortunately, the turmoil that engulfed the world during the first half of the 20th Century severely curtailed the spending of additional funds in order to purchase treated wood poles. During the depression era and the war years, many construction projects had to be postponed due to the Province's struggling economy.

Following World War II, most North American utilities experienced a construction boom that quickly depleted the cedar inventories of local pole suppliers. Subsequently, BC Hydro found it necessary to purchase alternate species. The treating plants in British Columbia also had to deal with frequent disruptions in the supply of creosote and the petroleum oil required for the treating solution. This meant that many of the non-cedar poles that BC Hydro purchased during the 1960s were untreated when they were installed. As anticipated, the service life of those alternative species was significantly less than that of the cedar.

By the 1970s, BC Hydro determined that improving the service life of wood poles required a cradle to grave approach. This led to the formation of a "Quality Control and Inspection" department (the predecessor of BC Hydro's Quality Management department). The principal responsibility of this new department was to monitor the quality of construction materials and electrical equipment purchased for generating facilities, substations and power lines.

Poor choices contribute to poor service life

An overly simplistic approach to purchasing and working with treated wood products was a common mistake that many user groups made in the past. Often, the responsibility of specifying or purchasing wood poles rested on the shoulders of ones with a very limited knowledge of wood characteristics or wood preservation technology. Despite their good intentions, poor choices were made that resulted in premature pole replacements or catastrophic failures.

The newly formed Quality Control & Inspection department offered a new approach to working with treated wood. Designers, specification writers and purchasing agents now had a team of knowledgeable individuals available for consultation when selecting products, such as wood poles. The duties of the Timber Section of QC & I encompassed a wide range of cradle to grave activities that included product evaluations, tender reviews, factory inspections, assessing used material and performing premature failure investigations. The Timber Section also provided BC Hydro personnel and private contractors with training that broadened their understanding of wood performance issues and the benefits of wood preservation. The goal of this training was to prevent ones from making poor choices involving treated wood.

Key factors that are within a utility's ability to address

Today, having a well-structured maintenance program in place is a very effective means of extending the service life of treated wood poles. Though this is true, BC Hydro believes that there are other factors that are within a utility's ability to address that can also have a significant impact on the performance of wood poles. One of these factors concerns the individuals, who are responsible for product selection. To ensure that the products they select are the most suitable for their intended use, these ones need to be familiar with the following:

- Know the hazards of the service area where the poles will be installed
- Know what type of poles to buy
- Know how to handle, store and work with treated wood
- Know when to buy wood poles?

BC Hydro has noted that when decision makers receive training relevant to performance related issues, they tend to be more proactive in how they deal with wood poles. They have a better understanding of the many challenges and unforeseen difficulties that are inherent to wood pole manufacturing and wood preservation. They also have a better understanding of the needs and concerns of line and construction crews.

Wood Pole Species Selection

Placing too much weight on the purchase price of a product is another common error that utilities tend to make. Often, the long-term financial benefit of purchasing a superior product that is slightly more expensive does not receive proper consideration. This usually happens when a business case does not present sufficient data to justify the spending of additional funds. For example, a business case that includes technical and performance data along with a life-cycle analysis report carries a lot more weight than a case that is solely based on personal opinions or unsubstantiated predictions. This analogy reflects BC Hydro's history relevant to wood pole species selection.

The following is a record of BC Hydro's wood pole purchases relevant to species:

- **1864 – 1950:** **100% Cedar (mostly untreated)**
- **1951 – 1975:** **Cedar**
Lodgepole pine
Douglas fir
Western Larch
Hemlock
- **1976 – 2009:** **Lodgepole pine**
Cedar
- **2009:** **100% Cedar**

From 1864 to 1950, the only two wood species that BC Hydro specified for poles were Western Red Cedar and Yellow Cyprus (Yellow Cedar). It appears that construction planners had the final say as to whether or not the poles required treatment with a wood preservative. They assessed the need for treatment based on factors such as, the environmental conditions of a construction site and the accessibility of the line. The average life span of the untreated cedar poles ranged from 30 to 35 years with a small number surviving considerably longer.

During the construction boom years of the 1950s and 1960s, BC Hydro found it necessary to purchase alternative species, such as Lodgepole pine, Douglas fir, Western Larch and Hemlock. A large number of these poles were also untreated when they were installed. This proved to be a very costly mistake. The service life of these alternative species ranged from 7 years to 25 years, depending on their service area.

The service life of the alternate species that were treated prior to installation greatly depended on the thickness of their treated shell.

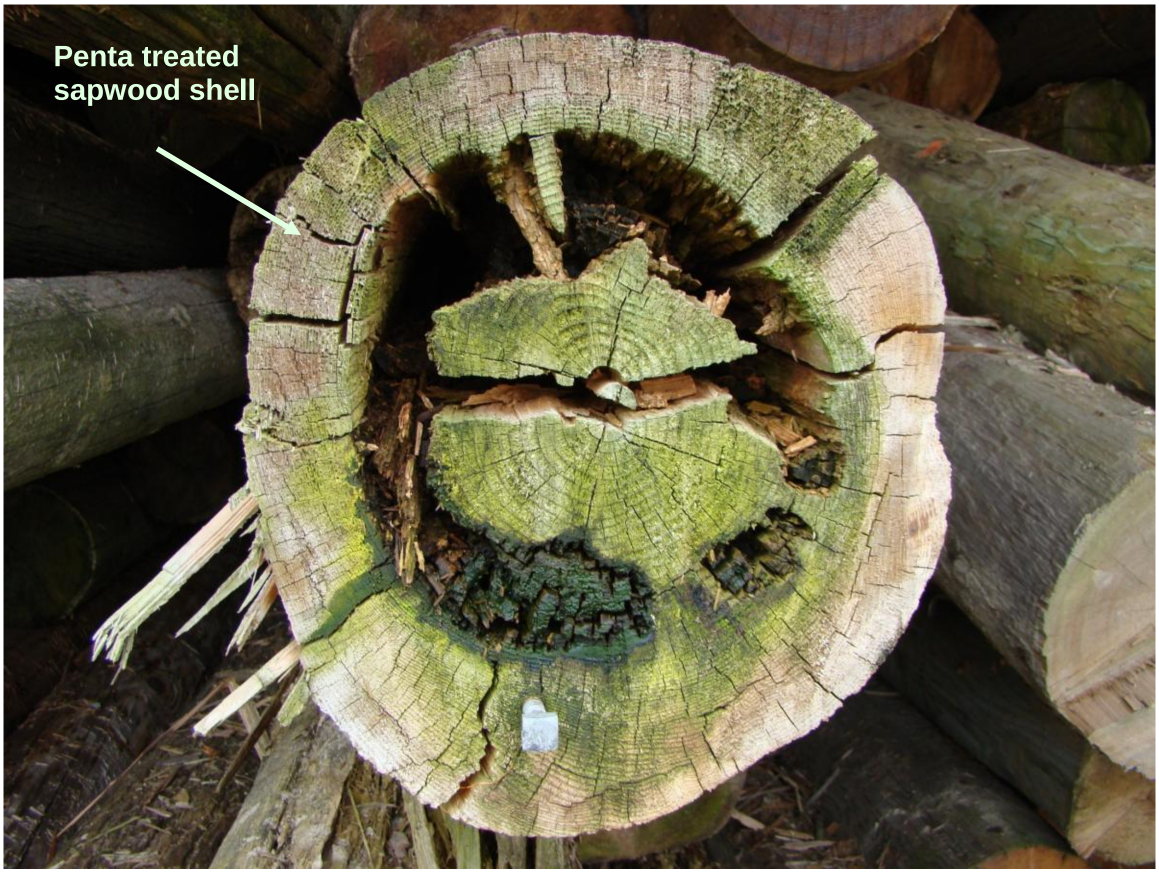

Photo 1

The value of treated wood is clearly seen in photo 1, which shows the butt of a 26-year-old, Pentachlorophenol treated Lodgepole pine pole. Though the heartwood of the pole contains extensive damage caused by brown rot fungi, the treated sapwood shell is still in very good condition. This raises an important strength-related point for discussion regarding a weakness in the minimum chemical penetration requirement for Lodgepole pine and Douglas fir poles as presented in the CSA 080 Wood Preservation Standard.

The outer 50mm (2”) shell of a pole represents 80% to 90% of a pole’s bending strength. Compare this to the minimum chemical penetration requirement of 19mm (3/4”) for of a Lodgepole pine or a Douglas fir pole. The weakness that exists between these two factors concerns the heartwood of these two species. It is common knowledge that decay fungi can easily infect the untreated heartwood of Lodgepole pine and Douglas fir products used for ground contact applications. If decay develops at a depth of 20mm to 50 mm in a pole that only has a 19mm (3/4") treated shell, the bending strength of the pole can be significantly reduced to a point that the pole experiences a catastrophic failure.

Photo 2

Photo 2 & 3 highlight another characteristic of Lodgepole pine that has proven to be very problematic for BC Hydro. Bark inclusions are a common characteristic that can range in number from a single pocket to dozens scattered the full length of a pole. The problem these inclusions present concerns the depth of the treated shell at the base of each inclusion. Premature failure investigations have determined that internal decay in Lodgepole pine is often linked to bark inclusions in poles that have a minimal yet acceptable sapwood shell thickness.

This was determined by extracting wood cores from poles that contained inclusions and decayed heartwood. The intent was to compare the depth of the treated shell in close proximity to an inclusion with the depth of the treated shell at the base of an inclusion. In most cases, the wood core samples clearly showed a dramatic difference in the thickness of the treated shell. For example, if the wood core that was extracted close to a pocket had a treated shell depth of 25mm (1"), the core extracted from the base of the pocket often would only have a treated shell depth of approximately 6mm (1/4"). In some cases, the core samples revealed that there was no chemical penetration at the base of some inclusions.

Photo 3

Paragraph 4.4.8.2 of the CSA 015 Wood Utility Pole Standard restricts the presence of bark inclusions in the ground line zone of a pole, but does not limit their presence or number outside of this zone. BC Hydro's investigations noted that inclusions located above the ground line zone were serving as doorways for fungal and/or insect attack, especially if the bark was not completely removed from the inclusions. (photo 3)

Factory Seconds Dilemma

Over the past several years, the misuse of factory seconds has been controversial problem that BC Hydro is currently attempting to resolve. As a Crown Corporation, BC Hydro frequently accepts ownership of pole lines built by private contractors. The line takeover agreement clearly states that all the materials used in line construction must conform to the requirements of BC Hydro's specifications. Despite this agreement, a province-wide investigation of premature pole failures involving line takeover projects revealed that many of the wood poles were substandard. Investigators noted that most of the poles contained evidence of rejection marks that were applied by BC Hydro inspectors during factory inspection visits.

Once again, the focus has been on Lodgepole pole pine. The majority of the failures were linked to poles that did not have an adequate treated shell. Photo 4 shows the cross section of a pine pole cut at approximately 280 cm (9') from the butt. The ground zone of this pole contained extensive brown rot fungi, which caused the pole to fail after only 13 years of service. It is clearly evident in the photo that the pole did not remotely conform to the 19mm chemical penetration requirement specified in the CSA 080.2 Wood Preservation Standard, Table 11. (photo 4)

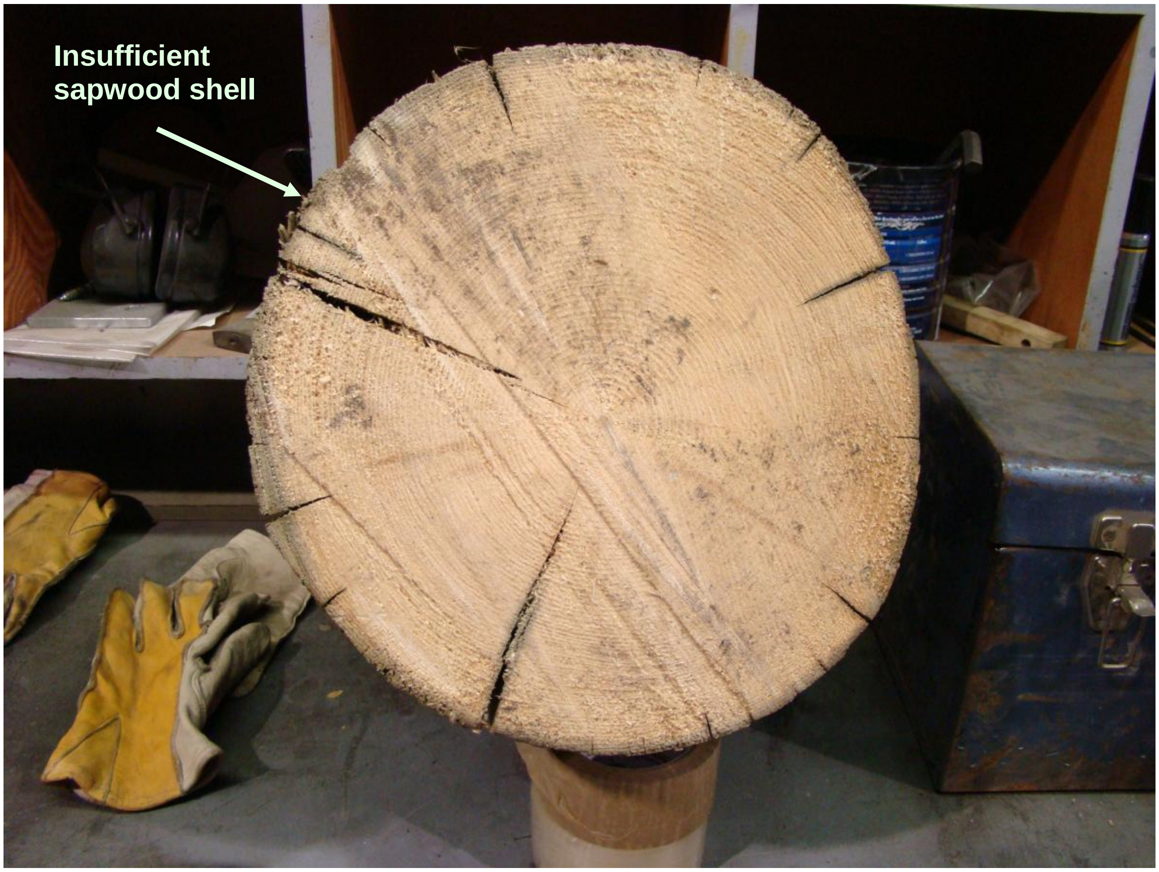

Photo 4

The Mountain pine beetle epidemic also raised a raft of concerns regarding the use of Lodgepole pine for poles. Once again, BC Hydro's concern focused on the sapwood of Lodgepole pine and its relation to the bending strength of a pole. Research has clearly demonstrated that beetle-kill trees can be salvaged and manufactured into various dimensional products, provided the trees are harvested within a reasonable amount of time. If decay is detected during sawing, it can easily be cut out and discarded. This is not possible for poles.

It is generally accepted that the presence of blue stain fungi (photo 5) does not adversely affect the strength of the discolored wood fiber. The concern is that, the longer the dead trees stand in the forest, the greater the possibility that decay fungi will develop in the stained sapwood. One of BC Hydro's suppliers has reported that a high percentage of the raw pole stock arriving at their plant contains pockets of brown rot fungi. As the race to salvage merchantable material continues, the supplier anticipates that the rejection rate of raw stock they are receiving will increase. The concern that utilities need to consider is that the presence of incipient decay can very easily go undetected. If the sapwood of a pole contains incipient decay prior to treating, it is very possible that the bending strength of the infected pole is lower than required for the particular class of pole.

Photo 5

BC Hydro is also concerned that, if the dead trees are not promptly harvested and peeled, it is likely that infestations of wood boring insects will occur. In the late 1990s, BC Hydro had to remove several hundred Lodgepole pine poles that were severely damaged by the larvae of Golden Buprestid beetles (*Buprestis aurulenta*). (photo 6) Internal records confirmed that the trees used to manufacture the poles were harvested from a forest fire area. Prior to logging, the injured trees stood for approximately two years. This was more than sufficient time for the buprestid beetles to move into the area and infest the trees. The beetle larvae, which survived the thermal treating process, were present in the heartwood of the poles for approximately 30 years prior to emerging as adult beetles.

This prompted BC Hydro is issue a province-wide alert, instructing line crews and contractors to pay particular close attention to the condition of all the pine poles in BC Hydro's system. Before attempting to climb or work on a pine pole, they were instructed to look for Buprestid exit holes. Within a relatively short timeframe, crews identified several thousand Lodgepole pine poles containing exit holes and internal damage caused by beetle larvae. A dissection of one particular pole that experienced a premature failure detected Golden Buprestid and Powder Post beetle larvae, pill bugs, termites and Carpenter ants. Woodpeckers also inflicted extensive damage as they feasted on the plump larvae. To eliminate the presence of insect larvae, in 1998, BC Hydro specified that all new pine poles had to undergo a sterilization process. This was an attempt to save the species and to calm the fears of ones, who questioned the continued use of pine. To achieve sterilization, suppliers used a conventional dry kiln.

Photo 6

Regardless of the species, the amount of time that passes from harvesting to bark removal can have an impact on the service life of a pole. Following bark removal, the manner in which poles are stored is also important. Photo 7 presents a good example of a storage yard that is free of vegetation and standing water. Poles should be stacked in a manner that allows for air circulation.

Photo 7

For many decades, wood pole species selection was a debated subject during procurement meetings. Line crews preferred cedar because it was by far the easiest species to climb. Storage yard personnel claimed that pine poles tended to be too brittle and therefore, easily broken during handling. On the other hand, the cost of cedar was significantly higher than pine. From a financial point of view, it did not make sense to purchase fewer poles for the same money.

In 2007, BC Hydro launched a Strategic Sourcing Project for wood poles. After a careful evaluation of life cycle analyses, the committee arrived at a decision to purchase only cedar poles. The Sourcing Committee concluded that the initial lower cost of the alternative species did not justify their poor performance. In March 2009, BC Hydro returned to its roots and made the switch to 100% cedar.

Wood Preservative Selection

The following is a breakdown of the various treatments and processes applied to poles purchased by BC Hydro.

- **Hand Treat:** **1864 – 1965: Creosote**
- **Butt Treatment:** **1905 – 1967: Creosote**
  1968 – 1990: Pentachlorophenol
- **Full Length Thermal:** **1941 – 1967: Creosote**
  1948 – 1990: Pentachlorophenol
- **Full length pressure:** **1910 – 1967: Creosote**
  1959 – 1990: Pentachlorophenol
  1974 – 1984: ACA
  1979 – Present: CCA

Prior to 1965, the majority of the poles installed by BC Hydro were untreated. When or if creosote solution was available, it was applied to the ground-line of a pole using a brush or a broom. For poles installed in close contact to salt water or in standing water, designers specified full-length creosote treatment.

BC Hydro's use of butt-treated cedar had mixed results that led to another lesson learned. The survival rate of butt-treated poles installed east of the Coastal Mountains was reasonably good. In contrast, the service life of poles installed in coastal areas was inconsistent and unpredictable. After only a few years of service, a large percentage of the poles quickly developed top rot to a degree that they required replacement or special remedial work. Defying the odds, are a small number of butt-treated poles that were installed in the 1950s, yet are still in good condition today. Though weathered and bruised on the outside, their interiors are still completely sound.

It was also noted that untreated Douglas fir crossarms attached to butt-treated poles did not perform as well as the crossarms attached to full-length treated ones. (Prior to the late 1960s, all the crossarms in BC Hydro's system were untreated.) When top rot developed in a butt-treated pole, the decay soon spread to the untreated crossarm. (photo 8) This observation prompted BC Hydro to reformulate its Test & Treat procedures, which primarily focused attention on the ground-line zone of a pole. Today, maintenance and line crews are required to assess the condition of the entire body of a pole, as well as the crossarm. The remaining butt-treated poles installed in coastal areas are currently being monitored to ensure they do not pose a safety hazard.

Photo 8

Photo 9 shows the extent of damage that may be present in a butt-treated pole installed in a coastal area of the Province. (photo 9) Though the shell of the pole in the photo appeared sound, just below the surface there was extensive decay. Line crews have to be very alert to the fact that this type of damage can be present at any location on a butt-treated pole.

Photo 9

The environmental movement of the 1980s inspired BC Hydro to take a close look at the company's practices and policies related to the use treated wood. In particular, the contamination of storage facilities was a problem that had the potential to generate a great deal of negative media attention and social concern. For this reason, the cleanliness of wood poles and other treated products became a top priority. The archaic belief that a properly treated pole was one that was "black and oily" was no longer appropriate. The new catch phrase "clean to the touch" became a requirement.

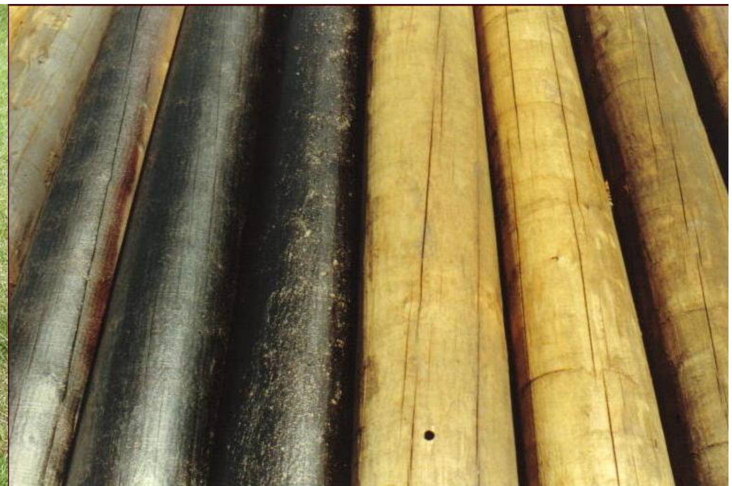

Photo 10

Photo 11

Tests were performed on several BC Hydro owned storage facilities to determine the level of contamination that was believed to be present under pole decks. The test results revealed that the soil contained levels of Pentachlorophenol that was considerably higher than anticipated. (photo 10) This proved to be a very costly lesson learned that reinforced the need to ensure that treated poles and timbers did not experience chemical bleeding.

The heightened environmental awareness was also reflected in the number of complaints received from field crews and local residents. Attempts to clean poles that were experiencing chemical bleeding after installation were mostly unsuccessful. (photo 11) The exercise only served to generate more concern and suspicion.

Photo 12

Another concern that BC Hydro had regarding Pentachlorophenol was the possibility that workers or residents could be exposed to trace levels of harmful dioxins. This concern primarily focused on poles damaged during grass burning or forest fires. Though most research claims that the type of dioxins that might be present in Pentachlorophenol are not harmful, it is acknowledged that exposure to extreme high temperature can dislodge chlorine molecules, thus altering the toxicity of the dioxins.

After several years of failed attempts on the part of BC Hydro's suppliers to eliminate Penta bleeding and dirty poles, BC Hydro decided to impose a moratorium on the purchase of Penta treated material. In 1990, BC Hydro's wood pole specification no longer listed Pentachlorophenol as an acceptable form of treatment.

On a more positive note, when exposed to fire, Penta-treated material tends to fair considerably better than that of CCA or ACA treated wood. In most cases, the fire damage is only superficial. In contrast, salt treated poles often experienced a condition known as afterglow or "embering" that can slowly consume a pole after a grass fire is extinguished. (photo 13) It appears that the absence of visible flames causes the person tending the fire to presume that it is out and that the exercise did not damage the pole.

Photo 13

In 1984, BC Hydro abandoned the use of ACA treated poles. Though ACA was a very effective wood preservative, its corrosive nature severely damaged the metal hardware attached to freshly treated material. (photo 14) On many occasions, crews had to replace the pole bolts after one year of service.

Photo 14

For the past twenty years, the only wood preservative that BC Hydro has specified for the initial treatment of new wood poles has been CCA Type C. The decision to use only CCA was based on a thorough evaluation of the pros and cons of all the available preservatives. The task force assigned to perform the evaluation concluded that CCA was by far, the easiest wood preservative to control.

BC Hydro believes that the key to preventing site and storage yard contamination is the strict enforcement of the "clean to the touch" requirement. During factory inspections, the presence of CCA contaminated surface deposits on poles or timbers is grounds for rejection. Prior to acceptance, suppliers must thoroughly wash any pole or timber that is not clean to the touch.

In 1996, BC Hydro revised its wood pole specification to require a mechanical fixation process of all CCA treated material. The purpose of this revision was to ensure that Chrome VI was not present in the poles or timbers delivered to storage yards or construction sites. BC Hydro did not specify the particular method that a supplier had to employ in order to achieve complete fixation. They could use a conventional dry kiln, a steam tunnel or a hot water bath. Photo 15 shows the first fixation tunnel to operate in British Columbia. It was a little rustic, but it did the job.

Photo 15

One of the characteristics of CCA that sets it apart from the oil-borne preservatives is that once the chemical components are fixed in the wood, they do not leach out. This characteristic ensures that properly treated poles will not experience chemical bleeding after installation…unless?

The CSA 015 Wood Utility Pole Standard permits ***firm red heart*** in poles. This provision is problematic because very few pole graders can differentiate incipient decay from firm red heart. The Standard also permits the decay in the knots and the butt of a pole.

These defects can pose a chemical bleeding problem for poles that are treated during subzero temperatures. CCA solution saturates the areas containing decay, but does not bind to the damaged wood fiber. When the poles are removed from the treating cylinder, the free CCA solution inside the damaged areas can freeze solid. Days or weeks later, when the pole is exposed to warmer temperatures, the frozen CCA solution melts and drains out the decayed areas. (photos 16 & 17) This can result in the contamination of a storage yard or a construction site.

Photo 16 **Photo 17**

Photo 17 presents an example of the level of chemical bleeding that can occur when a frozen pole thaws out after installation. The pole in the photo is situated on the corner of a busy street in North Vancouver. It was very fortunate that the individual who detected the problem did not make it a public issue. Incidents like this have the potential to spark a great deal of negative publicity. As soon as the problem was reported, BC Hydro dispatched a crew to wash the sidewalk with a special cleaner.

Other points of interest

Certain defects in poles are not easily detected during manufacturing or at the time of a pole's installation. Several months or years may pass before the presence of a defect may cause a problem, such as a premature failure. The balance of this report with focus on defects that BC Hydro has encountered that may be of interest to other utilities and wood pole manufactures. Photo 18 presents an example of an unusual defect that is difficult to detect during manufacturing.

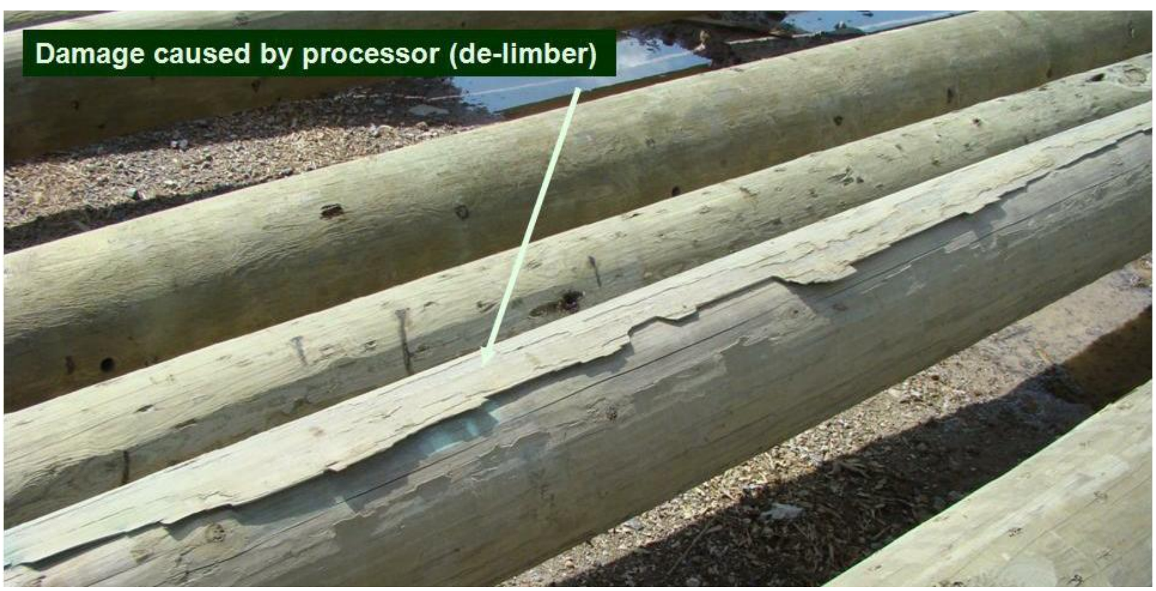

Photo 18

The damage that is clearly visible in the photo was caused by a mechanical processor, which is used to remove the limbs of a tree. During branch removal, a notice operator may apply too much pressure to the rollers that feed the tree through the de-limber. This usually happens during the winter months when there is ice and snow on the trees. When the rollers begin to slip, the operator applies more pressure in attempt to hold the tree in place. If the pressure is excessive, the rollers can crush the tree's outer growth rings. The resulting damage is not evident until the moisture content of the wood is well below the fibre saturation point. Eventually, the damaged layers will begin to cup and separate from the body of the pole.

This poses a danger to line personnel, who may have to climb a pole at times when visibility is poor, such as, night or during harsh weather conditions. The splintered fibre can cause a climbing spur to kick out or it can slice through the climber's protective clothing and cause an injury.

Internal heart rot can develop in the body of a living tree. During manufacturing, there may be no evidence of the rot on the outer surface of a pole, including the top or the butt. (photo 19) If the internal damage is extensive, the pole will most likely break during handling or installation. Whatever the case, any pole failure has the potential to cause personal injury or collateral damage. For a utility, identifying safety hazards and preventing accidents is a top priority.

Photo 19

Photo 20

A clear sign of internal rot is chemical bleeding from soft knots and drilled holes. (photo 20) This condition is most prevalent shortly after a pole has been removed from the treating cylinder. After a few days, the bleeding will usually stop. Other than a slight discoloration around the knots and the holes, there may be no evidence that the pole has internal damage. This emphasizes the importance of performing a physical examination of every pole as part of the post-treatment quality control procedure.

BC Hydro inspectors have noted that manufacturers, who limit their post-treatment inspection to core sampling and performing assays, tend to have a significantly higher rejection rate. Common post-treatment defects include; split tops, split butts, felling breaks that were not detected by graders and mechanical damage incurred during the loading and unloading of the treating trams. All of these defects can be easily be detected during a post-treatment inspection.

Western Red Cedar is traditionally referred to as a thin sapwood species. This characteristic is particularly evident in old growth trees harvested for Transmission-size poles. During bark removal, peeler operators need to exercise special care in order to avoid exposing patches of heartwood. A pole that contains exposed heartwood is called a "Red Bird". In nearly all cases, the growth rings of a Red Bird are extremely narrow with little difference in the appearance of the springwood compared to the summerwood.

Over the past several decades, BC Hydro inspectors have noted a gradual increase in the sapwood thickness of many Distribution-size cedar poles. (photo 21) Though increased sapwood depth does not impact the strength of a pole, it does make achieving BC Hydro's treatment requirement of 100% sapwood penetration more difficult. On a positive note, maintenance personnel have found that CCA treated cedar poles with deep sapwood rarely require a pole bandage.

It is believed that the deeper sapwood in poles is linked to climate change and today's modern reforestation practices. Many areas of the province of British Columbia are enjoying longer growing seasons and higher levels of precipitation. These factors combined with modern silviculture practices such as, the spacing of seedlings and forest thinning appear to be affecting the way trees grow.

Photo 21

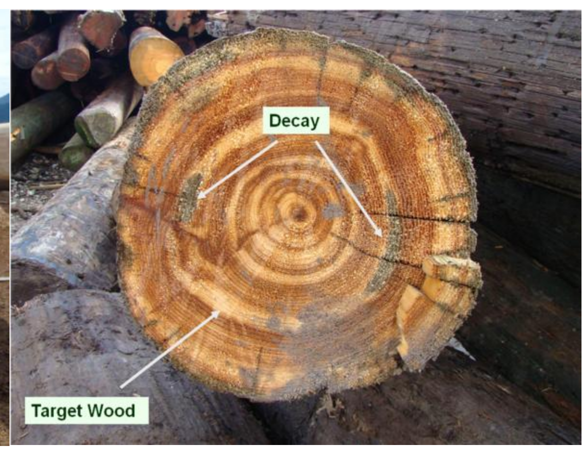

Photo 22

Another change that has been noted is an increase in the presence of ***"target wood"*** in cedar poles. This condition, which is also referred to as "included sapwood" is an undesirable characteristic because its wood extractives content and decay resistance is similar to sapwood. (photo 22) It is similar to heartwood in that it is resistant to penetration with wood preservatives.

Photo 22 presents an example of how pockets of decay can form in the bands of target wood. If these bands are close to the surface, a pole may experience a condition known as "banana peeling". This occurs when decay develops along the growth rings, immediately under the treated sapwood shell. As the decay spreads, the shell will separate from the body of the pole presenting a climbing hazard for line crews. Eventually, the decay will also consume the heartwood to a degree that the pole will require replacement.

Spiral grain is a condition that develops in a living tree. The CSA 015 Wood Pole Standard limits the degree of a spiral that may present in a utility pole, according to the length of the pole. The problem that spiral grain presents for a utility is that occasionally a pole will continue to twist after it has been installed in a power line. This twisting changes the alignment of the crossarm and the tension of the wire. A question that many utilities have been left to ponder is: Why do some poles that contain spiral grain twist after installation, while others do not?" BC Hydro has determined that the orientation of the spiral is the determining factor.

Right-hand

Left-hand

Photo 23 **Photo 24**

The difference between a right-hand and a left-hand spiral is not solely the direction of the grain. During the first few years of a tree's life, its grain usually grows in a straight upward direction. It may wander slightly to the right or left then return to straight. As the tree approaches maturity, a more dramatic clockwise spiral may develop. This is called a right-hand spiral or a sapwood spiral. (photo 23) BC Hydro has determined that a pole that contains a right-hand spiral rarely experiences any degree of twisting. It is believed that there is sufficient straight grain in the body of the pole to counteract the forces generated in the spiralled grain when natural shrinkage occurs.

In contrast, a left-hand spiral develops at the pith of a tree and continues to grow in a counter-clockwise direction throughout the tree's life. (photo 24) Since there is no straight grain present, when the wood fibre dries and shrinks, the spiral tightens thus causing a pole to twist.

Poles installed in sidewalks are a very common sight in most urban areas. (photo 25) While it may look ascetically pleasing, a pole installed in concrete or pavement may be providing an ideal environment for decay to develop. If the water table under the sidewalk is close to the surface, the concrete can serve as a barrier that inhibits evaporation during periods of hot weather. This can create a greenhouse environment under the concrete in which decay can flourish.

Photo 25

Photo 26

Photo 26 provides an example of a pole damaged by soft rot fungi. The presence of soft rot and the location of the decay are both very unusual. Decay normally occurs in the ground-line zone of a pole, not at the depth shown in the photo. The tests performed during maintenance inspections would not detect the presence of this type of damage. When several poles were discovered to be in a similar condition, BC Hydro's Quality Management department attempted to isolate any factors that the poles had in common.

The most significant factor was the development of soft rot, which is not normally found in a pole. This was attributed to the unusually high moisture content of the soil where the poles were installed. The second factor was that all of the poles were installed in either concrete or pavement. BC Hydro believes that these two factors created an ideal environment that precipitated the development of soft rot. The lesson learned in this case was that poles installed in a sidewalk or pavement should have a buffer zone of drain rock to facilitate evaporation and drainage. For added protection, it has been suggested that barrel shelves could be implanted in a sidewalk to keep the drain rock in place.

Vegetation clearing is another effective means of extending the service life of a pole. Unfortunately, it is also a losing battle for utilities. In British Columbia, the only thing that grows faster than vegetation is..., well, nothing grows faster than vegetation around a pole. Where there is vegetation, there is moisture. When combined, these two factors provide a fertile environment for decay fungi to develop. Where there is decay, there are usually insects hard at work.

During the past two decades, BC Hydro has noted a dramatic increase in the number of poles found to contain insect nests. Traditional insects such as, Powder Post beetles, pill bugs, centipedes and millipedes are often found in pockets of internal decay. Though all these insects are unwelcome pests, the spotlight has recently been focussed on one particular invader. This unwanted guest is growing in numbers and is on the move.

In recent years, ***Termite infestations*** (photo 27) have become increasingly common in the southern areas of the Province. BC Hydro believes that climate change is encouraging termites to expand northward into areas not considered termite zones. It may also be accelerating the population growth of termite colonies.

Photo 27

The presence of termites in a pole presents a threefold problem. First, termites can inflict a great deal of damage in a very short span of time. BC Hydro's maintenance program commences after a pine pole has been in the ground for (14) years and (20) years for a cedar pole. Follow-up inspections are performed every (8) years for the remainder of a pole's service life. If termites infest a pole prior to the first inspection or in the 7^{th} year thereafter, the extent of the damage will usually exceed the limitations defined in the maintenance procedures. The inspector will have no choice but to condemn the pole and tag it for replacement.

The second problem concerns the disposal of termite-infested wood. When a pole is removed from service, it is transported to a local storage yard where it is held until a truckload of rejected material is accumulated. The pole is then forwarded to a disposal facility where it may also sit for a while before it is processed. The concern is that the transporting of infested material around the province may be facilitating the spread of termites to areas that were previously termite free.

The third concern involves another insect that is known to have an overwhelming appetite for termites. These inexorable conquerors are ***Carpenter ants***. (photo 28) If they detect termites in a pole, they will launch a well-organised attack that can result in further damage to a pole. It has been observed that ants will often establish a nest directly above a termite colony. From this point, they will devour the termites and any other insects nearby.

While termites may be slobs of the forest, carpenter ants rate a Good Housekeeping seal. They sculpt long caverns along the growth rings of a pole, ejecting the sawdust as they tunnel. Their nests, which they will aggressively defend, tend to be very neat and artfully designed.

Photo 28

When attempting to assess the extent of damage caused by carpenter ants it is helpful to keep in mind that: the larger the ant, the older the nest, likely, the more severe the internal damage. Sawdust around the base of pole is a sure sign of carpenter ant activity.

When discussing climate change, subject experts often refer to a chain of events that is predicted to affect the Earth. For wood poles, the third link in the enemies of wood chain would have to be the ***woodpecker***. (photo 29) Where there is decay, there are insects and where there are insects, there are woodpeckers. Southern British Columbia appears to experiencing a huge increase in the woodpecker population. This conclusion is based on the number of complaints that have been received from field crews regarding woodpecker damage. Reports from the Gulf Islands and Vancouver Island claim that the number of poles that contain woodpecker holes has reached an unprecedented level.

Photo 29

BC Hydro believes that insect infestations can be discouraged by preventing moisture from entering a pole. This conclusion is based on the premise that, if the interior of a pole is dry, it is very unlikely that decay fungi will start to grow. In turn, the absence of a food source should render a pole unattractive to insects. An effective means of achieving this goal is the use of barrel sleeves and drain rock. (photo30)

Photo 30

BC Hydro anticipates that the additional cost of this enhanced protection will be offset by extended service life and reduced maintenance.

The activities of ***non-utility individuals*** can also have an impact on the service life of a wood pole. This is a very difficult challenge for a utility to address. In most cases, the damage is unintentional and does not come to the attention of a utility until there is a problem.

Example: It was recently discovered that a land development project unintentionally diverted a small underground stream. This resulted in the formation of a pond in a forest area, which is located below the development. (photo 31) Unfortunately, there was a wood pole line in the area now flooding. Since there is no way to drain the area, it is no longer possible to apply remedial treatment to the poles, which are standing in water.

Photo 31

Thoughtless actions of residents or contractors can also cause problems for a utility. Individuals, who are unfamiliar with wood characteristics or performance issues, may attach an object to a pole or alter its form. Their deliberate action may have unintentionally comprised a pole's strength and durability.

Example: A few years ago, a line crew was dispatched to investigate a report of pole that broke during a windstorm. When the crew arrived at the site, they were shocked to find that a local resident had somehow attached a large satellite dish to the pole. Though the windstorm may have prompted the failure, the weight and umbrella shape of the dish were the two factors that comprised the pole's bending strength.

Example: A contractor cut deep notches into several pine poles in order to mount electrical service boxes for a business complex. (photo 32) The thoughtless actions of this individual seriously comprised the structural integrity and the service life of the poles. Photo 31 shows that the notches exposed untreated heartwood, thus leaving the poles open to attack by decay fungi or insects.

Once again, it is likely that the contractor's actions were not malicious. Though the notching of the poles was deliberate, the intent was not to render them unsafe or to comprise their service life.

Photo 32

Summary

A properly treated and well-maintained wood pole should yield many years of trouble free service. It is important that utilities and the wood pole manufacturing industry realize that the service life of a product is not etched in stone. There are factors that can either enhance or impede performance such as, product selection, handling and storage methods and maintenance procedures. BC Hydro believes that decisions involving treated wood should be based on good science and not personal opinions or the flavour of the day.

The key to avoiding poor choices and costly mistakes is training. Employees and contractors, who have received training regarding wood characteristics and performance issues, tend to show greater interest in the products they work with. They comprehend how their actions can have an impact on the service life of a pole or timber.

Reflecting on lessons learned has helped BC Hydro to appreciate that quality control should not be limited to a procedure. Rather, it should reflect an interest in research and development with a focus on product improvement. It is a win/win situation when users and manufacturers work together to solve problems before they mushroom out of control. The use of wood preservatives did not spark the media attacks of the past decade. It was the abuse of wood preservatives and a lack of quality control that cast a negative light on the entire field of wood preservation.

BC Hydro is convinced that a treated wood pole can be - should be considered the most environmentally friendly product available for power and communication line construction. It is the only construction material that that is truly renewable. If due diligence is applied by users and manufacturers, the many benefits of treated wood should ensure its continued use as a product of choice for utilities poles.

Acknowledgements

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All other photos; courtesy of L Joseph fonds.

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